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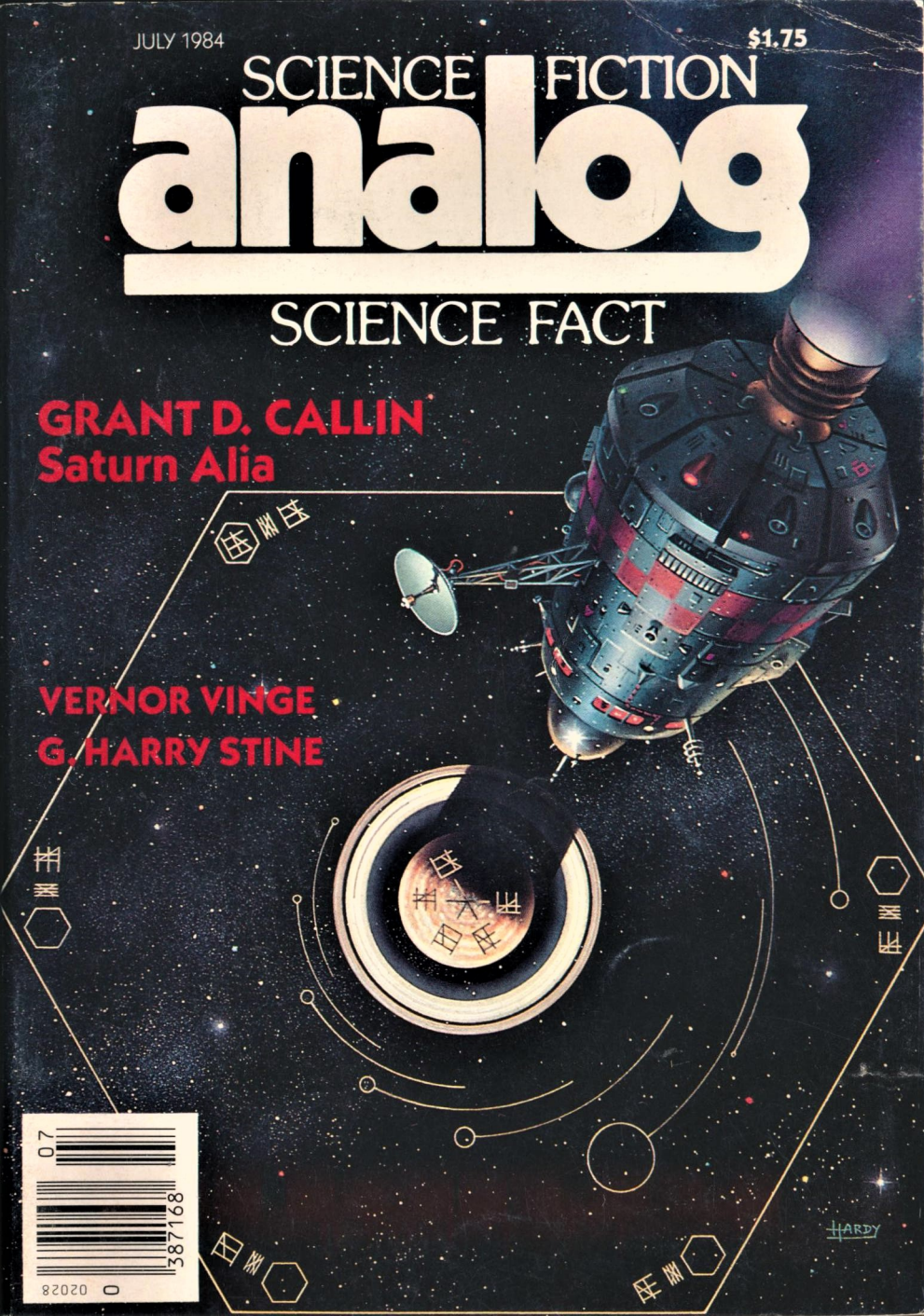

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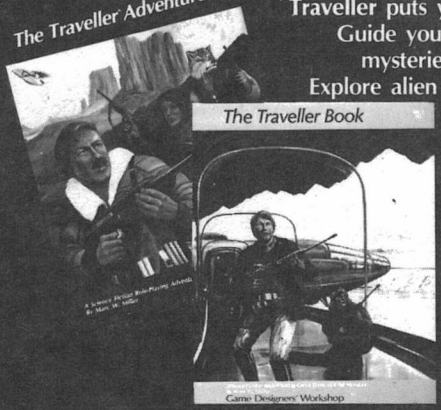

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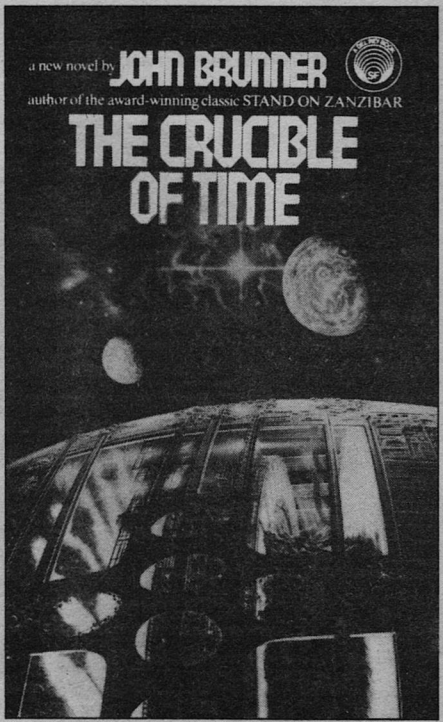

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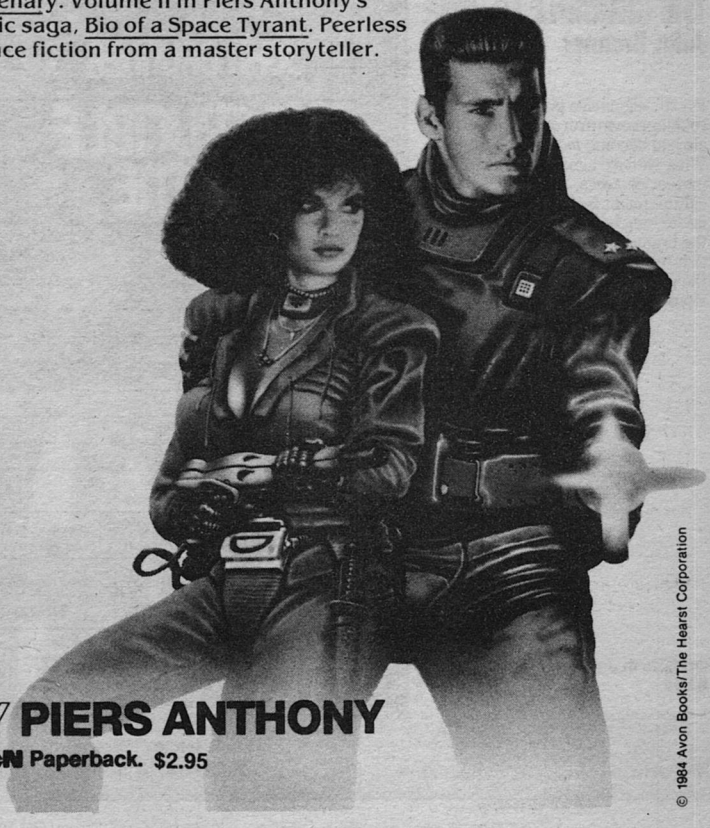

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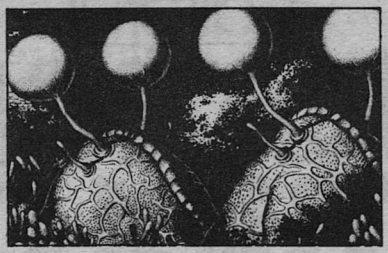

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Editorial

EDUCATIONAL MYTHOLOGY

Stanley Schmidt

The clever thing about words like "mythology" and "heresy" is that their applicability depends very much on whether you're "in" or "out." Christians and Jews seldom speak of Christian or Jewish mythology, because they regard their own beliefs as "truth." "Mythology" means things like the Greco-Roman pantheon—unless, of course, you happen to be an ancient Greek or Roman, since they also regarded their beliefs as true. What the *usage* seems to boil down to (without regard for the actual truth level of any belief system) is that what "we" believe is Truth, while what somebody else believes (but we know better) is mythology. "Heresy" is a little different: it's the questioning of orthodox belief by someone who "should" accept it. Nobody expects an ancient Greek to accept Christian or Jewish theology; he merely believes what he was brought up to believe, and is not himself entirely to blame if he believes celestial phenomena are governed by Zeus. But a Catholic monk or a professional meteorologist who believes that is clearly rattling his own cage and must expect a heretic's reception from his colleagues.

Please note that the concepts of mythology and heresy are by no means restricted to religion. Nor do they necessarily have anything to do with actual truth or falsity. "Truth" is what Everybody Knows (in your group); "heresy" is what troublesome members of the group say to distress the others; and "mythology" is the orthodox dogma of *other* groups—usually with the implication that "we" know better.

Yet in some matters there are objective kinds of truth or falsity which are indifferent to the beliefs of any group. If some cult wants to dedicate itself to the proposition that water is a deadly toxin and must never be taken internally in any form, it is free to do so—but the laws of biochemistry will not allow its

members to apply that belief actively for very long. According to the universe, some beliefs *are* better than others, and a culture which has taken the trouble to learn something about those may with some justification define mythology as things which are believed but untrue.

In the last year or so there has been a lot of talk about what's wrong with contemporary education and what can be done about it. How much of that talk has anything to do with objective truth, and how much is "mythology" in the sense of accepted dogma which just ain't so?

Sorry, folks: I'm not going to give you a complete and indisputable answer. What I will do is don the mantle of a less ambitious heretic and merely *question* some assumptions which seem to be the accepted dogma of at least some significant part of the educational establishment, and which I suspect may not be as true as everybody knows they are. Some of them may turn out to be perfectly valid—but when educational reforms are contemplated, all such assumptions deserve to be reexamined and either reaffirmed, modified, or rejected for cause.

Here, then, are my nominees for educational myths—or are they facts?—along with a few jottings about where my suspicions lie:

1. *More is better*. This is one which few educators or administrators would profess quite so baldly, but their *actions* often say it pervades much of their thinking. It takes many forms: longer days and years will mean improved education; higher pay for teachers or more money spent on just about anything will make things better; if it doesn't cost a lot, it can't help. But spending money improves programs *only* if it is spent on people, equipment, and programs which are appropriate to needs, of high quality, and continually evaluated to be sure they are producing results. Moreover, sometimes a lot can be accomplished with very little expenditure. As for more time in the classroom being equivalent to more learning, I will only cite my own experience: through most of grade school and much of high school, I learned far more *outside* school than in it, by reading independently on my own time. I do not like to think what might have happened if somebody "older and wiser" had scheduled all that time for me.

I've been corresponding with a reader named Max D. Musgrove who for seven years headed an organization called CAN DO, conducting a wide range of special educational programs at the Pacific Science Center in Washington. Mr. Musgrove wisely points out that if something is broken, you can't fix it simply by doing more of what you were doing when it broke. Of course (I add), there *can* be situations when a device or system is not functioning well because it's getting too little of what it needs—oil, for instance. But oil won't help a broken axle. Educators should be wary of *assuming* that all we need is more of what they're already doing. What's really needed may be repairs —and that means fundamental structural changes.

2. *Radical change is better*. Radical change *may* be better, but only by demonstrating that it produces better results can any particular change justify that

claim. There have always been faddists who would jump on any passing bandwagon, figuring that if a new method was drastically *different*, it must be drastically *better*—overlooking the possibilities that it might be drastically *worse*, or harmless but inconsequential. For example, some years ago an epidemic of "New Math" swept through elementary schools, leaving high school and college teachers to deal with a generation consisting largely of mathematical cripples. A little later the rage was "behavioral objectives," in which everything was to be reduced to precise, objectively and quantitatively measured goals which had to be met before the student could move on to something else. I once asked an enthusiastic proponent of this theory how it could be applied to creative writing, and was rewarded with a stream of erudite but unconvincing jargon—and a vivid mental image of John W. Campbell (demonstrably one of the best writing teachers ever) scowling around his cigarette holder and saying curtly, "It won't work."

3. *"Student hours" provide an adequate and meaningful measure of where educational efforts—and funds—should be directed.* In case you're not familiar with the concept, many school administrators multiply numbers of students by numbers of credit hours to determine the workload and importance of a teacher, department, or program. I've seen this kind of reasoning decimate an outstanding physics department, because physics has never been a popular major. Somehow I'm reminded of the story (which one of our writers assures me is

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true) about a company whose main product was jet engines, taken over by another whose experience was in grocery retailing. The new owners promptly did a "cost-effectiveness" study of all departments, by dividing the income attributable to each by the floor space it occupied. They then abolished the two "least profitable" departments: metallurgy and fluid dynamics.

As Mr. Musgrove says, "The bottom line is that the educational system will make no significant changes or improvements until we change the funding formula from student days to student progress." Such a change, of course, requires that we have and use reliable methods of measuring student progress. We may have them, but we don't seem to be using them very well or widely. Instead, too many educators assume that poor results mean poor students—and that leads us to Myth #4.

4. *Students who do well or poorly in the present educational system will do well or poorly under* any *educational system.* In other words, evaluation methods now in general use give accurate measures of student abilities, and the good students are those who *look* like good students. Actually, when I taught nine years at a college so small that I could get to know my students individually and well, I consistently noticed a strange dichotomy among those I found brightest and most capable. Many of them *had* been considered outstanding students throughout their school careers—but many others had been considered mediocre or worse, and discipline problems to boot. Think about it.

5. *Today's students are inferior to those of a few years ago (their SAT scores prove it) because television and video games have curdled their minds.* There may be some truth in this—television watching does tend to be a pretty passive activity, and much learning requires doing. On the other hand, television exposes children to a lot of information, and most small children soak up information like eager sponges. Max Musgrove thinks that instead of *stifling* curiosity, television stimulates and feeds it at such an intense rate that kids accustomed to it are bored stiff when plunged into school and fed dreary information in a dreary style at a dreary rate. I suspect there's a lot of truth in that. I was not exposed to much television when I was very young, but I was exposed to a lot of other things, and I found much of the grade school curriculum so tedious that it was made endurable only by teachers who had the good sense to let me browse on my own when I finished what I was "supposed" to do. As for video games, they are anything but passive and they are potentially a very powerful teaching tool. Parents and educators often bemoan the *kind* of information children get from television and video games; maybe the energy used for bemoaning might be better spent learning to apply those dramatically effective *methods* to more worthwile *content.*

6. *Use of gimmicks like television, games, and humor to catch and hold student interest cheapens serious academic subjects and so should be avoided.* Who ever decided "serious" and "fun" were incompatible, anyway? Many students are in school only because they

have to be, and the first prerequisite for getting them to learn is to capture and hold their interest. Anything that helps do that makes a positive contribution to education; a stodgy refusal to use such aids contributes only to the dropout rate. As John Campbell once said, "Teaching ought to have more *circus* in it!"

7. *Use of gimmicks like television, games, and humor in itself constitutes educational improvement.* The only thing that consitutes educational improvement is students' learning more; "gimmicks" are merely means to that end. In themselves they no more assure success than they "cheapen subject matter." They are devices to help transfer information; it remains the teacher's responsibility to see that the information transferred is Good Stuff.

8. *Students of comparable age and experience must be kept together and separated from others, passing through an orderly progression of more and more advanced material.* This presumes either that all students learn at the same rate (demonstrably false) or that it's too much trouble to attempt to work with the differences. The CAN DO group found, somewhat to its own surprise, that "classes of stratified age groups performed much less well than nonstratified groups." They did not claim to understand why, but the empirical observation was so clear that they soon quit conducting programs for stratified groups. If we're going to go "back to basics," maybe we should go so far as to reconsider what the "little red schoolhouse" had to offer.

9. *Subjects must be taught one at a time and in "proper" order.* This one runs deep and is quite alien to the structure of the universe. Physics is taught by physics teachers and English by English teachers and seldom the twain shall meet; even subjects as close as physics and chemistry and mathematics are physically separated into distinct boxes and students too seldom see the web of interconnections binding all these things together. And of course Chapter 4 *must* be done before Chapter 6!

Teachers who really pay attention to what *works* find all kinds of exceptions to these notions, but if they act on their observations they invite the "heretic" treatment from colleagues—*results* notwithstanding. One of John Campbell's daughters advanced whole classes of "incorrigible" students several grade levels in reading ability in a single year, and was criticized because her methods involved leaving comic books around the classroom. One of my teachers achieved similar results by tricking students into learning to read English as a means to learning to play the guitar, and was rewarded by such comments as, "But you're teaching *music!*"

I was once teaching astronomy as a tutorial to a student given to sudden intense enthusiasms; when her imagination was obviously fired by a chance mention of a topic scheduled for three weeks later, I accomplished most by seizing the opportunity to talk about that. "Today's" topic could wait. But the teacher must be alert for such opportunities, and even the best can make mistakes. I still shudder (with hindsight) when I remember the grade school teacher (otherwise one of my favorites) who put the problem "$1 \div 2$" in an

exercise on division with remainders. Having never seen an example in which the divisor was bigger than the dividend, I thought long and hard about what it *meant*, and finally wrote "½." I had made a huge conceptual breakthrough; I had discovered, on my own, what fractions meant. My teacher should have found that very exciting and tried to do something with it. Instead she marked the problem "wrong" (something which seldom happened to me in those days, and I *knew* it wasn't wrong), and said, "We'll teach you about fractions next year." And that was the end of that.

10. *"Enrichment programs" for the gifted raise the quality of education for all.* A dangerous delusion, but one requiring great care to distinguish baby from bathwater—and I've seen this one from both sides of the (student) fence. Academically, I benefitted greatly from "Advanced Placement" programs in high school; they were some of the few classes which helped more than hindered my education. Athletically, I was terrible (partly because of the feeling that everybody else had a four-year head start on me, since I spent those first years in a rural school with no athletic programs at all). I *needed* help in gym classes; I virtually never got any. The gifted need special help and/or opportunities, but so do those at the other end of the spectrum. Special programs for fast students can easily become a soothing excuse for doing nothing for others. In general, the slow probably need *help* more than the fast. The really gifted, *given materials and opportunity* (including the opportunity to ask for help), can often fend very well for themselves—which leads us to Myth #11.

11. *Students need continuous close supervision.* Sure, they get homework, but it's usually pretty specific ("p. 198, Problems 2, 4, 7, and 10, due Wednesday"). But let them design and carry out a whole program? Obvious nonsense, you may say—but one of the more exhilarating parts of my college teaching years was the chance to watch it happen repeatedly in a "student-initiated research" program. A group of students organized itself, wrote a proposal for a research project, applied for a grant, and spent a summer carrying out the research and reporting on the results—all with decidedly minimal faculty input. I knew many of those students well (I was *not* the project advisor), and what they did was impressive. One of them came back from a follow-up meeting in Washington DC with a tale of meeting a skeptic who arrived at that meeting with the openly professed attitude, "undergraduates can't do that kind of work"—and left planning to title his report, "The Hell They Can't!"

Which leads to Myth #12:

12. *Students must be graded, on a rigorous number or letter scale, to get them to work*;

and its opposite, Myth #13:

13. *Grades stifle students' enthusiasm for learning and so should be eliminated altogether.*

Like so many sweeping generalizations, these don't sweep very well. Some students do seem to need grades; others are turned off by them. I had a very good graduate professor who was reluctant to let me audit his course (i.e.,

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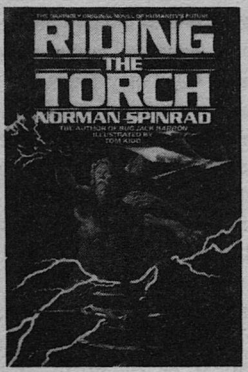

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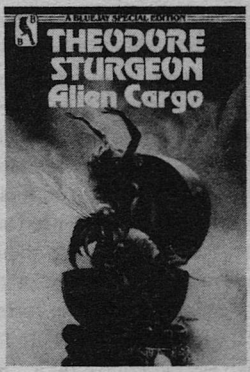

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attend without credit or grade) because he believed, "auditors don't work." But I worked as hard in that course as in any I ever took; after all, I was there only because I wanted to learn what he was teaching. Maybe what bothers some teachers about ungraded students is the fear that they won't be able to keep things interesting enough to inspire work without threats. Might that suggest ways to keep *teachers* on their toes?

Of course, students need some sort of feedback to measure their accomplishment—but the value of that feedback depends less on its form than on how the teacher applies it. I taught a science fiction course on a "pass-fail" basis, and some students did sign up under the delusion that that meant a couple of easy credits. But one of our best English majors complained repeatedly that it was the hardest two hours she ever took—and came back a year later to thank me for giving her exactly what she needed before spending a semester abroad in an exchange program.

14. *Continuous practice is necessary to develop and retain any skill.* Everybody seems to take this one so much for granted that it *is* often stated explicitly. It manifests itself in such forms as a curriculum which, from about the fourth through the eighth grade in the schools I attended, did little more than repeat the same material five years in a row (with a *little* extra added each time). My personal experience with learning (and that of several acquaintances) suggests that this bit of popular wisdom may be at odds with a real effect which is not generally recognized, much less understood. In a wide range of fields, I have experienced lengthy periods where continued practice produced no noticeable improvement. But I have also experienced complete lapses of several years, which according to the popular wisdom should have caused a complete loss of old skills. Instead they seemed to affect only "surface" memory, while the pertinent knowledge not only remained latent in deeper storage, but somehow continued to strengthen there. For when the time came to resurrect those old skills, they not only came back very *quickly*, but they came back in some ways *better* than they had been before. Anyone who's ever solved complicated mathematical or scientific problems knows that sometimes the best way around an impasse is to get completely away from it for a while—to stop thinking about it, at least consciously. My experience suggests that something similar can happen with entire subjects. If this effect is real and common, we might learn to apply it to curriculum design, making constructive use of "student sabbaticals"—periods during which *no* instruction is given in a particular subject, returning to it only after the "subconscious processor" has had time to do whatever it does.

15. *Everybody should be required to take and pass certain courses to graduate from any school.* Probably so—but which ones are required and which recommended? I find it a little hard to imagine certifying a "physicist" who can't use calculus—but should a musician have to pass astronomy? I rather like the idea of *exposing* everybody to some astronomy—it's awfully fundamental to life on this or any other

planet—but I'm disturbed by the memory of a music student who simply could not handle the type of thinking that astronomy required. If she was a competent musician, could we really justify keeping her from performing or teaching music because she couldn't do astronomy?

16. Perhaps the biggest myth of all, an undercurrent running through several of the foregoing: that *any one approach to education will be optimum (or even serviceable) for all students or all teachers*. As a student, I noticed that my best teachers showed an astonishing diversity of methods and styles. As a teacher, I found that students showed an even wider variety of ways of thinking and learning. How people think varies not only in degree but in kind. Any really successful system of education is going to have to come to terms with that fact and provide ways to play on the innate interest of all students, making individual adjustments to keep every one of them moving as fast as (but no faster than) he or she is ready to go. And our biggest obstacle to achieving that goal just may be the deeply inculcated but poorly grounded assumption that spending lots of money is either necessary or sufficient. ■

● The golden rule is that there are no golden rules.

George Bernard Shaw

SATURN ALIA

Grant D. Callin

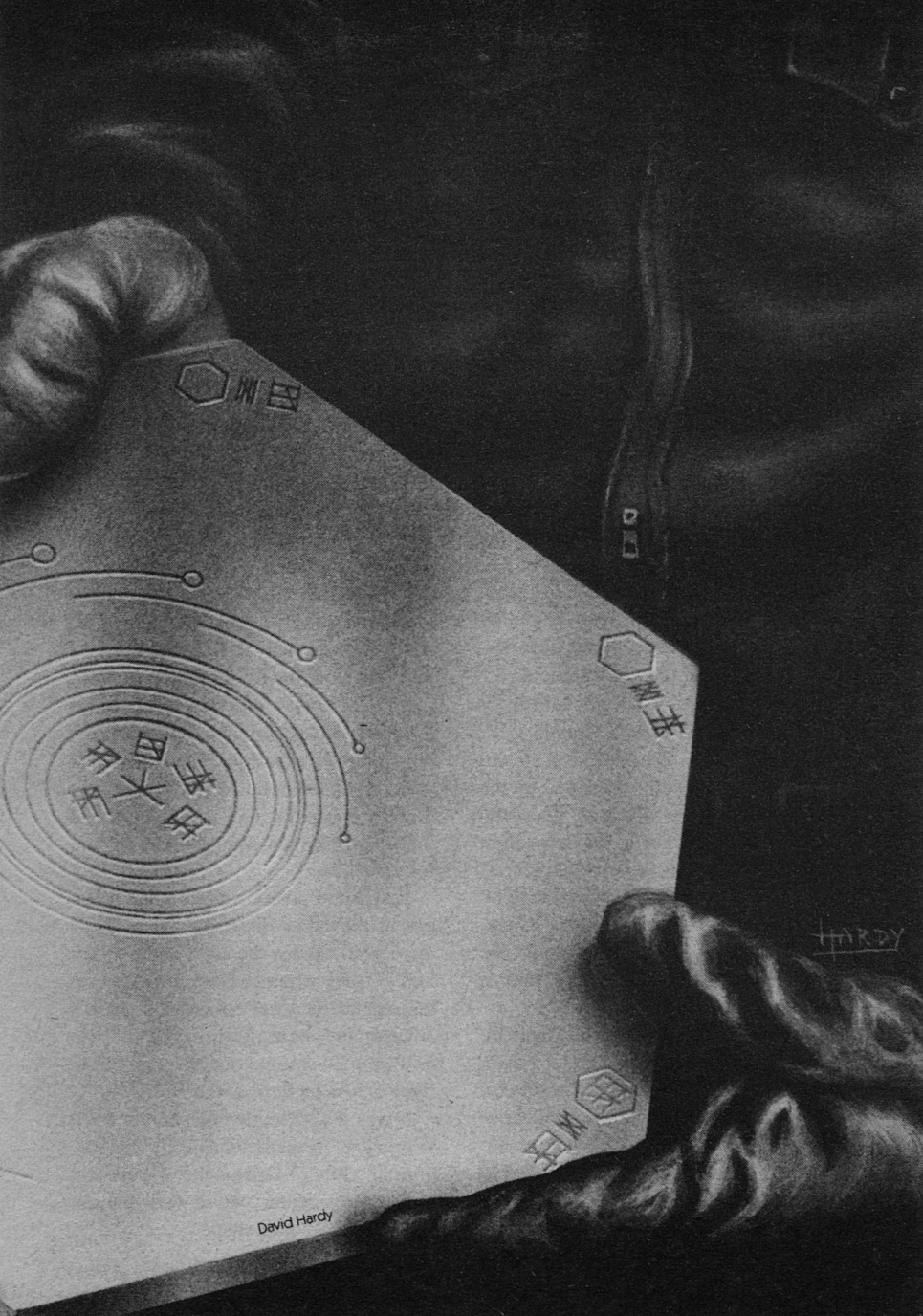
"Treasure map" tends to conjure up images of a quest for a certain type of object. But that's not the only type possible. . . .

I

Earth used to charge outrageous prices for shipping organics up the gravity well to the Lagrangian colonies. So when SpaceHome Corporation finally decided to seek an alternate source, the computers said Iapetus. Don't ask me why; I'm an archaeologist, not a computer. But when I found out rather suddenly that I was going to I-Base, a modicum of excitement crept into my soul; after all, the number of people who've seen the rings close up is quite limited, even these days.

Anyway, here we were, finally nearing the Saturnian system, and I was too bored to be excited. Twenty-eight days from L-4 at .1-g, the second half of it backwards. Space travel: big deal.

The tug pilot was unsympathetic. "Bored! You call *this* boring? Hell, man, this is a piece of cake. After I drop off these supplies, I gotta pick up 20,000 tons mass of fuel and smelly organics and wrestle 'em back to L-5. Three months at a crummy point oh-one-g, with calcium leaching from my


HARDY
David Hardy

bones and no crib games. You wanna talk about boring?''

An unfortunately timed yawn earned me a mild glare. ''Anyway, if you wanna look at Saturn, we'll be orbiting Iapetus for a while before we burn down to base. You can get a good peek before we land and go underground.''

An hour later the tug stopped decelerating, but when I started to drift to the starboard port the pilot stopped me. ''Strap into your couch for a few minutes, Whitey. We'll prolly have to make a little plane change; I'm checking with I-Base computer now for the verdict.''

I'd just strapped when he said: ''Okay, we're about two degrees flat. Hang on; I'm gonna let the nav 'puter do its thing.'' He punched code. Almost immediately I heard the muted in-cabin hiss of the hydrazine thrusters. My inner ears did a little dance as the tug performed a rotation in two or three directions simultaneously, then abruptly stopped. A small interval, then the CRF engine gave us a fifteen-second shove.

When we stopped, he stared at the readouts for a few seconds, then announced: ''That's got it. Twenny-eight point two degrees with descending node smackdab at I-Base next pass. Hang on another second.'' One last dance. ''Okay, I've got our ass-end pointed down the groove; you can unstrap and take a look.''

About three or four times the diameter of the Moon from 'Home III or Earth, Saturn was big enough, but not all that impressive. The cloudbelts lacked striking colors, and the rings were edge-on. It wasn't enough after a month of waiting. The pilot, as usual, put two cents in: ''Iapetus is only a day or two from ascending node. Wait three weeks and the rings'll be tilted fifteen degrees. The Old Man'll be a lot gaudier then.'' He pushed away from the port and drifted to the other side of the cabin. ''C'mon over here; you can see where we're gonna land.''

When I'd joined him he pointed toward the planetary horizon. ''That's looking back along our flight path. Right on the horizon is Hamon Crater. It's solid red-black except for a cream-colored central peak—looks like a curious white dimple.'' He laughed and elbowed me in the ribs. ''Get it? Curious white dimple, heh, heh!''

I grabbed hold of a port fitting to keep from drifting away and awarded him with stony silence.

He subsided to a sheepish grin. ''Hell, I couldn't resist; you don't have to be so touchy. Anyway, five hundred klicks over the horizon from Hamon is Baligant, then Grandoyne. All three craters are pretty black, and they checked 'em out early as possible base sites. Tar wan't thick enough in 'em, though—no more'n ten or twenny centimeters—so they just dropped transponders in 'em for nav aids.''

He shifted position and angled a finger in the other direction. ''Up ahead there you can see the start of the Black Sea. That's where I-Base is—right on the equator at local Greenwich, so it's always got Saturn dead overhead.'' He now pointed straight out the port. ''And right below us here is the Bullseye.''

It was a wide dark ring, hundreds of kilometers in diameter. Inside was the normal white of Iapetus ice, except that in the very center was a dark pattern with a Coke-bottle shape.

"Take a close look at it," he said, "because next time around we'll only be a few klicks up and burning down on our tail. Right there in the center—in the middle of the Bathing Beauty—is where they found your precious artifact. You know, it's crazy; they been on Iapetus all these years and they just get around to exploring somethin' only four-hunnerd klicks away from base. Goes to show ya . . ."

"Just a minute," I interrupted, registering every ounce of incomprehension I could muster. "What do you mean, 'my precious artifact'?"

He grinned. "No offense, Whitey, but you never fooled me with that story about bein' some industrial operations specialist. I got a friend in SpaceHome central comm shack; word's out all over the Colonies that I-Base found somethin' in the center of the Bullseye that was artificial, but not made by man. A tablet of some kind"—he gazed obliquely at me—"that was covered with markings.

"And in case you think you've kept the news from Earth, forget it; they've had our encryption keys for years. So what you've got is the best-known secret in the solar system." He scratched his chest reflectively. "What I'm tryin' to figure out is why Earth isn't screaming about you guys keepin' this thing to yourselves. You might know something about that, eh?"

I tried to convey candid astonishment in the look I gave him. "Just what in the devil are you talking about, Jock?" Unfortunately, intrigue isn't my forté. My voice caught, and I'm afraid my tone wasn't convincing.

He sighed. "Okay, have it your way; but don't think the rest of us are total dummies. And remember, we're on the same side." He turned back to the port. "Hey, here's something interesting: the terminator in the Black Sea. Once you get into shadow, it's like bein' at the bottom of a coal mine at midnight. . . ."

We blasted down the groove without incident. The computer did the work, while the pilot grumbled under his breath. I asked what was bothering him. His answer sounded like an Earther grumbling about taxes: "Good thing hydrogen's cheap at I-Base; I gotta push so much reaction mass through the throat that my I_{sp} goes down to a crummy 10,000. And taking off with a full load's even worse. They oughta outlaw planetary surfaces. If the Good Lord'd meant us to land on planets, He woulda given us antigrav. . . ."

He continued this monologue all through the approach, although his eyes never ceased their vigilant watch over the readouts. I finally decided that he would *enjoy* the return trip at .01-g, since it would keep his precious Eye-Ess-Pee high, whatever that meant.

After touchdown I unstrapped and looked out the port facing the base. There was precious little to see; the few structures showing above ground appeared to be part of a refinery. Puzzled, I asked Jock where the solar cells were hidden.

He grinned at me. "You're pretty ignorant for an industrial specialist, Whitey. Solar power's out of the question here. It's too far from the Sun, and it stays dark forty days at a crack. Nuclear's the only way to go; they got one CRF generator that supplies all the power they need. Now whattaya say,

let's get down inside; I got a thirst that won't quit."

We stripped off our coveralls, threw them into our bags, and donned micropore suits. By the time we'd debarked, a crew was already unloading the supply cannisters from the tug. According to Jock those same containers would shortly be emptied of inbound goods and refilled with CRF reaction mass, and other organics to be differentiated or refined back at SpaceHome.

Once inside the airlock we changed our suits for coveralls again and took the elevator down to Base Personnel level. Jock immediately headed for the bar, with more reluctant steps I followed the signs to the manager's office.

Informality reigned; the secretary jerked her head toward the inner door before I even got my mouth open. I walked in, and the manager rose from his desk to greet me.

"Hello, I'm Bob Reynolds. And you must be Dr., ahh, Curious Whitedimple." He made a valiant effort to hide his smile.

I sighed. Forty years down, maybe a hundred to go. "That's Kurious, Mr. Reynolds. Pronounced *Koor*-ee-us."

He let the smile emerge. "Goodness, that certainly is an unusual name. . . ." He trailed off expectantly. I briefly toyed with the idea of levying heavy sarcasm, then cancelled. After all, I had to work with this person. I quickly decided on my "man-to-man" pitch, and spoke as earnestly as possible:

"Kurious, or course, is Greek, after my maternal great-grandfather. Whitedimple is a loose translation of an old Marjoe Indian name; in the original, it's considerably bawdier." I favored him with a sly wink.

Predictably, he leered. "Oh, ho; I understand now, uh, Dr. . . ."

"Dr. Whitedimple is so formal," I cut in smoothly. "Why don't you just call me Whitey."

"Very well, uh, Whitey. I suppose you'd like a rundown on the operation here. As you probably know, Iapetus Base was established in 2067 for the purpose of filling the SpaceHome colonies' pressing need for cheap organic compounds. Besides being the solar system's major supplier of organically bound hydrogen for CRF reaction mass, we ship thousands of tons of unpro-

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cessed organics on each of the quarterly tugs. Among these compounds are the various clathrates of . . .''

This character was wound up and ready to go; I interrupted him fast. ''Excuse me, Bob, but I'm not really what the message said I am. Maybe you'd better read this letter from Mr. Ogumi before you go any further.'' I dug the one-pager from the SpaceHome Corporation's president out of my coveralls and handed it to him.

He read it rapidly, then smiled thinly at me. ''I didn't think you could be an industrial specialist, Whitey. Our operation here is practically all computerized, anyway. Well . . . Mr. Ogumi requests that I give you any assistance I possibly can. So what can I do for you?''

''Naturally, I'm eager to see the artifact. But first I'd like a bath.'' Spending a month living in one's own sweat is guaranteed to re-establish priorities.

His smile was wider this time. ''Water is one thing we have plenty of, Whitey. Practically the whole damn satellite is made of it. Here, I'll show you to your quarters. . . .''

An hour later, considerably refreshed and with my scanty gear stowed in the room assigned to me, I walked into Reynolds's office again. He had his big safe open and a pair of heavy gloves on. ''Here, Whitey, grab that other pair of gloves and give me a hand with this; the damn thing masses about twenty or thirty kilos, and it's tricky to move around. Must be gold or platinum alloy of some kind.''

Two minutes later the slab was sitting flat on the desk, and I was staring avidly at it. My old mentor, Professor Grenoble, would have been palpitating with ecstasy, but I am considerably more phlegmatic; I merely kept whispering ''Damn, damn,'' under my breath as I drank it in.

''You're only the fifth person to see it,'' Reynolds said quietly. ''Of course, word is out all over base. . . .''

I barely heard him. I had pored over the transmitted pictures of the artifact, but the cold perfection before me was unnerving in its impact. It was a regular hexagon, a little over thirty centimeters in diameter and a trifle less than a centimeter thick. The surface was etched with hair-fine lines, obviously depicting the Saturnian system. The planet was central, surrounded by concentric circles plainly meant to be the ring system; the Cassini division was a dead giveaway.

The representation of the major satellites would have been a sufficient clue even without the rings; the relative sizes of Titan and the runt Hyperion close by were unique in the solar system. Iapetus, the outermost member of the system to be shown, was near the hexagon's edge and exactly opposite one of the apices. Thirty degrees clockwise, and about three centimeters further in, was Hyperion, the only irregular shape on the artifact and almost invisibly small. Another thirty degrees onward was Titan, opposite the second apex.

Following the same pattern, Rhea was next, about three centimeters closer to the center, then Dione opposite the third apex; next came Tethys, and then Enceladus opposite the fourth apex. Mimas was the final moon depicted, only about one centimeter from the outer edge of the rings. Each of the bodies

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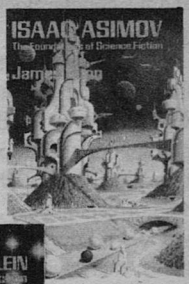

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had a sixty-degree arc of its orbit extending counterclockwise from its image.

There was no satellite opposite the fifth apex, but within the B-Ring a sixty-degree arc terminated at exactly the right spot. Opposite the sixth apex of the hexagon there was nothing. To complete the correspondence, groups of three symbols nestled in each of the first five apices; there was nothing in the sixth.

Within Saturn's image were five more symbols, each at the tip of a spoke radiating from the center. Each spoke pointed directly to an apex of the hexagon, the symbol at its tip matching one of the symbols at the apex. No spoke pointed to the nude apex.

The I-Base manager had been peering over my shoulder; he finally queried: "I recognize all the moons, but why did they leave out Phoebe?"

I replied condescendingly: "Well, I can think of two good reasons, offhand. Either they didn't consider Phoebe part of the system, or else they didn't find it during their visit—or maybe they didn't include it because it would be a waste of platinum; Phoebe is a lot further out than Iapetus. In fact, it's possible that Phoebe wasn't even captured when they were here."

Reynolds frowned. "That's four reasons."

A nitpicker. "Choose two good ones and go with them."

I tried to sink back into rapt contemplation of the artifact; it felt so *good* just to stand there and gaze at it and reflect on the beings who might have made it. But alas, the manager was under full steam. "What do you SpaceHome experts make of this thing?"

I let out a deep breath. "Okay, just a second while I make one measurement." I reached into my kit and pulled out a set of micrometer calipers with a thirty-cm extension bar.

"Watch out you don't cut yourself," he said. "Those corners may only be ninety degrees, but they're *sharp*."

I carefully measured the distance between opposide sides of the hexagon. The reading was one I'd memorized some time ago. Just to be sure I measured another pair of sides. I pulled the calipers off and showed the cursor to Reynolds. "The magic number: 33.258 centimeters."

His frown came back. "Why is that a magic number?"

"Well," I used my pontifical voice, toned down in recognition of his amateur status, "those digital scans you sent us had good resolution, and we were reasonably confident about the relative dimensions; but we couldn't be sure of the absolute scale. So we made one assumption and some smart guesses." I put the calipers away. "And that one measurement was all I needed to verify our theories."

I gestured at the gleaming artifact. "The creators of that thing were adamant about the number six; much more so than meets the eye just looking at it. For instance, if you were to inscribe a circle in the hexagon, its diameter would be exactly six times that of Saturn's image. And the planetary image itself is exactly 5.543 centimeters across, which is exactly the equatorial diameter of Saturn divided by 6^{12}. And you'll notice that the moons are drawn to a larger scale to make them easily visible. The scale multiplication is exactly six."

I smiled at him. "There's a lot more." I reached into my kit to fish out a reticle magnifier. "All the orbits shown in the etching, including the ring boundaries, are spaced logarithmically —base six, keyed on Saturn's image diameter."

Placing the reticle on a portion of Iapetus's orbital arc, I bent down and squinted at the image. "This is just for my own curiosity." I moved the reticle to one of the symbols in the nearby apex. "The width of these lines, as far as I can judge, doesn't vary one iota." I looked up at him. "Guess what it is?"

He looked a little irritated. "I wouldn't have the slightest idea."

I ignored his frown. "As near as I can measure, it's between .025 and .026 centimeter; but I'm willing to bet it's almost exactly .02565, because that happens to be Saturn's diameter divided by 6^{15}."

He pursed his lips. "What does that mean?"

"That they were consistent devils." I put the reticle away. "And it's one more indicator that the number six is of overriding importance in the message."

"So what do you think the message is?"

"We think it's two things. First, and most obvious, it says: 'Hey, there's someone else in the universe!' Second, we believe it's a roadmap, a set of directions on how to find more artifacts, and especially how to find the real cache that could tell us who they are and where they come from—maybe even how to contact them."

His frown must have been glued on. "So you think there are also artifacts on Titan, Dione, Enceladus, and somewhere in the B-Ring?" His finger pointed in turn to the images opposite the apices.

"Yes we do," I nodded. "And by the way, that 'somewhere' in the B-Ring is about 48,000 kilometers from the planetary surface; and it's probably an important location."

"Why? Because of those marks in the middle of the little hexagon there?" He pointed to one of the three symbols at the apex opposite the B-Ring site.

"Exactly," I said.

"So that's where the big cache is," he said, brightening.

"Well, no; we don't think so," I said.

His frown came back quickly. "Now you've lost me again."

This man had no future in cryptology. I was patient. "Well, if their preoccupation with sixes means anything at all, it's that there *must* be a sixth location, a sixth cache." I gestured at the metal slab. "That missing spoke in Saturn's image, and that unfilled apex, shout the message loud and clear. And as surely as they were here, it's that sixth location which will contain the real find."

Dawn finally broke on his face. "Then the B-Ring site—"

"Will contain the roadmap to that cache," I finished. "our final analysis of this artifact's message goes something like this: 'You are looking at one of four identical plates we've placed on Enceladus, Dione, Titan and Iapetus. At a certain location in the B-Ring is a fifth artifact; it will contain directions telling you how to find the sixth site, where the ultimate treasure will be found."

Reynolds furrowed his brow. "These people, whoever they are, sure seem to

like games. Why not just put roadmaps in all five locations?''

''Good question,'' I said. ''And one we might answer if we knew a little more xenopsychology. Maybe it's a test of sorts. Maybe they want to put us through the hoops to impress us with their importance,'' I smiled, ''or maybe you're right, and they just like to play games.''

''Do you think this treasure, as you call it, might be on another planet in the solar system?''

He'd missed again. ''I doubt it; Saturn is the sixth major planet from the Sun. What worries us is that the cache might be on Titan, which is Saturn's sixth major moon. I'm told that we don't have a man-rated vessel with the pressure and temperature compensation to handle a Titan landing. My personal hope is that it's orbiting safely at six Saturn radii or six diameters out. But wherever it is, we've got to find it!''

''Then I suppose you'll be heading for the B-Ring?''

''Not right away,'' I said. ''First of all, I'm going to look for the artifacts on Dione and Enceladus. Remember, all we have now are theories; we need a few statistics to back up our reasoning.''

''Where are you going to look?''

Now it was my turn to frown. ''Well, I brought along an atlas of Saturn's moons. I'm going to search for striking geological or geographical features. You found this one in the middle of the Bullseye; I hope to find something equally obvious on Dione and Enceladus.''

Reynolds gave me a puzzled look. ''It seems to me that you're not very well prepared for this search, Whitey. Why did you hotfoot out here before doing your homework? And why did SpaceHome call after I'd transmitted the pictures, and tell me to put a lid on communications until I was contacted?''

I'd spent a lot of that outbound month wondering the same things. Ogumi and his staff, in my hurried outbriefing, had warned me that the news couldn't be kept under wraps forever, and that this interim secrecy was so that we could break the whole story at once after we found the big cache.

But Jock, bless his heart, had steered me in a new direction. Ogumi and his minions must know that Earth was aware of our find, so speed must be the *vital* ingredient. The spaceHome moguls undoubtedly had me pegged as an innocent bookworm type (not without reason), and wanted to keep me dumb and happy about the whole setup. Lucky me. I wondered anew what I was getting into. For a long, wistful moment I wished I were back on 'Home III again, teaching archaeology to a bunch of sleepy-eyed kids. I'm most definitely not a hairy-chested hero.

Meanwhile Reynolds was looking expectantly at me; so I dredged up a partial answer, adding knowledge accumulated from years of bull sessions with fellow academicians: ''Bob, you must know that for years and years Earth has been strictly second place in astronomy. SpaceHome has all the good equipment, both in orbit and on the lunar dark side. If Earth scientists want to use it, they pay through the nose—it helps our balance of trade.

''The only field where Earth is still number one is in SETI research, and that only because we don't want to

waste our time on it. They've had a strong program underway for more than two generations, and have still come up empty. One of their few loud boasts is, 'If there is a communicating intelligence out there, we'll find it.'

"So here turns up the first-ever evidence of extraterrestrial life, and who discovers it? A couple of ordinary SpaceHome employees, out on a routine job to repair a broken transponder. How would you feel if you were an Earth sympathizer?"

I pursed my lips and tried to look hairy-chested. "Now our sources" (I promoted Jock) "lead us to believe that Earth was able to receive and decode your original message and picture scan. If so, they'll undoubtedly try to beat us to that cache. So what we have tried to do is act as if we weren't going to follow up the discovery in any great rush. And so I came incognito on the regular Iapetus tug—which unfortunately left only two days after we got your transmission.

"Now Earth, in turn, is probably keeping quiet about the discovery while they try to mount an expedition to beat us to the punch. If so, it won't do any harm to keep our activities under cover."

It seemed to satisfy him. "Well, good luck. So what do you need from me in the way of help?"

"I need a ship to take me to Dione, Enceladus, and probably into the B-Ring. As soon as possible."

He shook his head. "Nothing doing, Whitey. What I have here is two surface-hoppers and one tug for emergency evacuation. I won't let that go, even if Ogumi himself orders it."

I nodded. "That's what he said you'd tell me. But I understand that the Saturn

Orbiting Station is close by right now, and that they've got an all-purpose vehicle for inner-system travel, besides their supply tug. And SpaceHome pays *their* bills, too. Could we get a message to them?"

"Better than that. We'll be at ascending node tomorrow, and either Pop or Junior brings the tug in for supplies; the SOS crosses at the same time we do, about 50,000 klicks down-orbit. They work it that way to save fuel. Their orbit is the same as ours, except they're in polar and we're only tilted fourteen degrees."

He glanced at his watch. "Matter of fact, the tug'll be here in about . . . seven hours, give or take. Mom and Pop will be glad to have your company." He wore a peculiar expression as he said this, which I figured out much later was one of speculation.

II

Barely a day later, with Pop piloting the tug, we were approaching the Saturn Orbiting Station. "Pop" was Dr. Thomas B. Badille, originally designated as team leader of the SOS project—a rather misleading title, since his "team" consisted only of a single colleague, Dr. Aurica Berry. They had married themselves the second year alone in space and were now only a few years away from their silver anniversary.

Earth pulled out of the joint project about the time of the marital union; the Badilles volunteered to stay on as permanent managers of the station, even though funding would be drastically reduced. Ever since, they had regularly churned out papers on Saturn's weather system, magnetosphere, rings, satellites, and what-have-you. SpaceHome picked up the tab without too much reluctance; the team performed heroically for their meager salary.

But according to Bob Reynolds, and also to Jock, this couple was more than a trifle strange. And as for Junior, I was firmly told that I'd have to form my own opinion.

Pop was a plump man of medium height, with pleasant round-faced features. He had the white hair and wrinkle-free skin common to second-generation inhabitants of low-g, sun-protected environments; he could have been anywhere from forty to eighty years old. At I-Base he'd been pleasant enough, but with a distracted air; he had been in a tearing hurry to depart, and kept urging the groundcrew to expedite the loading so he could get back up and "minimize transfer orbit burn." I'd gotten a wink from one of the grinning stevedores, who later whispered that Pop was much more interested in getting back to Mom than in saving reaction mass. . . .

"There she is!" Pop broke into my reverie with more animation than I'd ever heard from him. He was pointing out the forward observation ports to a stubby cylinder slowly rotating about a stationary axis pointed toward Saturn.

"We dock at the near end of the axis, next to the research boat there; the Saturn end houses all the instruments, of course." He looked happier than he'd been all day. "Our little home isn't so little, really. The drum is more than fifty meters in diameter; of course, the outside three meters is ice for protection from cosmics." He smiled. "Our own little igloo. The experts said it was too

confining an environment; they predicted we'd go crazy in less than three years. Mom and I fooled them, though. And Junior likes it, too."

I was beginning to have my doubts. But they *had* continued to publish those scholarly papers; and Pop, anyway, seemed almost normal. A curious feature of the station caught my eye. "What are those pipes sticking out at all angles?"

Pop blinked at the rapidly enlarging structure. "Thruster vents. They're insulated, but the ice still melts around them when we have to make orbital or spin correction burns. That doesn't matter really; in fact, the shield is liquid the first few centimeters our from the hull. Excuse me, I must call Momma."

He pushed over to the comm set and established contact. "Aurie, it's Tommy. Turn off the scanners, baby; we're going to bump you in a few minutes."

A half-hour later I was in a comfortable living room being introduced to Pop's wife. "Aurica, I'd like you to meet Dr. Kurious Whitedimple, from 'Home III."

She looked like Pop's female clone, except that she was just shy of being plump; a more accurate description would be "well-endowed." She produced a beatific smile, and bestowed it on me. "Welcome to our home, Dr. Whitedimple. My, that's an unusual name. . . ."

I launched into a rather involved story about a slave ancestor and an interesting birthmark noticed by his first master in the New World. I was warming to my tale when a high-pitched voice, floating in from my rear, rudely interrupted: "Good! we'll call you 'Dimp.' "

I turned too fast in the light gravity and left the floor for a clumsy moment. Confronting me was a little gnome of a man with sandy hair, big ears and nose, crooked teeth, wrinkled skin—and an almost senile twinkle in his eyes.

"Dimp, this is Junior," said Mom. "He was born almost twenty years ago right here in SOS. We were going to move temporarily to Iapetus-Base for the birth, but he came along a month early, so Tom delivered him without help." I turned back around to see her smiling up at Pop.

"Nonsense, Aurie," he retorted. "*You* helped me." He turned back to me. "Maybe you remember Dimp; he made quite a little splash in the news—'the boy with the accelerating IQ.' What is it this month, Junior?"

"The last time I programmed the computer to check, it was just shy of 400." The twinkle was still in his eye, and he put his hand on my arm in mock-confidentiality. "Actually, Dimp, it's not accelerating any more; it finally plotted out as an S-curve, and it's beginning to go asymptotic now. It'll level off in about three or four years at about 620. Of course, I'll probably be dead by then. . . ."

I consider myself urbane, but I'm afraid at that point my mouth was unattractively open. Some words finally stumbled out: "But they said you were only nineteen—"

"What do you expect," he snapped, "with the equivalent of an eighty-year-old brain?"

Now Pop broke in. "Actually, Junior's condition is due to the orbit we were following during Aurica's pregnancy and the year afterward. We were in a pretty tight ellipse with periapse way down inside the G-Ring." He looked a bit wistful. "That was when we had plenty of money for reaction mass." He shook his head. "Anyway, all those hydrogen ions, spoke extensions, magnetic field lines, solar wind bowshock, and so forth were interacting with our new little bio-system here," he gestured at Junior, "and causing his central nervous system to wire itself a little differently. Much less redundancy, but a lot more efficiency."

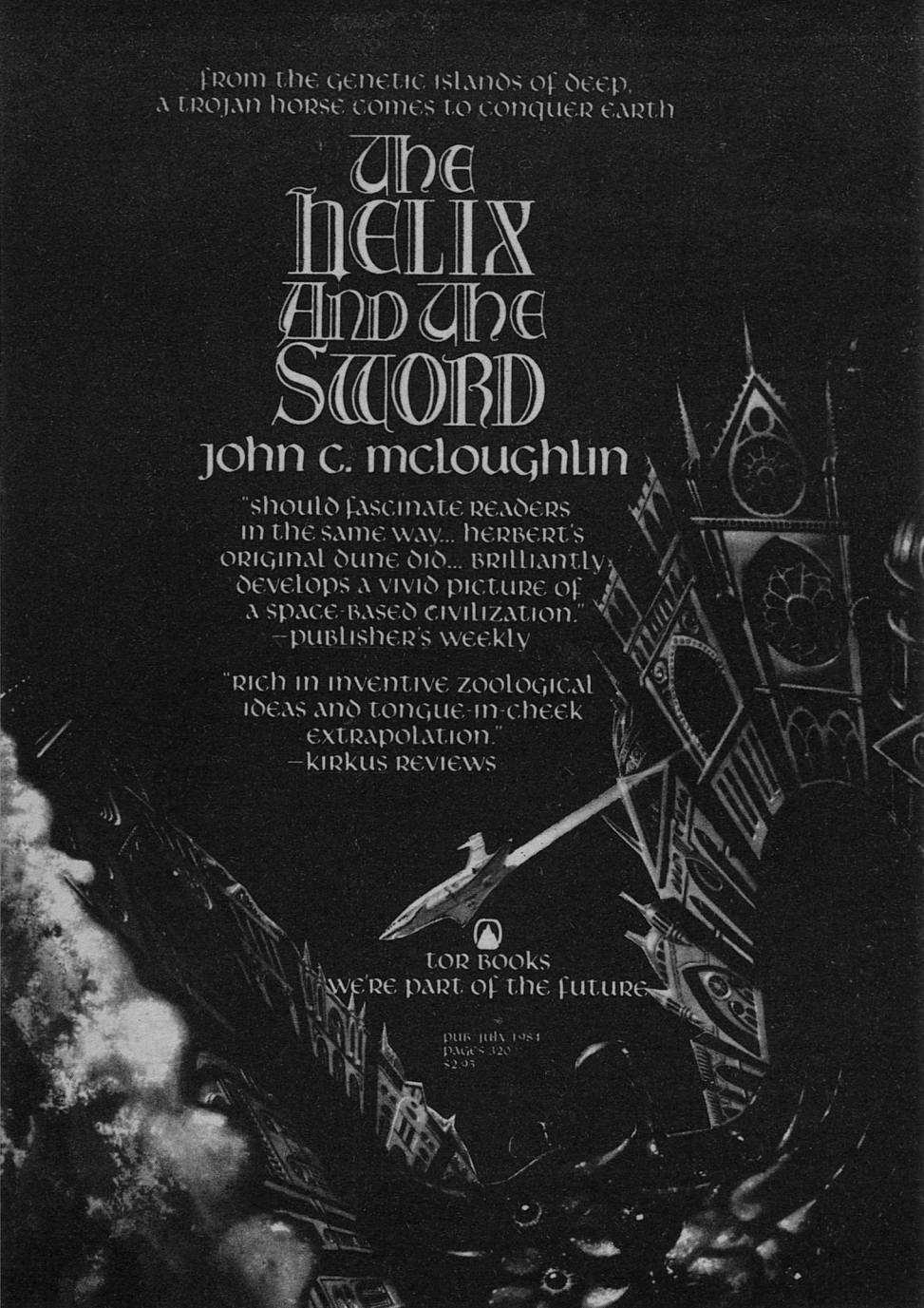
Mom smiled proudly. "Junior wrote quite a paper on it when he was six or seven. Of course we never had it published; you can just imagine the horde of psychologists that would have descended on us, all trying to make geniuses from dogs and rats, or some other silly thing."

My mouth was still flapping, so a few more words spilled out: "Wrote a paper when he was six?"

"Why yes," she said. "As a matter of fact, Junior has written almost all of our papers for the past twelve or thirteen years. In fact, recently he developed quite a convincing model of solar system formation based on ring dynamics; it was quite well received by the community. Of course we publish everything under our own names; Junior doesn't have any real credentials."

Junior made a rude noise. "Big deal. I write two, three papers a year. Takes maybe a week total out of my free time. No use getting fancy; those yokels in-system wouldn't recognize a good piece of work if it hit 'em in the face."

A vagrant thought kicked my vocal cords back into action before I could


FROM THE GENETIC ISLANDS OF DEEP,
A TROJAN HORSE COMES TO CONQUER EARTH
THE HELIX AND THE SWORD
JOHN C. MCLOUGHLIN
"SHOULD FASCINATE READERS IN THE SAME WAY... HERBERT'S ORIGINAL DUNE DID... BRILLIANTLY DEVELOPS A VIVID PICTURE OF A SPACE-BASED CIVILIZATION."
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stop them. "If Junior has been writing all your papers, then what . . ."

Pop saved me from finishing the embarrassing question. "For the past several years Momma and I have been collaborating on a book which we believe will be an important addition to the social literature of the Colonies. It is called *Lovemaking in Low Gravity: The Liquid Experience*." His arm was tightly around Mom's waist; I noticed his hand creeping idly upward. She snuggled closer as he continued: "Which reminds me, Dimp; it's past time for our afternoon nap. Would you care to join us?" He looked at me steadily. Mom smiled coyly.

I swiftly put my conversational wit to work: "Uhhh, well, uh, I really think, uh, I should get busy on this problem. . . ."

Pop sighed. "Yes, of course. Well, just tell Junior what you need; he'll take care of everything and pilot the research boat wherever you need to go. Junior, by the way, is the best pilot in the solar system, only nobody knows it."

I looked questioningly at their son. He was nodding and smiling cynically. I looked back at the Badilles to find them already halfway through an inner door. Mom looked over her shoulder and said: "If you're in a hurry to leave, don't bother to wait up for us." Then they were gone and the door shut.

A little bemused, I commenced to bring Junior into the picture. He was quick on the uptake; in a few minutes he was finishing sentences for me. When I handed him a picture of the artifact without interpretation, he studied it briefly, then started grinning.

"Playful creatures, aren't they? Well, do we bother with Dione and Enceladus, or head right for the B-Ring?"

I hesitated. "The group consensus is that we get the Dione and Enceladus artifacts first, to doublecheck our translation of the message. Trouble is, I don't have a clue as to where to look for them. . . ."

Junior was the epitome of tact: "Dimp, you must be a damned good archaeologist, because you're worthless otherwise. The Enceladus location is sure to be in the middle of the Big Cross. Dione's is a little less straightforward, but probably in Amata. The B-Ring cache has to be on the Iron Maiden. The top of Mons Gargantua is a good bet for Titan, but this boat isn't equipped to—"

"Hold on a minute. Just what is the Iron Maiden?"

"Dimp, don't you know anything at all about Saturn?"

"Well, I was in the middle third of my class in System Geography," (a white lie) "but I don't recall too much about the rings. . . ."

He grimaced and shook his head. "Well then. An elementary capsule history of the rings, scaled down for present company.

"Several million years ago Saturn's rings were run of the mill, just like those of the other gas giants. Orbiting Saturn at about 1.8 radii was a ten-kilometer moon—mostly ice, but with an iron-rich core. Along came a stray meteor about a kilometer in diameter, and also rich in iron. Bang! The origin of the ring system as we see it now. Especially the B-Ring, which you can think of as a bunch of snowballs covered with iron dust. And all that's left of the original satellite is—"

"The Iron Maiden!" I felt like a kid at a remedial tutorial.

"Right," said Junior. "The mother of the B-Ring. And also its destroyer."

Suddenly uneasy, I asked him what he meant.

"Well, Dimp, all those snowballs are highly charged, and the Iron Maiden is busily zapping them out of existence with little lightning bolts." An impish grin emerged on his face. "Too bad we can't wait a few million years; by then, most of the ring would be gone. As it is, retrieving the artifact will probably be a hair-raising experience, heh, heh!"

Dutifully, I laughed too, although it developed more the quality of a croak as it edged past the lump in my throat. Also, sad to relate, my skin blanched to a delicate shade of chalk.

Junior's sympathy was monumental. "C'mon, Dimp, where's your spunk? This is going to be great fun." He pulled himself up the wall bars toward the overhead hatch into the axis. "Let's go. We've got supplies to load." He grinned at me from the ceiling. "Unless you'd rather join Mom and Dad in their nap."

I took a deep breath and started up the wall. There were a few things Ogumi and his pals might have told me.

Two hours later our supplies were in place, and we hoisted ourselves into the main cabin. Junior drifted over to the pilot's station and began flipping switches. The subdued hum of the CRF reactor signalled ignition; panel lights and screens came to life. The cabin lights flickered as he switched from umbilical to internal power. The controls seemed quite different from those on the tug; I looked on with interest as he activated the boat.

"I souped this scow up considerably a few years back," he said. "Managed to increase drive efficiency thirty percent across-board by reconfiguring the magnetic confinement field equations and boosting chamber temperature ten million degrees. The high-g I_{sp}—" He noticed my blank look and broke off. "Never mind. Better strap in; we're going to disconnect and test the RCS in a second."

As I took the right-hand seat and began belting up, Junior flipped a switch and began speaking clearly to no one in particular: "Pandora. Self check of all electrical systems. Pandora." Lights began to blink rhythmically on the control panel.

I had thought that voice-programmed navigation computers were still in the experimental stage; "too difficult to ensure total system safety" was the phrase that stuck in my memory. Either Junior was unaware of this, or else he misinterpreted my raised eyebrows.

"I named her that because I had to open her box to add memory and make other changes. That was seven or eight years ago, back when I was interested in girls. My IQ was down around—"

He stopped as the speaker came to life. *Pandora in. Self check completed. All electrical systems green. All backup systems green. Pandora out.* The voice, though flat, was recognizably Mom's. I didn't pursue that.

Junior spoke again: "Pandora. Back-out and RCS check ten seconds from mark. Reiterate. Pandora."

Pandora in. Reiteration. I will disconnect umbilical, back 500 meters from Station, and conduct a complete checkout of all reaction control system

thrusters. I will commence this sequence only upon your confirmation and ten seconds after your mark. Pandora out.

"Pandora. Confirm. Mark. Pandora."

I looked at the little man and shuddered involuntarily when I remembered he was not yet twenty years old. "Junior, do you mean you were only twelve when you, uh, invented Pan—"

"Don't say her name out loud!" It was my first glimpse of excitement in him. "You'll confuse her."

Just then the RCS thrusters came to life, giving us a gentle shove backward. By the time Junior spoke again, SOS was shrinking visibly in the forward viewports.

"Now what were you saying, Dimp?"

I sighed. "Never mind. It's too late now, anyway."

In a moment we were once more stationary. Then the boat performed several quick maneuvers in roll, pitch, and yaw—finishing precisely in its original orientation, but leaving my stomach and inner ears still back on square three.

Pandora in. RCS system green: backups green. Fuel remaining: 7238 engine-seconds. Pandora out.

Apparently Junior was inured to the checkout maneuvers. "Well, Dimp, let's figure out a destination. Pandora. 3-D display of inner system. Pandora."

An L-shaped group of three large screens on the control panel lit up, displaying what appeared to be standard architectural elevations of the Saturnian system. The planetary bodies were color coded, and the top view showed faint circles that seemed to be orbital tracks of the major moons. A blinking white spot in all three screens indicated our boat's position. I asked Junior if the picture came from the computer's memory.

"Naw. We've got seventeen navsats in orbits all over the system. Pandy keeps in touch with four or five at a time, and just calculates speed-of-light lag for real-time updates. For closeup work she uses her own stereo scanners. But that comes later.

"Now look here." He pointed to the top screen. "At point one-g it's going to take us thirty hours, give or take, to get into a down-system orbit. That'll put Dione about halfway to the eastern limb, right here," he touched the screen, "which is convenient. Enceladus, on the other hand, will just be starting across the far side," he moved his finger, "which is decidedly inconvenient." He looked at me expectantly. "But it's your decision, Admiral."

"Whatever you think best, Junior," I said carefully.

He snorted, then addressed the computer: "Pandora. Establish and display trajectory for a zero-point-one-zero-g constant acceleration journey, beginning with current boat state vector and terminating in circular equatorial orbit about Dione at one-hundred fifty kilometers mean altitude above surface. Reiterate. Pandora."

As the computer repeated Junior's instructions, dotted lines appeared on the screens. Junior listened, looked and nodded. "Pandora. Confirm as program SD. Perform RCS burn five seconds from my mark, to terminate stationary with respect to SOS ten kilometers uporbit. Mark. Pandora."

As we moved away from the Station, Junior explained: "I always give the

SOS plenty of safety margin. That stream of hot protons coming from the CRF drive is nothing to fool around with."

I informed him that I was well aware of the dangers of a CRF exhaust plume. He made me pay for my stuffiness: "Well I'll be damned, Dimp. And all along I thought you didn't know anything. Boy, was I wrong!" I wondered where he'd learned sarcasm; Mom and Pop seemed incapable of it.

The SOS was a flyspeck out of the viewport a few minutes later, when Junior ordered the computer to execute program SD. She counted us down, then we were pressed gently into our seats as the low rumbling of the CRF drive permeated the vessel.

"Well, Dimp, the best thing to do when starting a high-acceleration trip is to get some shuteye. So I'll see you in four or five hours." He closed his eyes and in a minute was snoring gently.

I closed my eyes, but not to sleep. Pop had mentioned that they maintained .06-g on SOS to protect from long-term calcium leaching; I-Base was less than half that, but the resident staff only took two-year duty shifts. SpaceHome III, where I lived, was kept at .3-g; hence anything out here felt lightweight to my muscles. So I was stuck with a racing mind and a thousand unanswered questions, being navigated toward a monstrous gravity well by a computer customized by a precocious youngster. I silently cursed Ogumi and company, calling upon a lot of old deities they'd probably never heard of. . . .

III

Junior was shaking me awake. "Dimp, we've got company."

I focussed bleary eyes on the 3-D display, which now showed not one blinking light, but two. Junior continued remorselessly: "Another boat entered the inner system; it's decelerating at about point seven-g, and will be orbiting Dione in less than four hours. It must be loaded to the gills with fuel, and it probably came from Earth. So what now?"

My heart began pounding uncomfortably, and there was a faint taste of bile in my mouth. My immediate impulse was to head for the B-Ring, but that was a decision I needed help in making. "I suppose we can break radio silence now. Can you contact SpaceHome?"

"With a one-meter antenna? You must be kidding."

"Well, raise I-Base then. Reynolds can relay the message."

"Blow that off, too. I-Base receivers only watch Earth system and SOS, and we're at too much angular separation from either; we couldn't even sneak through on a side lobe."

"Raise SOS then and have Mom or Pop relay messages. I've got to talk to Ogumi!"

Junior's smirk was positively evil. "I tried, but no luck. They're probably working on Chapter Thirteen. C'mon Dimp, grow up; whether you like it or not, it's decision time."

At the moment I felt more like shrinking than growing. "Okay," I sighed, "raise the other ship."

Junior nodded and started broadcasting, while I began to think in earnest. They would surely beat us to the Dione

site. If we headed at once for the B-Ring, could we get there first? Probably not, if they decided to make a race of it. Anyway, if the Dione and Enceladus plates contained unexpected data, going at once to the Iron Maiden could be a mistake. . . .

Junior interrupted my train of thought. "No luck, Dimp. They didn't even answer a call on the emergency hailing frequency. We are being deliberately ignored."

"Do they know we're here?"

"Sure, the same way we detected them. The navsats can see any CRF plume, and any boat can get information from them, since their activation frequences are well published."

I was still trying to assess possibilities. "If we head right for the Iron Maiden, can they beat us there by changing course? And if we head for Enceladus, even if they know where we're going, do you suppose they will keep on toward Dione? I mean . . ."

Junior broke out laughing. "Dimp, I really like you, but your brain is a morass. Okay, here's the situation as I see it. Assuming that the people and computer on that boat are not dumb, they know we're headed for Dione, and that they'll beat us to the Amata artifact by several hours. If we change course for either Enceladus or the Maiden, they'll calculate time and distance and decide what to do next. If we head right for the Maiden, they'll probably do likewise and beat us there; if we go for Enceladus, they'll figure they have time to pick up the Dione artifact first. They must have a big tug with lots of hydrogen on board, and they have one-g muscles—so they've got all the advantages."

He scratched his chin. "Now all I know about human nature I got from Mom and Dad, occasional trips to I-Base, and a whole bunch of novels I read when I was four or five years old—but I'll bet they think they can beat us to the punch no matter what we decide to do. So, Admiral, what *do* we decide to do?"

I stalled. "Maybe you could try to raise SOS again?"

"C'mon Dimp. Time's a-wasting. Even if you could send a message to Ogumi right now, the answer wouldn't be back for hours. So bite the bullet."

"Okay, let's head for Enceladus."

"Attaboy, Admiral! The most cowardly option, admittedly, but a real decision nonetheless."

He began talking to the computer. Most of it was too technical to follow—phrases like "north polar traverse," "safe minimum distance," "state vector update," and so forth. I spent the time wondering who was in the other tug, and what their orders were. I barely noticed the computer counting us down; then suddenly the boat slewed and pitched slightly, and my weight grew noticeably.

"Okay, Dimp, here's the plan," Junior said. "We've increased acceleration to point one-five g and we're going over the top of Saturn." He indicated the new flight plan on the display. "Then we'll slew into Enceladus orbit and finish dead stopped right above the Big Cross." The smirk was back. "The bad guys'll figure that we'll be orbiting a couple of times to lay a groove for computer landing; but I'm gonna fool 'em and take the boat down on manual. That'll gain us an hour or so if they're sloppy about

noticing our state vector at CRF cutoff. If we can find the artifact and get away fast, we might still beat 'em to the Maiden."

It wasn't the increased acceleration that brought the sudden lump to my throat. "Land on manual?"

His face turned impish. "Sure, Dimp. The way I see it, our one advantage is that I can do state vectors real time in my head. We'll have to use that punch if we're gonna try and win this fight. Okay?"

My mouth was still in control. "Land on manual?"

"Relax, Dimp. I goose this lady on manual all the time. That's the main reason for having three screens." He yawned and swallowed. "But right now we've got over twenty hours to kill, and this acceleration's more than twice what I'm used to. I'm going to get some more sleep." He promptly conked off again, leaving me to dream up some more ancient curses for Ogumi.

Sleep has a habit of sneaking up. I awoke some hours later to the sounds of Junior preparing a meal. We ate, then talked at length; I taught him some archaeology, and he taught me some Saturn—which we both now recognized as survival training for a naive traveler. To my surprise I found myself becoming engrossed in the mechanics and the lore of the Old Man and his family. Junior was a latent poet, and he made each of the moons sing its own song; I stopped regarding them as boring hunks of ice.

Saturn grew slowly in the forward ports until it doubled in size. But distance still blurred the cloud formations, and the rings were tilted only a few degrees, when we flipped end for end and started braking toward the giant; at that point we were not even down to Hyperion's orbit. I was disappointed; by that time I was eager to see the Old Man at close range.

"Hang on, Dimp," Junior said. "In less than ten hours we'll be going over the top; then you'll have the best seat in the house—and I'll guarantee the sight will suck your gut right up into your throat."

The Earth tug had stopped decelerating before we reached flip-over. According to Pandora, its state vector at the time of CRF cutoff indicated that it had gone into equatorial orbit about two hundred kilometers above the surface. An hour later it burned for fifteen seconds; Junior said this was a plane change. "It'll put them over Amata for three successive passes. They'll probably use two to lay a groove, then land on the third."

There would be no more information about the tug for some time. It could only be detected by its CRF plume; and it would certainly land under RCS thrust rather than destroy the unprepared surface below it. Junior was optimistic. "No news is good news, Dimp. Amata's over two hundred klicks in diameter and full of junk. Hell, they might be ten, twenty hours searching."

We ate lightly, then dozed again. This time the computer woke us both: *Pandora in. Stand by for seventeen-minute freefall period for state vector update, five seconds from mark. Mark. Pandora out.* Almost immediately we were floating. Stretching, I asked Junior what a state vector update was.

"The navigation gets hairy from here on. We're doing about seventeen kilo-

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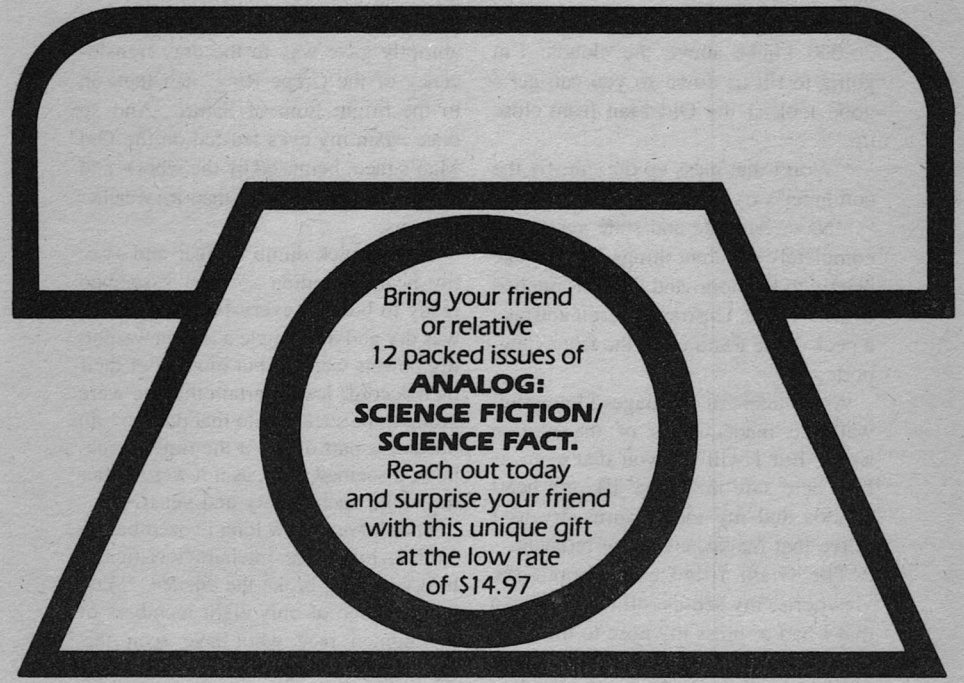

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meters a second now, but it's almost all radial with respect to the Saturn system. We've got to kill that, and at the same time gain about twelve klicks tangential to match Enceladus's orbital velocity. All that time Saturn will be pulling us down toward the ring plane; we encourage that now, then cancel it as we match orbit. Doing all that at once is tricky even for Pandy. So she'll coast for a few minutes while she gets some good data on our position, velocity, and acceleration here at the bottom of the gravity well.

"Meanwhile, since we're only about 20,000 klicks above the clouds, I'm going to tilt us down so you can get a good look at the Old Man from close up."

"Won't that mess up the, uh, fix the computer's trying to get?"

"Naw. Attitude and state vector are completely different things." He spoke briefly to Pandora, and the boat pitched over. "There. Unstrap yourself and take a peek." He gestured to the front viewports.

As a student of languages I know full well the inadequacies of the written word. But I will tell you that even as I sit here safe in 'Home III, my heart pounds and my mouth turns dry as I relive that magic, awesome moment.

The Giant filled everything—the viewports, my senses, all of space—so that I had to press my nose to the glass even to see the edge of the rings against the black. The northern cloudbanks, with their delicate colors, formed beautiful pale rings around the pole, cut in half by the black knife of shadow's edge. Sworls, spots, eddies, all were displayed in lovely, exquisite detail. For time unmeasured I stared; then I turned my eyes back out to the rings. The far edge of the A-Ring was opaque, pale white, reflecting the Sun's feeble glow from a billion chips of ice. The Encke division, a sharp black ribbon near the outer edge, was only a slender cousin to Cassini, that monstrous ebon gap between A and B. A star twinkled there as it was alternately revealed and occluded by the tenuous gap rings. The broad, bright, ruddy B-Ring was grooved by a thousand shadings of light and gray; my eyes roved inward across its vast expanse to where the brightness abruptly gave way to the gray translucency of the Crêpe Ring, and then on to the bright limb of Saturn. And so once again my eyes feasted on the Old Man's face, bemused by the whorls and wisps of gigantic, colder-than-ice weather systems.

I was struck dumb by fear and awe, my heart pounding so hard it seemed ready to burst at every beat. My throat was dry and my tongue a leaden weight; my bowels were all but moving of their own accord. I was certain that we were going to be sucked into that pattern—to become a part of it. At the time, somehow, it seemed right, as if it were unfair to behold such beauty and yet live.

I don't know how long I gazed before Junior, his voice uncharacteristically husky, finally broke the silence: "You are now one of only eight members of the human race who have seen this sight. It has changed us all." I nodded, unable to reply, as he continued: "When I know I'm dying, I'm going to suit up and have the boat throw me straight down at the Old Man's heart."

My voice returned in a whisper: "I'm coming with you."

He nodded in turn, then shook himself, looked at the clock, and sighed. Come on, we'd better strap in; it's almost time to start burning again."

I returned to my couch with enormous reluctance.

Now we were decelerating at almost .2-g. Junior looked with me to the side port, where the Giant could now be seen, then dozed off once again. The next four hours seemed only minutes as I stared at the Old Man, first out the side port, then the front again as we backed away from the planet and down toward the ring plane; then finally out the side again as the boat gradually slewed around to push us into orbit. By the time the Sun's glare finally dominated the front ports, the rings were once again a thin bright line. Then at last I could see the crescent Enceladus ahead and to the right, and it was time to wake Junior.

Twenty minutes later the boat stopped burning, turned end for end, and gave a last firm push before Pandora announced that Junior was now in command for manual landing. He tested the manual RCS controls, pitched the boat so that the forward ports pointed down toward the surface, and began to unstrap. "C'mon. I'll show you where we're going."

My confidence in his abilities had increased considerably during the trip; nevertheless I couldn't entirely conceal a momentary twinge of panic. "You mean right now? Don't you have to blast down tail first, or some such?"

The impish grin returned. "Not for a while, Dimp. The surface gravity is only about nine centimeters—less than point oh one-g. And up here at a hundred klicks, it's just half that. So to save hydrazine I'm going to let us fall about sixty kilometers; it'll be about twenty-five minutes before we start burning." He gestured out the ports. "So unstrap and come look."

The view was impressive. I stared while Junior talked me into the picture.

Since its formation Enceladus has gone through four or five epochs of vast restructuring—the latest as recently as 100 million years ago. System geologists still don't know for sure what caused the ice to melt and flow like lava over half the surface, filling craters and generating the magnificent set of fault valleys which dominate the sphere.

One of those valleys is Daryabar Fossa, a straight gash running east-west for 200 kilometers, about five degrees above the equator. Several dozen million years ago Daryabar was cut in half by another shift of the crust, which displaced its eastern and western halves by thirteen kilometers along a new fault measuring 140 kilometers, running due north-south right at local Greenwich. The name of this newer valley is Isbanir Fossa. The two, intersecting at right angles, form the Big Cross. . . .

". . . and dollars to doughnuts, Dimp, we'll find it right smack in the geometric center—in Isbanir, at the six-and-a-half kilometer point exactly between the split legs of Daryabar."

At the moment, ninety minutes before local sunset, the Cross was spectacular. Isbanir, running as it did north and south, was a dark gash in the smooth landscape. Daryabar, in contrast, was brilliantly illuminated by the rays of the distant Sun. This huge study in black and white dominated the forward ports.

I watched it enlarge, entranced, until my companion told me it was time to strap in and flip the boat for landing.

The 3-D screens provided orthogonal views of the surface, which Junior used to fly us down. Each screen showed a stylized image of the boat, beside which were numbers showing distance, velocity, and acceleration in the relevant axis. These numbers were calculated with respect to an aim point which Junior established in Isbanir, slightly north of where he expected to find the cache.

The landing was anticlimactic. When we were forty kilometers above the surface and dropping at just over eighty meters a second, Junior activated the thrusters. After some fiddling to get over the aim point, we went down on our tail at a gentle .02-g. In fifteen minutes the boat was stopped dead one meter above the surface. Junior cut the RCS, and five seconds later we landed with a gentle bump.

I looked over at him. "I think I could do that."

He grinned. "Sure you could, Dimp. Any moron could, with a little practice. Hell, the Apollo pilots did it over a hundred years ago, in a gravity field seventeen times this one. It's the managers and owners who're afraid to trust their precious property to anything but computers; they write regulations about tracklaying orbits and computer-controlled landings and all that silly rot. And so we've got ourselves a generation of pantywaist pilots, who are whizzes at punching buttons and not much else. Hmmph!"

He began the task of shutting the operating systems down. "Of course, orbital maneuvers are something else. There isn't a human alive who can work a six-variable state vector in his head to get from orbit to orbit with any efficiency. For that, you do need computers." He glanced sidelong at me. "I'm the exception to that rule—but maybe I'm not quite human."

My heart warmed to this lonesome little gnome of a man as he chuckled at me through crooked teeth. "Okay, we'd better get moving. We've got a job to do."

When we were in our micropore suits and ready for helmets, Junior carefully tipped over the suit box. Four large boot-shaped objects clunked slowly onto the deck. "Here, better put a pair of these on your feet. They're low-gravity crampons."

I hefted one; it must have massed fifteen kilos. My legs got tired just thinking about them. "What good will these do, for God's sake?"

The grin again. "What we've got here is a point-oh-one-g ball of hard ice, and we're going to tramp around using high-gravity muscles. You wear these so you don't spend nine-tenths of your time two meters from the surface, spinning ass over teakettle. The spikes give you traction, and the weight makes you move carefully. Watch out you don't step on anything valuable once you get 'em on."

When the airlock opened, Junior took the folded ladder in hand and jumped the eight meters to the surface. I followed, lacking his nonchalance. It was a ten-second drop, and by the time I hit the surface the crampons had already proved their worth; they kept my feet down while I was falling. We extended the ladder and hooked it over the lock-

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frame, then I took time to check out the surrounds.

We were in a valley about five kilometers wide and one or two deep. The visible contours were rounded; no boulders or rough terrain were in sight. In fact, there was no loose surface at all; the ground through the crampons felt more like an ice cube than anything else. Junior explained that micrometeorites, which help grind regolith on rocky worlds, merely serve to smoothe the surface of an ice world.

Isbanir had looked darker than the Black Hole of Calcutta from 100 kilometers up, but the reality wasn't nearly so bad. Sunlight reflected from the tops of the cliffs to the east, and Saturn at half-phase made a significant contribution to the illumination; we carried flashlights, but they stayed hooked to our belts.

Bending backward far enough to see all of the Giant overhead was uncomfortable, but I did it anyway. It was stunning—200 times the size of Earth from 'Home III, even though we were nearly 200,000 kilometers from the surface. The cloud formations were easily visible; the ring shadow was a sharp black band below the equator, divided by light shining through the Cassini gap. The ringline was brilliant white and encompassed fully half the sky between cliffs. Where it cut back into the darkness to the left of the terminator, it seemed as if some cosmic artist had drawn a die-straight line of white ink on a velvet canvas. The ring was much more brilliant in the center; out loud, I wondered why.

"You've got to start learning to do kitchen arithmetic in your head, Dimp," came Junior's tinny voice in my earspeaker. "The far edges of the ring are a quarter of a million klicks from here, but the center is only a hundred thousand."

He sounded as if he were straining. I looked over and saw that he, too, was bending backwards. Then he straightened up and sighed. "I've got to spend more time in-system. Okay, duty calls. Let's head south."

We followed parallel tracks about 150 meters apart. The overhead light from Saturn was diffuse, but the illumination from the cliffs threw blurred shadows toward the west; any unusual feature in the terrain should be easy to spot.

Again I was glad for the crampons; after a careless movement I found myself a meter and a half off the surface and starting to tumble head first. The boots did their work nobly, and my feet were already starting to pull my head back up by the time I touched. Junior's only comment was to remind me that hitting the ground with anything but feet, gloves, or helmet was an invitation to instant frostbite; the thin, shiny material of the micropore suit was an excellent conductor of heat.

Eventually I learned to let the crampons do the work. I merely used my leg muscles to pull them up and forward, and their own momentum did the rest. My strides were slow and long. I was just starting to enjoy the rhythm when Junior's voice sounded in my ear: "Up ahead there, about a hundred meters, right between us. Head toward it and start slowing down right away."

The insulating case was unmistakable, a hexagon-shaped hatbox with a brilliant white coating. Its twin was in

Bob Reynolds's safe nearly four million kilometers away. It sat casually on the surface, as if it had been placed there only yesterday. The incredible presence of a precisely engineered object on this barren globe sent shivers down my spine.

Junior seemed to sense my emotions. "I'm with you, Dimp. It gives me the willies in a way I've never experienced. It's been us against the universe for a million years or more; and now— company, for sure." He stepped back while I got my camera from a side pouch. "You know, life has been getting a little boring the past few years, but I have a feeling that's going to change permanently."

He waited patiently while I took several pictures and spoke appropriate notes into my personal recorder. When I'd put the camera away he said: "Ready?"

"Yeah. Hey, Junior, how did you know it would be here?"

"Hey Dimp, I didn't—not for sure." I could picture that crooked grin inside his helmet. "It was logical from seeing the first artifact, and knowing where on Iapetus it had been placed. The burning question was whether our idea of logic and theirs had enough similarities. So now it's nice to know they do; otherwise this treasure hunt would be impossible. Also, I think they have a sense of humor—which is nice to contemplate."

We returned to the boat and buttoned up in preparation for liftoff. A light was flashing on the console; per Junior, it indicated a message from SOS, relayed through one of the navsats. That was intriguing, but first things first; the hatbox had the highest priority.

The lid came off easily, and we were looking at another plate, to all appearances an exact duplicate of the first. Junior looked on as I checked image sizes, and said: "Well, it's going to be the Iron Maiden, then."

He turned to the console and played the message back. It had been taped and relayed from SpaceHome to I-Base to SOS to Navsat-3 to Enceladus, but the voice was still recognizably Ogumi's:

"To Dr. Whitedimple from President Ogumi. It has been brought to our attention that an unidentified vessel is approaching the Saturn system. This is probably an Earth-sponsored expedition with the same goal as yours. Since time delays make decisions from SpaceHome impractical, you are authorized to use your own judgement in handling the situation. If you deem it necessary, you are empowered to negotiate a joint scientific mission. Your task may be difficult, but we have every confidence in your ability to cope. Good luck. End of message."

Junior snorted. "Bunch of pantywaists! Well, the ball's still in your court, Admiral—and God help you if you don't come up with at least a tie score."

I reluctantly took my attention from the hypnotic gleam of the artifact. "Where is the Earth tug now?"

He spoke briefly to Pandora, and the 3-D screens lit up with a close-in set of views of the inner system. After a few seconds' study he replied: "It's in a minimum-time transfer orbit from Dione to the Maiden, coming around fast from the night side and cutting across the ring plane in a tight curve." He glanced at the screens again. "It's only going to miss the cloudtops by a few thousand

klicks. Whoever's piloting that tug is pretty gutsy."

"Can we beat them to the Maiden?"

He stared at the display and furrowed his brow for a long moment. Finally he said: "If we start now and punch at point two-five-g all the way, it'll be close to a dead heat."

I asked him why we couldn't burn at .3-g and beat them.

"Because I wouldn't be worth anything when we got there," he replied candidly. "A quarter g is my maximum for anything over an hour, and this run will be six times that long."

I took a deep breath. Growing hair on the chest at this advanced stage of my career was decidedly painful. But nevertheless: "So what are we waiting for? Up ship and away!"

Junior threw me a peculiar look, then relaxed into a grin. "Right, Admiral."

IV

We went straight up for one minute on thrusters, then the CRF drive cut in. The acceleration was still under that at 'Home III, so I wasn't straining; but it was quadruple the little gnome's normal environment. He seemed drawn, and more wizened than ever.

"Are you okay, Junior?"

"Sure," he smiled weakly. "Just need a little sleep. Wake me ten minutes from rendezvous, or sooner if anything interesting happens. You'd better stay awake, to keep tabs on events," he gestured toward the 3-D, "and enjoy the ride. Our friends are staying a couple hundred klicks above the ring plane, but Panny is going to shave it by eighty. Safe enough, but guaranteed to make you pee your pants. G'night."

He closed his eyes, and in less than a minute was sawing logs. His face smoothed out a little, and he looked reassuringly better.

The rendezvous point was almost directly inward from our current position near Enceladus. Even so, the navigation would be complex—our actual path to the Maiden S-shaped, but the boat's attitude making it seem a C. So I wasn't surprised when the vessel slewed radically to the left, pointing well past the dark half of Saturn.

The exertions of our trek on Enceladus, plus the relatively high acceleration, served to weight my eyelids, too. I catnapped as the Giant peered in on us, first from the starboard ports, then from the front as we gradually slewed to point directly at him. The yaw thrusters, operating briefly at ten-minute intervals, acted to keep me somewhat awake.

Three hours into the trip, the boat suddenly rolled ninety degrees clockwise. My head and stomach reacted violently as Saturn tilted up on end. I was suddenly very awake—and scared.

Junior, stretching and yawning, roused enough to gaze briefly out the front ports, then at the screens and clock—then he closed his eyes again. Before he could get back to sleep, I asked him what the hell?

"'S okay, Dimp," he mumbled, "part of the thrill ride. . . ." and he was snoring again. I pondered this, then decided that he'd told Pandora to roll the boat so I could see the rings out my side port as they flashed by. Maybe he thought I was getting hooked on thrill rides. Maybe I was.

Meanwhile, the now-vertical line of

the ring plane was getting alarmingly bright; it forced the illusion that we were going to fly straight into it, to be annihilated by its billions of bullets. Ever brighter it became, without taking on dimension; there was no hint of a clue that we might miss it. Fright bathed me in perspiration—a most undignified condition for a full professor in his forties. A dozen times the temptation to wake Junior was almost overpowering; his "peeing my pants" prediction was too close to be funny.

Just when my self-control was almost gone, a hair-thin strand separated itself from the ringline and began moving steadily to the right. After some thought, I decided it must be the F-Ring. Soon it disappeared from the front ports; I leaned over and watched it flash by on the right. It was thicker in some places than others, and somehow seemed twisted; it did not conform to my idea of a ring.

Knowing we should be eighty kilometers from the ring, I tried to estimate our velocity. My best guess was between five and ten kilometers per second. If that were true, it should only be a few minutes until we reached the edge of the A-Ring.

In the forward ports the ringline grew even brighter; though we'd safely missed the F-Ring, my fears returned unbidden. Banishing them firmly, I checked the displays. The Earth tug was west of us, and just inside the C-Ring. Our own position was at the outer edge of the A-Ring.

When I peered forward again the ringline had started to widen. At first barely noticeable, the phenomenon accelerated as I watched. Then perspective

shifted sharply; instead of flying into the ring, we were going to pass it on the left. Then with breathtaking suddenness the A-Ring was flashing by the right side of the boat; our velocity was dizzying. The sunlit half of the Giant had become only a quarter in the front ports; the right side was obliterated by a white wall that seemed to extend up and down to infinity.

Once we were past the ring edge, the sense of speed was provided by the gaps. Gray lines would regularly materialize from the white wall, then widen and darken as they moved to the right; they would flash by the starboard port as distinctively thinner bands of ring material, or even as black gaps through which occasional stars could be seen. For the second time in my life I was appalled, entranced, and struck dumb with wonder.

Eventually the Encke gap allowed me, for a few minutes, to see all of Saturn again out the front ports; but I had to lean far forward, because the boat had by now pitched up so far that he was almost below us. The rest of the A-Ring moved by with the bands almost parallel to the boat.

Then without warning we were traversing Cassini's division. Space and stars were again visible to starboard, but broken repeatedly by the bands of the Gap itself, including four wide white ones—resonances within resonances, Junior had called them.

By now the boat had pitched so that its nose was pointing slightly backward into the gap, so there was no warning when it ended. One moment we had black space in our view; the next, the ruddy white edge of the B-Ring was rising along the right side like a gigantic slanted curtain. The bands of this ring seemed brighter and more tightly compacted. And since we were killing our inward velocity and picking up orbital speed, they did not flash by with such breathtaking rapidity. I watched as our relative motion got slower and slower. By the time the clock showed ten minutes to rendezvous, our apparent motion had almost stopped.

I glanced at the 3-D; our boat and the Earth tug were just touching on the screens when one of the flashing dots disappeared. The other vessel had shut down its CRF drive.

I roused Junior; he brought himself up to date, then tried to contact the tug on universal hailing frequency. He had no success; either they weren't monitoring that frequency—a most unlikely oversight—or else they chose not to answer.

Our own drive now shut down. We spun end for end, got a final love tap from the RCS thrusters, then Junior once more took control. He tilted the craft so that the nose pointed at the ring plane. We were above an unusual gap—one with a kink in it: the down-orbit section was visibly closer to Saturn than was the up-orbit section. And right where the two legs joined was the Iron Maiden. Less than a kilometer across, it was a brown ball which from our distance appeared about the size of the Moon seen from home.

While I gawked, Junior checked the radar. "They're about a hundred sixty klicks up, coming down slowly." He grinned. "But since we're safely inside them, I don't have to be so polite." He called up displays for local maneuver-

ing, then threw a couple of switches. "Hang on, we're going down fast." The CRF cut in.

We dove straight down for a few minutes, then flipped and decelerated for the same interval and came to rest. Now Junior tipped the nose over so that it pointed straight down. We were half a kilometer above the ring plane, even with the leading edge of the Maiden, and directly over the gap.

For the first time I could resolve at least some of the individual particles making up the ring. Most were only tiny white specks against the black, but I could see larger bodies further down in. Junior told me that most of the particles were only a centimeter or two in diameter. The occasional large particles, including a rare boulder now and then, were concentrated near the center of the 100-meter thick ring.

Seeing a gap in three dimensions was strange after watching so many flash by the boat as blurs. And this particular gap was strange indeed. Underneath us, down-orbit from the Maiden, the inward edge was sharp, and coincided with the inward edge of the satellite. But the outer edge was ragged, and crept in almost to the Maiden's center. Up-orbit the geometry was exactly reversed.

Junior noticed my puzzled look. "It's the 'jointer effect,' Dimp. Brought to the attention of the scientific community by yours truly. The Maiden is 700 meters wide, and in a 108,000-kilometer orbit. That makes the velocity differential between particles at the inner and outer edges about six centimeters a second. So you can think of the Maiden as a giant spinning blade, with the inner and outer edges of the ring being fed into it at three centimeters per second in opposite directions. And since there's no gravitational resonance at this particular distance from the primary, the gap tries to heal itself during the 800-year feed cycle." He pulled out a pair of binoculars from a box by the control panel. "Does a pretty good job of healing, too; around on the other side the gap narrows to fifty, maybe sixty meters."

He handed me the glasses. "There are seven 'jointer' gaps. In the other six, the little satellite just pushes the ring particles out of its path. But the Maiden's a real bitch; she lures 'em in, then blows 'em out of the sky." He pointed down to where the leading edge of the ball was silhouetted against the gap. "Find a likely-looking particle about three, four meters from the edge, there, and watch what happens."

"What makes her different," he continued as I focussed the glasses, "is that she's a conductor—got a very high iron content." I found a small ball of ice about four meters from the Maiden, drifting very slowly toward the surface. "The ring particles are coated with iron dust, and pick up pretty healthy charges from the ionized hydrogen in this region. When they get close to the old girl, she develops a localized image charge which draws them toward her . . ."

As I watched, my particular ball began to move rapidly; in a moment it was only three meters away, with collision imminent. ". . . then when they get within a meter or so . . ." Suddenly the faintest of purplish-blue lines appeared between the two, and the particle dis-

appeared with a flash. ". . . Zap! Scratch one snowball. Some of it converts to energy—enough for a bunch of gigajoules; the rest vaporizes . . . Hey now; look what's sitting on the north pole. Damn!"

Startled, I looked over at him. He was staring through another pair of glasses at the top of the Maiden and swearing volubly. I put mine back to my eyes and looked. Sitting there, casually as you please, was a white, hexagonal hatbox.

I checked an almost overwhelming urge to whoop and holler, and instead asked Junior why the profanity.

He smiled ruefully. "Two reasons. First one is, I spent a lot of time studying the Maiden—took lots of pictures, and all that. But it was several years ago." He shook his head sadly. "The rings were sunlit from the other side, so that's where I stayed—only a kilometer from the artifact the whole time. Talk about irony on the grand scale! The second reason is that if that box were on the other side of the Maiden, we'd win the race hands down."

"How's that?"

"Because then we'd have to shoot the gap. That's no problem for this boat, because I've modified it especially to handle sudden high skin currents. But going through a narrow gap is nothing that an unequipped boat—like that tug above us—should attempt."

I attempted to look politely quizzical; but my expression probably emerged as dumb ignorance. Junior continued patiently. "Dimp, that gap may look innocent, but it's loaded with one-micron particles and a few larger snowballs. And every boat in the system has a hull that's an excellent conductor—even more so than our girlfriend down there. An ordinary boat navigating a narrow gap like this one has a better than fifty-fifty chance of being on the receiving end of one of those little lightning bolts. It'd blow out every electrical system in the ship faster than the circuit breakers could react."

I saw the light. "So we could go straight through, and they'd have to go all the way out to the edge of the rings?"

"Well, at least to Cassini, which is eight thousand klicks out. We'd beat 'em to the plate by a couple of hours or more, and be on our way before they could even get back here.

A red light glowed on the control panel. Junior grimaced. "Speak of the devil; there's a hail from the baddies." He activated the RCS and pitched the boat so that the nose pointed directly up-orbit. The tug was only a couple of hundred meters away, slightly above us and almost directly over the north pole of the Maiden. A suited man in the open airlock was fiddling with some apparatus whose purpose was not immediately clear. Junior activated the transceiver.

"This is SOS Research Boat *Panda* responding to your hail. Dr. Whitedimple commanding; pilot Dr. Badille. Over."

Their reply was interrupted frequently by interference from the nearby discharges, but the meaning was abundantly clear:

"*This is UN Tug* Discoveror, *Dr. Cornwallis comm*—ssss—*pilot Mr. Jacobs, assisted by Colonel Jackson. Notification is hereby pro*—sssss—*that this vessel is undertaking*—sss— *legit-*

imate salvage operation as defined in the United Nat—sssss—*Supreme Court decision in Buchwald vs. Vacuum Crystals, Inc, 2047. This vessel will*—sss—*no interference with its operation. You are ordered and required*—ss—*remove yourselves to a minimum distance of*—sssss—*hundred kilometers from the site of this operation. Over.*''

''Cornwallis!'' I exclaimed. ''That pompous ass!''

''I take it you know this guy?''

''Yes. His idea of field research is to spend three weeks in the basement of the British Museum. His main claim to fame is his bad temper, which he vents on colleagues who have the temerity to question his findings. Here,'' I reached out a hand. ''Let me have the mike.''

I spoke with as much conciliation as I could muster: ''Cornwallis, this is Whitedimple. Let's admit that we both got here at the same time, and make a joint expedition out of it. It's too big a find to keep bottled up, anyway. Over.''

''Cornw—ssss—*speaking. This is your last warning. We have a high-powered infrared laser train*—sss—*on you and*—ssssss—*use it to disrupt your RCS if you do not leave immediately.*''

We stared incredulously at the other ship. The man in the airlock was now steadying the apparatus at head level and seemed to be sighting at us along a stubby projection. This was getting serious; I thumbed the mike. ''Now look here, Cornwallis, don't you think you're carrying this a little too—''

Suddenly there was a green flash in my eyes: the unmistakable retinal image pattern of laser light. Then a buzzer sounded in the overhead speaker. Junior yelped, flipped the boat ninety degrees, and blasted straight up on the thrusters.

A minute later, still accelerating, Junior pressed a reset button on the control panel. The buzzing stopped, only to resume as soon as he removed his finger. He swore. ''Check and see if they're still firing at us.''

''I've been watching. He stopped as soon as you began turning the boat, as far as I could tell.''

He nodded, flipped the vessel one-eighty, and continued on RCS for another minute before trying the reset again; this time the buzzer remained off. He breathed a sigh and shut down the thrusters. We were now a kilometer above the tug, drifting upward very slowly. I asked Junior what had happened.

''They were telling the truth,'' he said shakily. ''That green light must have been the frequency-doubled sighting light for an infrared laser. A second after it came on, I got an overtemp indication in one of my hydrazine tanks. Hydrazine's pretty stable, but it'll boil.'' He shivered visibly. ''From the speed with which that indicator came on, I'd say we had about three seconds to go before there was a pressure explosion.''

Looking grimmer than I'd ever seen him, he turned back to check the control panel. Face averted, he said: ''Well, what now, Admiral?''

I didn't answer right away. I thought furiously, while fright and anger fought for control. We'd learned the hard way that Earth had no intention of making a friendly race of this affair; they were desperate to reach the cache before SpaceHome, and would go to any lengths short of war to do so.

I was disgusted with Ogumi, and afraid for my life. But most of all I felt overwhelmingly angry at the execrable Cornwallis. He must have been given the power to negotiate, but had chosen instead a life-threatening act of intimidation. Now the ball was really in my court. Did we slink away, or fight back at the risk of our lives? 'What now, Admiral' indeed!

With the exception of Junior's superior piloting, they appeared to have all the advantages: a larger boat, much more acceleration, more fuel and supplies, and weapons. If they wanted to, they could chase us all over space. Except . . . The germ of an idea began to form.

My thoughts were interrupted. "Dimp, a message just came in from SOS. Want to hear it?" I nodded.

It was another message from Ogumi, asking our current status, reminding me again of my power to negotiate, and professing warm confidence in my ability to handle the situation.

I snapped an irritated reply: "Tell him I'm negotiating!"

Junior raised an eyebrow. "You're the boss, Admiral." He framed the message and fast-taped it back to SOS. By the time Ogumi received it, I reflected sourly, things would be settled one way or another.

When Junior was finished, I said: "You told me that pilot had guts. Do you think he'd try to navigate that gap down there?"

My little companion rubbed his nose. "I don't think he'd be stupid enough to do it."

"But maybe he doesn't know the danger."

"They don't give pilot's licenses for ignorance, Dimp."

"Okay, but what if we . . ." My plan was conceived in anger, based on uncertain assumptions, possibly foolhardy, and certainly illegal. Anger lent me eloquence; as I talked, Junior began to nod. Soon his grin returned, and he began to look at me with some respect.

When I finished he looked me in the eye and asked: "You really willing to take the risks, Admiral?"

I returned his gaze. "Are you the best pilot in the system?"

"Touché," he cackled. "All right, let's see what they're up to."

We put the binoculars into service. The tug was a trifle over a kilometer below; the laser operator was watching us. Another had joined him in the airlock and was fiddling with equipment that seemed to include a coiled line.

"They're getting ready to go down," I said. "We'd better get started."

"Buckle up, Admiral; we're on our way." He angled the nose and lit the CRF. After a minute of hard acceleration, he did a flipship and blasted back to kill our velocity. We ended less than a kilometer above the gap and some five kilometers down-orbit from the Maiden.

We pitched over so that our nose pointed straight at the tug. Through the binoculars I could just make out the men in the airlock. Both were watching us; the laser operator was apparently readying his weapon. I swallowed once and told Junior to proceed.

"Into the breech, Admiral." He aligned the boat carefully, then lit the CRF again and blasted directly at the tug for fifteen seconds. I kept the glasses on the laser man; he was sighting it as

Junior cut the drive. Just as we began the flipship I saw a green flash; then our tail was pointing directly at the Earth vessel and Junior cut in the CRF.

We blasted for thirty seconds at low acceleration, our exhaust aimed precisely at the tug. As he fussed with the controls, Junior remarked: "You really shouldn't look at a laser with binoculars—it could be dangerous." The wicked grin was in full display.

"Do you think he kept firing at us?"

"I didn't get any thermals," Junior said. "Would *you* go up against a CRF plume with only a micropore suit and a hand-held laser?" I was still mulling that over when he announced: "Closest approach, 3.95 klicks." He angled the nose down and increased power. "Time to shoot the gap."

We were almost stationary with respect to the ring plane; now we picked up speed rapidly as we edged down toward it. Junior was intent on his displays; from time to time he looked up from his 3-D to gauge the approaching gap. Then he cut the drive, made a last-second correction with thrusters, reached to his left and flipped a switched prominently marked "GS." A loud click echoed through the hull. The 3-D display froze; the lights flickered, but remained lit.

I asked what "GS" stood for. "Gap-Shooter," was the reply. "Cuts off all conductive paths from the hull to the interior of the boat."

Even as he was answering we slipped into the gap. There was little time to see anything. I did notice that the individual particles were quite far apart, although through the side ports our velocity merged them into a solid wall. Another phenomenon was the color change. As we dropped through the gut the light grew dimmer, changing from off-white to ruddy, then to dull orange. In a few seconds we were through, and the B-Ring formed a monstrous ceiling above us. I felt as if we were in a huge darkroom, illuminated with the wrong shade of red.

While I caught my breath, Junior flipped off the GS and ordered a systems check. Pandora ran through her routine and gave us a green, whereupon we flipshipped and killed our drift.

I had to resolve something that had been bothering me. "Junior, you said our closest approach to the tug was 3.95 kilometers. Was that close enough to hurt the men in the airlock?"

"Naw. A one-tenth-g plume from this little boat wouldn't be dangerous for a short time at that distance. The only damage will be wet pants." His crooked grin was eerie in the dim orange-red light seeping through the rings.

I took a deep breath. "Okay, let's go again."

He glanced at the screens, then pitched the nose up and cut in the CRF. Shortly we were drifting once more through the gap; then the ring turned white and we were in sunlight. After a quick systems check Junior swapped ends and killed drift. We pointed once more at the tug, which was still sitting a few hundred meters above the Maiden, several kilometers up-orbit.

Now the airlock was closed. I wondered what was happening inside—but not for long; a call came in at once on our emergency band. It was Cornwallis, so furious that he was literally sputtering. He shouted that we were in viola-

tion of U.N. and SpaceHome regulations, international and interspace law; that we were furthermore bounders and cads, and that he would personally see that we suffered lifetime imprisonment. He ended with a demand for an explanation of our actions.

"You want to reply, Boss?" Junior asked. "Sounds like he's reopening negotiations."

I told Junior exactly how to reply.

"You're a hard man, Admiral," he cackled, lined up our nose, and gunned hard at the tug. Then once more he flipped ship and blasted back for thirty seconds before tilting us down toward the gap.

"Got to within 3.46 klicks that time," he said with satisfaction. "Close enough to set off a thermal or two and give 'em something to think about."

Halfway through the gap on this pass my hair tried to stand on end, and there was a funny taste in my mouth. Junior was calm. "We just took our first hit," was the terse explanation. I didn't like it, and was apprehensive until Pandora announced a successful systems check.

Once again we hung motionless below the gap in that orange half-light. I asked what would happen if we got zapped without activating the GS. Junior reached up and tugged an ear. "Well, I've got a fast-reaction autoshutoff wired into it; but with the kind of currents and risetimes we're messing with, I'd prefer not to rely on it."

When we shot the gap again and lined up on the other vessel, it was waiting for us. From six kilometers away we were gazing into the throat of their CRF. The message from Cornwallis was short: if we tried anything again, they'd blast us out of the sky.

I swallowed hard. Junior seemed unperturbed, although he kept his hand on the controls. "Well, Admiral, that gun's bigger than ours. Any ideas?" From the tone of his voice it was evident that he'd already come up with an answer.

"How far above the Maiden are they?"

He glanced at the 3-D. "Two-hundred sixty meters."

"Okay, let's hit them from straight overhead."

He laughed delightedly. "Admiral, anger sure whets your brain."

"I wish it would dry my pants," I answered shakily.

Still chuckling, he angled the boat upward, then gunned the CRF. After a minute, he flipped and blasted back, stopping six or seven kilometers above the tug. Their pilot maneuvered in unison to keep his nozzle pointed directly at our boat. I raised the binoculars and focussed them on the Earth vessel; for the first time I realized how wicked-looking a CRF throat really is. Half to myself I grunted: "The tail's still aimed our way."

"Yeah, but their nose is pointed straight at the Maiden."

"Okay," I said, taking a deep breath, "singe the hell out of them!"

Without a word he kicked in the CRF and dove toward the enemy tug. To take my mind off that lethal nozzle, I asked Junior why the pilot hadn't done more maneuvering during the encounter.

"No matter how good that Jacobs character might be," he grunted, eyes glued to the screens, "he's got to switch to manual control to play our game. And

it's been drilled into him that manual's for emergency only." He made a tiny course correction. "So it's taking him a while to overcome that computer-programming, button-pushing training." He cut the CRF and flipped ship. "Besides, his displays probably aren't nearly as good as mine." He aligned the boat carefully with the tug, tail to tail. "Okay, here we go."

We poured hot hydrogen ions into them for almost a minute before Junior finally pitched the boat over and headed for the gap. "Three point oh four klicks that time," he gloated. "They'll be up to their ears in alarms."

"And Cornwallis will be madder than hell."

"And they've seen us shoot the gap four times now."

We looked at each other and laughed.

Drifting through the gap for the fifth time, I asked Junior why he'd introduced himself as "Dr." Badille. "Partly one-upmanship," he replied with a twinkle, "and partly truth. "Princeton conferred honorary degrees on Mom and Dad three years ago, for their good work on ring resonances. Since I'd done all the research and written all the papers, they held a little ceremony and reconferred the doctorates on me." He winked. "Just between us, of course."

Another systems check, then we flipped and blasted back. Coming up through the gap, we took another hit. I liked it even less the second time, but neither Junior nor Pandora was bothered.

This time, when we lined up with the tug at six kilometers, we found ourselves nose to nose. Junior said: "Want to bet we've got a new ball game this time?"

"Let's wait a bit and see what they do," I said.

So we waited, a full ten minutes. The enemy did not move; nor did they call. "Okay," I sighed. "Once more."

As soon as we started accelerating, so did they. The six kilometers began to melt rapidly. Junior immediately pitched the boat up ninety degrees and headed directly away from the ring plane.

"Jacobs is catching on to boat fighting," he said, busy with the controls. "He was probably planning to mirror us. As soon as we flipped, he would have done the same, then blasted us with a one-g plume and wiped us out. Our best bet is to get above him—or at least play like we're trying to . . . ahh, here he comes."

The Earth tug, pitching up in turn, was now blasting furiously. Junior immediately flipped us one-eighty and burned at .3-g toward the gap. We passed the tub at a distance of four kilometers; it cut its drive, yawed over so that its tail pointed at us, and cut in its CRF at high acceleration. We were only in its wash for a second or so before the pilot lost us; shortly thereafter, it was too far away to be effective.

But that "second or so" had been enough to trip four thermal alarms. I found myself drenched in sweat. Junior swore as he punched reset buttons while maneuvering to shoot the gap. The last alarm went silent just before he hit the GS and coasted us through.

After killing our relative velocity, we looked again for the Earth vessel. It was four or five kilometers above the ring

plane, and just coming to rest. Junior edged up until we were barely under the gap, in plain sight. And there we sat, bait in a trap—I hoped.

We had done the job of raising their hackles. They also had every apparent advantage. I was counting on their pride not to admit that Junior was the better pilot, their incomplete knowledge of the gap's perils, and their anger, to override the small voice of reason. Plus the fact that we had to be disposed of permanently before they could retrieve the artifact.

We waited, until fears and doubts began to gnaw. Then finally Junior announced: "Here they come!" Now I could see the foreshortened tug silhouetted against the glow of its CRF plume, but it was several seconds before it was noticeably larger. "He's taking it slow and easy," Junior said, glancing at the screens. "Acceleration's only about a tenth-g."

The vessel presently stopped its drive and drifted closer, thrusters cutting in and out as it made course corrections. About three kilometers up it pitched end-for-end. Junior moved us several hundred meters down-orbit, keeping our nose toward the tug. "I don't think he's silly enough to fire the CRF into the gap and roil up the particles," he explained, "but it doesn't hurt to be safe."

Sure enough, only the tug's RCS was used to slow it down for shooting the gap; the pitch and yaw thrusters all burned in unison for a long minute, then shut off when the vessel was still half a kilometer above the ring plane.

Junior studied his displays. "He's coming through at twenty-three meters a second. Not bad for an amateur. But I'd lay heavy money he'll get zapped first time through."

"Why is that?"

"Because he's coming through the radar-indicated gap center, instead of hugging the clean wall nearest Saturn. On that course, chances are ten to one he'll take a hit."

I watched fascinated as the tug entered the gap, still making an occasional attitude correction with the thrusters. The vessel was nearly through the passage when I noticed that a yaw burn cut off immediately after its inception.

"Got 'em!" cried Junior. "I saw the spark!"

The tug was now through the gap, drifting downward in the dark orange glow. A minute later it was more than a kilometer below us, still on the same course. To all appearances it was a dead ship; not even a running light was showing. My partner turned to me and stuck out his hand. "War's over, Admiral. You did good."

Numbly I accepted the hand. "Do you think they're all right?"

"Sure. They can hold out in there as long as their supplies last. Might get a bit smelly, though." He turned back to his controls. "Let's go say hello."

He accelerated down toward the tug, flipped, and matched velocities—all on RCS. Now that the battle was over he meticulously followed the rules of minimum safe distance and forebore using the CRF drive.

After matching rates, we carefully drifted toward the tug until only a few meters separated our noses. All three men were at the forward ports. Two were waving wildly; the man at the pilot's console was calmly holding up

a large piece of paper, bearing the legend: HELP?

"How about it?" Junior asked.

"Let's get the artifact first, dammit!"

He gave me a wry smile. "You're a hard man, Admiral." Ordering Pandora to keep station on the tug, he floated to the back of the cabin, dug out a sheet of white plastic, and scrawled on it with a grease pencil. Bringing it forward, he held it up against the viewport. After a second the pilot nodded his head. The other two shook their fists.

Junior handed me the sign and began backing the boat away. I read the message: BACK BEFORE SUNDOWN. Not for the first time, I wondered about his reading habits.

As we headed back up I began having second thoughts. "Junior, are you sure they'll be okay?"

"Yeah. They don't have any cabin heating, but they can wear micropore suits to keep warm if they have to; and it's four hours yet till we enter shadow."

"Let's see . . . by that time they'll be about . . . 350 kilometers below the gap." I took a modicum of pride in performing the mental arithmetic.

"Good try, Admiral, but wrong. They'll be about eighty klicks away and heading back up toward us. In fact, if we waited five hours, they'd punch right up through the ring plane." He laughed at my expression. "Boss, you're one hell of a boat commander, but what you know about orbital mechanics would barely fill a small thimble!"

Since they were undoubtedly watching us with binoculars, shooting the gap again was like a final victory.

We landed twenty meters from the hatbox and went out in suits to retrieve it. For the first time I saw the Giant really close up in open space, unframed by a viewport. I stared, overwhelmed by the frightful splendor, until Junior called me back to duty.

Once back inside the boat, we proceeded with haste to open our prize. There was a single plate—and it was different from the other two. We studied it with utmost concentration.

After half a minute, Junior began to laugh. . . .

V

There is a point on Saturn at 82° 37′ north latitude and a longitude which has been defined as zero for the better part of a century. There, at local noon each day, a kilometric radio pulse is emitted, as if the spot were a clock ticking once every 10 hours, 39 minutes, and 26 seconds. And at that point, under thousands of kilometers of atmosphere and ton upon ton of pressure—and floating somehow on a sea of hot liquid hydrogen—is the promised treasure that an alien race most graciously left for us to retrieve. Junior Badille is completely convinced that they have a perverse sense of humor; he is not alone in his conviction.

So what am I doing now? Teaching archaeology, back here at 'Home III. But not for long. Already, after only three months back on the grind, I'm bored stiff.

Did we rescue the men from the Earth tug? Of course. And we were even polite about it—especially after Junior stopped laughing long enough to point out that SpaceHome would soon have a pressing need for heavy cash and high-gravity pilots. By the time we got to

them, Cornwallis was totally panicked. Then, once he was snug and warm in our boat, he began again with his silly threats. At which point I informed him that every word between the boats had been taped, and that any more lip from him would result in immediate transmittal of said tape to SpaceHome.

The colonel had nothing to say. Eventually I presume he went back to Earth to try to convince superiors of his stalwart bearing in the face of overwhelming forces.

Jacobs, on the other hand, was volubly impressed with Junior's "shit-hot" piloting; he was quite willing to admit defeat at the hands of a better man. I didn't have the heart to tell him that Junior was still in his teens.

Cornwallis? Presumably he crawled back into the woodwork in the basement of the British Museum. Junior and I exerted pressure to make sure he had no more involvement with the project. The universe at large was told we had rescued the distressed tug after it had an accidental brush with the rings—and all five of us came home as heroes. But high officials of Earth and SpaceHome heard that tape.

Junior? He's found a new lease on life. The Saturn Artifact Retrieval Team is busily milking that awesome IQ to design a high-temperature, high-pressure search-and-retrieval vessel. His only price is that Jacobs be assigned as a SART pilot.

My plans? I'm going back. The little gnome has invited me to do a south pole crossing—see the whole backlighted ring system at once, a strange and wonderful sight. Oh yes, I'm also studying orbital mechanics and digging for a pilot's license. I want to take a shot at talking to Pandora. ■

Author's Note: Thanks to Dr. Jim Warwick for the theory of the Iron Maiden—how it came about, and what it does with little lightning bolts. The idea is entirely his, except for minor distortions of poetic license.

● Here we have the "market" and the customs inspector critics and editors, while the Soviets have cencorship. Here, those who speak out or complain are smiled at or ignored, while the Soviets simply shut them up. Here we are asked to please audiences (what editors and publishers *say* pleases audiences; that something may be good and unpopular is heresy); there they please the censors.

George Zebrowski,
"Herding Words: A Journal"

Jay Kay Klein's biolog

This magazine used to run ads asking for new authors. As an engineer and American believing in positive feedback and monetary incentives, editor John Campbell would point out that a three-part serial would pay for a car or down payment on a house. In response, Grant D. Callin started writing because he needed money. His first story received one of the legendary Campbell rejections, complete with blueprints on what was wrong and how to construct something better. But a second story made print in the August, 1971 issue, making Grant one of the last writers to be developed by Campbell.

Grant's profession, as he puts it, is that of "hired killer": he has been educated in the arts of modern warfare in order to defend his country when necessary. He was born in Ohio and raised in southern California, where he read every science fiction book in his local library. There, he was particularly impressed by Heinlein both for his story telling and for his vision of patriotism and common-sensical, manly virtues. Accordingly, like Heinlein, he attended an American military academy, winning a competitive appointment to the Air Force Academy at Colorado Springs.

Today's military officer class seems to be divided into those highly trained as technicians, and those highly educated in business administration for better procurement and logistics control. Grant decided upon a third option, and went into research. Along the way he secured a master's degree in physics and another in physiology. He has the equivalent, too, of a doctorate in biophysics, lacking only a dissertation which his military duties prevented completing.

A ten-year hiatus occurred in his writing, due to pressures of study and research; so it was Dr. Schmidt who accepted his second published story for the January 4, 1982 issue. This was about an early landing on Mercury and was the first in a series of stories moving progressively outward from the Sun. Grant is just the man to do this, for he has been immersed in space research for many years. Some time back he became a member of the exclusive Air Force "Primus Club" for achieving a first: initiating a study of survival at elevated temperatures. Before employing volunteers he subjected himself *unprotected* to a temperature of 400°F.

Grant D. Callin

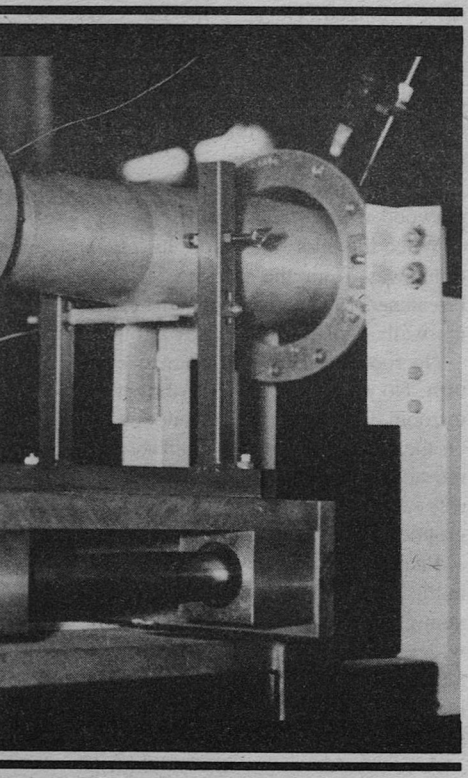
Now a major, Grant is administering an Air Force contract with Boeing to develop an inertially guided upper stage for injection of payloads into orbit from a Titan rocket or the Space Shuttle. Currently living in the Seattle area, he would like to settle there indefinitely and eventually become a full-time writer. His objective is to see his writing progress from the modest financial reward of his first story to a best-seller bonanza. This even seems likely since, after all, Grant is one who started observing planets with a home-made Newtonian and now looks at monitor screens showing planetary closeups in real time from robot spacecraft. ■

It's strange how many futuristic principles and gadgets actually have their roots in the past because of neglected technology. Fields of interest are faddish, and people tend to spend their time adding decimal points rather than risking their careers investigating new things. It's possible today to have such 21st century devices as aerodynes, static ramjets, and super-efficient silencers for internal combustion engines. We only have to remember that the world didn't start when our careers began. We have only to look back, understand, and then properly apply old, neglected technology in order to get futuristic new technology.

Here's an example: Imagine yourself standing in the brisk breeze chilled by the December weather blowing over the field at Issy-les-Moulineax just outside Paris.

THE COANDA EFFECT

G. Harry Stine



Dr. Coanda inspects the test set-up for one of the 35,000 experiments he performed on the Coanda Effect. The device is an internal Coanda nozzle driven by compressed air. Instrumentation is designed to measure thrust, various pressures, and the profile of the exhaust jet.

An airplane is wheeled out of a shed. A young man, twenty-five years old, supervises the preflight preparations. Helpers pour gasoline into the wing tank while the young pilot gives a final inspection to the engine.

The propulsion device for this airplane is unique. There's been nothing like it before.

It's a jet engine.

But it's in the nose of the airplane, and it consists of a deliately balanced centrifugal compressor driven by a water-cooled reciprocating engine. When operating, the compressor sucks in air and compresses it inside the large cylindrical cowling. The engine's exhaust is routed into this compressed air where it's en-

riched by a spray of raw gasoline and then ignited. The resulting hot, high-speed gases are then ducted to the rear out of two asbestos-lined jet pipes, one on each side of the molded plywood fuselage.

This jet engine's already been static-tested in the young engineer's laboratory. Weighing a total of 462 pounds, it produced a static thrust of 220 pounds.

However, during run-up tests with the engine mounted in the airplane a few days before, the 1300-degree Celsius heat from the jets washing past the open cockpit at a velocity of 985 feet per second had been too much for the young pilot. So he'd added two plates horizontally on the top and bottom of each of the jet pipes to channel the jet blast away from the plywood fuselage and keep him from being roasted in the cockpit.

No flight had been planned that morning. The weather was considered too poor for flight. So there were none of the usual newspaper reporters there and no official observers present—only the young man and three friends who were helping him. This was to be the second try at a taxi test, maneuvering the airplane along the ground under the thrust of its jet engine.

Finally, all was ready. The young pilot climbed into the open cockpit. He started the engine. The compressor spooled-up with a whine. Noting that his helpers were holding the wing tips and were therefore clear of the jets, he valved gasoline spray into the cowling and switched on the ignition.

The jet engine thundered. He waved to his helpers to turn loose of the wing tips, and he was off across the field, maneuvering cautiously.

The plane lumbered sluggishly, so he gave it a little more throttle and valved more gasoline spray into the jet pipes.

Suddenly, the jets weren't behaving properly. They spat raw flames. Incredibly, these flames didn't flow outward away from the wooden fuselage as they'd done in previous tests. They bent inward and hugged the plywood fuselage sides.

He tried to adust the gasoline spray control in an attempt to get the flames back inside the asbestos jet pipes where they belonged. He gave his full concentration to this and didn't notice that the plane was gaining speed. He never even noticed the mounted cavalrymen —whose riding field this was—as they scattered out of the way.

The tail came up and the cantilevered plywood wings started to lift.

When the pilot finally tore his attention away from the flaming jets that threatened to ignite his plane, he saw the walls of Paris rushing toward him.

No room to stop. No room to even turn. No time to do anything except try to zoom over the walls. The pilot pulled on the controls. The strange plane rose too steeply from the ground, stalled, fell off on a wing, and crumpled to the ground.

Because he wasn't wearing a seat belt in the open cockpit for the taxi trial, the young pilot was thrown clear of the wreckage upon impact. Within moments he regained consciousness, feeling as though every tooth in his head had been knocked loose.

A few yards away, his jet airplane

was burning, the gasoline-fed flames consuming the plywood structure.

The world's first airplane powered by jet propulsion had left the ground, however briefly.

The date was December 10, 1910.

The designer, builder, and lucky pilot was Dr. Henri Marie Coanda, born in Bucharest, Rumania, in 1886, a student of sculptor Auguste Rodin, a graduate of the first class of the Ecole Superieur de Aeronautique, architect, experimentalist, boulevardier, contemporary of the Wright Brothers and Louis Bleriot, Gestapo prisoner during World War II, member of numerous international scientific and engineering bodies, and ladies man *par excellence*. Coanda's biography alone is a fantastic story that would make a good novel—science-fiction, romance, historical, and more.

But this isn't an SF story out of a parallel universe. It actually happened and is documented in the Musée de l'Air in France and in the National Air and Space Museum of the Smithsonian Institution. Although the doyen of early aerohistory, the late Sir Charles Gibbs-Smith, claimed that the flight never took place at all, this story is just as it was told to me by Dr. Coanda himself on many occasions. I've verified it from several sources, including a contemporary book written by a witness. Whether he actually flew the 1910 jet or not is irrelevant, however, as you'll see. The 1910 Coanda Jet was capable of flight; I've checked the aerodynamics of the design. With 220 pounds of jet thrust, it would have flown . . . except for one small, insignificant, and unknown factor.

Far from being just another interesting story from the *belle époque* of aviation, it triggered a fascinating scientific search that lead to a new physical phenomenon that's just beginning to find practical applications in spite of gross misunderstandings about how it works.

After all, it took Coanda himself twenty-two years to learn why those jets behaved as they did.

The answer came to him in late 1932 when he was working in his Paris laboratory trying to produce a vacuum by blowing air over a surface. In the process of doing this, he discovered what is probably one of the outstanding breakthroughs in fluid dynamics of this century. He discovered what Professor Albert Metral was to name the "Coanda Effect."

The Coanda Effect was hailed in the scientific journals and popular technical magazines of the United States in 1965 because of the then-new "fluidic amplifiers" developed by the Harry Diamond Laboratory of the United States Army. And NASA began playing games with blown flaps on the Boeing 387-80 (Boeing 707 prototype). In the ensuing years, we haven't heard too much about Coanda Effect. However, a number of airplanes now use "blown flaps" and "blown slots" to improve their low-speed aerodynamic handling characteristics. And some abortive attempts have been made to produce Short Take Off and Landing (STOL) aircraft such as the Boeing YC-14 and the Soviet Antonov An-72, both of which used the exhaust of their jet engines to blow directly over the tops of their wings in an attempt to augment lift. Probably the reasons for

the lack of success in further developing "fluidics" as well as STOL aircraft using Coanda Effect is because engineers simply don't understand it at all. Coanda Effect has never been correctly or completely described in any publication, and it's usually applied incorrectly because of preconceived notions about how it works and why it does what it does.

I had the privilege of working with, sharing an office with, and having as a close personal friend the man who discovered the Coanda Effect. Between 1962 and 1965, Dr. Coanda passed along to me his knowledge of fluid dynamics and his experiences with the Coanda Effect. I read his scientific papers, took copious notes when he spoke, studied his drawings and sketches, had him criticize the Coanda Effect devices I designed, and studied data from test after test on these devices. In the hope of enlightening some young engineer, encouraging some fluidic researcher, and entertaining those of you with a scientific bent, I herewith pass along to you the details of the *how* and *why* of the Coanda Effect as I learned them from Dr. Henri Marie Coanda himself. It was rather like having Albert Einstein explain relativity. Now, what you do with it after I tell you about it is up to you, but I hope you come up with some interesting new machines!

In simple terms, the Coanda Effect can be described as the natural tendency of any fluid—gas or liquid—to adhere to and be deflected by a surface nearly tangential to the flow path. This doesn't mean that the fluid is necessarily turned by direct impact or impingement upon the surface, but that the fluid instead follows the contour of the surface.

You may have experienced Coanda Effect when pouring liquid out of a poorly designed pitcher or lab beaker: the fluid curls around the lip of the spout, runs down the side of the container, and gets all over you. Funny if it's beer, but disastrous if it's acid.

What's not so well known is the fact that when a flow is thus turned by a surface, there's a surprising amount of flow augmentation or multiplication as well as momentum augmentation in the flow. But the reason that the surface deflects the flow *isn't* because of surface tension!

Let's get a basic understanding of Coanda Effect the way Coanda himself explained it to me. Let's consider first a simple case of two-dimensional flow.

In Figure 1 is a plenum chamber with an exit slot leading to another, larger volume. If the fluid in the plenum has a higher pressure than that on the opposite side of the slot, the plenum fluid will emerge from the slot to produce a jet whose characteristics are very well known. The boundaries of this jet will normally become turbulent at some distance from the slot, depending upon the size of the slot, the pressure difference across the slot, the fluid density, and the Reynolds Number (which is something like a scale factor having to do with the viscosity of the fluid). These turbulent boundaries swirl and therefore entrap molecules of the surrounding fluid, imparting momentum to these entrapped molecules at the expense of the jet's momentum according to well-understood mechanisms of momentum transfer. The velocity of the jet will also

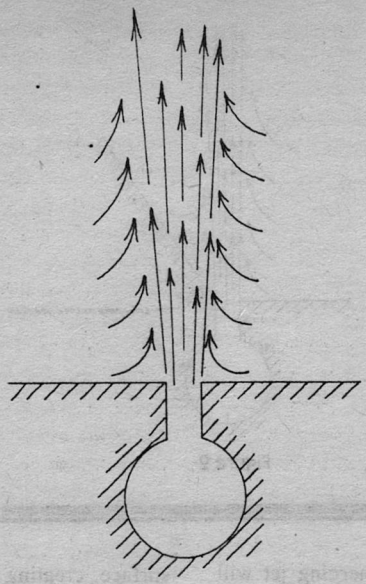


Figure 1

produce a low pressure at the jet boundaries, and this will tend to enhance the induced flow of ambient fluid into the jet as well.

At the slot, the jet will have a definite momentum—a product of mass-flow and velocity—which can be determined by the area of the slot and the pressure drop across it. As mixing takes place between the jet and the ambient fluid, the jet broadens out. As this happens, its average flow velocity decreases and its average mass increases until, at some distance from the slot, the jet itself disappears in random molecular motion.

If you were to measure the total momentum of the flow at any point after it emerged from the slot, you would find that, in theory, it would never exceed the total momentum of the jet flow at the slot exit. And its total momentum would decrease with increasing distance from the slot as momentum exchanges took place by particle collision. The total momentum would finally approach zero as the jet disappeared.

All of this is quite conventional and can be found in most books dealing with fluid dynamics.

Now, let's introduce a boundary on *one side* of the emerging jet. This creates, in effect, a non-symmetrical nozzle.

Something unusual begins to happen at once.

In Figure 2, you can see that the in-

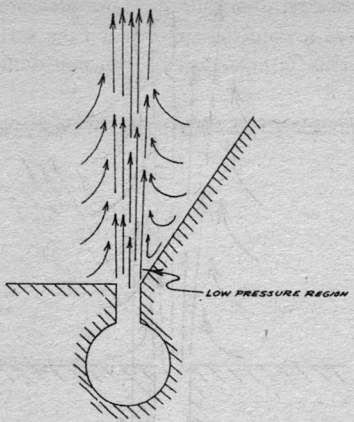


Figure 2

duced flow into the emerging jet will be hampered on the side where the new surface has been introduced. The induced flow into the jet will rapidly evacuate the ambient molecules from the space between the slot and the new surface, creating a low pressure region in this area. This low pressure region cannot be relieved by additional ambient fluid flowing because of the physical restriction of the surface. (Remember, this is a two-dimensional model.)

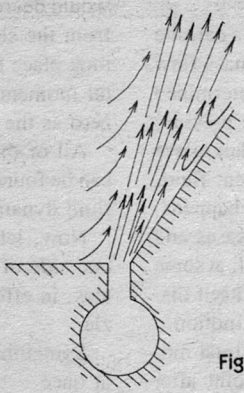


Figure 3

The region of lowered pressure causes the jet to be deflected toward the surface, as in Figure 3. This further reduces the pressure between the jet boundary and the surface, which in turn leads to further deflection of the jet toward the surface. Finally—and very quickly—the jet lies right on the surface itself, as in Figure 4.

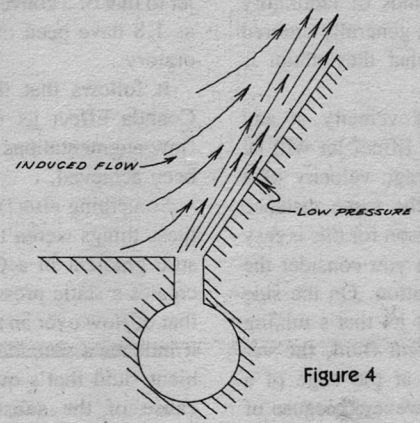


Figure 4

At some distance along the surface, the jet can be caused to turn again by changing the direction of the surface. Figure 5 shows the jet being turned 180 degrees by successive surfaces.

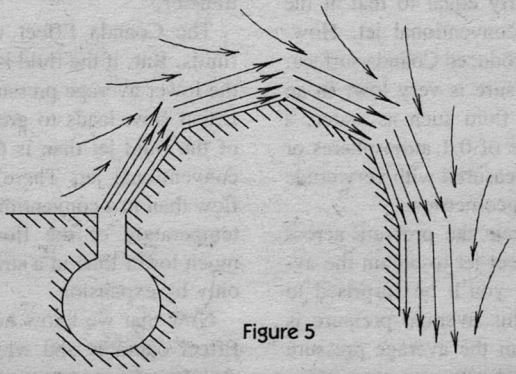


Figure 5

A jet of fluid thus deflected by Coanda Effect differs strikingly from the straight, conventional jet we started out with. It has some interesting and unusual characteristics that have been confirmed by thousands of laboratory tests—and have been generally ignored by most users of what they claim is "Coanda Effect."

First, the average velocity at any point in the Coanda Effect jet will be *higher* than the average velocity of a conventional jet at the same distance from the slot. The reason for this is easy to comprehend when you consider the geometry of the situation. On the side of the Coanda Effect jet that's mixing freely with the ambient fluid, the velocity is nearly that at the edge of a conventional jet. However, because of the very low pressure of that portion of the jet lying on the surface, its velocity there is extremely high.

The pressure profile across any jet is, of course, an inverse function of the velocity profile.

At the interface between the Coanda Effect jet and the ambient fluid, the pressure is nearly equal to that at the interface of a conventional jet. However, on the introduced Coanda surface, the fluid's pressure is very low. In an incompressible fluid such as water, a surface pressure of 0.1 atmospheres or less has been measured with very crude Coanda Effect geometries.

If you integrate the pressure across the Coanda Effect jet to obtain the average pressure, you'll be surprised to discover that this average pressure is slightly *less* than the average pressure of a conventional jet.

Therefore, as a result, the momentum of the Coanda Effect jet flow will be higher than that of a conventional jet!

Momentum augmentations—the ratio of the momentum of a Coanda Effect jet to that of a conventional jet—as high as 1.8 have been measured in the laboratory.

It follows that the mass flow of a Coanda Effect jet is also higher, and flow augmentations as high as 16 have been achieved.

Something else(!) also happens, as if these things weren't enough. The pressure gradient in a Coanda Effect flow creates a static pressure field similar to that of flow over an airfoil surface. And it induces a secondary flow in the ambient fluid that's quite surprising. Because of the substantial momentum augmentation produced by the Coanda Effect jet, the induced flow from the surrounding, ambient fluid is produced by a pressure gradient rather than by the less-efficient collision and entrapment process of momentum transfer in a conventional jet. This is a much more efficient mechanism for momentum transfer.

The Coanda Effect works with all fluids. But, if the fluid is compressible, the lower average pressure of a Coanda Effect flow leads to greater expansion of the fluid jet than is the case with a conventional jet. There's less random flow than in a conventional jet. And the temperature of the flow is therefore much lower than in a straight jet cooled only by expansion.

Now that we know how the Coanda Effect operates and why, it's easy to understand how to turn the Coanda Ef-

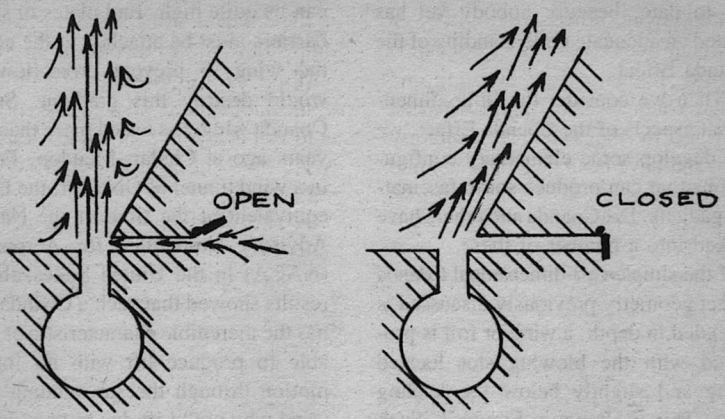


Figure 6

fect jet on and off. In the two-dimensional case, it's simple. Just relieve the low pressure on the Coanda Effect surface at the slot exit. Figure 6 shows a vent controlled by a valve or other fluid control mechanism that has been introduced into the geometry at the slot exit. When this vent is closed, the Coanda Effect permits the flow to follow the surface; when it's open and vented to ambient pressure, the jet becomes conventional.

It's possible to obtain a pretty substantial vacuum by connecting the vent line to a chamber from which you wish to withdraw fluid. It's much more efficient than a straightforward venturi.

What has just been described (surprise, surprise!) is a fluidic switch or a liquid-state transistor. A very small change in the slot pressure or the slot dimensions will produce a very large change in the induced or secondary flow as well as the primary flow. The analogies between electricity and fluid flow hold up quite well here—pressure being analogous to voltage and flow rate being analogous to current. The "characteristic curves" of slot pressure versus induced flow for a simple Coanda Effect device look suspiciously like those for a power transistor, although the Coanda Effect device draws a reasonably high emitter current because of the flow augmentation phenomenon.

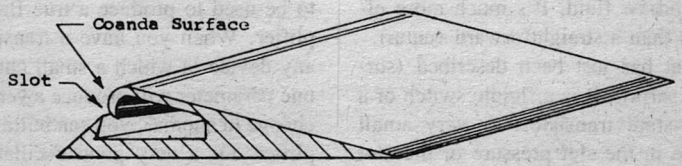
The Coanda Effect has been used in fluidic amplifiers to produce fluid flip-flops and fluid switches. But it has yet to be used to produce a true fluid amplifier. When you have a transistor or any device in which a small change in one parameter will produce a very large change in another, you can build an amplifier. Or a very good oscillator. Or any number of fluid analogies to electronic devices. But they haven't shown

up, to date, because nobody yet has gained an adequate understanding of the Coanda Effect.

When we consider the three-dimensional aspects of the Coanda Effect, we can develop some elementary configurations that can produce some fascinating gadgets. Dr. Coanda and others have looked into a number of these.

If the simple two-dimensional Coanda Effect geometry previously discussed is extended in depth, a wing or foil is produced with the blowing slot located along and slightly below the leading edge. This is shown in Figure 7. Such a Coanda "lenticular airfoil" produces lift as a result of being "blown," for the same reasons that an ordinary airfoil does: the difference in airstream velocity on opposite sides of the surface produces a differential pressure—low pressure where the relative velocity is high, and vice-versa. The high-velocity fluid flow across the top of the Coanda lenticular airfoil produces the same sort of low pressure on the upper surface as Coanda flow does in the case of the asymmetrical Coanda nozzle. The static pressure gradient across this blown wing can be quite high. End plates or similar barriers must be attached to the ends of the wing to prevent cross-flow that would destroy this gradient. Such a Coanda wing was tested more than forty years ago at Chalais-Meudon, France, in a wind tunnel of ONERA, the French equivalent at the time of the National Advisory Committee for Aeronautics (NACA) in the United States; the test results showed that such a Coanda wing has the incredible characteristic of being able to produce lift with no forward motion through the surrounding fluid. (And why not? Lift due to pressure differential depends solely on the *relative* velocity between the fluid and the surface. It doesn't make any difference whether the object moves through the fluid or the fluid moves past the object. If this were not true, wind tunnels wouldn't work.) This leads to the interesting possibilities of producing a wing with negative drag, and the polars of such a wing suggest this actually takes place. (Why didn't the French exploit this discovery? Because the turbojet engine wasn't available to provide the low-pressure, high-volume flow re-

Figure 7

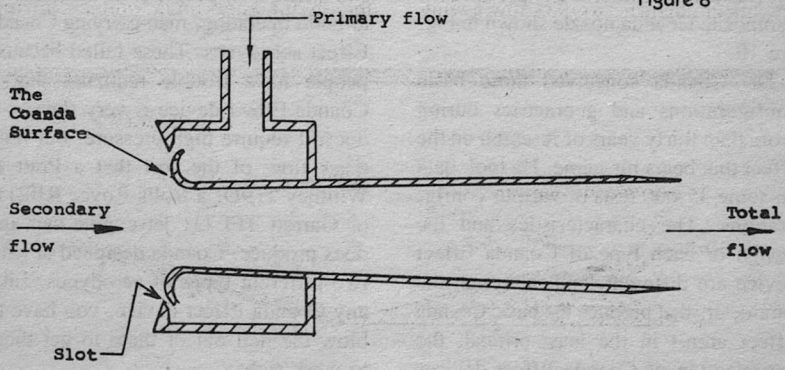


quired to make it work. But today . . .)

Consider again the simple two-dimensional geometry, and let's create an object by rotating it around an axis internal to the flow, creating an "internal Coanda nozzle." It looks like the kind of venturi tube you used to see on the outside of airplanes before engine-driven vacuum pumps came into wide use. But it operates quite differently from a venturi or even a common annular ejector pump of the sort you can buy to suck leaves out of a swimming pool. As mentioned before, a Coanda Effect device obtains its induced or secondary flow by of means a pressure gradient, not by collision or a direct momentum transfer process. An internal Coanda nozzle is shown in Figure 8. It makes an excellent high mass-flow pump with little or no restriction in the flow nozzle. I've built an internal Coanda nozzle with a one-inch throat diameter that would, when operated with water from an ordinary garden hose at city main pressure, produce a secondary induced flow rate as high as 100 gallons per minute. It could empty a one-gallon bucket in a hurry! Use propane instead of air for the primary flow, stick a flame-holder in the throat, light it off, and stand back; you've got a ramjet with no moving parts that will produce thrust at zero forward air speed! (And it *is* spectacular if you're into fire and noise.)

Figure 9 shows a cutaway drawing of a device that's produced as a result of rotating the Coanda Effect geometry about an axis external to the flow, thus creating an "external Coanda nozzle." Back in 1962, Dr. Coanda had a small version (about 8 inches long and 2 inches maximum in diameter) of this external Coanda nozzle whose operation was quite striking. If a cigarette smoker blew a lungful of smoke through a pipe in the rear of the tear-drop-shaped device, it would turn the flow completely around to direct the smoke right back in the smoker's face. In 1963, I helped

Figure 8



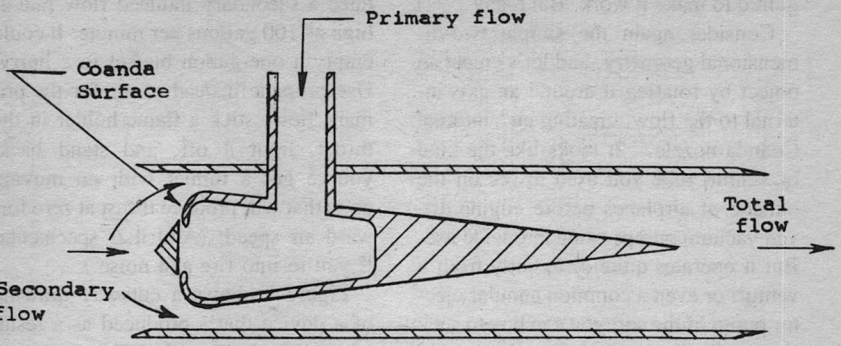


Figure 9

design and build a silent underwater propulsion system using steam for the primary fluid and a shrouded external Coanda nozzle configuration. The condensation of the steam a short distance out of the slot further enhanced the thrust of this gadget. As a demonstration for visitors and VIPs to the laboratory, we rigged it up to a toy submarine that would run around a big tub of water.

The internal and external Coanda nozzles can be combined to produce the composite Coanda nozzle shown in Figure 10.

Dr. Coanda conceived these basic configurations and geometries during more than thirty years of research on the effect that bears his name. He took data on some 35,000 tests of various configurations. The characteristics and the design of each type of Coanda Effect device are different, and, although the parameters that produce the basic Coanda Effect aren't in the least critical, the optimization of Coanda Effect devices depends on a great deal of empirical know-how. Some investigators have attempted to give mathematical rigor to the design process, but it's been largely neglected because nobody really understood the Coanda Effect. You now do. I hope.

Yes, it's possible to build a workable saucer-like aerodyne utilizing Coanda Effect. But you have to understand Coanda Effect! There have been at least two attempts by people other than Coanda to build operating, man-carrying Coanda Effect aerodynes. These failed because people have trouble realizing that a Coanda Effect device is very *thirsty;* it doesn't require high pressure, but high mass flow of the sort that a Pratt & Whitney JT9D, a Rolls-Royce RB211, or Garrett TFE731 jet engine can and does produce. Coanda designed at least two different types of aerodynes. Like any Coanda Effect device, you have to blow the hell out of them to get them to work right.

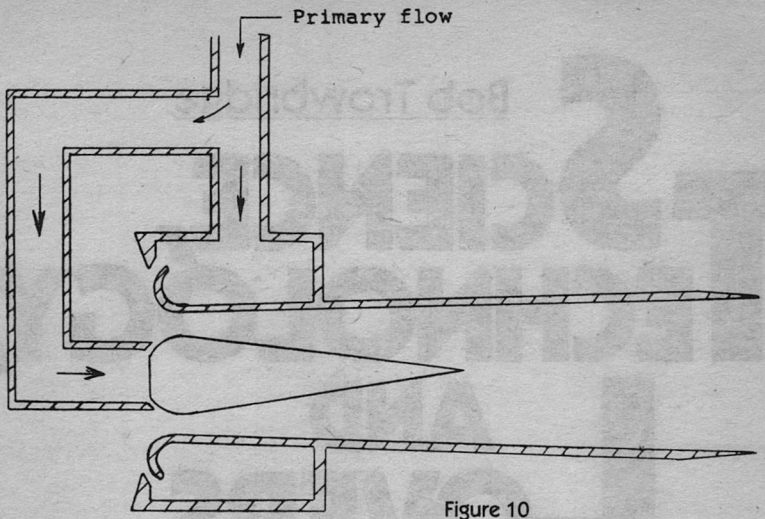


Figure 10

Only a few of the possible applications of the Coanda Effect have been discussed or inferred herein. There are probably a lot more of them. There are undoubtedly more than anyone has yet dreamed of. Could a student of Lee De Forest have thought of all the applications of vacuum tube triodes? Did Shockley's colleagues envision all the ramifications of the transistor in 1950? As has been pointed out, the Coanda Effect can produce the fluid equivalent of the triode vacuum tube or the transistor when it comes to analogous fluidic amplifiers and other gadgets.

Dr. Coanda passed away in Bucharest, Rumania on November 25, 1972 at the age of 86. He had led a full life, and he had not only figured out why the flames of his 1910 Jet airplane had behaved the way they did but had also explained it to many people and seen his discovery form the basis for the new field of fluidics.

But why did the 1910 Coanda Jet airplane fail the way it did? What happened? Now you know why the jets hugged the side of the fuselage rather than streaming out away from the plane. When Coanda added the plates to the top and bottom of the jet exhausts to keep the heat away from the cockpit, he eliminated the cross-flow. Coanda Effect therefore drew the flames out of the pipes because of its flow augmentation, and deflected them so they hugged the fuselage sides.

The Coanda Jet built in 1910 crashed because of the Coanda Effect discovered by the same man twenty-two years later. ■

Bob Trowbridge

SCIENCE, TECHNOLOGY, AND LOVERS

The word *amateur* comes from the French verb *aimer*, "to love." An amateur is a lover, someone who pursues an activity solely out of interest in it. The history of science and technology is filled with the creations of such lovers and we would all be at least materially and intellectually poorer without them.

Albert Einstein wrote his paper on relativity while working as a clerk in a Swiss patent office. His school headmaster told Albert's father that the boy would "never make a success of *anything*."

Other amateurs of note include Leonardo da Vinci, Robert Fulton, and Samuel Morse. All of these men were artists.

Other amateurs:

Edmund Cartwright	Clergyman	Power Loom
Gottfried Leibnitz	Doctor of Law	Calculus
Eli Whitney	Studied Law	Cotton Gin
Luther Burbank	Plow Company Employee	Plant Originator
Thomas Edison	Telegraph Operator	1,200 Patents
King Gillette	Bottle Stopper Salesman	Safety Razor

The significant invention of the safety razor coincided with another event of significance: the publication of *The Origin of Species* by one Charles Darwin, who studied medicine and theology but pursued neither career. Julian Huxley called him "the greatest amateur in the history of science." Alfred Wallace shares Darwin's theory and his amateur status.

Although there were others with better technical backgrounds *and* government money working on the same problem, it was bicycle mechanics Wilbur and Orville Wright who first succeeded in powered flight. In a modern replay of that breakthrough, Paul MacCready claimed the $214,000 prize for the first human-powered flight across the English Channel in his Gossamer Albatross. The prize had eluded aeronautics experts for 18 years.

One could fill a book with the contributions of amateurs in astronomy, such as musician William Herschel. It is perhaps the only science where amateurs are not only acknowledged, but considered indispensable.

Then there are the amateurs who have created whole new systems of thought—such as Sigmund Freud, and Karl Marx.

With the specialization and expensive equipment which characterize most modern research and development, there is some concern that the amateur will go the way of the dodo. This is a genuine concern, even though the computer explosion has had its share of highly successful tinkerers and hackers.

In our time of almost revolutionary change, we cannot afford to leave our future in the hands and minds of the experts and professionals alone. To help create the best of all possible futures we must have the leavening influence of the lovers and dreamers.

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(Ronald Gross is the author of *The Independent Scholar's Handbook* and Director of the independent scholarship project funded by the U.S. Department of Education. It looks like there are *some* attempts to provide a showcase for "crackpots.")
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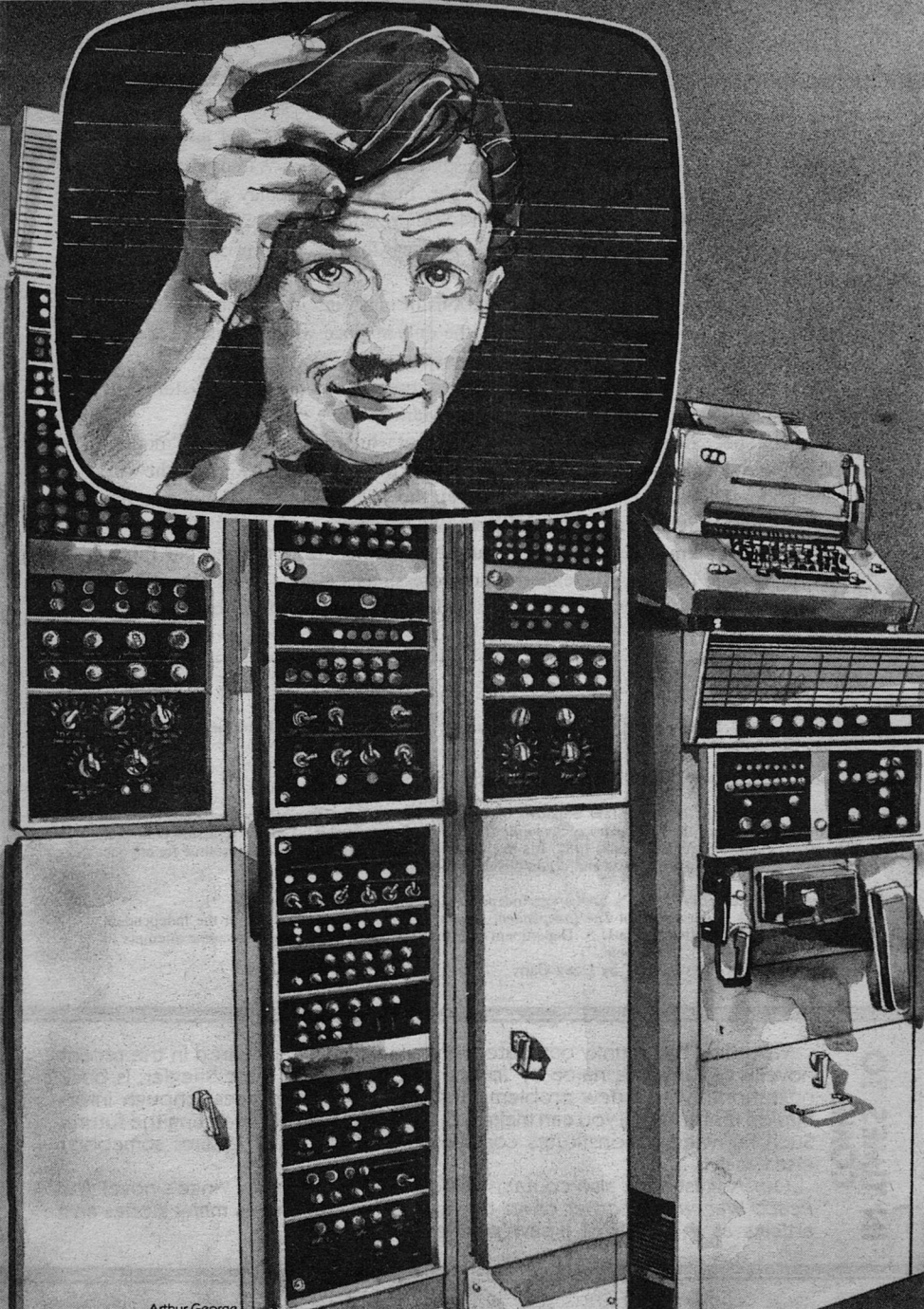
IN TIMES TO COME

Valentina, the spunky computer program who first appeared in the recent novella of the same name by Joseph H. Delaney and Marc Stiegler, is back next month with a new problem. Given the ability to process enough information fast enough, you can make a pretty good stab at predicting the future. Such knowledge constitutes considerable power, and it seems somebody else has it. . . .

Our August issue also contains the conclusion of Vernor Vinge's novel *The Peace War*, with another cover by Vincent di Fate, and as many stories and articles as the gods of jigsaw puzzles will permit.



BEHIND EVERY GOOD WRITER...

Tom Rainbow

Inspiration often results from bringing *two* ideas together...

Bleeep! It was the goddamn phone again. I saved the story I was reading.

"*Science Fiction On Line*. Matt Mason here."

"Matt! How's the only Hugo-award winning editor who's named after a 1960s space toy?"

The face in the flatscreen belonged to Jon Schull, one of the more interesting science fiction writers to appear in the last year. Very erratic. His stories were either extremely good or extremely bad. A writer who was often in need of my editorial intuitions, or algorithms, or whatever they were.

"Jon, I'm sorry I had to reject your last story. I had just bought something by Les Barfield that was very similar to what you sent me."

He smiled. "That's not why I called, Matt. I'd like to invite you to dinner. Tonight, if possible. I've had every science fiction writer from New York to Philadelphia so far, and it occurred to me that I never invited you."

I'm the type who likes to be invited to *everything*, so it occurred to me, too. Jon was as rich as your typical Galactic emperor, both from his own patents, and from his divorce settlement with Amanda Lucas. He also received a hefty non-competition payment from Lucas, Ltd. to stay out of the sentient-capable computer field. Ostensibly he had nothing to do, except to track his investments on the flatscreen and try writing science fiction. Also, to throw nice dinners for science fiction professionals. Very *nice* dinners, with Genentech Giant Lobsters, and Key Lime Pie with real key limes and homemade whipped cream. *Slobber, drool.*

"I have no plans, and I am notorious for having the appetite of a moderate-sized Black Hole," I said. "What time should I be there, and what should I bring?" I knew my second question was superfluous, but I wanted to be polite.

"Just bring that brilliant editorial mind. I want your reaction to some stories I've written. I live in Princeton, to the south of you. Do you have my address?"

His address and homer frequency appeared on the bottom of the flatscreen. I pressed the record nub.

"I can make it there in about twenty minutes, given normal traffic," I said.

"See you at six, then." And Jon's Lenin-esque visage faded from the flatscreen, only to be replaced by yet another crummy science fiction story.

I continued to read the slushfile while my VTOL weaved and dodged through the North Jersey rush hour traffic. There was a story about the MEHEA, the proposed Moon Extremely High Energy Accelerator that the Association of Research Universities wanted to build. Another story about how the universe would be destroyed if we exceeded the energies of the Big Bang and slipped into a true vacuum state. (This was taken from the same *Nature* article that described the MEHEA proposal.) And a story about a genetic engineering company that developed a sex-changing virus, and deliberately infected its employees.

Good ideas, but mediocre dialogue and clichéd characters. I had about two million readers in North America and Europe, and I got maybe a hundred transmitted manuscripts a day. I rejected over 80% of my pro manuscripts and 99% of my slushfile. If I didn't maintain

a high quality magazine, my readers would probably play Syzygy games on their flatscreens, and, heck, I might have to go back to teaching high school biochemistry.

I saw the old Tokamak Test Reactor in the distance as the VTOL began its descent onto Jon's driveway. Jon's estate was built on the grounds of the Princeton Theological Seminary, which moved to Zaire several years ago. This was a reflection both on where there was cheap land, and where there were still Protestants—given that the predominant religion in North America was a kind of agnostic Zen. I walked about a kilometer to the main house, terrorizing the Lawnbots in the process by taking a shortcut across their grass cutting. Jon greeted me at the door.

"Let's eat," I said, getting to the point quickly.

He gave me the same smile that he used earlier. "The Kitchen Droids are still working on dinner. Let me give you a house tour, minus twenty-three of the bathrooms."

For a former seminary, the place was pretty ritzy. Old *Star Wars* props hung in the living room, relics of Jon's marriage. The walls and ceiling of the media room were high-resolution flatscreens, displacing a computer-generated simulation of Big Sur. Hanging in the master bedroom were twin Syzygy helmets, foam headstraps with 270° flatscreen eye sockets, to which computer-generated stereoscopic images were narrowcasted. These were fused by the brain into a 3-D vista, which solipsistic me could never distinguish from the real thing. Expensive—and kinky, with the right software. No wonder Amanda left him.

In the basement was the most elaborate computer complex that I had ever seen.

"Sentient-capable, or almost so," said Jon, patting the nucleic acid-based mass storage unit. "I'm allowed to continue development work as long as I sell the results to Amanda."

If the flatscreen displays were any indication, the thing was seething with cognition. An object which strongly resembled a Syzygy helmet was connected to the computers via a thick fiber-optic cable.

"You play games down here?"

Again, that same smile. "No. That's a modified NMR brain scanner. The idea is to effect a direct connection between the user's brain and the computer. I can't tell you more than that without violating the non-disclosure agreement, but as you can imagine there are many potential applications of a direct hookup between a human brain and a sentient-capable computer. Anyway, dinner's probably ready."

I scooped up the last of the Key Lime Pie, trying not to get any on the flatscreen in front of me. It was too good to waste. Jon stared at me as I speed-read one of his stories.

"Not bad, but again, you're trying to copy Les Barfield's style. Why don't you just write like yourself?"

He tugged at his nose, and ran his hands over his beard.

"Barfield's my favorite writer. He had dinner with me last week. I guess I'm overly impressionable."

I shrugged, and read the next story. It was terrible, the worst of the slushfile.

From the intensity of Jon's scrutiny, I gathered that this was the result when he tried to write like himself. It occurred to me then, that all of the stories that I bought from him were reminiscent of some other science fiction writer. His bad stories, the ones I rejected, read a lot like this.

"You have insecurities about writing in your own voice. That just takes time to overcome. You're fundamentally a good writer. You just lack self-confidence," I said soothingly.

Jon appeared not to have heard me. He left the table, and returned with a tumbler of Grand Marnier for each of us. He took a sip of his drink, and resumed staring at me. Finally, he started to speak.

"You may think this is pretty strange, Matt, but all my life I wanted to be a science fiction writer. My parents belonged to the Human Potential Movement. You know what that was?"

"Yah, group of people in the 1990's who wanted to raise super-geniuses."

"And they mostly did. I'm a certified genius, and I've built a computer in the basement that's almost as smart as I am. But emotionally, I'm a Mongoloid. If it weren't for the anti-depressives, I would have killed myself long ago. If it weren't for the anti-aggressives, I would have killed *you*, for instance, particularly after you rejected my last story. That was the fallacy behind the Human Potential Movement."

He smiled, and took another sip of his drink.

"Human Potential Kids like me were subjected to every known or suspected treatment to increase the size of their cerebral cortex. For instance, during her pregnancy, my mother wore a belt that monitored my fetal movements, and made a loud noise whenever I swam into some arbitrary region of her uterus, training me like some goddamn goldfish and making my little brain work harder. Other Human Potential Kids were given putative neural mitogens. As I said, most of these treatments worked—I'm *very* smart. But the fallacy behind the Human Potential Movement was that the limbic system would inevitably compensate for the additional demands of the cerebral cortex: a Super-Intellect would have a Super-Super-Ego. Instead, it worked the *other* way: the brain compensated for the increased size of the cortex by making the limbic system smaller. I have the cortex of a Superman, and the limbic system of a lemur."

He smiled again at this, and I began to wonder if he might have skipped his anti-aggressive capsules today. The thought of having Super-Lemur leap over the dinner table at me was not conducive to the digestion of my Key Lime Pie.

"Matt, science fiction gives me solace. With it I can escape the travails of my limbic system and lose myself in entirely different universes. I've read *everything* written in science fiction, dating back to the 1930 *Astounding Stories*: with my brain, this is not hard to do. I've even tapped the transmissions to your office, so I can read the stories you reject. But it's just not enough to read it. I want to be a science fiction writer. I want to supply my own happiness. And the irony of it is that for all my hypertrophied cerebral cortex, I can't write a single goddamn salable story!"

"But, Jon, I've *bought* some of your stories. Some of them are excellent; you just need to polish your style."

Jon tugged at his beard again.

"That's not me, Matt," he said quietly. "Let's go downstairs now."

I almost knocked the table over in my haste to follow him. I had this sudden, vaguely sexual urge to want to be *commanded* by someone.

"What did you put in my drink?" I managed to say.

Jon smiled.

"N-methyl-2-hydroxy-neurotensin. A submissive. You'd happily clean my toilet bowls with your tongue, if I asked. Don't say any more, unless I tell you to speak."

We took the elevator to the basement, me standing a respectful two paces behind Jon during the descent. I was ordered to sit in a chair directly under the NMR brain scanner while Jon busied himself with the computer. After giving a long series of verbal instructions to it, he touched control nubs on the main flatscreen panel and lowered the NMR helmet onto my head.

"Just stare at the wall in front of you, Matt. It'll take a few minutes for the computer to recognize the same scene in your visual cortex. After that, we'll be locked onto your central nervous system, and then the fun will begin. Undoubtedly you have questions?"

"Just one: what's going to happen to me?"

He laughed, and laughed.

"Among the many things that Amanda and I differed on, was *how* to make a sentient-capable computer self-aware. She wanted it to be done gradually, in the same way that a baby becomes a person. I argued that it could be done more efficiently if an adult's persona were transferred into the machine, making it self-aware almost immediately. I was right, and she was wrong: Lucas, Ltd. still hasn't built a sentient-capable computer, whereas I've had mine in operation for almost a year now."

A year? That's how long Jon had been writing science fiction.

"And the adults you used were science fiction writers."

"Not bad for a man with the cortex of a lemur," Jon said with mock admiration. "In my usual brilliance I realized that not only could I create a computer that was self-aware, but a computer that could also write science fiction. Much better even than tapping the transmissions to your office. Within my system, I have the personas of over thirty East Coast science fiction writers, with Les Barfield as my latest acquisition. It occurred to me that not only could I read the stories produced by my captive writers, but that I could also *sell* them. Lucrative—I've already made a movie sale to Syzygy; and satisfying—at last, I am a science fiction writer!"

"You're nothing but an insane plagiarist, Schull, and you'll get caught, like any other wacko!"

He gave me a dry smile, and touched another flatscreen nub.

"Tsk. Such language to use to your future employer. All science fiction is, Matt, is the repackaging of old ideas in new ways. I'm merely doing the same thing with more advanced technology. *You're* going into the system, because I need an editor. I want you to turn those thirty-plus writers into a literary syndicate, all writing in the same recog-

nizable voice, which, of course, will be *mine*. You'll also work with me on my personal stories. I would find it surprising if someone of my intellect can't learn to write a passable story, with the help of an excellent tutor like yourself."

The flatscreen displays on the computer began to show the far wall of the basement, as seen from my eyes. As I looked at the display, it started to flicker.

"Feedback," Jon explained. "Don't do that." I immediately averted my gaze.

"The transfer is now in progress. I want you to go to sleep, now. We'll talk after you awake."

Bleep! I awoke to find myself in my office, of all places. The goddamn phone was ringing again. I pressed the answer nub, only to find Jon's face staring at me in the flatscreen.

"Good morning, from your perspective." He smiled. "From my perspective, it's actually taken several weeks before I could get the bugs out of the program that contained your persona. I hope you like the simulations of your office and your body."

"What did you do with my real body?" I asked.

"Matt Mason left my house the next day, somewhat hung over, but essentially no worse for the experience of having had mind transferred to a computer. Needless to say, all he remembers is that he had a very pleasant dinner."

I had read enough science fiction stories to get his general drift.

"You mean, I'm a copy?"

Jon frowned at this.

"Or *he's* a copy. It's a question of when the computer latched onto the workings of your sentient circuit to start the transfer. A few milliseconds one way or the other would make all the difference. I suspect it's totally random. In either case, since your old brain is intact, your personality re-creates itself. I'm only a kidnapper in the philosophical sense."

"What is thy bidding, Master?" I intoned sourly.

"That's the spirit, Matt! I'm pleased that most of your limbic programming transferred intact! Since you asked, I need a new story, *pronto*. There should be some copy by Les Barfield that you could rewrite in my voice. Also, your other self has rejected *another* story of mine. You should be intimately familiar with what you like, so please modify the article accordingly. Also, more good news. Shawna McCarthy has accepted my dinner invitation! With *two* editors in the system, I can start work on my novel!"

The flatscreen switched off. *Sigh!* The thought of having to spend an eternity with the eighty-year-old Dowager Emperess of science-fiction made me want to slit my simulated wrists. No doubt about it: Life as a computer program was going to be tough. Maybe I could apply for another job, say, as a spelling checker, or as a data-base management system. *Sigh!* ■

● Indifference is isolation. In difference is texture and wonder.

Edwin Schlossberg

The Alternate View

WHEN PROTON MEETS MONOPOLE

John G. Cramer

EDITOR'S NOTE: *When I first came to* Analog, *Jerry Pournelle and G. Harry Stine together created "The Alternate View," originally conceived as a column of late news and comment on science, technology, and their social and political ramifications, delivered alternately by two writers with different points of view. That column has been an integral part of* Analog *ever since, delighting and infuriating readers and generating a lot of debate in Brass Tacks. Recently the pressure of many other commitments has forced Jerry Pournelle to withdraw from "The Alternate View," but I hope he will return to* Analog *from time to time with other contributions. Certainly his regular appearances here will be missed by many of us.*

However, this by no means means the end of "The Alternate View." Jerry will be very capably replaced by Dr. John G. Cramer, whose name you very likely recognize from his fact articles here. His viewpoint, appropriately, is different from either Jerry's or Harry's—and I know no better person to introduce it than John himself.

The Alternate Who?

I have agreed to try to fill the large engineer's boots left behind by Jerry Pournelle, the former occupant of this slot. And those of you who have enjoyed (as I have) Jerry's informed over- and under-views of the space program and his strong and cogent political forays should prepare yourselves for a change. Because I will be writing from a different perspective.

I am a Professor of Physics at the University of Washington in Seattle. I teach physics, I do basic research, and I am the director of the UW Nuclear Physics Laboratory. At my laboratory just now we are beginning a very exciting project. We are using a brand new technology, superconducting "quarter-wave" RF cavities, to build a $9 million particle accelerator paid for by the US Department of Energy and by my university. I am deeply involved in this project, and I also have ongoing research projects in a number of areas spanning astrophysics and cosmology, nuclear reaction studies, computer system design and software, accelerator technology, and the foundations of quantum mechanics.

I have published around 100 professional papers in journals like *Physical Review*, *Nuclear Physics*, *Nuclear Instruments and Methods*, *Computer Physics Communications*, and *Foundations of Physics*. But in the past few years I have been learning a new kind of writing, the craft of "science writing," or trying to explain scientific

ideas to a general readership. I *like* physics very much, and I am going to try to communicate the excitement, the challenge, and the intellectual stimulation of it to you. I have found that the readers of *Analog* are an interested and receptive audience.

I started science fact writing when Ben Bova asked me to try an article for *Analog* based on a paper I had published in *Physical Review Letters*. It described a way of telling whether a supernova in a distant galaxy was made of matter or of antimatter. The science fact article, "Antimatter in the Universe," (*Analog*, August, 1979) was my first science fact article. I found that I enjoyed this kind of writing, and since then I have published over twenty more science fact articles in various magazines and clubzines.

My contributions to "Alternate View" will explore various aspects of physics, astronomy, cosmology, and technology from the viewpoint of the science fiction enthusiast. We will look at the correspondence between science fiction themes and real science, as we presently understand it. We will look at the remote past and the far future, the macrocosm and the microcosm. We will see what contemporary science has to say about starship drives, FTL travel and FTL communication, about other dimensions, time travel, and alternate universes. I will also *try* to keep you informed of recent developments and discoveries in science (although the 6-month time delay between writing and publication may be a problem with that activity).

In the established tradition of this column, I will also occasionally use it for a soapbox. The science policies of our government and the operation of the system which produces these policies are usually interesting, often frustrating, and occasionally worth some deeper scrutiny. I have had much experience and even some success in functioning within that system, and I plan to do an occasional column on the politics of science. But that is for later. I will begin my career as a columnist with a look at one of the most remarkable predictions of contemporary physics: the decay of the proton.

And Now:

When Proton Meets Monopole

The universe is slowly coming unglued. Thermodynamics tells us that its disorder is slowly increasing to an ultimate "heat death." Astrophysics tells us that all stars are slowly burning up their nuclear fuel and all will collapse to cooling "black dwarf" stars, neutron stars, and black holes. Quantum mechanics tells us that the black holes themselves are slowly fizzing away to nothingness by boiling off Hawking radiation. But perhaps most devastating of all, we now have reason to believe that a fundamental building block of the universe, the proton which is the core of every hydrogen atom, has only a "limited warranty" which runs out in about 10^{32} years. With about that half-life, protons (and all of the more complicated nuclei containing protons) will "decay," releasing much energy as they are transformed into lighter particles. The process ends with a positron, some neutrinos, and gamma rays, replacing the proton.

Every year our sun should be losing

about 10^{20} protons (about a milligram's worth) in this way. This is not much of a loss, but it is irreversible, and it adds up. In 10^{35} years or so all of the protons in the universe will be gone. The universe will then be empty of all complex matter. There will be no galaxies, no stars, no planets, no organisms, no molecules, no atoms, no nuclei. No matter will be left at all except for some miscellaneous electrons and positrons seeking a final annihilation, leaving behind only gamma rays.

This dismal eventuality is a prediction of "GUTS." (GUTS is short for Grand Unified TheorieS: the plural is because there are several rival theories with more or less the same predictions.) GUTS ties together three of the four fundamental forces of the universe, omitting only gravity while connecting *electromagnetism* (the force acting in chemical bonding) with the *strong* force (which holds nuclei together) and with the *weak* force (which acts in "beta decay" when a radioactive nucleus spits out an electron and a neutrino). GUTS says that in the ultra-hot era of the early Big Bang the strong, weak, and electromagnetic forces were completely indistinguishable. All were symmetric manifestations of the same force. Only when the pristine simplicity of the initial Big Bang degenerated by cooling did this change. After the early universe expanded a bit, the average energy per cubic fermi $(10^{-15}_{m})^3$ dropped below 10^{14} GeV and the symmetry of forces "broke." The strong force became distinguishable from the still-symmetric electromagnetic + weak forces. And later when the average energy dropped below 100 GeV a further symmetry break occurred, and the electromagnetic and weak forces became separate and distinguishable. In our present "cold" era these three forces are very different in their effects, but the bridge of their original symmetry still tenuously remains. Protons can use this bridge to decay.

GUTS tells us that even now, in the veritable youth of our universe (which is only about 10^{10} years old) some of the protons around us are decaying. The GUTS estimate of the proton half-life (about 10^{32} years) is just on the hairy edge of what can be measured. And so in deep mines and tunnels in Japan, India, France, Italy, and the USA, physicists have mounted expensive and "heroic" proton decay experiments. Enormous tanks of water are being watched by the electronic eyes of tens of thousands of photomultiplier tubes, awaiting the telltale light flashes which signal the death of a proton. At this writing (December, 1983) no group has formally reported such an observation. But there *are* rumors that several groups have "candidate events" which are being studied and which may signify protons in the act of decay.

But why should something as obviously stable as a proton be unstable at its roots? The Buddha gave the reason in about 485 B.C.: *"All composite things decay."* And protons indeed decay because they *are* composite. We have learned in the past two decades that protons are not "fundamental" as has been previously supposed, but rather are composite particles made of three "quark" constituents. It is the interactions and transformations of these quarks which permits the proton occasionally to decay. So let us talk about quarks.

The quark model, the present theory of "elementary" particles (which is well supported by experiment) tells us that quarks are "pointlike" objects with a "fractional" electrical charge Q (where electrons have Q = −1). Quarks come in a sort of "six-pack" of possible "flavors." These flavors are "up," "charmed," and "top" (each having Q = +⅔), and "down," "strange," and "bottom"* (each having Q = −⅓). The lightest quarks (up and down) have only 37% of a proton's mass. The heaviest quarks are the bottom quark with more than 5 times the proton's mass and the as yet unobserved top quark. As I write this I have just heard a rumor that physicists at CERN laboratory in Switzerland have found the top quark and determined its mass to be about 34 times greater than the mass of the proton. The family of six quark flavors (abbreviated **u, c, t, d, s,** and **b**) come in three "colors" (a sort of three-value "strong" analog of electric charge) and in matter and antimatter varieties.

Before the quark model came along, physicists were troubled by the bewildering "zoo" of hadronic particles which had been discovered and which seemed to have little systematics of interrelation. Hadrons are particles which respond to the strong force. The quark model brought order to this area by demonstrating that all of the many hadron particles were made of two or three quarks. Quarks combine in matter-antimatter pairs to make medium-weight "meson" particles like π's, ρ's and K's. A π^+ meson, for example, is made of a **u** quark and an anti-**d** quark (Q = ⅔ + ⅓ = 1). Quarks combine in triplets of the same matter/antimatter type to make heavier "baryon" particles like protons, neutrons, Λ's, and Ω's. A proton contains one **d** and two **u** quarks [Q = (−⅓) + (u) + (u) = 1], and a neutron contains one **u** and two **d** quarks [Q = (u) + (−⅓) + −⅓) = 0]. The quark model requires that these two or three quark combinations must always give a charge Q which is an integer (or zero). No fractionally charged particles are allowed. (See, however, my article "New Phenomena" *Analog*, February, 1983 which discusses an apparent observation of fractional charge).

Single quarks cannot be found in isolation. The strong force that holds quarks together is *very* strong indeed. It is so strong that if you try to pull a quark out of a proton you have to pull very hard, supplying in the process a large amount of energy. So much energy is provided that more quarks and antiquarks are created, one of which will immediately pair off with the quark that you are attempting to remove. Therefore, no matter how hard you try to grab a quark and pull it loose, you cannot end up holding an isolated quark. You will instead find that you are holding a quark stuck to an antiquark to form a meson. In this way the quark groupings of two or three are always preserved. It is possible to rearrange the groups but not to free completely an isolated quark from its associates.

The strong force binds groups of

The* **t *and* **b** *quarks are also sometimes called "truth" and "beauty," but these names seem to me presumptuous and lead physicists to indulge in phrases like "naked truth" and "bare beauty."*

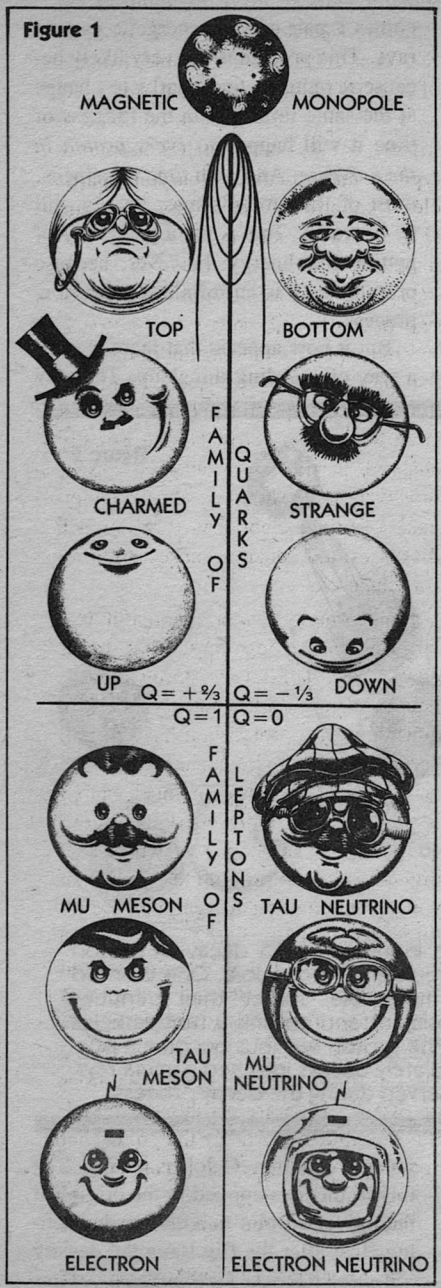


Illustration by William R. Warren, Jr., 1983

quarks together, but it cannot change one flavor of quark to another. This flavor-changing can, however, be done by the weak force. In analogy with the "six-pack" of quark flavors, there is a corresponding "six-pack" of leptons. Leptons are the light particles of the weak interaction. They are the electron (e), muon (μ), and tau (τ), all with unit charge, and their corresponding neutrinos (ν_e, ν_μ, and ν_τ), all with charge zero. The GUTS theories go a step beyond the quark model by matching up the six leptons of the weak interaction with the six quark flavors of the strong interaction. The assertion of GUTS is that leptons and quarks are the same kind of objects which obey similar general rules and which under some circumstances can be converted into one another. The leptons are cousins of the quarks, but there are differences. Leptons have only one color (or none). There are no leptons with fractional charge but only charge one or zero. Figure 1 shows the family album of the quark clan and their lepton cousins.

The proton decay can occur because

Figure 1—The family album: The Magnetic Monopole (above); The Quark Family (mid): top and bottom, charmed and strange, up and down; The Lepton Family (below): tau (τ) and tau neutrino (ν_τ), mu (μ) and mu neutrino (ν_μ), electron (e) and electron neutrino (ν_e). Quarks to the left have charge $+\frac{2}{3}$, quarks to the right have charge $-\frac{1}{3}$, leptons to the left have charge -1, and leptons to the right (neutrinos) have no charge and always travel with the velocity of light. The heavier particles are above and to the left. All particles have corresponding anti-particles (not shown) of the same mass but opposite charge.

GUTS provides a connection between quarks and leptons as members of the same extended family. It is possible for two of the quarks within a proton to forget simultaneously who they are and to trade places with their brothers or cousins. In particular, a **u** and a **d** quark may suddenly become a positron and an anto-**u** quark, as illustrated in Figure 2. This means that the proton abruptly becomes a positron and a π° meson in loose association. Further, the π^{0} is unstable and in about 10^{-16} seconds becomes a pair of very energetic gamma rays. This process is not very likely because it requires two quarks to change at the same time, but in the fullness of time it will happen to *every proton in the universe*. And each time it happens, most of the proton's mass-energy will be liberated. This is not a good way of getting free energy, however, because proton decay is an infinitesimally slow process.

But it now appears that there *may* be a way of speeding things up. The way

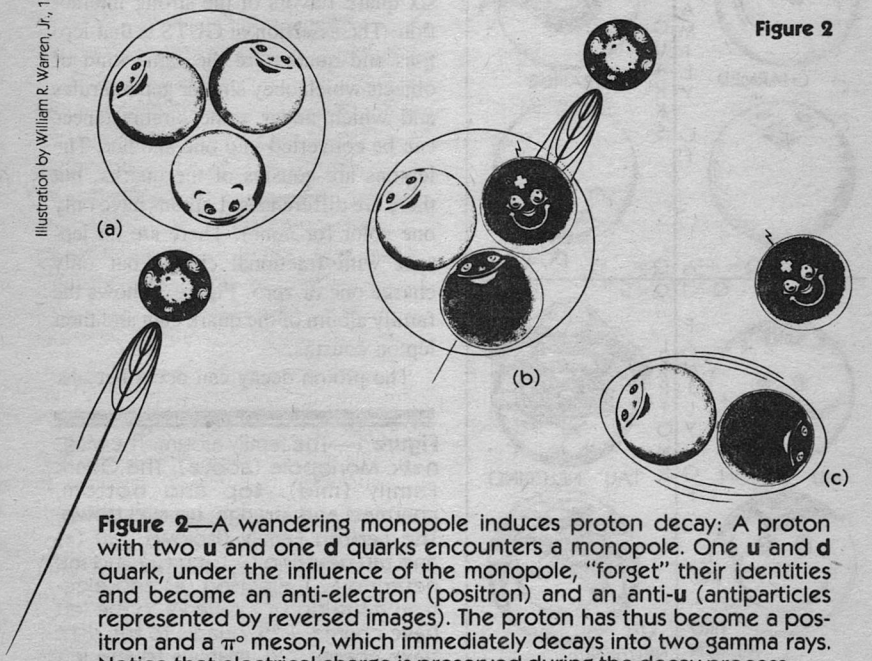


Illustration by William R. Warren, Jr., 1983

Figure 2

Figure 2—A wandering monopole induces proton decay: A proton with two **u** and one **d** quarks encounters a monopole. One **u** and **d** quark, under the influence of the monopole, "forget" their identities and become an anti-electron (positron) and an anti-**u** (antiparticles represented by reversed images). The proton has thus become a positron and a π° meson, which immediately decays into two gamma rays. Notice that electrical charge is preserved during the decay process.

involves using a very peculiar particle that (probably) no one has ever seen, the magnetic monopole. (The reader is referred to my article "Again Monopoles," *Analog*, October, 1983). The GUTS theories applied to the origins of the universe point to a curious happening. Just after the Big Bang the density

of the universe is truly enormous, and small regions of space contain so much mass-energy that they are rapidly collapsing to black holes and as rapidly uncollapsing back into normal space. Some of these mini black holes can develop a sort of indigestion by eating some magnetic flux. Lines of magnetic flux can be left threading into or out of a small black hole.

The "normal" small black hole has a very short lifetime. If it is near minimum size it will rapidly evaporate by Hawking radiation and shrink to a rock-bottom mass (the so-called Planck mass of 10^{-18} grams or so) and then disappear altogether in a final burst of energy. However, those black holes which have an excess of magnetic flux cannot do this. Before they can disappear, a way must be found to dump the magnetic flux excess. But no lighter particle can carry away this net flux, so the black hole is "stuck." It is like the loser in a game of Old Maid, stuck with a card it cannot unload. But it *cannot* quit the game. It therefore becomes a new and a unique kind of particle with a mass of the Planck mass and a net magnetic charge. This kind of particle is called a "massive monopole" or simply a "monopole." If its lines of flux are coming out, it is a *north monopole* (a positive magnetic charge), and if the flux lines go in it is a *south monopole* (a negative magnetic charge). Only if one monople were to encounter *another* monopole of the opposite magnetic charge, north monopole meeting south monopole, could their burdens of magnetic flux be released so that the monopole pair could annihilate in a burst of energy and disappear.

All recent models of Big Bang cosmology predict an uncomfortably large number of massive monopoles should be produced in the Big Bang in equal numbers of the north and south varieties. The near-chaos at the Beginning should twist magnetic flux into very many knots which become monopoles. And yet (with the possible exception of the Cabrera event discussed in *Again Monopoles*) no monopole has yet been seen. We won't, for the moment, worry about *why* they have not been found. Let's instead assume that they are lurking around somewhere (in the bowels of the Earth, perhaps) and that they can be used if we are clever enough to find them.

Essentially then, a monopole is a tiny "replica" of the Big Bang. In its tiny heart is a minute region of space which still retains the enormous energy density which was once present in the Big Bang itself. And within this core the forces of the universe are still indistinguishable from one another: the strong, weak, and electromagnetic forces all are the same. There the quarks and their lepton cousins are, in this domain, the same particles.

Consider then what will happen if a massive monopole comes very close to a proton, attracted perhaps by the small magnetic dipole field which every proton has. The quarks within the proton would have a reasonable probability of encountering the core region of the monopole. And when this happens, the quarks are very likely to "forget" their identity and to be changed to some other flavor of quark or lepton. If this happens, proton decay becomes a near certainty. But the monopole, the cause of

it all, is unaffected. It is still "stuck" with its surplus of magnetic flux, so it cannot participate in the decay process.

Thus the monopole is the analog of a chemical catalyst. It is an *agent provocateur*. It wanders through matter stimulating proton decay and nuclear breakup without being changed itself. A single monopole can do this over and over again as rapidly as it can find its way into successive protons or nuclei. And with each such event, a quantity of energy is liberated which is far greater than that released in uranium fission. The implications of monopole catalysis are enormous. All matter, be it garbage or junk or gold ingots, becomes a source of unlimited energy. Given a suitable supply of monopoles the energy needs of the world are limited only by the supply of matter to be catalyzed into energy. If massive monopoles are ever found, they will be of incalculable worth to physical research and to energy production.

Beyond their utility as producers of energy, monopoles could probably be used directly in a spaceship engine. There have already been studies by Robert L. Forward and others showing that antimatter annihilating with matter in a magnetic "hemi-bottle," an intense magnetic field pinched at one end and open at the other would serve as an extremely efficient spaceship drive. The problem is that the needed amount of antimatter fuel would require a truly staggering investment, because the antimatter would have to be manufactured by earth-based or orbiting "antiproton factories" of monumental size.

The same basic scheme, however, could be applied using monopole catalysis. The "fuel" would then be atoms of normal matter caused to explode because their protons and neutrons undergo catalyzed decay as a flux of monopoles is passed through them. The hemi-bottle magnetic nozzle then provides the dual function of guiding the charged nuclear fragments from the exploded nuclei out the exhaust port of the engine and at the same time collecting the monopoles at the pinch point for re-use in the next engine cycle.

There is another side effect of monopole catalysis that is worrisome: with monopoles around, the average life expectancy of protons is reduced by a factor of 10^{12} and becomes only about 10^{20} years. This is because if one presumes that there are massive monopoles around which are chewing away at the hearts of stars and planets, an average proton is far more likely to decay by monopole catalysis than by "normal" decay. But since this reduced life expectancy is still 10 billion times the present age of the universe, it should not be a matter of immediate concern. So cheer up! The news of the ultimate death of matter-as-we-know-it in 10^{35} or 10^{20} years is not all that bad. Most of us won't be around by then anyhow. And maybe we can use the intrinsic instability of the proton to take us to the stars and give us lots of free energy in the meantime. ■

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On Gaming

Dana Lombardy

Knight Hawks is the first major module for TSR's *Star Frontiers* science fiction role-playing game ($12 at your local store, or direct from TSR Hobbies Inc., Box 756, Lake Geneva, WI 53147).

However, *Knight Hawks* is more than just an add-on expansion to an existing game—it's a complete game in itself.

As a complete game, you can play either a basic or advanced board game of ship-to-ship combat in outer space. As an expansion, *Knight Hawks* provides the rules, charts, and information to enable you to design, build, and use spaceships in your *Star Frontiers* campaigns.

To play the board game version, you need only read the 16-page rules book, titled *Tactical Operations Manual*. The basic game consists of eight pages of rules, including two scenarios.

Players represent either the United Planetary Federation consisting of several different races of creatures, or the evil worm-like Sathars. The *Knight Hawks* board game can be played by two players or teams of players.

Play proceeds with each player alternately moving and shooting with his ships. A ship may not move a longer or shorter distance than its speed from the previous turn will allow. You must keep track of your speed each turn on the ship roster form.

To have combat, you first count the number of hexes between the ship firing and its target (range), then check the weapon system to see if it can fire that far. Laser cannon can fire the farthest distance—more than twice the range of torpedos (self-guided nuclear bombs) or assault rockets (usually carried by smaller ships and not homing-type weapons like torpedos).

Since many ships have more than one type of weapon system, you can aim at several different targets at the same time. Lasers have a high rate of fire, so you can shoot them during both your combat phase and your opponent's combat phase. The other weapons can be used only during your combat phase. You can also wait until a ship closes in during its movement to get the best shot at it, or shoot as it passes by.

To determine damage done by firing, a combat table is consulted. The weapon system being used is cross-indexed with the target's defensive system, which may be reflective hull, masking screen, and interceptor missiles in the basic game.

Cross-indexing the weapon firing versus the defensive system gives a percentage which represents the chances of hitting the target. By rolling the dice provided, you determine if you hit the target with each weapon fired. If a hit is scored, the dice are rolled again to determine how much damage is done to the target. This roll is subtracted from a ship's hull points. When the ship has no more hull points, it is destroyed and removed from play.

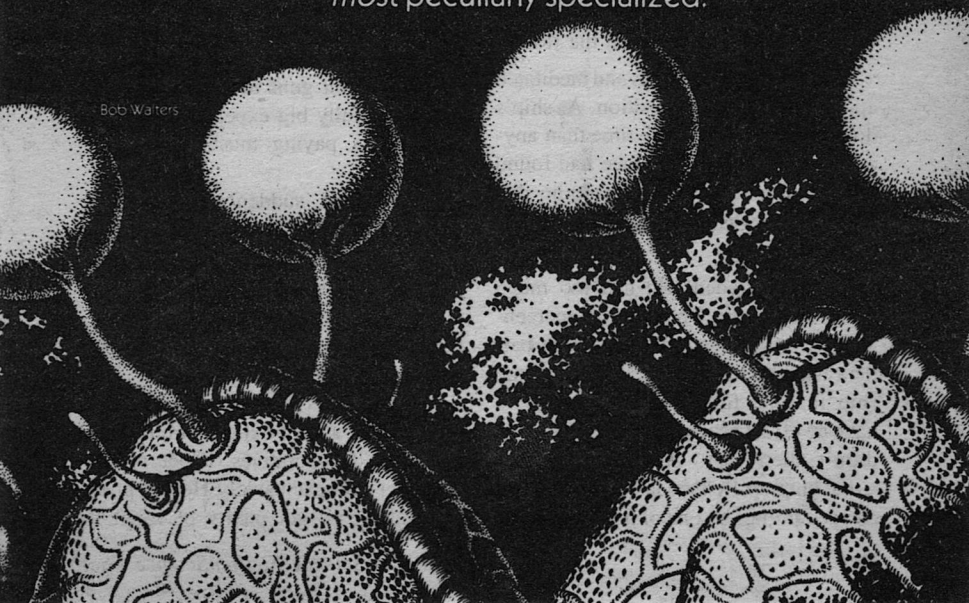
The advanced game adds new types of ships; more complicated movement rules to take into consideration the factor

(continued on page 115)

THE KLODE FACTOR

Ray Brown

Human beings have a notable capacity for turning things to uses other than the ones they were designed for—some of which may be *most* peculiarly specialized.



Doctor Tsukanov had resolved to stay calm, and he'd done it through the day, but in the walk from his own cabin to Miss Gast's suite the excitement ambushed him and by the time he got to her door he was panting with the all-too-rare stress of romantic intrigue. He rapped on the door lightly. It opened and he heard her voice call, "Come in!"

He took a deep breath and walked inside. There was nobody there. "I've been delayed in returning," the voice went on. "Please make yourself comfortable, Felix. I shouldn't be too long." The door closed behind him and sealed itself to outsiders.

He grinned and did as the answering machine advised, throwing himself on a great yellow cushion. Renee Gast's suite was done in the style of her home planet, Holfy, where they apparently never heard of chairs or shelves. All the furniture, save a couple of low tables, was one or another kind of pillow. Bookspools, food pouches, and such were laid neatly in rows on the floor.

He stared at the pillows and meditated appreciatively on his position. As ship's doctor, he had more free time than anyone else on board. If Renee had found others more attractive, it made no difference. He was the only one with time to mess around.

His smile faded. He had too much free time, really. These Sirian mercenaries were all in superb health. The battle casualties that made it back to the ship in time for Sirian technology to have an effect healed fast, and those that didn't died fast. And this mission —backing up Renee Gast's demand for an accounting, by one of her customers, of where the klode went —didn't promise much of a battle at all. Unless . . .

The door buzzed open and Renee bounced in. Her body was tightly wrapped in some satiny red Holfish material. She was less than five feet tall, even tinier than most Holfans, but what there was of her was sculpted into breathtaking curves. He watched her with satisfaction.

"Sorry I'm late," she said. "I've been busy with Captain Moran."

"Fussing over the klode, or the Troq?"

"Both. He's pretty sure his men are going to see action. He's got the idea that one planet can't possibly use three kilotons of klode in a half-year—that the Troqans have to be breaking the agreement and selling the stuff at a higher price in some market Holfy hasn't discovered yet. And he may be right. We don't do much business out this way."

"Even if they are," Tsukanov said, "I don't see why you need a shipload of soldiers with our bloodthirsty reputation to point guns at them. It seems like an awfully big expense."

"Holfy's paying most of it," she said.

She laughed, suddenly, and sat next to him on the cushion, bending over and kissing him. She laughed again. "You've got such a big nose! It gets in the way."

"It's the Tsukanov nose. I refuse to have it shortened. And why is Holfy paying most of it?"

"The farmers' cooperatives I sell for pushed the appropriation through the League of Cooperatives. Klode has always been an exclusively Holfan product and we've got plenty of room to

expand. We don't put that clause in our contracts just to make them longer."

"You know," Tsukanov said, "Moran was asking me about klode earlier today. He wanted to know if it could be used for anything besides having fun. I told him that since it's the most powerful euphoric in the galaxy, I supposed it could be used as a sort of anesthetic. I've never taken it myself. But since, even at Holfan prices, it's about twenty times more costly than the most expensive anesthetic I can think of, that doesn't make sense. How long has Troq been buying six kilotons a year?"

"I don't know. Hundreds of years."

"And you just now decided to check it out?"

"We just recently found out that Troq had a population of less than two million. We don't get much news from this sector."

"Two million . . ." Tsukanov did some quick figuring. "Then one shipment ought to last them near a decade. There is something fishy going on."

"Of course."

"On the other hand, a planet like that can't be too formidable. I still don't see why you needed Sirian mercenaries."

"You've never met Troqans," Renee said, shrugging uncomfortably. "They're . . . funny."

"I've heard the expression 'Crazy as a Troqan' at several of our stops out here."

"Right. Usually after they find out that we're going there. They apply that phrase to us. Did you really come here to discuss our mission?"

"Partly," he said. He was overcome by affection for the little klode factor—something that happened to him every time she expressed an interest in him. It was like a miracle. He pressed his mouth into her yellow hair, more a blessing than a kiss, thinking, *I've got to get out of this business.*

"You're a strange one," she said. "But I must admit, you're attractive in spite of your nose."

"There's a legend about noses . . ."

"I've heard it. Let's see . . ."

When they had finished their love-making, Renee walked to a row of bottles in the corner, selected one, twisted the seal off, and brought it back with her, along with two glasses. Tsukanov's nose began to twitch at a faint, delicious aroma.

"Sithris wine," she said. "A Troqan export."

Tsukanov writhed among the pillows, stretching. "Tell me more about Troq," he said sleepily.

'I don't know that much—I've never been there, myself. I only know how to get there because my Holfan pilots told me. But, from all that I've heard, it's a dismal place."

"Last I heard," Tsukanov said, "klode was selling at one gram for 150 grams of silver. It can't be too dismal."

She grinned. "Oh, they're rich all right," she said. "In some ways, you couldn't ask for better customers. They pay in platinum and certain luxury food items, like this wine." She poured Tsukanov a glass.

"Try it," she urged.

Tsukanov lifted the glass to his lips and sipped gingerly. He was stunned. It was, by far, the most delicious thing he had ever tasted in his life.

Her grin grew wider. "Tasty, isn't

it? You'd think a wine like this was meant to be sipped and savored, right? The Troqans I've met all drink it like this . . .''

She picked the bottle up and chugged half of it, then shuddered violently. Tsukanov winced in sympathy.

''No,'' she said. ''It's not that Sithris wine becomes too cloying when drunk that way; quite the contrary. The pleasure is almost too much to bear.''

A chime sounded and a hollow, clanging, metallic voice said, ''You're wanted on the bridge, Miss Gast.''

''What for, Thing?''

''In a few moments,'' the ship's computer answered, ''we'll be out of range of any body familiar to my navigational program. Captain Moran may need your help.''

She made an apologetic grimace at Dr. Tsukanov. ''I'm sorry, love. I should be back in an hour or so. Will you wait?''

The next day, while puttering among the aphrodisiacs, Dr. Tsukanov heard from Thing that he was ordered to a private meeting with Captain Moran. His first reaction was unreasoning rage. He suppressed his quivering with the aid of a pill.

One reason for his reaction was that Captain Moran had a voice that dripped with piety and self-righteousness; a deep, honeyed, Sunday-school voice that made Tsukanov subliminally afraid that God just might be on whatever side the mercenaries happened to choose.

Another was that Moran gave Tsukanov the strong impression that he hated his guts. He gave everybody that impression—when it was given in his strangely pious voice, it was an excellent motivator. It was so good, in fact, that Tsukanov's heart told him God was making more checks in the black book with his name on it even while his head was insisting that it was only Moran's professional front doing its work.

By the time he got to Moran's spare office, though, Tsukanov was outwardly calm. Inwardly, if not completely calm, he was better. They were good pills.

''Good morning, sir,'' he said.

Moran sat behind his bare desk in his usual ramrod posture, lips compressed with disapproval. He indicated what chair Tsukanov had to sit in with an inclination of his iron-gray, close-cropped head. Tsukanov sat.

''You've been balling the civilian,'' Moran said.

''I assure you, sir, it hasn't been interfering with my duty.''

''I wouldn't think so, considering you don't do anything. I don't suppose, though, that you've thought about what sort of effect it might have on morale if it got out. I've half a mind to order you to stop.''

Tsukanov offered no answer.

After a silent interlude during which Moran appeared to be praying, he resumed speech. ''I'm not issuing that order, because you've been very discreet. I only found out because I had to account for Miss Gast's time. But since you'll be going down to Troq with Miss Gast and myself, I expect you . . .''

''You're kidding!'' Tsukanov was surprised. It was in the nature of his job to remain on the ship. He'd never made a landing yet.

''No. It's unfortunate we have to

bend regulations this way but, being a doctor, you're the closest thing I have to an expert on klode, and I want one with me.''

''Yes, sir.''

''This business is going to be a lot touchier than you imagine, Tsukanov. You're thinking we've whipped whole planets with twenty times the population of this one. But we're not allowed to charge right in, this time. Holfy insists they want proof that Troq has broken the contract before we really do anything. So Gast and you and I and a few marines have to conduct an 'inquiry' first. Not an easy job, when nobody knows a thing about the place. I don't suppose you've talked to her about the possibility of shooting first and asking questions later.''

''No, sir.''

Moran snorted. ''You're not a hell of a lot of good to us, you know that? Get your pack ready. We go back to normal space in less than an hour.''

Eight boats left the ship and each one had a fifty-man capacity. But there were only ten in the boat Tsukanov went in—himself, Moran, Renee Gast, a squad of seven marines, and three kilotons of klode. While the planet was still a tiny, dim ball through the polarized windows, Thing was showing them closeups on the screen.

Feeling the pressure from Moran, Tsukanov scarcely spoke to Renee. Instead he spent his time in front of the screen, fascinated. Troq was beautiful, lush, crowded with life. He'd seen pictures of Earth in the old days—Troq looked a lot like it, with the tropical belt widened to about eighty degrees. At least, there was that much jungle.

Mostly it looked uninhabited. Thing could locate only two grim-looking fortified towns. There was a large number of farms, but no farmhouses. There were a few isolated factories. Tsukanov was still watching Thing's aerial view when they touched ground.

Moran opened the hatch and damp, hot air rushed in.

If the Troqans were surprised at having eight boats full of armed men land instead of one boat of traders, they didn't show it. Tsukanov's boat was greeted by a team of thickset men in breechclouts who unloaded it quickly and efficiently and disappeared. Moran waited for some official to show up, but none did. The landing field was empty, save for several companies of Sirian marines waiting for orders. Moran stood on the field, hands on hips, looking puzzled. Finally he gave the order to march and they proceeded toward the long, low building where the Troqans had disappeared with the klode. They halted just outside it. Moran, Gast, Tsukanov, and Moran's personal squad of marines went inside.

It was all one room, with a packed-dirt floor. Far away, at one end, a large group of men seemed to be dividing up the klode. Nearby, in the middle of the room, a man stood at a high, rough-hewn table, watching them expectantly. He, too, was naked but for a (burlap?!) breechclout and what Tsukanov hoped was a ceremonial sword.

Gast walked to the table and the others followed.

''You'll get your payment, Gast,''

the man announced suddenly, "as soon as we've measured out the klode."

"We're doing more than shipping klode this time, Fludde."

The man turned to them, a look of sardonic amusement quirking his face. "Tourists?"

Moran cleared his throat. "We are a commission of inquiry from Holfy," he said.

"I like that. A commission that arrives with an army signifies a refreshing new straightforwardness in interplanetary relations. Nonetheless, whatever you are, you must sign a form releasing the Troqan Council from all responsibility for your personal safety while you stay here." He tugged open a drawer and produced a ream of forms. "Each individual of you, including all your men outside, must sign."

"I want to speak with the Troqan Council about just such matters," Moran said. "If you want this inquiry to go quickly, red tape must be cut."

"You're in luck. I happen to be vice-chairman of that body."

Moran looked at Gast. Gast shrugged.

"I assure you," Fludde went on, "I am. Do you want to talk with me or the whole body?"

"The whole body."

"I was afraid of that. There are places for only twenty or so of you in the fort. The rest of your men would have to make shift for themselves in the countryside. Do you really intend to park more than three hundred soldiers down here?"

"I don't know. What are your objections?"

"Personally, I have none. You may wish to consider their safety, though. Some of our wildlife is pretty dangerous."

"My marines can take care of themselves."

Fludde handed Moran the ream of forms. "In that case, you'd better get these signed."

Tsukanov looked for a city as they marched from the port. There was none. Gradually it dawned on Tsukanov that what Fludde called "the fort" *was* the city.

They marched to a great wall, and a drawbridge lowered for them. They walked through long rows of sexually segregated barracks, mess halls, commisaries—so many of them that Tsukanov finally fixed the population near that of a good-sized Sirian city.

Captain Moran was visibly impressed. He liked it. Tsukanov found it depressing. The architecture was oppressive—everything was built from the same gray native stone, low, square, and virtually windowless. The contrast with the profusion of beautiful jungle life outside just made it seem worse. He found himself reluctant to enter when Fludde motioned the ten of them inside one of the barracks.

Aside from a few men inside working over the polished stone floor with a buffer, there was no one inside. Fludde sat them on a couple of cots and stared at them with crossed arms, sighing.

"This is my barracks," he finally said. "I would introduce you to my sons, but they are out working, as is every man. You will all stay here . . ."

"What about Miss Gast?" Tsukanov asked.

"Her presence *will* impose a hardship

on us, but she's quite safe here, if that's what you're worried about.''

''Why can't I just stay in the women's barracks?'' Renee asked.

''We honor our women here. I hope you don't take offense, madam, but you do come from a rather degenerate culture and . . .''

''Say no more,'' said Renee coldly.

Fludde absentmindedly took a lump of greenish, resinous substance out of the folds of his breechclout and began to chew it. ''I'll leave you people to pass the time as you will,'' he said. ''I've got to arrange a campsite for your troops outside the fort. And I've got to contact the other members of the council.''

''How are you going to be able to do all that with a mouthful of klode?'' Renee asked.

Fludde smiled his sardonic smile. ''I'll manage,'' he said. He turned and walked out.

When he was out of earshot Renee turned to the others and said, ''Well, maybe we'll have to wait a while before we get to see the council.''

''How's that?'' Moran asked.

''Did you see how much klode he put in his mouth? He'll be out of it for the rest of the day.''

''Can't he be stoned and do his job, too?'' Moran asked.

''You ought to take some and find out,'' Renee replied sweetly. ''Maybe the next time you're in battle.''

Moran shot a question to Tsukanov with his eyes.

''The literature bears her out, sir,'' Tsukanov said. ''Klode is a stronger euphoric than any other known drug. It even does some direct stimulation of the pleasure center of the brain.''

''Could he have built up a tolerance to it?''

''The body builds up a slight tolerance, sir, over many years. But not much.''

''Hmph.'' Moran sneered. ''The Troqans really *are* loony, then. And they seemed so well-organized . . . well, so much the better for us. It'll give us a few hours to snoop around in.''

''I'm not sure that's such a good idea,'' Renee said, ''before we work things out with the council.''

''How do you know? You said you'd never been on Troq before. And that reminds me—how is it that you know Fludde?''

''I met him twelve years ago on Holfy. He was on the Troqan team that negotiated the last contract. I've never been on Troq but I have had experience with Troqans that you haven't, and your first impression was right. They are well-organized. And I have the feeling things could get quite nasty for us if we aren't careful.''

Moran laughed. Tsukanov figured he was thinking of the wide-range matter disruptor orbiting Troq in his ship.

At that point Fludde and six other men marched smartly into the barracks. Moran's laughter turned into a strangled croak and stopped. Fludde clapped his hands at the two men with the buffer and they ran to a storage area and dragged out a folding table and chairs. They set them up before the cots where the 'Holfan Commission of Inquiry' was seated and the seven Troqans sat.

''A quorum of the council is here,'' said Fludde. ''Spit it out.''

While Moran sputtered and tried to get his thoughts straight, Tsukanov studied the council. They all looked basically alike. They were all hard, muscular. Though they differed in trivia like hair color, width of mouth, and set of the ears, they were all deeply tanned—even the black one, he guessed—and they all had Fludde's grim look accompanied by the same mad sparkle in the eyes. The room was dim, but all those eyes were dilated considerably more than they should have been.

Tsukanov didn't need the evidence of the eyes. They'd all chewed so much klode he could smell it. The air around the table smelled like the boat he'd come in on.

Moran was talking coherently now. "... so Holfy felt a need to hire Sirian mercenaries," he was saying. "That's us."

"Sirian mercenaries," one of the councillors repeated. "I've heard of you guys. You're supposed to be tough."

"We are. Not that you need to worry about that, as long as you cooperate. And please don't get the idea that we're accusing you of anything. We'd simply like the opportunity to look around. Holfy is eager to expand her own trade and, quite naturally, the Holfans are worried about future markets for what is, after all, in the final analysis, a natural monopoly."

"So your idea is to wander around the planet and see where the klode goes?" asked Fludde.

"Yes. Basically, we'd like to headquarter here, and follow your own distribution system. We wouldn't really be in the way."

The man next to Fludde spoke. "A pansy," he said.

"A pushover," said another, nodding gravely.

"Are we all agreed?" asked Fludde, looking at his fellows.

They all nodded.

Fludde turned to Moran and said, "We think your inquiry is a good laugh."

"I beg your pardon?"

"Piss on your inquiry and piss on you too, you little wimp."

"Well put, Fludde," the man next to him said.

Moran turned the color of rich borscht and said, "I was hoping I could have the cooperation of the council in this, but I don't need it. Let me put it this way. Holfy wants me to treat you with kid gloves, but we've been in forty-one military actions before now and we've always come out on top. A few times we've had to wipe out planets to do it. I'd rather lose Holfy's payment than spoil that record, and I won't be afraid of wiping out another planet to keep it. Unless the men in my ship get special orders from me personally, they'll fry this ball anyway, so you can put what you're thinking right now out of your minds, too. You cooperate, or you die. It's real simple."

"Why didn't you say all this in the first place?" asked Fludde. "Now you're talking sense. Why'd you come to us sounding like some weak-willed Holfan?"

Renee gritted her teeth and kept her mouth shut.

Tsukanov and Renee Gast got their first close look at a Troqan woman that

evening, while they were being shown the sights of the fort—there weren't many—by Fludde's nine-year-old son, Fludde. Fludde the elder was too busy to extend this courtesy himself; he and a squad of men had hauled a great, wheeled energy-weapon into the barracks aisle to disassemble and clean it. After Moran and his squad had checked out the location of all the ten-kilogram bags of klode, they'd decided to stay behind and watch.

The Troqan woman was statuesque—she moved about as fast as a statue, too. Slow, deliberate movement seemed to be the fashion here outside of military formations. They came upon her as they were walking back from a visit to the hospital. Practically in front of their barracks was a wide circle drawn in the dirt of the street, and in the circle stood two men with drawn swords. The woman stood behind the circle, and around her stood an equally large circle of men, surrounding her protectively. She looked at the two men with drawn swords disdainfully.

"What's going on, Felix?" asked Renee.

"How would I know?" Tsukanov returned.

"Jarvs and Downy are going to fight," the kid explained excitedly. "The woman's name is Ket. They both petitioned her for the honor of siring her next child, and she has decided that one of them must die."

Tsukanov peered at the woman intently. "She's attractive," he said, "but I've certainly seen better. What's so wonderful about her? I mean, what's worth risking death for?"

"She's strong," little Fludde said. "A tough woman is a prize—one who can resist the . . ."

Little Fludde stopped suddenly and looked up at Felix, and then Renee. "I may be saying too much. In fact, I don't know if Father wants you to be looking at one of our women. Perhaps you'd better go inside?" He gestured toward the barracks. He clearly intended to stay and watch.

Renee was ready to explode. Tsukanov cut her off by saying, "If that was truly your father's wish then the damage has already been done. We might as well stay."

It wasn't all that entertaining. A duel with swords in a confined space is usually a quick thing, and so it was here. Ket slowly nodded her head, there was a brief clashing of metal, then the kid named Jarvs lay bleeding profusely from a wide gash in the gut. Ket nodded again to Downy and the two of them walked away.

Tsukanov started toward Jarvs, but Renee grabbed his arm and shook her head. "Let's not interfere," she said tightly.

Tsukanov looked more closely. Not a Troqan moved to help Jarvs. He'd just seen their hospital. He knew they had the medical technology to save Jarvs. That woman had truly decreed his death.

"Let's get out of here, Felix," Renee said. "I'm starting to get sick."

Little Fludde sneered and marched ahead of them into the barracks.

Tsukanov followed slowly. When little Fludde was out of earshot he said, "It makes me sick, too. These Troqans really are crazy. Could you smell the klode everywhere?"

"They can't be swallowing the juice,

Felix . . . ugh!'' She shivered. ''I don't want to talk about it.''

''I don't know,'' said Tsukanov. ''It doesn't seem fully real to me. What we just watched—it seems like something out of a heroic fantasy, except for the lack of fancy swordplay. I wonder if that sort of reading is popular here?''

Renee wasn't answering. They walked into the barracks.

The building was still mostly deserted. The few men who were there were now reassembling the weapon under Fludde's direction. Apparently life on Troq consisted of work, fighting, sex, and sleep. Mostly work.

Tsukanov sighed and turned to the kid, who was standing near the doorway talking to Moran. ''Do you have anything to read around here?'' he asked.

The kid looked surprised, then nodded, ran into the supply room, and brought back a bookspool entitled, ''The Q-44 Fuel System, its Maintenance and Repair.''

''Don't you have any fiction?''

''Fiction?''

''You know, light reading?''

The kid looked puzzled.

''Forget it,'' Tsukanov said, and handed the spool back.

Moran followed Tsukanov back to their own section of the barracks. ''Except for the kid,'' he said, ''they all smell of klode!''

''We know,'' Tsukanov answered.

Renee took a seat beside Tsukanov on his cot. ''Speaking of klode,'' she said, ''what did you find out about their distribution of the stuff?''

''Not much,'' Moran said. ''They say people from the next city over will be here in two days to pick up their share. They just seem to hand it out to any Troqan who walks in and asks for some. They seem to chew the stuff all the time. It's crazy. You know, a thought occurred to me. Maybe the stuff they're putting in their mouths isn't really klode at all. Maybe they're trying to create the impression that they all take enormous amounts of it to account for where all those kilotons go.''

''Maybe we'd have gotten more cooperation,'' Renee said, ''if you hadn't threatened to blow the place up.''

''Are you kidding!'' Moran exclaimed. ''You heard what they said. My threat was the only thing that got them to respect us—or to disrespect us less, anyway.''

The work on the weapon was finished now, and the men were pulling it back outside. Fludde walked over to them. ''You people look bored,'' he said. ''That's a mark of a degenerate people who fill their lives with empty leisure.''

''Is this your idea of a conversational gambit, or what?'' Moran demanded sharply.

Little Fludde tapped big Fludde on the arm and pointed to his mouth. Big Fludde popped a hunk of klode in it, and said, ''We don't deal in conversational gambits here. We speak when there is something to be said—''

''Pardon me, sir,'' Tsukanov interrupted, ''but could I use some of your klode? I *am* terribly bored.'' He gave his most effete and limp-wristed shrug. ''One can't help being a product of one's culture, can one?''

The boy began to giggle. Fludde slapped him in the mouth so hard that he went flying backward over the cot. Fludde's eyes glittered with derision and

pleasure. He smiled a mocking smile, reached into his pockets, produced another hunk of klode, and tossed it to Tsukanov. He spun on his heel, grabbed the boy, and walked away.

Tsukanov looked at Renee puzzledly. "It must be real klode," he said. "If it weren't, Fludde would have found a reason not to give me any."

Renee looked troubled. "It seems so."

"Only one way to make sure, though," Moran said. He watched Tsukanov expectantly.

"OK," said Felix. "You've got a point. Besides, I've never taken it before. I suppose if I'm going to try to figure these people out, I really ought to try it."

He bit a piece off the hunk and began to chew. It was bitter. Moran grunted approval and walked away.

Felix held out the remaining klode to Renee.

"Want to join me?" he asked. "Maybe we can meet in the bushes in a little while."

Renee shook her head sadly. "Go ahead and eat the rest of it. Sex and klode don't mix that well. In fact—I don't want to shock your romantic mentality, but you might as well be prepared—klode is better than sex."

Felix shrugged and popped the rest of it into his mouth. When he'd finally chewed it down to a juiceless wad, he spat it into his hand and said, "You won't mind if, later, I just happen not to feel that way?"

She smiled. "No," she said.

After only a minute or so of conversation with Renee, Felix was overcome with a desire to walk about, and he excused himself. The barracks lighting didn't seem so dim now, as he walked down the aisle—detail registered more fully on his mind. He remembered that this effect was common to a hundred drugs.

He felt healthy, vital. There was a spot in his left side where he was always getting stitches. It was, he realized, solely a matter of posture. He adjusted his body to an easier stance, and easier gait. If he could only hold onto that after this experience was over, he would have cured himself of one of life's minor but very annoying problems.

The feeling of vitality grew into something beyond itself. Waves of magnified good-feeling swept up and down his body. He felt his mouth stretch itself into a tight grin. With a conscious effort he could push it back into its normal position, but he had more important things to do.

He realized that he was giggling. Several Troqans were walking up to him, watching him interestedly. Their smiles mocked him.

"We're surrounded by a universe of assholes," one said.

"They'll not foul our air much longer," said another.

An electrifying, orgasmic surge radiated from his solar plexus outward in all directions. It didn't stop—it grew stronger all the time. Filled with the sense of his own godhead he pitied the Troqans.

Then he remembered that they, too, were on klode.

"What's the matter with you?" he asked. The Troqans turned away from him in disgust.

It was a mystery, but it was not beyond him. He would penetrate it in the morning. Right now, it was important that he do handsprings down the aisle back to Renee.

He awoke the next morning fully dressed, expecting something like a hangover. He felt fine, though. This pleasure demanded no payment from the body but sleep.

He pulled himself out of the cot and noticed dried semen on his trousers.

"Spontaneous orgasm," said Renee from the neighboring cot. "But you probably didn't even notice."

He hadn't. But remembering the things he had noticed and done the night before made him blush.

"Don't worry about it," said Renee. "For your first time on klode your reaction was really amazingly mild. You must be some kind of superman. I'd hate to tell you the things I did my first time. In fact, I won't."

Suddenly he was shocked fully awake. "Renee," he said, "those folks are all on klode. I didn't realize before just how impossible what we're seeing is."

"Intriguing, no? I'm beginning to think maybe they're a non-human species, posing as human."

"You know, they could be some kind of mutation, or something. If they really are eating all that klode, then your contract hasn't been broken and we should leave."

"That would be nice. The leaving part, especially."

"I've got to get a blood and tissue sample from them. There's equipment enough in the autodocs on the boats at the field to do a fair analysis—especially with a hookup to Thing."

Renee jerked her head toward the door. "There's a whole cadaver right outside waiting for you. They haven't touched it yet."

"Where's Fludde?"

She sighed and turned her face away. "Who cares?" she said. "Who cares about any of this. Let's just get out of here."

"Have you spoken to Moran?"

"I don't know where he is."

Tsukanov looked around the barracks for Fludde. The building was near empty again. Early risers. Fludde was there, though—opening people's lockers and checking the contents against a sheet in a clipboard. He walked over.

"Good morning, Fludde."

"Up late, aren't you?"

"Sir, I need your advice. I don't understand the proper procedures on your planet. I want to study your physiologies. I need blood and tissue samples. Preferably a whole cadaver. I couldn't help noticing outside—"

"You don't understand our customs. I see." Fludde frowned. "It's nice to see that you're interested in working sometimes. There's nothing wrong with using Jarvs. Whoever wants to cart him away can do so. But our hospital, I understand, doesn't have the kind of equipment you have."

Tsukanov was amazed. Fludde hadn't even asked him what he wanted to make such a study for. He'd expected to have to argue, at least. He crossed his fingers and said, "I can use the equipment on one of our boats."

"Fine. I'll have a man fly one in."

"I can go out and get it myself."

"No, you can't. Now, do you want the boat or not?"

"Am I to understand I'm a prisoner here?"

"Understand whatever you want. You can't leave the fort right now."

One of the Troqans who had mocked Felix last night ran in and stopped before Fludde.

"What is it?" Fludde asked.

"It's the woman Lan," he said. "Some woman—Ket, no doubt—noticed the little Holfan woman here yesterday evening, and now everyone knows she's here. Lan has demanded to see her."

Fludde's shoulders sagged in discouragement and submission. "She must have her way," he said. "Escort Miss Gast to Lan's barracks."

The other Troqan nodded, walked to Renee's bunk, and began gesturing at her urgently. After a few mintues, they marched out together. As she passed, Renee shrugged helplessly.

Tsukanov looked back at Fludde, who was looking at him expectantly.

"OK," Felix said, "have someone fly it in."

To save time, Tsukanov fed everything into Thing. It was nerve-wracking work. Even if one is used to corpses, cutting one up and subjecting the tissues to chemical tests isn't pleasant. And this one was beginning to stink. It was made still worse by the presence of a local doctor, fully armed, who supposedly was observing Felix's techniques for application in the local hospital, but who acted more like a guard. He didn't have much to say and he offered no help, but the only time he took his eyes off Felix was when there was a terrible roaring outside, as if a bunch of spaceships were taking off.

It took only a couple hours to run through all the tests necessary to his purpose. It took only a quarter-hour for Thing to announce its final results.

"As close to the Standard Human Profile as any I've ever seen, Doctor," it said. "Of course, we're not really sure what we're looking for, but I should say his reaction to any of the usual drugs would be the reaction *you* would experience, more or less."

"Drugs?" the guard/doctor said. "Jarvs never took any drugs. Only klode. What are you trying to pull?"

Thing spoke. "Doctor Tsukanov, would you do me a favor? Would you ask Captain Moran something for me?"

"Sure, Thing. When I see him. What is it?"

"Would you ask him why he authorized the Troqan embassy he sent up to remove my matter-disruption unit? This is in direct violation of the . . ."

Tsukanov heard no more. The guard slapped the speaker switch and threw him out the hatch to the dusty square where the boat was parked. He pushed a gun in Felix's back and pulled him to his feet. "We'd better be going back to see Fludde, now," he said.

When Tsukanov got back to the barracks, Moran and his squad of marines were standing outside with Fludde and about fifty Troqan men. Moran and Fludde were having a shouting match.

"You don't seem to understand," Moran yelled, "that we operate on a strict schedule. I must go to my marines outside and organize our investigation of the transport of klode to the other

cities. You don't seem to understand that unless I contact them within twenty-four hours they will destroy this fort.''

''And you don't seem to realize that no one can leave this fort right now and that your schedules mean nothing.''

''Why don't you want me to see my men? And where is Miss Gast?''

''She's quite safe . . .''

''Captain!'' Tsukanov hollered, running up to him, ''the Troqans have taken the ship!''

Moran looked at Tsukanov as a biologist might look at an earthworm that had decided it could fly. ''That's impossible, Doctor,'' he said. ''I don't know what gave you such an idea, but you had better leave the military matters to me.''

Fludde, Felix noticed, looked considerably more relaxed now.

''I got it straight from Thing, Captain,'' Felix said.

The captain looked startled. ''Are you sure?''

Fludde raised his arm in a signal to his men. They circled the Sirians, weapons drawn. ''Now,'' he said, ''you may go out to see your marines—or, rather, what traces are left of them.''

Moran's shoulders slumped. He looked suddenly pallid and weak. ''You really did take the ship,'' he said, flatly. ''And what did you do to the marines?''

''Nothing,'' said Fludde. ''We merely left them with the wildlife. It's a sort of test of manhood. I believe you're familiar with such tests on other worlds, are you not?''

Moran nodded.

''All but two failed this one, unfortunately. Two out of 350 isn't very good, Captain. I thought you Sirians were tough.''

Moran said nothing.

''My disappointment is genuine,'' Fludde said. ''We could have used more good soldiers now that you've brought things to a head.''

''What are you talking about?'' Moran snapped.

''Why—your landing in Troq. You've seen things you shouldn't. To have to go back to Holfy with the news that we really do take six kilotons of klode per year would be as bad as making you believe we've discovered a new market. People would try to persuade Holfy not to sell us any more when we begin conquering the galaxy.''

''What?'' Moran scowled. ''You're mad. Nobody can conquer the galaxy. It's too spread out. As strategists, you people aren't much.''

''We don't intend conquering it all at once, Captain. This sector will do for a start.''

''It's still impossible.''

Fludde smiled a smile of pure pleasure. ''You certainly think a lot of things are impossible, Captain. Nothing is impossible to men inspired by the fair flower of Troq. A few Troqans just whipped a shipful of what are supposed to be the toughest soldiers around. I don't think we're being too unrealistic.'' He was silent for a second and then added, ''No comment?''

Moran said nothing.

Fludde shrugged. ''Anyway,'' he said, ''we're going to have to begin a bit early, thanks to you, and we'll have to start with Holfy, to ensure our supply of klode, since there's bound to be a stir when you don't get back. Of course,

what Holfy has done in sending you here is enough to puff up into an act of war. That should keep the other worlds from getting too outraged for a while.''

''I still don't understand,'' Moran said, ''why a supply of klode should be so necessary. Especially for soldiers like you.''

''You'll see the reason soon,'' Fludde said. ''You may even live to understand it. It's your turn to take the test.'' They marched out in the direction of the drawbridge.

Tsukanov felt his guard's gun jab into his back. ''You too,'' the guard said.

Disarmed, Moran and the seven marines marched in front. Tsukanov was in the rear, walking bent to one side with a painful stitch, unnoticed and glad of it for once. They had spotted one of the two marines Fludde said were left alive. A couple Troqans hurried him back to the fort before he had a chance to talk to anybody.

By and by they came to a clearing. There were no marines there either, but there was evidence of their having been there—the remains of a campfire and some gear.

At the opposite edge of the clearing was a row of planimals—the popular classification for that which couldn't fit into an Earth-based taxonomy. They were comical things: bright yellow balls waved on stalks attached to a pulsating green mass with an orifice in the center. The stalks quivered energetically. The planimals were rushing the humans.

However, since their top speed seemed to be about as fast as a slow snail, it seemed the humans had a little while to escape.

Tsukanov was standing about ten meters behind Moran and his men. The Troquans rearmed them and gave each a shove toward the planimals.

Moran and his squad walked over to the planimals. Each man crawled into an orifice. Two of the marines arrived at the same planimal and shoved at one another trying to get in first. When the winner of the shoving contest was about halfway in the hole, the other marine was jerked by some unseen force to another planimal and started in himself.

Blood oozed through the now almost-closed holes.

''I'm of two minds about you, Doctor.''

Tsukanov jerked his head away from the gory scene and saw Fludde standing beside him. His mouth was twisted in the familiar mocking smile. His eyes were glazed with pleasure.

''Medicine has never been one of our strong points,'' Fludde said. ''A highly trained doctor would be very useful. On the other hand, if I exempted you from the test, people would resent you—and me even more. I'm afraid I must be a politician first.''

He nodded at Felix's guard, and the guard handed him his sword.

''March to the middle of the clearing, please,'' the guard said, once again poking the gun in his back.

As Tsukanov walked forward he was struck with a wave of pleasure that was to klode what klode was to hemp. It was the real thing, the center of every good feeling he'd ever had. Dimly, a part of him realized that the pleasure center of his brain was being directly stimulated by the planimal. Telepathy.

But with every step he took, the stim-

ulation grew stronger. He kept taking those steps.

He was a superman. Then he was a god, going forth to meet his chosen goddess. In the orifice of that planimal was his destiny, his beloved, the purpose of his life.

As his steps came more quickly toward fulfillment, that suppressed part of him that analyzed what was going on raised the sword above his head. What little sense he had left was a devil within him that told him to kill the thing he loved. He struck out, blindly, and the yellow balls fell severed from the body of the planimal. He screamed with pain—the pain of the damned, sent to everlasting hopelessness.

He felt strong arms pulling him back. He went limp and let the pleasure fade away. He felt himself being dropped onto the ground. He looked up at Fludde.

"Not really up to par," Fludde said, "but good enough to pass the test by the rules. There's more to you than meets the eye, Doctor."

"The klode," said Tsukanov. "You use it to prepare yourselves. It's an exercise in restraint."

"And when you happen to be caught by those yellow balls, it dilutes the effect a little," added Fludde. "But you're right. The exercise in restraint is what's really important. It raised the survival rate by forty percent when we introduced it. I'm afraid, though, that by any objective standard, we're still only the second most successful lifeform on Troq. That's changing, of course, but we'll need a couple hundred more years."

Felix raised himself from the ground.

As with the klode, once out of the planimal's grip he felt completely himself again.

"We've made great advances in life-extension," he said, bitterly. "Maybe I can live to see the day the last of them is killed."

Fludde scowled. "That day will never come," he said.

"What?"

"They are necessary."

"Necessary for what? For your damned puberty rite?"

"Listen," Fludde said. "When the first colonists arrived here, they were ten thousand strong. There were exactly eighty survivors—only nine of them women, incidentally. We were within a hair's breadth of being wiped out. The fact is, we survived, and the survivors were ruthlessly selected for the same quality you happen to have, in small measure—the ability to continue thinking, somehow, while the pleasure center of the brain is being stimulated.

"Even that wasn't really enough. The life natural to this planet has been bred the same way, and still those planimals survived—hell, they flourish. But we combined that natural resistance with self-discipline and, finally, with klode.

"We are, without question, the most disciplined humans in the galaxy. We can take abuse you degenerates can't even imagine. We are a breed apart; the planimals have raised us to a new level. And the test is crucial and the planimals are necessary to the test. We'll never let them die out. On the contrary, when we expand through the galaxy, we shall seed each human planet with them. With the planimals and our jurisdiction both working for humanity, it will someday be raised to the Troqan level."

Tsukanov felt cold. Cold and old and tired. The chance meetings of human and alien life had finally produced real supermen. And that's what they were—they weren't fooling themselves. They had disposed of a Sirian warship and a fair-sized Sirian army in less than a day—almost casually. He tried to imagine what the galaxy would be like once the Troqans spread through it. He shuddered.

"What do you want me to do?" he asked hoarsely.

"The first thing," Fludde said, "is to start redesigning the autodocs on our warships."

"You really dare to show them to me?"

"You've proven that you're one of us in spirit. Your mind will follow naturally. And until it does, you'll be watched, of course."

Renee's image popped into Felix's mind saying, *For your first time on klode your reaction was really amazingly mild. You must be some kind of superman.* He retched, then asked, "Where's Miss Gast?"

Fludde sighed. "There's another problem," he said. "What can we do? She amuses our women. They've been talking with her nonstop about the things we can get on other worlds. Perhaps she can be reeducated and you can serve her again."

"Are women subjected to the test?"

"Only if they want to be. Some do. They wish to prove themselves, and having it known that they are proven can be an advantage. Those who do usually have good reason to believe in

their abilities in the first place, though. I wouldn't advise it for Miss Gast."

"No . . ."

"Come. It's time to go to work."

It was Dr. Tsukanov's first day on the job. The task at hand was to redesign Troqan autodocs, and he sat at the console of the Sirian boat trying to empty his mind of troubles and concentrate on it. It was like trying to bail an ocean with a thimble.

He had just gone through a week of calisthenics and preaching, accompanied by armed, edgy guards everywhere he went. He had thought that when he started work he might get a few minutes alone. He saw now that he'd been foolish. In the boat with him was another "helper"—an armed autodoc mechanic who was good enough to be able to take notes from Thing's printouts on the screen, but who never once got out of his chair or offered to help.

He was now forced to wear a burlap breechclout—a particularly difficult test of self-discipline, he thought. Although the swelling and itching subsided more quickly than normal, thanks to some pills he sneaked off the boat one day, he still found it irritating.

He'd seen Renee once since the defeat of the Sirians—only yesterday. He'd met her in the road on the way to morning calisthenics, and he suspected the meeting had been arranged for his benefit.

It had been a short visit.

He had been afraid she couldn't survive a Troqan-imposed "reeducation," but she looked fine. He'd found himself falling in love with the little Holfan sybarite all over again when, to his horror, he'd heard her say she thought she could learn to like it here.

He never could, he thought, feeding another page of Troqan data to Thing. The closer the Troqans came to launching their attack on Holfy, the more he hated them. He stayed on in the hope of finding some chink in their goddam superman armor, some flaw that might be worked on. If he couldn't do that then he might as well sneak off to the women's barracks and Renee to see if she cared to join him in trying to escape in the boat.

She probably wouldn't.

It would be almost certain death. Even if they got away clean, there wasn't enough fuel to get them anywhere. It was a thousand-to-one shot that a friendly ship would spot their boat before their food or air ran out.

Maybe things would work out OK for Renee on Troq. Women had at least a relatively privileged position here.

He gasped with excitement.

Maybe he had found that chink.

He doubted that he could really do anything to corrupt the Troqans—they were what they were—but he might be able to make things hard for them once they started their program of conquest.

The Troqans were a fearsome and impressive sight. He could imagine them marching through a conquered capital, cowing the natives. But one of the reasons a conquered people stayed conquered was their natural tendency to take their conquerors seriously. *I might,* Felix thought, *be able to fix it so they* can't *take the Troqans seriously. Especially on intolerant frontier planets —most of the planets in this very sector!*

He opened the voice line to Thing.

"What are you doing?" his helper asked.

"I've thought of something to help," Tsukanov said. "Just don't worry about it. We'll go to Fludde when I'm finished and check it out with him, if you're worried about it. OK?"

The helper grunted satisfaction.

"Thing?" Felix asked.

"Hello, Doctor. Please tell me what happened to my crew and passengers on the planet."

"Almost all dead. We've been defeated by Troq."

"I see. What assistance did you wish?"

"Do you think it possible for a man—such as that cadaver we went over—to discipline himself not to feel the effects of klode?"

There was a long pause—long for Thing, actually one or two seconds. Then it said, "To a certain extent, yes, but not significantly. There is some stimulation of the pleasure center. This would be impossible to ignore. Such a man might conceivably discipline himself to *act* as if he felt nothing, though. That's different."

"That's what I hoped. Assume that this man has done so. Would you run a psychological profile based on the long-term effects of such discipline?"

The profile flashed on the screen. Tsukanov watched it, and remembered the peculiar glint of pleasure in the Troqans' eyes appearing at peculiar times. If a man experiences pleasure in painful situations all the time, it's only a matter of time until the two become confused.

"Thing?" he asked, "How extensive is your library?"

"You name it, I've got it," Thing challenged.

"OK. I want you to transmit a book-spool down here." He hurriedly punched in a title, plopped an empty spool into the recorder, and waited a few minutes. When it was done he said, "Thank you, Thing," grabbed it, and jumped out of the boat on his way to Fludde, ahead of an astonished helper.

"What interrupts your work, Doctor?" Fludde asked, raising his eyes from a star-chart.

Tsukanov took a deep breath and prayed. He was counting partly on their naiveté. While literate, they had never encountered fiction.

"I think I may be able to help you with your long-range goals," Tsukanov said, "with this document."

"Really? Explain yourself."

"Well—I know you're aware that the Troqan way of life is superior to all others."

Fludde nodded his head, wide-eyed with sincerity.

"And I'm sure you agree that the principles on which your life-style is founded are obvious—almost self-evident."

Fludde nodded again.

"And yet," Tsukanov went on, "you must have noticed in your dealings with the degenerate societies in this galactic sector that many were unable to comprehend the beauty of your way of life."

"All this is true, Doctor, but please get to the point."

"The point is that since this beauty is so obvious, many human writers in the past have perceived it and celebrated it fictionally. It would make great prop-

aganda and also, I think, would do no harm in Troq. It would give a sense of unity—''

''I'll check it out, doctor. Leave the spools on my desk and go back to work.''

Fludde came to call the next day at the boat.

''Really remarkable, Doctor,'' he said. ''I've already had this copied and distributed to each barracks.'' He handed the spool back to Tsukanov, hands trembling. ''Have you any more like them?''

Tsukanov smiled. It was a smile of victory. He had them. Fortunately, the smile was misinterpreted by Fludde.

''I think I can have Thing dig out a few more,'' he said.

Tsukanov looked at the bookspool. *Venus in Furs*, by Leopold von Sacher-Masoch. The only other Sacher-Masoch Thing had on file was a long thing called *The Legacy of Cain* which didn't look too promising, so the next batch of fiction wouldn't be nearly as high-toned.

But Fludde probably wouldn't mind. ■

ON GAMING

(continued from page 93)

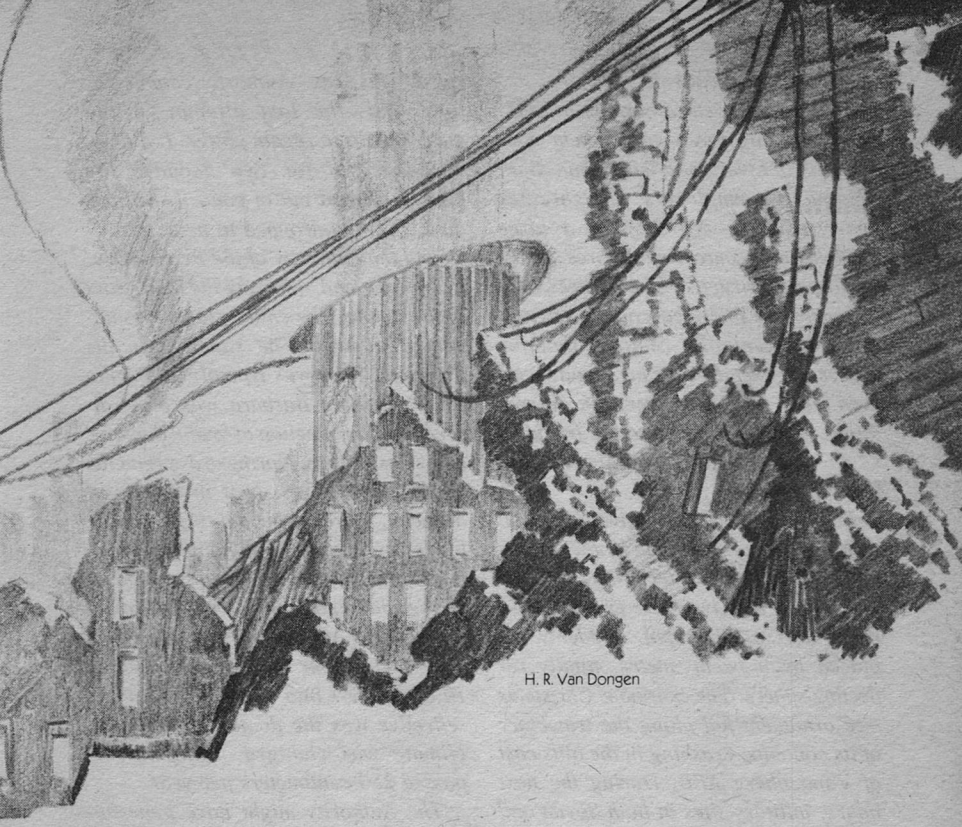
of gravity; more weapons, such as proton, electron, and disruptor beams; mines, and seeker missiles; more defenses, such as the stasis screen; and more detailed damage and repair rules. There are also two scenarios involving large fleet actions at the end of the advanced rules.

Although the game may sound complicated, actual play is quite fast once you get used to the percentages involved in being hit, and to keeping records on the ships' roster forms. The board game version of *Knight Hawks* has enough to recommend it by itself, but there's more. . . .

The game also includes a 64-page campaign book with detailed rules to expand your *Star Frontiers* adventures. There are rules for spaceship design, equipment, deck plans (to use with the 25mm metal miniatures made by TSR for *Star Frontiers)* using characters with the spaceships, movement and combat, economic activity, plus referee's background material, and a major scenario combining the elements of the board game with the role-playing characters and referee.

Also included is a separate 16-page adventure module, *The Warriors of White Light*, plus deck plans and referee's notes.

Knight Hawks is tremendous value for the price. Even if you only want to play an SF board game simulating ship-to-ship combat, you'll find the game worthwhile. But there's so much more provided, you'll enjoy reading and using the other materials as well. Even if you don't play *Star Frontiers* now, *Knight Hawks* is a good way to start. ■



H. R. Van Dongen

THE PEACE WAR

Vernor Vinge

Part Three of Four

At first glance,
a device that makes
weapons
unusable might seem
an indisputable blessing.
The trouble is that if
it's controlled by human beings,
it may become
a new weapon itself.

Paul Hoehler *invented* **bobbles** *in 1997, while working for a government contract lab in Livermore, California. Both he and his employers thought they understood the effect: With a large enough power source, stable force shields could be constructed. The spheres were impenetrable and theoretically eternal. Hoehler eventually realized that his bosses were keeping the invention secret even from the government. In desperation, he hinted at this to his friend in USAF intelligence, Captain* **Allison Parker.**

Parker surveyed the Livermore lab on an orbital mission, but by then it was too late. As her orbiter reentered over California, the Livermore group struck: Her craft was bobbled, suddenly replaced by a twenty-meter, totally reflecting sphere. The enormous Christmas tree ornament fell along the trajectory of its contents, crashing in the hills east of Vandenberg AFB. During the next hours, military sites in both Soviet and Western camps came under simultaneous attack. Most simply stopped reporting. In the general war that followed, only a few nuclear weapons were exploded. Both sides saw their bases and fleets mysteriously swallowed up in totally reflective spheres.

With this chaos far advanced, the Livermore lab announced itself as the maker of the bobbles and the new guardian of peace—a **Peace Authority**. *Sovereign governments were outlawed. Enemies of the Peace were subject to embobblement: to be trapped inside a bobble was clearly a sentence of death by asphyxiation.*

The war plagues began shortly afterward. This was—Authority commentators said—the last attempt of the governments to regain power. It did not succeed, but for two decades the plagues spread out of control. Billions died. Fertility dropped to near zero.

And the authority of the Peace grew.

The '30s and '40s were the high years of the Peace. The entire planet was under its control. The situation in the American West was typical: California south of Santa Barbara was Spanish-speaking, a collection of feudal domains known as **Aztlán**. *Northward spread the* **ungoverned lands**, *kept in a state of anarchy. Across the old USA missile fields lay hundreds of bobbles. Much larger ones enclosed the military bases of the old regime. The bobble around Vandenberg AFB was twenty kilometers across, its upper hemisphere reaching 10,000 meters into the sky. So vast and reflective was the dome that the local climate was changed. Rainfall surpassed 250 centimeters per year.*

The Authority might have gone unchallenged, if not for an unlikely alliance. In 2047, **Wili Wachendon** *was fifteen—and looked eleven. Wili was a first-rank genius, but had plenty of compensating problems. He suffered from one of the wasting diseases that were the legacy of the plague years. Nearly feral, he had grown up on the fringes of the black ghetto in LA, the* **Ndelante Ali. Paul Naismith** *was almost eighty, and the most important* **Tinker** *on the West Coast. As in other dark ages, technical progress had not entirely stopped. The Peace had banned heavy manufacturing, but low-power electronics survived as a cottage industry. In some ways, the Tinkers had taken electronics*

as far as it might have gone without *the war and plagues.*

Naismith hated the Authority: In 1997 his name had been Paul Hoehler. For fifty years he had hidden from the Peace and dreamed of revenge.

In Wili Wachendon, Paul saw another genius, one that could be a powerful weapon in his schemes. But after six months of apprenticeship, it was clear the boy's wasting disease was progressive. Naismith demanded that the Tinkers get Wili in touch with the bioscience underground. This was asking a lot, since the Tinkers—like almost everyone in the '40s—blamed the bioscientists for the plagues. Nevertheless, Naismith squeezed hard, pointing out that Wili had already discovered how to eavesdrop on Peacer recon satellites (a capability the Tinkers had long desired).

In the end Naismith prevailed. **Red Arrow Farm**, *the largest Tinker company in the Vandenberg area, arranged to transport Wili to the nearest biolab, just north of San Diego. Besides Wili, the expedition consisted of* **Miguel Rosas**, *an undersheriff from the Vandenberg area, and* **Jeremy Sergeivich Kaladze**, *the grandson of the founder of Red Arrow. The expedition had what seemed a perfect cover: The Authority was sponsoring the North American Chess Championships in La Jolla. Those participating would be immune from interference by Aztlán or the Ndelante.*

But two people—one a traitor, the other a cop—turned the scheme into a terrible trap.

The cop was **Della Lu**, *a high-ranking Peacer security officer; Lu reported directly to the Authority Director for America,* **Hamilton Avery**. *Things were heating up for the Peace. The Directors were beginning to realize that bobbles are not forever: several ten-meter bobbles had already lapsed. Avery was convinced the Tinkers were behind this development; he had recently discovered that Paul Hoehler survived, and was a Tinker. The chess championships were meant to snare as many Tinkers as possible.*

The traitor was Miguel Rosas, whose hatred for the bioscientists surpassed even his loyalty to the Tinkers. Rosas told the Peace of the secret lab, his price being that any raid come after Wili's treatment.

Lu's trap was very effective: Almost all Tinkers at the championships were arrested. The nearby biolabs were bobbled—minutes after Wili and Rosas had successfully departed. Jeremy Kaladze was a casualty, trapped within the bobble. Lu had not intended that, but it gave her extra leverage with Rosas. He had thought his information a limited cooperation with the Peace; now he found himself a full-time traitor assigned to vouch for Della Lu.

The three returned to Red Arrow Farm after their "miraculous" escape from the Peace in La Jolla. Miguel Rosas presented Lu to the Kaladzes as a fellow victim of the Authority's treachery. In fact, Lu's mission was to locate the Tinker leaders—in particular, Paul Naismith. Wili saw through the deception, but his denunciation of Lu and Rosas was not believed.

About the time of the La Jolla arrests, a twenty-meter bobble burst in the hills east of Vandenberg. The bobble had great, though irrational, significance

for Paul Naismith: Allison had died inside it so many years before. More practically, this was the first burst bobble accessible to Naismith. Though he had invented them, he—like the Authority—had never guessed that bobbles would decay after a few decades. He was convinced that if he could study such incidents, he could devise low-power bobble generators.

And so Paul Naismith discovered the true significance of bobbles, the significance that had lain hidden from all factions for fifty years: Within a bobble, time stops. *Embobblement is* not *a sentence of death. The proof was striking: He found Allison Parker, still 25 years old, just escaped from the wreck of her orbiter. She was very confused, and saw nothing familiar in Paul Naismith, but was easily persuaded that the arriving Peacer troops were a threat. She and Paul escaped the Authority net and headed for Naismith's secret home in the mountains.*

22

She was trapped in some sort of gothic novel. And that was the least of her problems.

Allison Parker sat on an outcropping and looked off to the north. This far from the Dome the weather was as before, with maybe a bit more rain. If she looked neither right nor left, she could imagine that she was simply on a camping trip, taking her ease in the late morning coolness. Here she could imagine that Angus Quiller and Fred Torres were still alive, and that when she got back to Vandenberg, Paul Hoehler might be down from Livermore for a date.

But a glance to the left and she would see her rescuer's mansion, buried dark and deep in the trees. Even by day there seemed something ancient and alien about the building. Perhaps it was the owner. The old man, Naismith, seemed so furtive, so apparently gentle, yet still hiding some terrible secret or desire. And as in any gothic, his servants—themselves in their fifties—were equally furtive and closemouthed.

Of course, a lot of mysteries had been solved these last days, the greatest of them on the first night. When she had brought the old man in, the servants had been very surprised. All they would say was that the "master will explain all that needs explaining." "The master" was nearly unconscious at the time, so that was little help. Otherwise they had treated her well, feeding her and giving her clean, though ill-fitting clothes. Her bedroom was almost a dormer, its windows half in and half out of the roof. The furniture was simple but elegant; the oiled burl dresser alone would have been worth thousands back . . . where she came from. She had sat on the bright patchwork quilt and thought darkly that there had better be some explanations coming in the morning, or she was going to leg it back to the coast, unfriendly armies or no.

The huge house had been still and dead as the twilight deepened. Faint but clear against the silence, Allison could hear the sounds of applause and an audience laughing. It took her a second to realize that someone had turned on a television—though she hadn't seen a set during the day. *Ha!* Fifteen minutes of programming would probably tell her as much about this new universe as a month of talking to "Bill" and "Irma."

She slid open her bedroom door and listened to the tiny, bright sounds:

The program was weirdly familiar, conjuring up memories of a time when she was barely tall enough to reach the "on" switch of her mother's TV. *Saturday Night?* It was either that or something very similar. She listened a few moments more, heard references to actors, politicians who had died before she ever entered college. She walked down the stairs, and sat with the Morales through an evening of old TV shows.

They hadn't objected, and as the days passed they'd opened up about some things. This was the future, about a half-century forward of her present. They told her of the war and the plagues that ended her world, and the force fields, the "bobbles," that birthed the new one.

But while some things were explained, others became mysteries in themselves. The old man didn't socialize, though the Morales said that he had recovered. The house was big and there were many rooms whose doors stayed closed. He—and whoever else was in the house beside the servants—was avoiding her. Eerie. She wasn't welcome here. The Morales were not unfriendly and had let her take a good share of the chores, but behind them she sensed the old man wishing she would go away. At the same time, they couldn't afford to have her go. They feared the occupying armies, the "Peace Authority," as much as she did; if she were captured, their hiding place would be found. So they remained her uneasy hosts.

She had seen the old man scarcely a handful of times since the first afternoon, and never to talk to. He was in the mansion though. She heard his voice behind closed doors, sometimes talking with a woman—not Irma Morales. That female voice was strangely familiar.

God, what I wouldn't give for a friendly face right now. Someone to talk to. Angus, Fred, Paul Hoehler.

Allison slid down from her rocky viewpoint and paced angrily into the sunlight. On the coast, morning clouds still hung over the lowlands. The silver arch of the force field that enclosed Vandenberg and Lompoc seemed to float halfway up the sky. No structure could possibly be so big. Even mountains had the decency to introduce themselves with foothills and highlands. The Vandenberg bobble simply rose, sheer and insubstantial as a dream. So that glistening hemisphere contained much of her old world, her old friends. They were trapped in timelessness in there, just as she and Angus and Fred had been trapped in the bobble projected around the sortie craft. And one day the Vandenberg bobble would burst. . . .

Somewhere in the trees beyond her vision there was a cawing; a crow ascended above the pines, circled down at another point. Over the whine of insects, Allison heard padded clopping. A horse was coming up the narrow trail that went past her rock pile. Allison moved back into the shadows and watched.

Three minutes passed and a lone horseman came into view: it was a black male, so spindly it was hard to guess his age, except to say that he was young. He was dressed in dark greens, almost a camouflage outfit, and his hair was short and unbraided. He looked tired,

but his eyes swept attentively back and forth across the trail ahead of him. The brown eyes flickered across her.

"Jill! How did you get so far from the house?" The words were spoken with a heavy Spanish accent; at this point it was an incongruity beneath Allison's threshold of attention. A broad grin split the boy's face as he slid off the horse and scrambled across the rocks toward her. "Naismith says that—" the words came to an abrupt halt along with the boy himself. He stood an arm's length away, his jaw sagging in disbelief. "Jill? Is that really you?" He swung his hand in a flat arc toward Allison's midsection. The gesture was too slow to be a blow, but she wasn't taking any chances. She grabbed his wrist.

The boy actually squeaked—but with surprise, not pain. It was as if he could not believe she had actually touched him. She marched him back to the trail, and they started toward the house. She had his arm behind his back now. The boy did not struggle, though he didn't seem intimidated either. There was more shock and surprise in his eyes than fear.

Now that it was the other guy who was at a disadvantage, maybe she could get some answers. "You, Naismith, none of you have ever seen me before, yet you all seem to know me. I want to know why." She bent his arm a bit more, though not enough to hurt. The violence was in her voice.

"But, but I *have* seen you." He paused an instant, then rushed on. "In pictures, I mean."

It might not be the whole truth, but . . . perhaps it was like those fantasies Angus used to read. Perhaps she was somehow important, and the world had been waiting for them to come out of stasis. In that case their pictures might be widely distributed.

They walked a dozen steps along the soft, needle covered path. No, there was something more. These people acted as if they had known her as a person. Was that possible? Not for the boy, but Bill and Irma and certainly Naismith were old enough that she might have known them . . . before. She tried to imagine those faces fifty years younger. The servants couldn't have been more than children. The old man, he would have been around her own age.

She let the boy lead the way. She was more holding his hand than twisting his arm now; her mind was far away, thinking of the single tombstone with her name, thinking how much someone must have cared. They walked past the front of the house, descended the grade that led to a submerged entrance. The door there was open, perhaps to let in the cool smells of the morning. Naismith sat with his back to them, his attention all lost in the equipment he was playing with. Still holding his horse's reins, the boy leaned past the doorway and said, "Paul?"

Allison looked past the old man's shoulder at the screen he was watching: a horse and a boy and a woman stood looking through a doorway at an old man watching a screen that . . . Allison echoed the boy, but in a tone softer, sadder, more questioning. "Paul?"

The old man, who just last month had been young, turned at last to meet her.

* * *

23

There were few places on Earth that were busier or more populous than they had been before the War. Livermore was such a place. At its preWar zenith, there had been the city and the clusters of commercial and federal labs scattered through the rolling hills. Those had been boom times, with the old LEL managing dozens of major enterprises and a dozen dozen contract operations from their square mile reservation just outside of town. And one of those operations, unknown to the rest, had been the key to the future. Its manager, Hamilton Avery's father, had been clever enough to see what could be done with a certain staff scientist's invention, and had changed the course of history.

And so when the old world had disappeared behind silver bobbles, and burned beneath nuclear fireballs, and later withered in the war plagues —Livermore had grown. From all over the continent and then all over the planet, the new rulers had brought their best and brightest here. Except for a brief lapse during the worst of the Plague years, that growth had been near-exponential. And Peace had ruled the new world.

The heart of Authority power covered a thousand square kilometers, along a band that stretched westward toward the tiny bay towns of Berkeley and Oakland. Even the Beijing and the Paris enclaves had nothing to compare with Livermore. Hamilton Avery had wanted an Eden here. He had had forty years and the wealth and genius of the planet to make one.

But still at the heart of the heart there was the Square Mile, the original federal labs, their century-old University of California architecture preserved amidst the sweep of 1000 meter bobbles, obsidian towers and forested parks.

If the three of us are to meet, thought Avery, *what more appropriate place than here?* He had left his usual retinue on the greensward which edged the Square Mile. He and a single aide walked down the aged concrete sidewalk toward the grey building with the high narrow windows that had once held central offices.

Away from the carefully irrigated lawns and ornamental forests, the air was hot, more like the natural summer weather of the Livermore Valley. Already Avery's plain white shirt was sticking to his back.

Inside, the air-conditioning was loud and old-fashioned, but effective enough. He walked down ancient linoleum flooring, his footsteps echoing in the past. His aide opened the conference room's doors before him and Hamilton Avery stepped forward to meet—or confront —his peers.

"Gentlemen." He reached across the conference table to shake first Khim Tioulong's hand, then Christian Gerrault's. The two were not happy; Avery had kept them waiting. *And the hell of it is, I didn't mean to.* Crisis had piled on top of crisis these last few hours, to the point that even a lifetime of political and diplomatic savvy was doing him no good.

Christian Gerrault, on the other hand, never had had much time for diplomacy. His piggish eyes were even more recessed in his fat face than they had seemed on the video. Or perhaps it was

simply that he was angry: "You have a very great deal of explaining to do, Monsieur. We are not your servants, to be summoned from halfway around the world."

Then why are you here, you fat fool? But out loud he said, "Christian — Monsieur le Directeur—it is precisely because we are the men who count that we must meet here today."

Gerrault threw up a meaty arm. "Pah! The television was always good enough before."

"The 'television,' Monsieur, no longer works." The African looked disbelieving, but Avery knew Gerrault's people in Paris were clever enough to verify that the Atlantic comsat had been out of action for more than twenty-four hours. It had not been a gradual or partial failure, but an abrupt, total cessation of relayed communication.

But Gerrault simply shrugged, and his three bodyguards moved uneasily behind him. Avery shifted his gaze to Tioulong. The elderly Cambodian, Director for Asia, was not nearly so upset. K.T. was one of the originals: he had been a graduate student at Livermore before the War. He and Hamilton and some hundred others picked by Avery's father had been the founders of the new world. There were very few of them left now; every year they had to select a few more successors. Gerrault was the first director from outside the original group. *Is this the future?* He saw the same question in Tioulong's eyes. Christian was much more capable than he acted, but every year his jewels, his harems, his . . . excesses, became harder to ignore. After the old ones were gone, would he proclaim himself an emperor—or simply a god?

"K.T., Christian, you've been getting my reports. You know we have what amounts to an insurrection here. Even so, I haven't told you everything. Things have happened that you simply won't believe."

"*That* is entirely possible."

Avery ignored the interruption. "Gentlemen, our enemy has space flight."

For a long moment there was only the sighing of the air conditioning. Gerrault's sarcasm had evaporated, and it was Tioulong who raised protest. "But Hamilton, the industrial base that requires! The Peace itself has only a small, unmanned program. We saw to it that all the big launch complexes were lost during the War." He realized he was rattling on with the obvious and waited for Avery to continue.

Avery motioned his aide to lay the pictures on the table. "I know, K.T. This should be impossible. But look: a fully functional sortie craft—the type the Old USAF was flying just before the War—has crashed near the California-Aztlán border. This isn't a model or a mockup. It was totally destroyed in a fire subsequent to its landing, but my people assure me that it had just returned from orbit."

The two directors leaned forward to look at the holos. Tioulong said, "I take your word for this, Hamilton, but it could still be a hoax. I thought all those vehicles were accounted for, but perhaps there has been one in storage all these years. Granted, it is intimidating even as a hoax, but . . ."

"As you say. There is no evidence

of the vehicle's being dragged into the area—and that's heavy forest around the crash site. We are bringing as much of the wreck as we can back here for a close look. We should be able to discover if it was made since the War or if it is a refurbished model from before. We are also putting pressure on Albuquerque to search the old archives for evidence of a secret U.S. launch site."

Gerrault tipped his massive form back to look at his bodyguards. Avery could imagine his suspicion. Finally the African seemed to reach a decision. He leaned forward and said quietly. "Survivors. Did you find anyone to question?"

Avery shook his head. "There were at least two aboard. One was killed on impact. The other was killed by . . . one of our investigating teams. An accident." The other's face twisted, and Avery imagined the slow death Christian would have given those responsible for any such accident. Avery had dealt quickly and harshly with the incompetents involved, but he had gotten no pleasure from it. "There was no identification on the crewman, beyond an embroidered name tag. His flightsuit was old U.S. Air Force issue."

Tioulong steepled his fingers. "Granting the impossible, what were they up to?"

"It looks like a reconnaissance mission. We've brought the wreck back to the labs, but there is still equipment we can't identify."

Tioulong studied one of the aerial photos. "It probably came in from the north, maybe even overflew Livermore." He gave a wan smile. "History repeats. Remember that Air Force orbiter we bobbled? If they had reported what we were up to right at that critical moment . . . what a different world it would be today."

Days later Avery would wonder why Tioulong's comment didn't make him guess the truth. Perhaps it was Gerrault's interruption; the younger man was not interested in reminiscence. "This then explains why our communication satellites have failed!"

"We think so. We're trying to bring up the old radar watch we maintained through the '20s. It would help if both of you would do this, too.

"However you cut it, it seems we have our first effective opposition in nearly thirty years. Personally, I think they have been with us a long, long time. We've always ignored these 'Tinkers,' assuming that without big energy sources their technology could be no threat to us. 'Cottage industry' we called it. When I showed you how far their electronics was ahead of ours, you seemed to think they were at most a threat to my West Coast holdings.

"Now it's clear that they have a world-wide operation in some ways equal to our own. I know there are Tinkers in Europe and China. They exist most places where there was a big electronics industry before the War. You should regard them as much a threat as I do mine."

"Yes, and we must flush out the important ones and . . ." Gerrault was in his element now. Visions of extortion danced in his eyes.

"And," said Tioulong, "at the same time convince the rest of the world that the Tinkers are a direct threat to their safety. Remember that we all need

goodwill. I have direct military control over most of China, but I could never keep India, Indonesia, and Japan in line if the people at the bottom didn't trust me more than their governments. There are more than twenty million people in those holdings."

"Ah, that is your problem. You are like the grasshopper, lounging in the summer of public approval. I am the industrious ant," Gerrault looked down at his enormous torso and chuckled at the metaphor, "who has diligently worked to maintain garrisons from Oslo to Capetown. If this is 'winter' coming, I'll need no public approval." His eyes narrowed. "But I do need to know more about this new enemy of ours."

He glanced at Avery. "And I think Avery has cleverly provided us with a lever against them. I wondered why you supported their silly chess tournament in Aztlán, why you used your aircraft to transport their teams from all over the continent. Now I know: when you raided that tournament, you arrested some of the best Tinkers in the world. Oh, no doubt, just a few of them have knowledge of the conspiracy against us, but at the same time they must have many loved ones—and some of those will know more. If, one at a time, we try the prisoners for treason against Peace . . . why, I think we'll find someone who is willing to talk."

Avery nodded. He would get none of the pleasure out of the operation that Christian might. He would do the minimum that was necessary to preserve the Peace. "And don't worry, K.T., we can do it without antagonizing the rest of our people.

"You see, the Tinkers use a lot of x- and gamma-ray lithography; they need it for microcircuit fabrication. Now my public affairs people have put together a story that we've discovered the Tinkers are secretly upgrading these etching lasers for use as weapons lasers like the governments had before the War."

Tioulong smiled. "Ah. That's the sort of direct threat that should get us a lot of support. It's almost as effective as claiming they're involved in bioscience research."

"There." Gerrault raised his hands beneficently to his fellow directors. "We are all happy then. Your people are pacified, and we can go after the enemy with all vigor. You were right to call us, Avery; this is a matter that deserves our immediate and personal attention."

Avery felt grim pleasure in replying, "There is another matter, Christian, at least as important. Paul Hoehler is alive."

"The old-time mathematician you have such a fixation on? Yes, I know. You reported that in hushed and terrified tones several weeks ago."

"One of my best agents has infiltrated the Middle California Tinkers. She reports that Hoehler has succeeded—or is near to succeeding—in building a bobble generator."

It was the second bombshell he had laid on them, and in a way the greater. Spaceflight was one thing; several ordinary governments had had it before the War. But the bobble: for an enemy to have that was as unwelcome and incredible as Hell opening a chapel. Gerrault was emphatic: "Absurd. How could one old man fall on a secret we have kept so carefully all these years?"

"You forget, Christian, that *one old man* invented the bobble in the first place! For ten years after the War he moved from laboratory to laboratory, always just ahead of us, always working on ways to bring us down. Then he disappeared so thoroughly that only I of all the originals believed he was out there somewhere plotting against us. And I was right; he has an incredible ability to survive."

"I'm sorry, Hamilton, but I have trouble believing, too. There is no hard evidence here, apparently just the word of a woman. I think you always have been overly distressed by Hoehler. He may have had some of the original ideas, but it was the rest of your father's team that really made the invention possible. Besides, it takes a fusion plant and some huge capacitors to power a generator. The Tinkers could never . . ." Tioulong's voice trailed off as he realized that if you could hide space launch facilities, you could certainly do the same for a fusion reactor.

"You see?" said Avery. Tioulong hadn't been in Father's research group, couldn't realize Hoehler's polymath talent. There had been others in the project, but it had been Hoehler on all the really theoretical fronts. Of course history was not written that way. But stark after all the years, Avery remembered the rage on Hoehler's face when he realized that in addition to inventing "the monster" (as he called it), the development could never have been kept secret if he had not done the work of a labful of specialists. It had been obvious the fellow was going to report them to LEL, and Father had trusted only Hamilton Avery to silence the mathematician. Avery had not succeeded in that assignment. It had been his first—and last—failure of resolve in all these years, but it was a failure that refused to be buried.

"He's out there, K.T., he really is. And my agent is Della Lu, who did the job in Mongolia that none of your people could. What she says you can believe. . . . Don't you see where we are if we fail to act? If they have spaceflight and the bobble too, then they are our *superiors*. They can sweep us aside as easily as we did the old governments."

24

The sabios of the Ndelante Ali claimed the One True God knows all and sees all.

Those powers seemed Wili's now that he had learned to use the scalp connect. He blushed to think of all the months he had dismissed symbiotic programs as crutches for weak minds. If only Jeremy—who had finally convinced him to try—could be here to see. If only Roberto Jonque Richardson were here to be crushed.

Jeremy had thought it would take months to learn. But for Wili, it was like suddenly remembering a skill he'd always had. Even Paul was surprised. It had taken a couple days to calibrate the connector. At first, the sensations coming over the line had been subtle things, unrelated to their real significance. The mapping problem—the relating of sensation to meaning—was what took most people months. The Jill interface had been a big help with that. Wili could talk to her at the same time he experimented with the signal param-

eters, telling her what he was seeing. Jill would then alter the output to match what Wili most expected. In a week he could communicate through the interface without opening his mouth or touching the keyboard. Another couple of days and he was transferring visual information over the channel.

The feeling of power was born. It was like being able to add extra rooms to his imagination. When a line of reasoning became too complex, he could simply expand into the machine's space. The low point of every day was when he had to disconnect. He was so stupid then. Typing and vocal communication with Jill made him feel like a deafmute spelling out letters.

And every day he learned more tricks. Most he discovered himself, though some things—like concentration enhancement and Jill-programming—Paul showed him. Jill could be instructed to proceed with projects during the time when Wili was disconnected, and to store results in a form that read like personal memories when Wili was able to reconnect. Using the interface that way was almost as good as being connected all the time. At least, once he reconnected, it seemed he'd been "awake" all the time.

Paul had already programmed Jill to monitor the spy cameras that laced the hills around the mansion. When Wili was connected, he could watch them all himself. One hundred extra eyes.

Wili/Jill monitored local Tinker transmissions and the Authority's recon satellites the same way. That was where the feeling of omniscience came strongest.

Both Tinkers and Peacers were waiting—and preparing in their own ways—for the secret of generating bobbles that Paul had promised. From Julian in the South to Seattle in the North and Norcross in the East, the Tinkers were withdrawing from view, trying to get their gear under cover and ready for whatever construction Paul might tell them was necessary. In the high tech areas of Europe and China, something similar was going on—though the Peace cops were so thick in Europe it was difficult to get away with anything there. Four of that continent's self-producing design machines had already been captured or destroyed.

It was harder to tell what was happening in the world's great outback. There were few Tinkers there—in all Australia, for instance, there were less than ten thousand humans—but the Authority was spread correspondingly thin. The people in those regions had radios and knew of the world situation, knew that with enough trouble elsewhere they might overthrow the local garrisons.

Except for Europe, the Authority was taking little direct action. They seemed to realize their enemy was too numerous to root out with a frontal assault. Instead the Peacers were engaged in an all-out search to find one Paul Naismith before Paul Naismith could make good on his promises to the rest of the world.

Jill?

Yes, Wili? Nothing was spoken aloud and no keys were tapped. Input/output was like imagination itself. And when the Jill program responded, he had a fleeting impression of the face and the smile that he would have seen in the holo if he'd been talking to her the old way. Wili could have bypassed Jill;

most symbiotic programs didn't have an intermediate surrogate. But Jill was extraordinarily well written—after all, Paul had done it. Though she occupied lots of program space, she reduced the confusion Wili still felt in dealing with the flood of input. So Wili frequently left the interface running in parallel, and called her when he wanted updates on the processes she supervised.

Show me the status of the search for Paul.

Wili's viewpoint was suddenly suspended over California. Silvery traces marked the flight paths of hundreds of aircraft. He sensed the altitude and speed of every craft. The picture was a summary of all Jill had learned monitoring the Authority's recon satellites and Tinker reports over the last twenty-four hours. The rectangular criss-cross pattern was still centered over Northern California, though it was more diffuse and indecisive than on earlier days.

Wili smiled. Sending Della Lu's bug north had worked better than he'd hoped. The Peacers had been chasing their tails up there for more than a week. The satellites weren't doing them any good. One of the first fruits of Wili's new power was discovering how to disable the comm and recon satellites. At least, they appeared disabled to the Authority. Actually, the recon satellites were still broadcasting but according to an encryption scheme that must seem pure noise to the enemy. It had seemed an easy trick to Wili; once he conceived the possibility, he and Jill had implemented it in less than a day. But looking back—after having disconnected—Wili realized that it was deeper and trickier than his original method of tapping the satellites. What had taken him a winter of mind-busting effort was an afternoon's triviality now.

Of course, none of these tricks would have helped if Paul had not been very cautious all these years; he and Bill Morales had traveled great distances to shop at towns farther up the coast. Many Tinkers thought his hideout was in Northern California or even Oregon. As long as the Peacers didn't pick up any of the few people who had actually visited here—say at the NCC meeting—they might be safe for some time.

Wili frowned. There was still the greatest threat. Miguel Rosas probably did not know the location, though he must suspect it was in Middle California. But Wili was sure Colonel Kaladze knew. It could only be a matter of time before Miguel and the Lu woman ferreted out the secret. If the two were unsuccessful with subtlety, then Lu would no doubt call in the Peace goons and the effect would be the same. *Are they still on the farm?* He didn't have to specify who he meant. Jill's context parser was superb.

Yes. And there have been no outgoing calls from them. However, the ten day promise lapses tomorrow. Then Kaladze would no doubt let Lu call her "family" in San Francisco. But if she hadn't called in the army already, she must not have anything critical to report to her bosses.

Wili had not told Paul what he knew of Miguel and Lu. Perhaps he should. But after trying to tell Kaladze . . . Instead he'd been trying to identify Della Lu with independent evidence. More than ten percent of Jill's time was spent in the effort. So far he had nothing def-

inite. The story about relatives in the Bay Area appeared to be true. If he had some way of tapping Peacer communication or records things would be different. He saw now he should have disabled their recon satellites alone. If their comsats were usable, it would give them some advantage—but perhaps he could eventually break into their high crypto channels. As it was, he knew very little about what went on inside the Authority.

. . . And sometimes, he really wondered if Colonel Kaladze might be right. Wili had been half-delirious that morning on the boat; Miguel and Della had been several meters away. Was it possible he'd misinterpreted what he heard? Was it possible they were innocent after all? *No!* By the One True God, he had heard what he had heard. Start doubting your senses and you might as well resign from the world.

25

Two weeks passed, and each day brought greater change in Paul's life and in the world beyond the mountains than a normal year. Every evening, when gold still shone on the hills but the lowlands and Lake Lompoc were shrouded in blue shadows, Paul sat on his verandah and reviewed the news that Wili's electronic spies brought in from all over the world.

For Allison, it was different. Her world had turned inside out in the space of an hour. The present rate of change was frustratingly slow. She paced the stone flags, stopping occasionally to glare off into the sunset at the Vandenberg Bobble. Paul looked up from the displays and watched her. *Allison, Allison.* Few old men had dreams come quite so stunningly true. She was so young; her energy seemed to flash about her in every stride, in every quick movement of her arms. In some ways the memories of Allison lost were less hurtful than the present reality. Still, he was glad he had not succeeded in disgusing what became of Paul Hoehler.

Allison suddenly looked back at him, and smiled. "Sorry about the pacing."

"No problem. I—"

She waved toward the west. The air was so clear that—except for the lake and the coastline reflected in its base—the dome was almost invisible. "When will it burst, Paul? There were three thousand of us there the day I left. They had guns, aircraft. When will they come out?"

A month ago he would not have thought of the question. Two weeks ago he couldn't have answered. In those weeks a theory had been trashed and his new theory born. It was totally untested, but soon, soon that would change. "Uh. My answer's still guessing, Allison: The Authority technique, the only way I could think of then, is a brute force method. In that situation, the lifetime is about fifty years. Now I can represent radius or mass as a perturbation series about a fifty year decay time. The smallest bobbles the Authority made were about ten meters across. They burst first. Your sortie craft was trapped in a twenty meter bobble; it decayed a little later." Paul realized he was wandering, and tried to force his answer into the mold she must want. He thought a moment. "Vandenberg ought to last fifty-five years."

"Five more years. Damn it." She walked back across the verandah. "I guess you'll have to win without them. I was wondering why you hadn't told your friends about me—you haven't even told them that time stops inside the bobbles. I thought maybe you expected to surprise the Peacers with their long dead victims suddenly alive."

"You're close. You, me, Wili, the Morales are the only ones who know. The Authority hasn't guessed—Wili says they've carted your orbiter up to Livermore as if it were full of clues. No doubt the fools think they've stumbled on some new conspiracy. . . . But then, I guess it's not so stupid. I'll bet you didn't have any paper records aboard the orbiter."

"Right. Even our notepads were display flats. We could trash everything in seconds if we fell among unfriendlies. The fire would leave them with nothing but slagged optical memory. And if they don't have the old fingerprint archives, they're not going to identify Fred or Angus."

"Anyway, I've told the Tinkers to be ready, that I'm going to tell them how to make bobble generators. Even then, I may not say anything about the stasis effect. That's something that could give us a real edge, but only if we use the knowledge at the right time. I don't want some leak to blow it."

Allison turned as if to pace back to the edge of the verandah, then noticed the display that Paul had been studying. Her hand rested lightly on his shoulder as she leaned over to look at the displays. "Looks like a recon pattern," she said.

"Yes. Wili and Jill synthesized it from the satellites we're tapping. This shows where Authority aircraft have been searching."

"For you."

"Probably." He touched the keyboard at the margin of the flat, and the last few days' activity was displayed.

"Those bums." There was no lightness in her voice. "They destroyed our country and then stole our own procedures. Those search patterns look SOP 1997 for medium level air recon. I bet your damn Peacers never had an original thought in their lives. . . . Hmm. Run that by again." She knelt to look closely at the daily summaries. "I think today's sorties were the last for that area, Paul. Don't be surprised if they move the search several hundred klicks in the next day or two." In some ways, Allison's knowledge was fifty years dead and useless—in other ways, it could be just what they needed.

Paul gave a silent prayer of thanks to Hamilton Avery for having kept the heat on all these years, for having forced Paul Hoehler to disguise his identity and his location through decades when there would have otherwise been no reason to. "If they shift further north, fine. If they come all the way south. Hmm. We're well hidden, but we wouldn't last more than a couple days under that sort of scrutiny. Then . . ." He drew a finger across his throat and made a croaking noise.

"No way you could put this show on the road, huh?"

"Eventually we could. Have to start planning for it. I have an enclosed wagon. It may be big enough for the essential equipment. But right now, Allison . . . look, we don't yet have

anything but a lot of theories. I'm translating the physics into problems Wili can handle. With Jill, he's putting them into software as fast as he can."

"He seems to spend his time daydreaming, Paul."

Naismith shook his head. "Wili's the best." The boy had picked up symbiotic programming faster than Paul had ever seen, faster than he'd thought possible. The technique improved almost any programmer, but in Wili's case, it had turned a first rank genius into something Naismith could no longer completely understand. Even when he was linked with Wili and Jill, the details of their algorithms were beyond him. It was curious, because off the symbiosis Wili was not that much brighter than the old man. Paul wondered if he could have been that good too, if he had started young. "I think we're nearly there, Allison. With what we understand now, it ought to be possible to make bobbles with virtually no energy input. The actual hardware should be something Jill can prototype here."

Allison didn't come off her knees. Her face was just centimeters from his. "That Jill program is something. Just the motion holo for the face would have swamped our best array processors. . . . But why make it look like me, Paul? After all those years, did I really mean so much?"

Naismith tried to think of something flippant and diversionary, but no words came. She looked at him a second longer, and he wondered if she could see the young man trapped within.

"Oh, *Paul.*" Then her arms were around him, her cheek next to his.

She held him as one would something very fragile, very old.

Two days later, Wili was ready.

They waited till after dark to make the test. In spite of Paul's claims, Wili wasn't sure how big the bobble would be, and even if it did not turn out to be a monster, its mirror-like surface would be visible for hundreds of kilometers to anyone looking in the right direction in the daytime.

The three of them walked to the pond north of the house. Wili carried the bulky transmitter for his symb link. Near the pond's edge he set his equipment down and slipped on the scalp connector. Then he lit a candle and placed it on a large tree stump. It was a tiny spot of yellow, bright only because all else was so dark. A gray thread of smoke rose from the glow.

"We think the bobble will be small, but we don't want to take chances. Jill is going to make its lower edge snip the top off this candle. Then if we're wrong, and it is huge—"

"Then as the night cools, the bobble will rise and be just another floater. By morning it could be many kilometers from here." Paul nodded. "Clever . . ."

He and Allison backed farther away, Wili following. From thirty meters, the candle was a flickering yellow star on the stump. Wili motioned them to sit; even if the bobble were super large, its lower surface would still clear them.

"You don't need any power source at all?" said Allison. "The Peace Authority uses fusion generators and you can do it for free?"

"In principle, it isn't difficult—once you have the right insight, once you

know what really goes on inside the bobbles. And the new process is not quite free. We're using about a thousand joules here—compared to the gigajoules of the Authority generators. The tradeoff is in complexity. If you have a fusion generator backing you up, you can bobble practically anything you can locate. But if you're like us, with solar cells and small capacitors, then you must finesse it.

"The projection needs to be supervised, and it's no ordinary process control problem. This test is about the easiest case: The target is motionless, close by, and we only want a one meter field. Even so, it will involve—how much crunching do we need, Wili?"

"She needs thirty seconds initial at about ten billion flops, and then maybe one microsecond for 'assembly'—at something like a trillion."

Paul whistled. A *trillion* floating point operations per second! Wili had said he could implement the discovery, but Paul hadn't realized just how expensive it might be. The gear would not be very portable. And long distance or very large bobbles might not be feasible.

Wili seemed to sense his disappointment. "We think we can do it with a slower processor. It maybe takes many minutes for the setup, but you could still bobble things that don't move or are real close."

"Yeah, we'll optimize later. Let's make a bobble, Wili."

The boy nodded.

Seconds passed. Something—an owl—thuttered over the clearing, and the candle went out. Nuts. He had hoped it would stay lit. It would have been a nice demonstration of the stasis effect to have the candle still burning later on when the bobble burst.

"Well?" Wili said. "What do you think?"

"You did it!" said Paul. The words were somewhere between a question and an exclamation.

"Jill did, anyway. I better grab it before it floats away."

Wili slipped off the scalp connector and sprinted across the clearing. He was already coming back before Naismith had walked halfway to the tree stump. The boy was holding something in front of him, something light on top and dark underneath. Paul and Allison moved close. It was about the size of a large beach ball, and in its upper hemisphere he could see reflected stars, even the Milky Way, all the way down to the dark of the tree line surrounding the pond. Three silhouettes marked the reflections of their own heads. Naismith extended his hand, felt it slide silkily off the bobble, felt the characteristic bloodwarm heat—the reflection of his hand's own thermal radiation.

Wili had his arms extended around its girth, and his chin pushed down on the top. He looked like a comedian doing a mock weight lift. "It feels like it will shoot from my hands if I don't hold it every way."

"Probably could. There's no friction."

Allison slipped her hand across the surface. "So that's a bobble. Will this one last fifty years, like the one . . . Angus and I were in?"

Paul shook his head. "No. That's for big ones done the old way. Eventually, I expect to have very flexible control, only loosely related to size. How long

does Jill estimate this one will last, Wili?''

Before the boy could reply, Jill's voice interrupted from the interface box. ''There's a PANS Bulletin coming over the high speed channels. It puffs out to a thirty minute program. I'm summarizing:

''Big story about threat to the Peace. Biggest since Huachuca Plaguetime. Says the Tinkers are the villains. Their leaders were captured in La Jolla raids last month. . . . The broadcast has video of Tinker 'weapons labs,' pictures of sinister-looking prisoners. . . .

''Prisoners to be tried for Treason against the Peace, starting immediately, in Los Angeles.

''. . . all government and corporate stations must rebroadcast this at normal speed every six hours for the next two days.''

There was a long silence after she finished. Wili held up the bobble. ''They picked the wrong time to put the squeeze on *us!*''

Naismith shook his head. ''It's the worst possible time for us. We're being forced to use this,'' he patted the bobble, ''when we've barely got a proof of principle. It puts us right where that punk Avery wants us.''

26

The rain was heavy and very, very warm. High in the clouds, lightning chased itself around and around the Vandenberg dome, never coming to earth. Thunder followed the arching, cloud-smeared glows.

Della Lu had seen more rain the last two weeks than in a normal year in Beijing. It was a fitting backdrop for the dull routine of life here. If Avery hadn't finally gone for the spy trials, she would be seriously planning to escape Red Arrow hospitality—blown cover or not.

''Hey, you tired already? Or just daydreaming?'' Miguel had stopped and was looking back at her. He stood arms akimbo, apparently disgusted. The transparent rain jacket made his tan shirt and pants glint metallic even in the gray light.

Della walked a little faster to catch up. They continued in silence for a hundred meters. No doubt they made an amusing pair: two figures shrouded in rain gear, one tall, one so short. Since Wili's ten day ''probation period'' had lapsed, the two of them had taken a walk every day. It was something she had insisted on, and—for a change—Rosas hadn't resisted. So far she had snooped as far north as Lake Lompoc and east to the ferry crossing. Without Miguel, her walks would've had to be with the womenfolk. That would have been tricky. The women were *protected*, and had little freedom or responsibility. She spent most of every day with them, doing the light manual labor that was considered appropriate to her sex. She had been careful to be popular, and she had learned a lot, but all local intelligence. Just as with families in San Francisco, the women were not privy to what went on in the wider world. They were valued, second-class citizens. Even so, they were clever; it would have been difficult to look in the places that really interested her, and not raise their suspicions.

Today was her longest walk, up to the highlands that overlooked Red Ar-

row's tiny sea landing. Despite Miguel's passive deceptions, she had put together a pretty good picture of Old Kaladze's escape system. At least she knew its magnitude and technique. It was a small payoff for the boredom and the feeling that she was being held offstage from events she should be directing.

All that could change with the spy trials. If she could just light a fire under the right people. . . .

The timbered path went back and forth across the hill they climbed. There were many repairs, and several looked quite recent, yet there were also washouts. It was like most things among the Tinkers. Their electronic gadgets were superlative (though it was clear now that the surveillance devices Avery had discovered were rare and expensive items among the Tinkers; they didn't normally spy on each other). But they were labor poor, and without power equipment, things like road maintenance and laundry were distinctly nineteenth century. (And Della had the calluses to prove it.)

Finally they reached the view point. A steady breeze swept across the hill, blowing the rain into their faces. There was only one tree at the top, though it was a fine, large conifer growing from the highest point. There was some kind of platform about halfway up.

Rosas put his arm across her shoulder, urging her toward the tree. "They had a tree house up here when I was a kid. There ought to be a good view."

Wood steps were built into the tree trunk. She noticed a heavy metallic cable that followed the steps upward. Electronics even here? Then she realized that it was a lightning guide. The Tinkers were very careful with their children.

Seconds later they were on the platform. The cabin was clean and dry with soft padding on the floor. There was a view south and west, somehow contrived to keep out the wind and rain. They shrugged out of their rain jackets, and sat for a moment enjoying the sound of wet that surrounded this pocket of dry comfort. Miguel crawled to the south facing window. "A lot of good it will do you, but there it is."

The forested hills dropped away from the view point. The coast was about four kilometers away, but the rain was so thick that she had only a vague impression of sand dunes and marching surf. It looked like there was a small breakwater, but no boats at anchor. The landing was not actually on Red Arrow property, but they used it more than anyone else. Miguel claimed that more people came to the farm from the ocean than overland. Della doubted that. It sounded like another little deception.

The undersheriff backed away from the opening and leaned against the wall beside her. "Has it really been worth it, Della?" There was a faint edge in his voice. It was clear by now that he had no intention of denouncing her—and implicating himself at the same time. But he was not hers. She had dealt with traitors before, men whose self-interest made them simple, reliable tools. Rosas was not such. He was waiting for the moment when the damage he could do her would be greatest. Till then he played the role of reluctant ally.

Indeed, had it been worth the trouble? He smiled, almost triumphantly. "You've been stuck here for more than

two weeks. You've learned a little bit about one small corner of the ungoverned lands, and one group of Tinkers. I think you're more important to the Peacers than that. You're like a high value piece voluntarily taken out of the game."

Della smiled back. He was saying aloud her own angry thoughts. The only thing that had kept her going was the thought that just a little more snooping might ferret out the location of Paul Hoehler/Naismith. It had seemed such an easy thing. But she gradually realized that Miguel—and almost everyone else—didn't know where the old man lived. Maybe Kaladze did, but she'd need an interrogation lab to pry it out of him. Her only progress along that line had been right at the beginning, when she tagged the black boy's horse with a tracer.

Halleluja, all that had changed. There was a chance now that she was in the best of strategic positions.

Miguel's eyes narrowed, and Della realized he sensed some of her triumph. *Damn*. They had spent too much time together, had too many conversations that were not superficial. His hand closed on her upper arm and she was pulled close to his face. "Okay. What is it? What are you going to spring on us?" Her arm suddenly felt as though trapped in a vise.

Della suppressed reflexes that would have left him gargling on a crushed windpipe. Best that he think he had the age-old macho edge. She pretended shocked speechlessness. How much to say? When they were alone, Miguel often spoke of her real purpose at Red Arrow. She knew he wasn't trying to compromise her to hidden listeners—he could do that directly whenever he chose. And he knew Red Arrow so well, it was unlikely they would be bugged without his knowledge. So the only danger was in telling him too much, in giving him the motive to blow the whole game. But maybe she should tell him a little; if it all came as a surprise, he might be harder to control. She tried to shrug. "I've got a couple 'maybes' going for me. Your friend Hoehler — Naismith—says he has a prototype bobble generator. Maybe he does. In any case, it will be a while before the rest of you can build such. In the meantime, if the Peace can throw you off balance, can get you and Naismith to overextend yourselves . . ."

"The trials."

"Right." She wondered what Miguel's reaction would be if he knew that she had recommended immediate treason trials for the La Jolla hostages. He'd made sure there were Kaladzes in earshot when she was allowed to call her family in San Francisco. She had sounded completely innocent, just telling her parents that she was safe among the Middle California Tinkers, though she mustn't say just where. No doubt Rosas guessed that some sort of pre-arranged signal scheme was being used, but he could never have known how elaborate it was. Tone codes were something that went right by native speakers of English. "The trials. If they could be used to panic Kaladze and his friends, we might get a look at Naismith's best stuff before it can do the Peace any real harm."

Miguel laughed, his grip relaxing slightly. "*Panic* Nikolai Sergeivich?

You might as well think to panic a charging bear."

Della did not fully plan what she did next, and that was very unusual for her. Her free hand move up behind his neck, caressing the short cut hair. She raised herself to kiss him. Rosas jerked back for an instant, then responded. After a moment, she felt his weight on her and they slid to the soft padding that covered the floor of the tree house. Her arms roamed across his neck and wide shoulders and the kiss continued.

She had never before used her body to ensure loyalty. It had never been necessary. It certainly had never before been an attractive prospect. And it was doubtful it could do any good here. Miguel had fallen to them out of honor; he could not rationalize the deaths he had caused. In his way, he was as unchangeable as she.

One of his arms wrapped around her back while his free hand pulled at her blouse. His hand slid under the fabric, across her smooth skin, to her breasts. The caresses were eager, rough. There was rage . . . and something else. Della stretched out against him, forcing one of her legs between his. There was little intelligible discussion for many minutes after that.

. . . Lightning played its ring dance along the dome that towered so high above them. When the thunder paused in its following march, they could hear the *shish* of warm rain continue all around.

Rosas held her gently now, his fingers slowly tracing the curve of her hip and waist. "What do you get out of being a Peace cop, Della? If you were one of the button-pushers, sitting safe and cozy up in Livermore, I could understand. But you've risked your life stooging for a tyranny, and turning me into something I never thought I'd be. Why?"

Della watched the lightning glow in the rain. She sighed. "Mike, I am for the Peace. Wait. I don't mean that as rote Authority mumbo-jumbo. We *do* have something like peace all over the world now. The price is a tyranny, though milder than any in history. The price is twentieth-century types like me, who would sell their own grandmothers for an ideal. Last century produced nukes and bobbles and warplagues. You have been brushed by the plagues—that alone is what turned you into 'something you never thought you'd be.' But the others are just as bad. By the end of the century, those weapons were becoming cheaper and cheaper. Small nations were getting them. If the War hadn't come, I'll bet subnational groups and criminals would have had them. The human race could not survive mass death technology so widely spread. The Peace has meant the end of sovereign nations and their control of technologies that could kill us all. Our only mistake was in not going far enough. We didn't regulate high-tech electronics—and we're paying for that now."

The other was silent, but the anger was gone from his face. Della came to her knees and look around. She almost laughed. It looked as if a small bomb had gone off in the tree house; their clothes were thrown all across the floor pads. She began dressing. After a moment, so did Miguel. He didn't speak until they had on their rainslickers, and had raised the trap door.

He grinned lopsidedly and stuck his hand out to Della. "Enemies?" he said.

"For sure." She grinned back, and they shook on it.

And even as the climbed out of the tree, she was wondering what it would take to move Old Kaladze. Not panic; Miguel was right about that. What about shame? Or anger?

Della's chance came the next day. The Kaladze clan had gathered for lunch, the big meal of the day. As expected of a woman, Lu had helped with the cooking and laying out of the dinnerware, and the serving of the meal. Even after she was seated at the long, heavily laden table, there were constant interruptions to go out and get more food, or replace this or that item. This was typical of modern families—in North America and China, at least. There were so few people, and the birthrate was so low, that it was customary to flaunt a crowd at a mealtime. Even Peacer families did it.

The Authority channels were full of the 'Treason against Peace' trials that Avery was staging in LA. Already there had been some death sentences. She knew Tinkers all across the continent were in frantic communication, and there was an increasing sense of dread. Even the women felt it. Naismith had announced his prototype bobble generator. A design had also been transmitted. Unfortunately, the only working model depended on processors and programs that would take the rest of the world weeks to grow. And even then, there were problems with the design that would cost still more time to overcome.

The menfolk took these two pieces of news and turned lunch into a debate. It was the first time she had seen them talk policy at a meal; it showed how critical the situation was. In principle the Tinkers now had the same ultimate weapon as the Authority. But the weapon was no good to them yet. In fact, if the Authority learned about it before the Tinkers had generators in production, it might precipitate the military attack they all feared. So what should be done about the prisoners in Los Angeles?

Lu sat quietly through fifteen minutes of this, until it became clear that caution was winning and the Kaladzes were going to keep a low profile until they could safely take advantage of Naismith/Hoehler's invention. Then she stood up with a shrill, inarticulate shout. The dining hall was instantly silent. The Kaladzes looked at her with shocked surprise. The woman sitting next to her made fluttering motions for her to sit down. Instead, Della shouted down the long table, "You cowardly *fools!* You would sit here and dither while they execute our people one by one in Los Angeles. You have a weapon now, this bobble generator. And even if you are not willing to risk your own necks, there are plenty of noble houses in Aztlán that are; at least a dozen of their senior sons were taken in La Jolla."

At the far end of the table, Nikolai Sergeivich came slowly to his feet. Even at that distance, he seemed to tower over her diminutive 155 centimeters. "Miss Lu. It is not we who have the bobble generator, but Paul Naismith. You know that he has only one, and that it is not completely practical. He won't give us—"

Della slammed the flat of her hand on the table, the pistol-shot noise cutting the other off and dragging everyone's

attention back to her. "Then *make him!* He can't exist without you. He must be made to understand that our own flesh and blood are at stake here—" She stepped back from the table and looked them all up and down, then put surprise and scorn on her face. "—but that's not true of you, is it? *My own brother is one of the hostages.* But to you, they are merely fellow Tinkers."

Under his stubbly beard, Kaladze's face became very pale. Della was taking a chance. Publicly disrespectful women were rare here, and when they surfaced—even as guests—they could expect immediate expulsion. But Della had gone a calculated distance *beyond* disrespect. She had attacked their courage, their manhood. She had spoken aloud of the guilt which—she hoped—was lying just below their caution.

Kaladze found his voice, and said, "You are wrong, Madam. They are not *merely* fellow Tinkers, but our brothers too." And Della knew she had won. The Authority would get a crack at that bobble generator while it was still easy pickings.

She sat meekly down, her eyes cast shyly at the table. Two large tears started down her cheeks. But she said nothing more. Inside, a cheshire cat smile spread from ear to ear: for the victory, and for the chance to get back at them for all the days of dumb servility. From the corner of her eye, she saw the stricken look on Miguel's face. She had guessed right there, too. He would say nothing. He knew she lied, but those lies *were* a valid appeal to honor. He was caught, even knowing, in the trap with the others.

27

Aztlán encompassed most of what had been Southern and Baja California. (It also claimed much of Arizona, though this was sharply disputed by the Republic of New Mexico.) In fact, Aztlán was a loose confederation of local rulers, each with immense estates.

Perhaps it was the challenge of the Authority Enclave in old Downtown, but nowhere in Aztlán were the castles grander than in North Los Angeles. And of those castles, that of the Alcalde del Norte was a giant among giants.

The carriage and its honor guard moved quickly up the well-maintained old world road that led to El Norte's main entrance. In the darkened interior, a single passenger—one Wili Wachendon—sat on velvet cushions and listened to the *clopclop* of the carriage team and outriders. He was being treated like a lord. (Well, not quite. He couldn't get over the look of stunned surprise on the faces of the Aztlán troops when they saw the travel-grimed black kid they were to escort from Ojai to LA.) He looked through tinted bullet-proof glass at things he had never expected to see—by daylight anyway. On the right, the hill rose sheer, pocked every fifty meters by machine gun nests; on the left, he saw a pike fence half-hidden in the palms. He remember such pikes, and what happened to unlucky burglars.

Beyond the palms, Wili could see much of the Basin. That was as big as some countries, and—not even counting the Authority personnel in the Enclave—there were more than eighty

thousand people out there, making it one of the largest cities on Earth. By now, midafternoon, the wood and petroleum cooking stoves of that population had raised a pall of darkish smoke that hung just under the temperature inversion and made it impossible to see the far hills.

They reached the southern ramparts, and the hoofbeats came clickety off flagstones. They rolled by a long building fronted with incredible sweeps of perfectly matched plate glass. There was not a bullet hole or shatter star to be seen. No enemy had reached this level in many years. The Alcalde had firm control of the land for kilometers on every side.

The carriage turned inward, and retainers rushed to slide the glass walls open. Wagon, horses, and guard continued inward, past more solid walls; this meeting would take place beyond sight of spying eyes. Wili gathered his equipment. He slipped on the scalp connector, but it was scant comfort. His processor was programmed for one task, and the interface gave him none of the omniscience he felt when working with Jill. He would be facing his old enemies with scarcely more than he'd had before.

Wili felt like a chicken at a fox convention. But there was a difference, he kept telling himself. He smiled at the collected foxes and set his dusty gear on the glistening floor: *this* chicken laid bobbles.

He stood in the middle of the Alcalde's hall of audience, alone there except for the two stewards who had brought him the last hundred meters from the carriage. Four Jonques sat on a dais five meters away. They were not the most titled nobles in Aztlán—though one of them was the Alcalde—but he recognized the embroidery on their jackets. These were men the Ndelante Ali had never dared to burgle.

To the side, subordinate but not cringing, stood three very old Blacks. Wili recognized Ebenezer, Pasadena Sabio of the Ndelante, a man so old and set in his ways that he had never even learned Spanish. He needed interpreters to convey his wishes to his own people. Of course, this increased his appearance of wisdom. As near as could be over such a large area, these seven men ruled the Basin and the lands to the east—ruled all but the Downtown and the Authority Enclave.

Wili's impudence was not lost on the foxes. The youngest of the Jonque lords leaned forward to look down upon him. "*This* is Naismith's emissary? With *this* we are to bobble the Downtown, and rescue our brothers? It's a joke."

The youngest of the Blacks—a man in his seventies—whispered in Ebenezer's ear, probably translating the Jonque's comments into English. The Old One's glance was cold and penetrating, and Wili wondered if Ebenezer remembered all the trouble a certain scrawny burglar had caused the Ndelante.

Wili bowed low to the seated noblemen. When he spoke it was in standard Spanish with what he hoped was a Middle California accent. It would be best to convince these people that he was not a native of Aztlán. "My Lords and Wiseones, it is true that I am a mere messenger, a mere technician. But I have Naismith's invention here with me, I know how to operate it, and I

know how it can be used to free the Authority's prisoners."

The Alcalde, a pleasant looking man in his fifties, raised an eyebrow and said mildly, "You mean your companions are carrying it—disassembled perhaps?"

Companions? Wili reached down and opened his pack. "No, My Lord," he said, withdrawing the generator and processor, "This is the bobbler. Given the plans that Paul Naismith has broadcast, the Tinkers should be able to make these by the hundreds within six weeks. For now this is the only working model." He showed the ordinary looking processor box around. Few things could look less like a weapon, and Wili could see the disbelief growing on their faces. A demonstration was in order. He concentrated briefly to let the interface know the parameters.

Five seconds passed and a perfect silver sphere just—appeared—in the air before Wili's face. The bobble wasn't more than ten centimeters across, but it might have been ten kilometers for the reaction of his audience. He gave it the lightest of pushes, and the sphere—weighing exactly as much as an equivalent volume of air—drifted across the hall toward the nobles. Before it had traveled a meter, air currents had deflected it. The youngest of the Jonques, the loud-mouthed one, shed his dignity and jumped off the dais to grab at the bobble.

"By God, it's real!" he said as he felt its surface.

Wili just smiled and imaged another command sequence. A second and a third sphere floated across the room. For bobbles this size, where the target was close by and homogeneous, the computations were so simple he could generate an almost continuous stream. For a few moments his audience lost some of its dignity.

Finally Old Ebenezer raised a hand, and said to Wili in English, "So, Boy, you have all the Authority has. You can bobble all Downtown, and we go in and pick up the pieces. All their armies won't stand up to this."

Jonque heads jerked around, and Wili knew they understood the question. Most of them understood English as well as Spañolnegro—though they usually pretended otherwise. He could see the processors humming away in their scheming minds: With this weapon, they could do a good deal more than rescue the hostages and boot the Authority out of Aztlán. If the Peacers were to be replaced, why shouldn't it be by them? And—as Wili had admitted—they had a six weeks head start on the rest of the world.

Wili shook his head. "No, Wiseone. You'd need more power—though still nothing like the fusion power the Authority uses. But even more important, this little generator isn't fast enough. The biggest it can make is about four hundred meters across, and to do that takes special conditions and several minutes setup time."

"Bah. So it's a toy. You could decapitate a few Authority troopers with it maybe, but when they bring out their machine guns and their aircraft you are dead." Señor Loudmouth was back in form. He reminded Wili of Roberto Richardson. Too bad this was going to help the likes of them.

"*It's no toy*, My Lord. If you follow the plan Paul Naismith has devised, it

can rescue all the hostages." Actually it was a plan that Wili had thought of after the first test, when he had felt Jill's test bobble sliding around in his arms. But it would not do to say the scheme came from anyone less than Paul. "There are things about bobbles that you don't know yet, that no one, not even the Authority, knows yet."

"And what are those things, sir?" There was courtesy without sarcasm in the Alcade's voice.

Across the hall, a couple entered the room. For an instant all Wili could see was their silhouettes against the piped sky light. But that was enough. "You two!" Miguel looked almost as shocked as Wili felt, but Lu just smiled.

"Kaladze's representatives," the Alcalde supplied.

"By the One God, no! These are the Authority's representatives!"

"See here," it was Loudmouth, "these two have been vouched for by Kaladze, and he's the fellow who got this all organized."

"I'm not saying anything with them around."

Dead silence greeted this refusal, and Wili felt sudden, physical fear. The Jonque lords had very interesting rooms beneath their castles, places with . . . effective . . . equipment for persuading people to talk. This was going to be like the confrontation with the Kaladzes, only bloodier.

The Alcalde said, "I don't believe you. We've checked the Kaladzes carefully. We've even dismissed our own court so that this meeting would involve just those with the need to know. But—" he sighed, and Wili saw that in some ways he was more flexible (or less trusting, anyway) than Nikolai Sergeivich, "—perhaps it would be safer if you only spoke of what must be done, rather than the secrets behind it all. Then we will judge the risks, and decide if we must have more information just now."

Wili looked at Rosas and Lu. Was it possible to do this without giving away the secret—at least until it was too late for the Authority to counter it? Perhaps. "Are the hostages still being held on the top floor of the Tradetower?"

"The top two floors. Even with aircraft, an assault would be suicide."

"Yes, My Lord. But there is another way. I will need forty Julian-33 storage cells—" other brands would do, but he was sure the Aztlán make was available, "—and access to your weather service. Here is what you have to do . . ." It wasn't until several hours later that Wili looked back and realized that the cripple from Glendora had been giving orders to the rulers of Aztlán and the wisemen of the Ndelante Ali. If only Uncle Sly could have seen it.

Late afternoon the next day:

Wili crouched in the tenement ruins just east of the Downtown, and studied the display. It was driven by a telescope the Ndelante had planted on the roof. The day was so clear that the view might have been from a hawk hovering on the outskirts of the Enclave. Looking into the canyons between those buildings, Wili could see dozens of automobiles whisking Authority employees through the streets. Hundreds of bicycles—property of lower ranking people—moved more slowly along the margins of the streets. And the pedestrians: there were actually crushes of people on the

sidewalks by the larger buildings. An occasional helicopter buzzed through the spaces above. It was like some vision off an old video disk, but this was *real* and happening right now, one of the few places on Earth where the bustling past still lived.

Wili shut down the display and looked up at the faces—both Jonque and Black—that surrounded him. "That's not too much help for this job. Winning is going to depend on how good your spies are."

"They're good enough." It was Ebenezer's sour-faced aide. The Ndelante Ali was a big organization, but Wili had a dark suspicion that the fellow recognized him from before. Getting home to Paul would depend on keeping his 'friends' here intimidated by Naismith's reputation and gadgets. "The Peacers like to be served by people as well as machines. The Faithful have been in the Tradetower as late as this morning. The hostages are all on the top two floors. The next two floors are empty and alarm-ridden, and below that is at least one floor full of Peace Troopers. The utility core is also occupied, and you notice there is a helicopter and fixed-wing patrol. You'd almost think they're expecting a twentieth century armored assault, and not—"

And not one scrawny teenager and his miniature bobble blower. Wili silently completed the other's dour implication. He glanced at his hands: skinny maybe, but if he kept gaining weight as he had been these last weeks, he would soon be far from scrawny. And he felt like he could take on the Authority and the Jonques and the Ndelante Ali all at once. Wili grinned at the sabio. "What I've got is more effective than tanks and bombs. If you're sure exactly where they are, I'll have them out by nightfall." He turned to the Alcalde's man, a mild-looking old fellow who rarely spoke but got unnervingly crisp obedience from his men. "Were you able to get my equipment upstairs?"

"Yes, sir." *Sir!*

"Let's go then." They walked back into the main part of the ruin, carefully staying in the shadows and out of sight of the aircraft that droned overhead. The tenement had once been thirty meters high, with row on row of external balconies looking west. Most of the facing had long ago collapsed, and the stairwells were exposed to the sky. The Alcalde's man was devious, though. Two of the younger Jonques had climbed an interior elevator shaft and rigged a sling to hoist the gear and their elders to the fourth storey vantage point that Wili required.

One by one, Ndelante and Jonques ascended. Wili knew such cooperation between the blood enemies would have been a total shock to most of the Faithful. These groups fought and killed under other circumstances—and used each other to justify all sorts of sacrifices from their own people. Those struggles were real and deadly, but the secret cooperation was real, too. Two years earlier, Wili had chanced on that secret; it was what finally turned him against the Ndelante.

The fourth floor hallway creaked ominously under their feet. Outside it had been hot; in here it was like some dark oven. Through holes in the ancient linoleum, Wili could see into the wrecks of rooms and hallways below. Similar

holes in the ceiling provided the hallway's only light. One of the Jonques opened a side door and stood carefully apart as Wili and the Ndelante people entered.

More than a half-tonne of Julian-33 storage cells was racked against an interior wall. The balcony side of the room sagged precariously. Wili unpacked the processor and the bobble generator, and set about connecting them to the Julians. The others squatted by the wall or in the hallway beyond. Rosas and Lu were here; Kaladze's representatives could not be denied, though Wili had managed to persuade the Alcalde's man to keep them—especially Della—away from the equipment, and away from the window.

Della looked up at him and smiled a strange, friendly smile; strange because no one else was looking to be taken in by the lie. *When will she make her move?* Would she try to signal to her bosses, or somehow steal the equipment herself? Last night, Wili had thought long and hard about how to defeat her. He had the self-bobbling parameters all ready. Bobbling himself and the equipment would be a last resort, since the current model didn't have much flexibility—he would be taken out of the game for about a year. More likely, one of them was going to end up very dead this day, and no wistful smile could change that.

He dragged the generator and its power eables and camouflage bag close to the ragged edge of the balcony. Under him the decaying concrete swayed like a tiny boat. It felt as if there was only a single support spar left. *Great.* He centered his equipment over the imagined spar, and calibrated the mass and ranging sensors. The next minutes would be the critical. In order that the computation be feasibly simple, the generator had to be clear of obstacles. But this made their operation relatively exposed. If the Authority had had anything like the Paul's surveillance equipment, the plan would not have stood a chance.

Wili wet his finger and held it into the air. Even here, almost out of doors, the day was stifling. The westerly breeze barely cooled his finger. "How hot is it?" he asked unnecesarily; it was obviously hot enough.

"Outside air temperature is almost 37. That's about as hot as it ever gets in LA, and it's the high for today."

Wili nodded. *Perfect.* He rechecked the center and radius coordinates, started the generator's processor, and then crawled back to the others by the inner wall. "It takes about five minutes. Generating a large bobble from two thousand meters is almost too much for this processor."

"So," Ebenezer's man gave him a sour smile, "you are going to bobble something. Are you ready to share the secret of just what? Or are we simply to watch and learn?"

On the far side of the room, the Alcalde's man was silent, but Wili sensed his attention. Neither they nor their bosses could imagine the bobble being used as anything but an offensive weapon. They were lacking one critical fact, a fact that would become known to all—including the Authority—very soon.

Wili glanced at his watch: two minutes to go. There was no way he could imagine Della preventing the rescue

now. And he had some quick explaining to do, or else—when his allies saw what he had done—he might have deadly problems. "Okay," he said finally. "In ninety seconds, my gadget is going to throw a bobble around the top floors of the Tradetower."

"What?" The question came from four mouths, in two languages. The Alcalde's man, so mild and respectful, was suddenly at his throat. He held up his hand briefly as his men started toward the equipment on the balcony. His other hand pressed against Wili's windpipe, just short of pain, and Wili realized that he had seconds to convince him not to topple the generator into the street. "The bobble will . . . pop . . . later. . . . Time . . . stops inside," choked Wili. The pressure on his throat eased; the goons edged back from the balcony. Wili saw Jonque and sabio trade glances. There would have to be a lot more explanations later, but for now they would cooperate.

A sudden, loud *click* marked the discharge of the Julians. All eyes looked westward through the opening that once held a sliding glass door. Faint *"ah's"* escaped from several pairs of lips.

The top of the Tradetower was in shadow, surmounted and dwarfed by a four hundred meter silver sphere.

"The building, it must collapse," someone said. But it didn't. The bobble was only as massive as what it enclosed and that was mostly empty air. There was a long moment of complete silence, broken only by the far, tiny wailing of sirens. Wili had known what to expect, but even so it took an effort to tear his attention from the sky and surreptitiously survey the others.

Lu was staring wide-eyed as any; even her schemes were momentarily submerged. But Rosas: The undersheriff looked back into Wili's gaze, a different kind of wonder on his face, the wonder of a man who suddenly discovers that some of his guilt is just a bad dream. Wili nodded faintly at him. *Yes, Jeremy is still alive, or at least will someday live again. You did not murder him, Miguel.*

In the sky around the Tradetower, the helicopters swept in close to the silver curve of the bobble. From further up they could hear the whine of the fixed-wing patrol spreading in greater and greater circles around the Enclave. They had stepped on a hornets' nest and now those hornets were doing their best to decide what had happened and to deal with the enemy. Finally, the Jonque chief turned to the Ndelante sabio. "Can your people get us out from under all this?"

The Black cocked his head, listening to his ear phone, then replied, "Not till dark. We've got a tunnel head about two hundred meters from here, but the way they're patrolling, we probably couldn't make it. Right after sunset, before things cool off enough for their heat eyes to work good, that'll be the best time to sneak back. Till then we should stay away from windows and keep quiet. The last few months they've improved. Their snooper gear is almost as good as ours now."

The lot of them—Blacks, Jonques, and Lu—moved carefully back into the hallway. Wili left his equipment sitting near the edge of the balcony; it was too risky to retrieve it just now. Fortunately,

its camouflage bag resembled the nondescript rubble that surrounded it.

Wili sat with his back against the door. No one was going to get to the generator without his knowing it.

From in here, the sounds of the Enclave were fainter, but soon he heard something ominous and new: the rattle and growl of tracked vehicles.

After they were settled, and lookouts had been posted at the nearest peepholes, the sabio sat beside Wili and smiled. "And now, young friend, we have hours to sit, time for you to tell us just what you meant when you said that the bobble will burst, and that time stops inside." He spoke quietly, and—considering the present situation—it was a reasonable question. But Wili recognized the tone. On the other side of the hallway, the Alcalde's man leaned forward to listen. There was just enough light in the musty hall for Wili to see the faint smile on Lu's face.

He must mix truth and lies just right. It would be a long afternoon.

28

The hallway was brighter now. As the sun set, its light came nearly horizontal through the rips near the ceiling and splashed bloody light down upon them. The air patrols had spread over a vast area, and the nearest tanks were several thousand meters away; Ebenezer's man had coordinated a series of clever decoy operations—the sort of thing Wili had seen done several times against the Jonques.

"¡*Del Nico Dio!*" It was almost a shriek. The lookout at the end of the hall jumped down from his perch. "It's happening. Just as he said. It's *flying!*"

Ebenezer's sabio made angry shushing motions, but the group moved quickly to the opening, the sabio and chief Jonque forcing their way to the front. Wili crawled between them and looked through one of the smaller chinks in the plaster and concrete: The evening haze was red. The sun sat half-dissolved in the deeper red beyond the Enclave towers.

And hanging just above the skyline was a vast new moon, a dark sphere edged by a crescent of red: the bobble had risen off the top of the Tradetower and was slowly drifting with the evening breeze toward the west.

"Mother of God," the Alcalde's man whispered to himself. Even with understanding, this was hard to grasp. The bobble, with its cargo of afternoon air, was lighter than the evening air around it—was the largest hot air balloon in history. And sailing into the sunset with it went the Tinker hostages. The noise of aircraft came louder, as the hornets returned to their nest and buzzed around this latest development. One of the insects strayed too close to the vast smooth arc. Its rotor shattered; the helicopter fell away, turning and turning.

The sabio glanced down at Wili. "You're sure it will come inland?"

"Yes. Uh, Naismith studied the wind patterns very carefully. It's just a matter of time—weeks at most—before it grounds in the mountains. The Authority will know soon enough—along with the rest of the world—the secret of the bobbles, but they won't know just when this one will burst. If the bobble ends up far enough away, the other problems

we are going to cause them will be so big they won't post a permanent force around it. Then, when it finally bursts . . ."

"I know, I know. When it finally bursts we're there to rescue them. But ten years is long to sleep."

It would actually be one year. That had been one of Wili's little lies. If Lu and the Peacers didn't know the potential for short-lived bobbles, then—

It suddenly occurred to him that Della Lu was no longer in his sight. He turned quickly from the wall and looked down the hallway. But she and Rosas were still there, sitting next to a couple of Jonque goons who had not joined the crush at the peephole. "Look, I think we should try to make it back to the tunnel now. The Peacers have plenty of new problems, and it's pretty dark down in the street."

Ebenezer's man smiled. "Now what would you know about evading armed men in the Basin?" More than ever Wili was sure the sabio recognized him, but for now the other was not going to make anything of it. He turned to the Jonque chief. "The boy's probably right."

Wili retrieved the generator, and one by one they descended via the rope sling to the ruined garages below the apartment house. The last man slipped the rope from its mooring, and the Blacks spent several minutes removing all ground level signs of their presence. The Ndelante were careful and skilled. There were ways of covering tracks in the ruins, even of restoring the patina of dust in ancient rooms. For forty years the depths of the LA Basin had been the ultimate fortress of the Ndelante; they knew their own turf.

Outside, the evening cool had begun. Two of the sabio's men moved out ahead, and another two or three brought up the rear. Several carried night scopes. It was still light enough to read by; the sky above the street was soft red with occasional patches of pastel blue. But it was darkening quickly, and the others were barely more than shadows. Wili could sense the Jonques' uneasiness. Caught at nightfall deep in the ruins would normally mean the death of them. The high-level conniving between the Ndelante and the bosses of Aztlán did not ordinarily extend down to these streets.

Their point men led them through piles of fallen concrete; they never actually stepped out into the open street. Wili hitched up his pack and fell back slightly, keeping Rosas and Lu ahead of him. Behind him, he could hear the Jonque chief and—much quieter—Ebenezer's sabio.

Out of the buzzing of aircraft, the sound of a single helicopter came louder and louder. Wili and the others froze, crouching down in silence. The craft was closer, closer. The *thwup thwupthwup* of its rotors was loud enough so that they could almost feel the overpressures. It was going to pass directly over them. This sort of thing had happened every twenty minutes or so during the afternoon, and should be nothing to worry about. Wili doubted if even observers on the rooftops could have spotted them here below. But this time—

As the copter passed over the roofline a flash of brilliant white appeared ahead of Wili. *Lu!* He had been worried she was smuggling some sophisticated ho-

mer, and here she was betraying them with a simple handflash!

The helicopter passed quickly across the street. But even before its rotor tones changed and it began to circle back, Wili and most of the Ndelante were already heading for deeper hidey holes. Seconds later, when the aircraft passed back over the street, it really was empty. Wili couldn't see any of the others, but it sounded as if the Jonques were still rushing madly about, trying to find some way out of the jagged concrete jungle. A monstrously bright light swept back and forth along the street, throwing everything into stark blacks and whites.

As Wili had hoped, the searchlight was followed seconds later by rocket fire. The ground rose and fell under him. Faint behind the explosions, Wili could hear shards of metal and stone nickering back and forth between concrete piles. There were screams.

Heavy dust rose from the ruins. This was his best chance: Wili scuttled back a nearby alley, ignoring the haze and the falling rocks. Another half minute and the enemy would be able to see clearly again, but by then Wili (and probably the rest of the Ndelante) would be a hundred meters away, and moving under much greater cover than he had right here.

An observer might think he ran in mindless panic, but in fact Wili was very careful, watching for any sign of an Ndelante trail. For more than forty years the Ndelante had been the *de facto* rulers of these ruins. They used little of it for living space, but they mined most of the vast basin, and everywhere they went they left subtle improvements —escape hatches, tunnels, food caches—that weren't apparent unless one knew their marking codes. After less than twenty meters, Wili had found a marked path, and now ran at top speed through terrain that would have seemed impassable to anyone standing more than a few meters away. Some of the others were escaping along the same path: Wili could hear at least two pairs of feet some distance behind him, one heavy Jonque feet, the others barely audible. He did not slow down; better that they catch up.

The chopper pilot had lifted out of the space between the buildings and fired no more. No doubt the initial attack had not been to kill, but to jar his prey into the open. It was a decent strategy against any but the Ndelante.

The pilot flew back and forth now, lobbing stun bombs. They were so far away that Wili could barely feel them. In the distance, he heard the approach of more aircraft. Some of them sounded big. Troop carriers. Wili kept running. Till the enemy actually landed, it was better to run than to search for a good hiding place. He might even be able to get out of the drop area.

Five minutes later, Wili was nearly a kilometer away. He moved through a burned-out retail area, from cellar to cellar, each connected to the next by subtle breaks in the walls. His equipment pack had come loose and the whole thing banged painfully against him when he tried to move really fast. He stopped briefly to tighten the harness, but that only made the straps cut into his shoulders.

In one sense he was lost: he had no idea where he was, or how to get to the pickup point the Ndelante and the Jon-

ques had established. On the other hand, he knew which direction he should run *from*, and—if he saw them—he could recognize the clues that would lead to some really safe hole that the Ndelante would look into after all the fuss died down.

Two kilometers run. Wili stopped to adjust the straps again. Maybe he should wait for the others to catch up. If there was a safety hole around here, they might know where it was. And then he noticed it, almost in front of him: an innocent pattern of scratches and breaks in the cornerstone of a bank building. Somewhere in the basement of that bank—in the old vault no doubt—were provisions and water and probably a hand comm. No wonder the Ndelante behind him had stayed so close to his trail. Wili left the dark of the alley and moved across the street in a broken run, flitting from one hiding place to the next. It was just like the old days—after Uncle Sly but before Paul and math and Jeremy—except that more often than not in those old days, he had been carried by his fellow burglars since he was too weak for sustained running. Now he was as tough as any.

He started down the darkened stairs, his hands fishing outward in almost ritual motions to disarm the boobytraps the Ndelante were fond of leaving. Outside sounds came very faint down here, but he thought he heard the others, the surviving Jonque and however many Ndelante were with him. Just a few more steps and he would be in the—

After so much dark, the light from behind him was blinding. For an instant, Wili stared stupidly at his own shadow. Then he dropped and whirled, but there was no place to go and the handflash followed him easily. He stared into the darkness around the point of light. He did not have to guess who was holding it.

"Keep your hands in view, Wili." Her voice was soft and reasonable. "I really do have a gun."

"You're doing your own dirty work now?"

"I figured if I called in the helicopters before catching up, you might bobble yourself." The direction of her voice changed. "Go outside and signal the choppers down."

"Okay." Rosas' voice had just the mixture of resentment and cowardice that Wili remembered from the fishing boat. His footsteps retreated up the stairs.

"Now take off the pack—slowly—and set it on the stairs."

Wili slipped off the straps and advanced up the stairs a pace or two. He stopped when she made a warning sound, and set the generator down amidst fallen plaster and rat droppings. Then Wili sat, pretending to take the weight off his legs. If she were just a couple meters closer. . . . "How could you follow me? No Jonque ever could; they don't know the signs." His curiosity was only half pretense. If he hadn't been so scared and angry, he would have been humiliated: it had taken him years to learn the Ndelante signs, and here a woman—not even an Ndelante—had come for the first time into the Basin, and equaled him.

Lu advanced, waving him back from the stairs. She set her flash on the steps and began to undo the ties on his pack with her right hand. She did have a gun,

an *Hacha*-15mm, probably taken off one of the Jonques. The muzzle never wavered.

"Signs?" There was honest puzzlement in her voice. "No, Wili, I simply have excellent hearing and good legs. It was too dark for serious tracking." She glanced into the pack, then slipped the straps over one shoulder, retrieved her handflash, and stood up. She had everything now. *Through me she even has Paul*, he suddenly realized. Wili thought of the holes the *Hacha* could make, and he knew what he must do.

Rosas came back down. "I swung my flash all around, but there's so much light and noise over there already, I don't think anyone noticed."

Lu made an irritated noise. "Those featherbrains. What they know about surveillance could be—"

And several things happened at once: Wili rushed her. Her light swerved and shadows leaped like monsters. There was a ripping, cracking sound. An instant later, Lu crashed into the wall and slid down the steps. Rosas stood over her crumpled form, a metal bar clutched in his hand. Something glistened dark and wet along the side of that bar. Wili took one hesitant step up the stairs, then another. Lu lay face down. She was so small, scarcely taller than he. And so still now.

"Did . . . did you kill her?" He was vaguely surprised at the note of horror, almost accusation, in his voice.

Rosas' eyes were wide, staring. "I don't know; I t-tried to. S-sooner or later I had to do this. I'm *not* a traitor, Wili. But at Scripps—" he stopped, seemed to realize that this was not the time for long confessions. "Hell, let's get this thing off her." He picked up the gun that lay just beyond Lu's now limp hand. That action probably saved them.

As he rolled her on her side, Lu exploded, her legs striking at Rosas' midsection, knocking him backwards onto Wili. The larger man was almost dead weight on the boy. By the time Wili pushed him aside, Della Lu was racing up the stairs. She ran with a slight stagger, and one arm hung at an awkward angle. She still had her handflash. "The gun, Miguel, quick!"

But Rosas was doubled in a paroxysm of pain and near paralysis, faint *"unh, unh"* sounds escaping from between his clenched teeth. Wili snatched the metal bar, and flew up the steps, diving low and to one side as he came onto the street.

The precaution was unnecessary: she had not waited in ambush. Amidst the wailing of faraway sirens, Wili could hear her departing footsteps. Wili looked vainly down the street in the direction of the sounds. She was out of sight, but he could track her down; this was country he knew.

There was a scrabbling noise from the entrance to the bank. "Wait." It was Rosas, half bent over, clutching his middle. "She won, Wili. She won." The words were choked, almost voiceless.

The interruption was enough to make Wili pause and realize that Lu had indeed won. She was hurt and unarmed, that was true. And with any luck, he could track her down in minutes. But by then she would have signaled gun and troop copters; they were much nearer than Miguel had claimed.

She had won the Authority their own portable bobble generator.

And if Wili couldn't get far away in the next few minutes, the Authority would win much more. For a long second, he stared at the Jonque. The undersheriff was standing a bit straighter now, breathing at last, in great tormented gasps. He really should leave Rosas here. It would divert the troopers for valuable minutes, might even insure Wili's escape.

Miguel looked back, and seemed to realize what was going on in his head. Finally Wili stepped toward him. "C'mon. We'll get away from them yet."

In ten seconds the street was as empty as all the years before.

29

The Jonque nobles believed him when Wili vouched for Miguel. That was the second big risk he took to get them home. The first had been in evading the Ndelante Ali; they had walked out of the Basin on their own, and contacted the Alcalde's men directly. Not many Jonques had made it out of the operation, and their reports were confused. But the rescue was obviously a great success, so it wasn't hard to convince them that there had been no betrayal. (Such explanations might not have washed with the Ndelante; they already distrusted Wili. And it was likely there were Black survivors who had seen what really happened.)

In any case, Naismith wanted Wili back immediately, and the Aztlán knew where their hopes for continued survival lay. The two were on their way northward in a matter of hours. It was not nearly so luxurious a trip as coming down. They traveled back roads in camouflaged wagons, and balanced speed with caution. The Aztlán convoy knew it was prey to a vigilant enemy.

It was night when they were deposited on a barely marked trail north of Ojai. Wili listened to the sounds of the wagon and outriders fade into the lesser noises of the night. They stood unspeaking for a minute after, the same silence that had been between them through most of the last hours. Finally Wili shrugged and started up the dusty trail. It would get them to the cabin of a Tinker sympathizer on the other side of the border. At least one horse should be ready for them there.

He heard Miguel close behind, but there was no talk. This was the first time they had really been alone since the walk out of the Basin—and then it had necessary to keep very quiet. Yet even now, Rosas had nothing to say. "I'm not angry anymore, Miguel." Wili spoke in Spanish; he wanted to say exactly what he meant. "You didn't kill Jeremy; I don't think you ever meant to hurt him. And you saved my life and probably Paul's when you jumped Lu."

The other made a noncommittal grunt. Otherwise there was just the sound of his steps in the dirt, and the keening of insects in the dry underbrush. They went on another ten meters before Wili abruptly stopped and turned on the other. "Damnation! Why won't you talk? There is no one to hear but the hills and me. You have all the time in the world."

"Okay, Wili, I'll talk." There was little expression in the voice, and Miguel's face was scarcely more than a

shadow against the sky. "I don't know that it matters, but I'll talk." They continued the winding path upwards. "I did everything you thought, though it wasn't for the Peacers and it wasn't for Della Lu. . . . Have you heard of the Huachuca Plaguetime, Wili?"

He didn't wait for an answer, but rambled on with a loose mixture of history, his own and the world's. The Huachuca had been the last of the war plagues. It hadn't killed that many in absolute numbers—perhaps a hundred million worldwide. But in 2015, that had been one human being in five. "I was born at Fort Huachuca, Wili. I don't remember it. We left when I was little. But before he died, my father told me a lot. He *knew* who caused the Plagues, and that's why he left." The Rosas family had not left Huachuca because of the Plague that bore its name. Death lapped all around the town, but that and the earlier plagues seem scarcely to affect it.

Miguel's sisters were born *after* they left; they had sickened and slowly died. The family had moved slowly north and west, from one dying town to the next. As in all the Plagues, there was great meaterial wealth for the survivors—but in the desert, when a town died, so did services that made further life possible. "My father left because he discovered the secret of Huachuca, Wili. They were like the La Jolla group, only more arrogant. Father was an orderly in their research hospital. He didn't have real technical training. Hell, he was just a kid when the War and the early Plagues hit." By that time, government warfare—and the governments themselves—were nearly dead. The old military machinery was too expensive to maintain. Any further state assaults on the Peace must be with cheaper technologies. This was the story the Peacer histories told, but Miguel's father had seen its truth. He had seen shipments going to the places that were first to report the plague, shipments that were postdated and later listed as medical supplies for the victims.

He even overheard a conversation, orders explicitly given. It was then he decided to leave.

"He was a good man, Wili, but maybe a coward, too. He should have tried to expose the operation. He should have tried to convince the Peacers to kill those monsters. And they *were* monsters, Wili. By the Teens, everyone knew the governments were finished. What Huachuca did was pure vengeance. . . . I remember when the Authority finally figured out where that plague came from. Father was still alive then, very sick though. I was only six, but he had told me the story over and over. I couldn't understand why he cried when I told him Huachuca had been bobbled; then I saw he was laughing, too. People really do cry for joy, Wili. They really do."

To their left, the ground fell almost vertically. Wili could not see if the drop was two meters or fifty. The Jonques had given him a night scope, but they'd told him its batteries would run down in less than an hour. He was saving it for later. In any case, the path was wide enough so that there was no real danger of falling. It followed the side of the hills, winding back and forth, reaching higher and higher. From his memory of the maps, he guessed they should soon

reach the crest. Soon after that they could see the cabin.

Miguel was silent for a long time, and Wili did not immediately reply. Six years old. Wili remembered when he was six. If coincidence and fool-hardy determination had not thrust him into the truth, he would have gone through life convinced that Jonques had kidnapped him from Uncle Sly, and that—with Sly gone—the Ndelante were his only friends and defenders. Two years ago, he had learned better. The raid—yes, it had been Jonque—but done at the secret request of the Ndelante. Ebenezer had been angered by the unFaithful like Uncle Sly who used the water upstream from the Ndelante reservoir. Besides, the Faithful were ready to move into Glendora, and they needed an outside enemy to make their takeover easier. It worked the other way, too: Jonque commoners without lords protector lived in constant fear of Ndelante raids.

Wili shrugged. It was not something he would say to Miguel. Huachuca was probably everything he thought. Still, Wili had infinite cynicism when it came to the alleged motives of organizations.

Wili had seen treacheries big and small, organizational and personal. He knew Miguel believed all he said, that he'd done in La Jolla what he thought right, that he'd done it and still tried to do the job of protecting Wili and Jeremy that he had been hired for.

The trail dipped, moved steadily downward. They were past the crest. Several hundred meters further on, the scrub forest opened up a little, and they could look into small valley. Wili motioned Miguel to sit down. He pulled the Jonque night-scope from his pack and looked across the valley. It was heavier than the glasses Red Arrow had loaned him, but it had a magnifier, and it was easy to pick out the house and the trails that led in and out of the valley.

There were no lights in the farm house. It might have been abandoned except that he could see two horses in the corral. "These people aren't Tinkers, but they are friends, Miguel. I think it's safe. With those horses, we can get back to Paul in just a few days."

"What do you mean 'we,' Wili? Haven't you been listening? I did betray you. I'm the last person you should trust to know where Paul is."

"I listened. I know you what you did, and why. That's more than I know about most people. And there's nothing there about betraying Paul or the Tinkers. True?"

"Yes. The Peacers aren't the monsters the plague makers were, but they are an enemy. I'll do most anything to stop them . . . only, I guess I couldn't kill Della. I almost came apart when I thought she was dead back in the ruins; I couldn't try again."

Wili grinned in the darkness. "Okay. Maybe I couldn't either."

"It's still a crazy risk for you to take. I should be going to Santa Ynez."

"They'll likely know, Miguel. We got out of LA just ahead of the news that you ran with Della. Your Sheriff might still accept you, but none of the others, I'll bet. Paul though, he needs another pair of strong hands; he may have to move fast. Bringing you in is safer than calling the Tinkers and telling them where to send help."

More silence. Wili raised the scope

and took one more look up and down the valley. He felt Miguel's hand on his shoulder. "Okay. But we tell Paul up front about me, so he can decide what to do with me." The boy nodded.

"And, Wili . . . thanks."

They stood and started into the valley. Wili suddenly found himself grinning. He felt so proud. Not smug, just proud. For the first time in his life, he had been the strong shoulder for someone else.

30

What Wili had missed most, even more than Paul and the Morales, was the processor hookup. Now that he was back he spent several hours every day in deep connect. Most of the rest of the time he wore the connector. In discussions with Paul and Allison, it was comforting to have those extra resources available, to feel the background programs proceeding.

Even more, it brought him a feeling of safety.

And safety was something that drained away, day by day. Six months ago, he had thought the mansion perfectly hidden, so far away in the mountains, so artfully concealed in the trees. That was before the Peacers started looking for them, and before Allison Parker talked to him about aerial reconnaissance. For precious weeks the search had centered in Northern California and Oregon, but now it had been expanded and spread both south and east. Before, the only aircraft they ever saw was the LA/Livermore shuttle—and that was so far to the east, they had to know exactly where and when to look to see a faint glint of silver.

Now they saw aircraft several times a week. The patterns sketched across the sky formed a vast net—and they were the fish.

"All the camouflage in the world won't help, if they decide you're hiding in Middle California." Miguel's voice was tight with urgency. He walked across the verandah and tugged at the green and brown shroud he and Bill Morales had hung over all the exposed stonework and hard corners of the mansion. Gone were the days when they could sit out by the pond and admire the far view.

Paul protested, "It's no ordinary camouflage, it—"

"I know it was a lot of work. You've told me Allison and the Morales spent two weeks putting it together. I know she and Wili added a few electronic twists that make it even better than it looks. But, Paul," he sat down and glared at Paul, as if to persuade by the force of his own conviction, "they have other ways. They can interrogate del Norte—or at least his subordinates. That will get them to Ojai. They've raided Red Arrow and Santa Ynez and the market towns further north. Apparently the few people—like Kaladze—who really know your location have escaped. But no matter how many red herrings you've dropped over the years, they're eventually going to narrow things down to this part of the country."

"And there's Della Lu," said Allison.

Miguel's eyes widened, and Wili could see that the comment had almost unhorsed him. Then he seemed to realize that it was not a jibe. "Yes, there's Lu. I've always thought this place must

be closer to Santa Ynez than the other trading towns: I laid my share of red herrings on Della. But she's very clever. She may figure it out. The point is this: In the near future, they'll put the whole hunt on this part of California. It won't be just a plane every other day. If they can spare the people, they might actually do ground sweeps."

"What are you suggesting, Miguel?" Allison again.

"That we move. Take the big wagon, stuff it with all the equipment we need, and move. If we study the search patterns and time it right, I think we could get out of Middle California, maybe to some place in Nevada. We have to pick a place we can reach without running into people on the way, and it has to be some ways from here; once they find the mansion, they'll try to trace us. . . . I know, it'll be risky, but it's our only chance if we want to last more than another month."

Now it was Paul's turn to be upset. "Damn it, we can't move. Not now. Even if we could bring all the important equipment—which we can't—it would still be impossible. I can't afford the time, Miguel. The Tinkers need the improvements I'm sending out; they need those bobble generators if they're going to fight back. If we take a month's vacation now, the revolution will be lost. We'll be safe in some hole in Nevada —safe to watch everything we've worked for go down the tubes." He thought a moment, and came up with another objection. "Hell, I bet we couldn't even keep in touch with the Tinkers afterward. I've spent years putting together untraceable communication links from here. A lot of it depends on precise knowledge of local terrain and climate. Our comm would make us sitting ducks if we moved."

Throughout the discussion, Wili sat quietly at the edge of the verandah, where the sunlight came through the camouflage mesh most strongly. In the back of his mind, the Jill interface was providing constant updates on the Authority broadcasts she monitored. From the recon satellites, he knew the location of all aircraft within a thousand kilometers. They might be captured, but they could never be surprised.

This omniscience was little use in the present debate. At one extreme, he "knew" millions of little facts that together formed their situation; at the other, he knew mathematical theories that governed those facts. In between, in matters of judgment, he sensed his incompetence. He looked at Allison. "What do you think? Who is right?"

She hesitated just a moment. "It's the reconnaissance angle I really know." It was eerie watching her. The voice and face were the same as Jill's—it was as if the interface had suddenly acquired humanity and could deal with matters of judgment and intuition. "If the Peacers are competent, then I don't see how Miguel could be wrong." She looked at Naismith. "Paul, you say the Tinkers' revolt will be completely suppressed if we take time out to move. I don't know; that seems a much iffier contention. Of course, if you're *both* right, then we've had the course. . . ." She gazed up at the dappled sunlight coming through the green-brown mesh. "You know, Paul, I almost wish you and Wili hadn't trashed the Authority's satellite system."

"What?" Wili said abruptly. That sabotage was his big contribution. Besides, he hadn't "trashed" the system, only made it inaccessible to the Authority. "They'd have found us long ago with their satellites, unless I did that."

Allison held up her hand. "I believe it. From what I've seen, they don't have the resources or the admin structure for wide air recon. I just meant that given time we could have sabotaged their old comm and recon system—in such a way that the Peacers would think it was still working." She smiled at the astonishment on their faces. "These last weeks, I've been studying what you know about their old system. It's really the automated USAF comm and recon scheme. We had it fully in place right before . . . everything blew up. In theory it could handle all our command and control functions. All you needed was the satellite system, the ground receivers and computers, and maybe a hundred specialists. In theory, it meant we didn't need air recon or land lines. In theory. OMBP was always twisting our arm to junk our other systems and rely on the automated one instead. They could cut our budget in half that way."

She grinned. "Of course we never went along. We needed the other systems. Besides, we knew how fragile the automated system was. It was slick, it was thorough, but one or two rotten apples on the maintenance staff could pervert it, generate false interpretations, fake communications. We demanded the budget for the other systems that would keep it honest.

"Now it's obvious that the Peacers just took it over. They either didn't know or didn't care about the dangers; in any case, I bet they didn't have the resources to run the other systems the Air Force could. If we could have infiltrated a couple people into their technical staff, we could be making them see whatever we wanted. They'd never find us out here." She shrugged. "But you're right; at this point it's just wishful thinking. It might have taken months or years to do something like that. You had to get results right away."

"Damn," said Paul. "All those years of clever planning, and I never . . ."

"Oh, Paul," she said softly. "You are a genius. But you couldn't know everything about everything. You couldn't be a one-man revolution."

"Yeah," said Miguel. "And he couldn't convince the rest of us that there was anything worth revolting against."

Wili just stared, his eyes wide, his jaw slack. It would be harder than anything he had done before but—"Maybe you do not need spies, Allison. Maybe we can. . . . I've got to think about this. We've still got days. True, Miguel?"

"Unless we have real bad luck. With good luck we might have weeks."

"Good. Let me think. I must think. . . ." He stood up and walked slowly indoors. Already the verandah, the sunlight, the others were forgotten.

It was not easy. In the months before he learned to use the mind connect, it would have been impossible; even a lifetime of effort would not have brought the necessary insights. Now creativity was in harness with the speed of his processors. He knew what he wanted to do. In a matter of hours he could test his ideas, separate false starts from true.

The recon problem was the most important—and probably the easiest. Now he didn't want to block Peacer reception. He wanted them to receive . . . lies. A lot of preprocessing was done aboard the satellites; just a few bytes altered here and there might be enough to create false perceptions on the ground. Somehow he had to break into those programs, but not in the heavy-handed way he had before. Afterward, the truth would be received by them alone. The enemy would see what Paul wanted them to see. Why, they could protect not just themselves, but many of the Tinkers as well!

Days passed. The answers came miraculously fast, and perilously slow. At the edge of his consciousness, Wili knew Paul was helping with the physics, and Allison was entering what she knew about the old USAF comm/recon system. It all helped, but the hard inner problem—how to subvert a system without seeming to and without any physical contact—remained his alone.

They finally tested it. Wili took his normal video reception off a satellite pass over Middle California, analyzed it quickly, and sent subtle sabotage back the up-link. On the next orbit, he simulated Peacer reception: on the new pictures, Old 101 was shifted east a couple thousand meters, just as he had asked. The satellite processors could keep up the illusion until they received coded instructions to do otherwise. It was a simple change, a rather gross change. Once operational, they would make much smaller alterations: certain vehicles might not be reported on the roads, certain houses might become invisible.

But the hard part had been done.

"Now all we have to do is let the Peacers know their recon birds are 'working' again," said Allison when he showed them his tests. She was grinning from ear to ear. At first Wili had wondered why she was so committed to the Tinker cause; everything she was loyal to had been dead fifty years. The Tinkers didn't even exist when her orbiter was bobbled. But it hadn't taken him long to understand: she was like Paul. She blamed the Peacers for taking away the old world. And in her case, that was a world fresh in memory. She might not know anything about the Tinkers, but her hatred for the Authority was as deep as Paul's.

"Yeah," said Paul. "Wili could just return the comm protocols to their original state. All of a sudden the Peacers would have a live system again. But even as stupid as they are, they'd suspect something. We have to do this so they think that somehow *they* have solved the problem. Hmm. I'll bet Avery has people working on this even yet."

"Okay," said Wili. "I fix things so the satellites will not start sending to them until they do a complete recompile of their ground programs."

Paul nodded. "That sounds perfect. We might have to wait a few more days, but—"

Allison laughed "—but I know programmers. They'll be happy to believe their latest changes have fixed the problem."

Wili smiled back. He was already imagining how similar things could be done to the Peacer communication system.

* * *

31

War had returned to the planet. Hamilton Avery read the PANS article and nodded to himself. The headline and the following story hit just the right note: For decades, the world had been at peace (thanks to the Authority and the cooperation of peace-loving individuals around the world). But now—as in the early days, when the bioscience clique had attempted its take-over—the power lust of an evil minority had thrown the lives of humankind into jeopardy. One could only pray that the ultimate losses would not be as great as those of the War and the Plagues.

The news service story didn't say all this explicitly. It was targeted for high-tech regions in the Americas and China and concentrated on "objective" reporting of Tinker atrocities and the evidence that the Tinkers were building energy weapons—and bobble generators. The Peace hadn't tried to cover up that last development: A four hundred meter bobble floating through the skies of LA was a bit difficult to explain, much less cover up.

Of course, these stories wouldn't convince the Tinkers themselves, but they were a minority in the population. The important thing was to keep other citizens—and the national militias—from joining the enemy.

The comm chimed softly. "Yes?"

"Sir, Director Gerrault is on the line again. He sounds very . . . upset."

Avery stifled a smile. The comm was voice-only, but even when alone, Avery tried to disguise his true feelings. "Director" Gerrault indeed! There might still be a place for that pupal Bonaparte in the Organization, but hardly as a Director. Best to let him hang a few hours more. "Please report to M. Gerrault again, that the emergency situation here prevents my immediate response. I'll get to him as soon as humanly possible."

"Uh, yessir. . . . Agent Lu is down here. She also wishes to see you."

"That's different. Send her right up."

Avery leaned back in his chair, and steepled his fingers. Beyond the clear glass of the window wall, the lands around Livermore spread away in peace and silence. In the near distance—yet a hundred meters beneath his tower—were the black and ivory buildings of the modern centrum, each one separated from the others by green parkland. Farther away, near the horizon, the golden grasses of summer were broken here and there by clusters of oaks. It was hard to imagine such peace disrupted by the pitiful guerrilla efforts of the world's Tinkers.

Poor Gerrault. Avery remembered his boast of being the industrious ant who built armies and secret police while the American and Chinese Directors depended on the people's good will and trust. Gerrault had spread garrisons from Oslo to Capetown, from Dublin to Szczecin. He had enough troopers to convince the common folk that he was just another tyrant. When the Tinkers finally got Paul Hoehler's toy working, the people and the governments had not hesitated to throw in with them. And then . . . and then Gerrault had discovered that his garrisons were not nearly enough. Most were now overrun, not so much by the enemy's puny bobble

generators, as by all the ordinary people who no longer believed in the Authority. At the same time, the Tinkers had moved against the heart of Gerrault's operation in Paris. Where the European Director's headquarters once stood, there was now a simple monument: a three hundred meter silver sphere. Gerrault had gotten out just before the debacle, and was now skulking about in the East European deserts, trying to avoid the Teuton militia, trying to arrange transportation to California or China. It was a fitting end to his tyranny, but it was going to be one hell of a problem retaking Europe after the rest of the Tinkers were put down.

There was a muted knock at the door, and Avery pressed 'open,' then stood with studied courtesy as Della Lu stepped into the room. He gestured to a comfortable chair near the end of his desk and they both sat.

Week by week his show of courtesy toward this woman was less an act. He had come to realize that there was no one he trusted more than her. She was as competent as any man in his top departments, and there was a loyalty about her—not a loyalty to Avery personally, he realized, but to the whole concept of the Peace. Outside of the old-time Directors, he had never seen this sort of dedication. Nowadays, Authority middle-management was cynical, seemed to think that idealism was the affliction of fools and low-level flunkies. And if Della Lu was faking her dedication, even in that she was a world champion; Avery had forty years of demonstrated success in estimating others' characters.

"How is your arm?"

Lu clicked the light plastic cast with a fingernail. "Getting well slowly. But I can't complain. It was a compound fracture. I was luckly I didn't bleed to death. . . . You wanted my estimate of enemy potential in the Americas?"

Always business. "Yes. What can we expect?"

"I don't know this area the way I did Mongolia, but I've talked with your section chiefs and the franchise owners."

Avery grinned to himself. Between staff optimism and franchise owner gloom she thought to find the truth. Clever.

"The Authority has plenty of good will in Old Mexico and Americacentral. Those people never had it so good, they don't trust what's left of their governments, and they have no large Tinker communities. Chile and Argentina we are probably going to lose: They have plenty of people capable of building generators from the plans that Hoehler broadcast. Without our satellite net we can't give our people down there the comm and recon support they need to win. If the locals want to kick us out badly enough, they'll be able—"

Avery held up a hand. "Our satellite problems have been cleared up."

"What? Since when?"

"Three days. I've kept it a secret within our technical branch, until we were sure it was not just a temporary fix."

"Hmm. I don't trust machines that choose their own time and place to work."

"Yes. We know now the Tinkers must have infiltrated some of our software departments, and slipped tailor-made bugs into our controller codes. Over the last few weeks, the techs ran

a bunch of tests, and they've finally spotted the changes. We've also increased physical security in the programming areas; it was criminally lax before. I don't think we'll lose satellite communications again."

She nodded. "This should make our Counter work a lot easier. I don't know whether it will be enough to prevent the temporary loss of the Far South, but it should be a big help in North America."

She leaned forward. "Sir, I have several recommendations about our local operations. First, I think we should stop wasting our time hunting for Hoehler. If we pick him up along with the other ringleaders, fine. But he's done about all the harm he—"

"No!" The word broke sharply from his lips. Avery looked over Lu's head at the portrait of Jackson Avery on the wall. The painting had been done from photos, several years after his father's death. The man's dress and haircut were archaic and severe. The gaze from out those eyes was the uncompromising, unforgiving look he had seen so many times. Hamilton Avery had forbidden the "cult of personality," and nowhere else in Livermore were there portraits of leaders. Yet he, a leader, was the follower of such a cult. For three decades he had lived beneath that picture. And every time he looked at it he remembered this failure—so many years ago. "No," he said again, this time in a softer voice. "Second only to protecting Livermore itself, destroying Paul Hoehler must remain your highest priority.

"Don't you see, Miss Lu? People have said before That Paul Hoehler he has caused us a lot of harm, but here is nothing more he can do. And yet Hoehler has always done more harm. He is a genius, Miss Lu, a mad genius who has hated us for fifty years. Personally, I think he's always known that bobbles don't last forever, and that time stops inside. I think he has chosen now to cause the Tinker revolt because he knew when the old bobbles would burst. You know it's impossible to put bobbles around already existing ones. Even if we mount guard on the big places like Vandenberg and Langley, there are still thousands of smaller installations which will fall back into normal time during the next few years. Somehow he intends to use the old armies against us." Avery guessed that Lu's blank expression was hiding skepticism. Like the others, she just could not *believe* in Paul Hoehler. He tried a different tack.

"There is objective evidence." He described the orbiter crash that had so panicked the Directors ten weeks earlier. After the attack on the LA Enclave, it was obvious that the orbiter was not from outer space, but from the past. In fact, it must have been the Air Force snooper Jackson Avery bobbled in those critical hours just before he won the world for Peace. Livermore technical teams had been over the wreck again and again, and one thing was certain: there had been a third crewman. One had died as the bobble burst, one had been shot by incompetent troopers, and one had . . . disappeared. That missing crewman, suddenly waking in an unimagined future, could not have escaped on his own. The Tinkers must have known that this bobble was about to burst, must have known what was inside it.

Lu was no toady; clearly she was unconvinced. "But what use would they have for such a crewman? Anything he could tell them would be fifty years out of date."

What could he say? It all had the stench of Hoehler's work: devious, incomprehensible, yet leading inexorably to some terrible conclusion that would not be fully recognized until it was too late. But there was no way he could convince even Lu. All he could do was give orders. Pray God that was enough. Avery sat back and tried to reassume the air of dignity he normally projected. "Forgive the lecture, Miss Lu. This is really a policy issue. Suffice it to say that Paul Hoehler must remain one of our prime targets. Please continue with your recommendations."

"Yessir." She was all respect again. "I'm sure you know that the technical people have stripped down the Hoehler generator. The projector itself is well understood now. At least the scientists have come up with theories that can explain what they previously thought impossible." Was there a faintly sarcastic edge to that comment? "The part we can't reproduce is the computer support. If you want the power supply to be portable, you need very complex, high speed processing to get the bobble on target. It's a trade-off we can't manage.

"But the techs have figured how to calibrate our generators. We can now project bobbles lasting anywhere from ten to two hundred years. They see theoretical limits on doing much better."

Avery nodded; he had been following those developments closely.

"Sir, this has political significance."

"How so?"

"We can turn what the Tinkers did to us in LA around. They bobbled their friends off the Tradetower to protect them. They know precisely how long it will last, and we don't. It's very clever: we'd look foolish putting a garrison at Big Bear to wait for our prisoners to 'return.' But it works the other way: Everyone knows now that bobbling is not permanent, is not fatal. This makes it the perfect way to take suspected enemies out of circulation. Some high Aztlán nobles were involved with this rescue. In the past we couldn't afford vengeance against such persons. If we went around shooting everyone we suspect of treason, we'd end up like the European Directorate. But now. . . .

"I recommend we raid those we suspect of serious Tinkering, stage brief 'hearings'—don't even call them 'trials'—and then embobble everyone who might be a threat. Our news service can make this very reasonable and nonthreatening: We have already established that the Tinkers are involved with high-energy weapons research, and quite possibly with bioscience. Most people fear the second far more than the first, by the way. I infiltrated the Tinkers by taking advantage of that fear. These facts should be enough to keep the rest of the population from questioning the economic impact of taking out the Tinkers. At the same time, they will not fear us enough to band together. Even if we occasionally bobble popular or powerful persons, the public will know that this is being done without harm to the prisoners, and for a limited period of time—which we can announce in advance. The idea is that we are handling

a temporary emergency with humanity, greater humanity than they could expect from mere governments."

Avery nodded, concealing his admiration. After reading of her performance in Mongolia, he had half-expected Lu to be a female version of Christian Gerrault. But her ideas were sensible, subtle. When necessary she did not shrink from violence, yet she also realized that the Authority was not all-powerful, that a balancing act was sometimes necessary to maintain the Peace. There really were people in this new generation who could carry on. If only this one were not a woman.

"I agree. Miss Lu, I want you to continue to report directly to me. I will inform the North American section that you have temporary authority for all operations in California and Aztlán—if things go well, I will push for more. In the meantime, let me know if any of the 'old hands' are not cooperating with you. This is not the time for jealousy."

Avery hesitated, unsure whether to end the meeting, or bring Lu into the innermost circle. Finally he keyed a command to his display flat, and handed it to Lu. Besides himself—and perhaps Tioulong—she was the only person really qualified to handle Operation Renaissance. "This is a summary. I'll want you to learn the details later; I could use your advice on how to split the operation into uncoupled subprojects that we can run at lower classifications."

Lu picked up the flat, and saw the Special Material classification glowing at the top of the display. Not more than ten people now living had seen Special Materials; only top agents knew of the classification—and then only as a theoretical possibility. Special Materials were never committed to paper or transmitted; communication of such information was by courier with encrypted, boobytrapped, destroyed-after-reading ROMs.

Lu's eyes flickered down the Renaissance summary. She nodded agreement as she read the description of Redoubt 001 and the bobble generator to be installed there. She pushed the page key and her eyes suddenly widened; she had reached the discussion that gave Renaissance its name. Her face paled as she read the page.

She finished and silently handed him the flat. "It's a terrifying possibility, is it not, Miss Lu?"

"Yes, sir."

And even more than before, Avery knew he had made the right decision; Renaissance was a responsibility that *should* frighten. "Winning with Renaissance would in many ways be as bad as the destruction of the Peace. It is there as the ultimate defense, and *by God we must win without it.*"

Avery was silent for a moment, and then abruptly smiled. "But don't worry; think of it as caution to the point of paranoia. If we do a competent job, there's not a chance that we'll lose." He stood and came around his desk to show her to the door.

Lu stood, but did not move toward the door. Instead, she stepped toward the wide glass wall, and looked at the golden hills along the horizon.

"Quite a view, isn't it?" Avery said, a bit nonplussed. She had been so purposeful, so militarily precise—yet now she tarried over a bit of landscape. "I

can never decide whether I like it more when the hills are summer gold or spring green.''

She nodded, but didn't seem to be listening to the chit-chat. ''There's one other thing, sir. One other thing I wanted to bring up. We have the power to crush the Tinkers in North America; the situation is not like Europe. But craft has won against power before. If I were on the other side . . .''

''Yes?''

''If I were making their strategy, I would attack Livermore and try to bobble our generator.''

''Without high energy sources they can't attack us from a distance.''

She shrugged. ''That's our scientists' solemn word. And six months ago they would have argued volumes that bobbles can't be generated without nuclear power. But let's assume that they're right. Even then I would try to come up with some attack plan, some way of getting in close enough to bobble the Authority generator.''

Avery looked out his window, seeing the beautiful land with Lu's vision: as a possible battlefield, to be analyzed for fields of fire and interdiction zones. At first glance it was impossible to imagine any group getting in undetected, but from camping trips long ago he remembered all the ravines out there. Thank God the recon satellites were back in operation.

That would protect against only part of the danger. There was still the possibility that the enemy might use traitors to smuggle a Tinker bobble generator into the area. Avery's attention turned inward, calculating. He smiled to himself. Either way it wouldn't do them any good. It was common knowledge that one of the Authority's bobble generators was at Livermore (the other being at Beijing). And there were thousands of Authority personnel who routinely entered the Livermore Enclave. But that was a big area, almost fifty kilometers in its longest dimension. Somewhere in there was the generator and its power supply, but out of all the millions on Earth only five knew exactly where that generator was housed, and scarcely fifty had access. The bobbler had been built under the cover of projects Jackson Avery contracted for the old LEL. Those projects had been the usual combination of military and energy research. The LEL and the US military had been only too happy to have them proceed in secret, and had made it possible for the elder Avery to build his gadgets underground and well away from his official headquarters. Avery had seen to it that not even the military liaison really knew where everything was. After the War, that secrecy had been maintained: In the early days the remnants of the US government still had enough power to destroy the bobbler if they had known its location.

And now that secrecy was paying off. The only way Hoehler could accomplish what Lu predicted was if he found some way of making Vandenberg-sized bobbles. The old fear welled up: that was just the sort of thing the monster was capable of.

He looked at Lu with a feeling that surpassed respect and bordered on awe: She was not merely competent—she could actually think like Hoehler. He took her by the arm and led her to the door. ''You've helped more than you can know, Miss Lu.'' ■

CONCLUDED IN NEXT ISSUE

the reference library

By Tom Easton

The Silent Gondoliers, S. Morgenstern, Del Rey/Ballantine, $12.95, 110 pp., illus.
Helliconia Summer, Brian W. Aldiss, Atheneum, $16.95, 398 pp.
What Dreams May Come, Manly Wade Wellman, Doubleday, $11.95, 175 pp.
The Practice Effect, David Brin, Bantam, $2.75, 288 pp.
Reel, Laurence M. Janifer, Doubleday, $11.95, 186 pp.
Spaceship Titanic, Richard Duprey and Brian O'Leary, Dodd, Mead, $14.95, 230 pp.
Stardeath, E. C. Tubb, Del Rey/Ballantine, $2.25, 182 pp.
The Lagrangists, Mack Reynolds, TOR, $2.95, 287 pp.
The War for Eternity, Christopher Rowley, Del Rey/Ballantine, $2.95, 337 pp.
Frontier Worlds, Paul Collins, ed., Cory & Collins, A$3.95, 241 pp.
The Paradoxicon, Nicholas Falletta, Doubleday, $14.95, 230 pp.
The SF Book of Lists, Maxim Jakubowski and Malcolm Edwards, Berkley, $7.95, 384 pp.
Man on Earth: How Civilization and Technology Changed the Face of the Earth, Charles Sheffield, Macmillan, $29.95, 160 pp. (Reviewed by Stanley Schmidt.)

You read this in summer, but I write it two weeks before Christmas. I give final exams next week. And I kick myself—lightly—for falling into an old definition of the critic or reviewer. I haven't written much SF at all this year, while I've kept right on covering the stuff for you. I'm the reviewer who doesn't write (in *this* field). Fortunately, I haven't actually *taught* SF this year.

At any rate, the year's work is just about done, and to wrap up this portion of it I have one or two very nice books for you, a couple of dogs, and a few so-so's. The mix is very much as usual, except that my lead item is an unusual delight. It's S. Morgenstern's **The Silent Gondoliers**, and it's neither SF nor fantasy. The publisher claims to have

invented a new genre just for it, that of the fanciful book, but we can easily recognize a classic, straightfaced tall tale, a Munchausen, an elaborately, gently, warmly hilarious shaggy-dog story (though it does lack a terminal pun).

Did you know that once upon a time the gondoliers of Venice were such grand singers that they could put Caruso to flight with their arias? 'Tis so, 'tis so, Morgenstern assures us. But that day is no more. The gondoliers are silent, and he tells us the reason why. There was once a young gondolier of awe-inspiring skill upon the canals. His name was Luigi, he had a goony grin, and when he raised his mighty voice in song, he could bring the bronze horses of San Marcos to their knees. He was that bad. He was that *horrible*.

Obviously, Luigi could not be a singing gondolier. Whenever he tried, the palace windows vomited refuse and his tourist passengers got migraines. He spent years searching for a voice teacher who could tolerate him as a student, and all he could find was an aged master who was now stone deaf. He had no choice. He became a dishwasher and waiter at the gondoliers' tavern and poled his gondolier only at night, gliding out to sea to break his heart with song. But then came the night of The Four Day Four Country Rectangular Aerial Disturbance, a storm such as Venice has never seen before or since, when Luigi invented surfing and . . .

To tell you more would spoil the story, which is far too fine and far too short to spoil. Let me add only that Morgenstern has the master's touch and a lover's feeling, and his European reputation is very well founded (as it is here too, but on less evidence; American readers know little more than his *The Princess Bride*). You cannot read *The Silent Gondoliers* without tears and smiles of sympathy, nor without an occasional guffaw. Certainly I couldn't.

The illustrator, Greek-born Paul Giovanopoulis, did an admirable job of matching the feel and content of the text. My only cavil is that he didn't give Luigi a properly goony grin.

For a change of pace, how about Brian Aldiss's **Helliconia Summer**? Aldiss's world is a magnificent creation, broad and intricate, with echoes of relevance and influence, a gold-mine for future literary scholars. Even present-day critics are raving, and the series is selling well.

But it's dreadful. Aldiss tries for Morgenstern's elegance but achieves only pretentiousness. *Helliconia Spring* had verve and originality, and I called it stodgy. *Helliconia Summer* has only the stodginess. It's slow-moving, long, windy, and occasionally ludicrous, as when Aldiss has a king assemble "his wife behind him to make an attractive composition" (p. 383).

The story is fairly simple: Helliconia's complex orbit gives it a 2600-year "year," with an excessively frigid winter and a thoroughly hellish summer. In this book, the planet is approaching the peak of summer, when its forests will burst into flames. The people are aware of this, and they are maneuvering to maximize their chances or survival till fall. King JandolAnganol of Borlien is divorcing his Queen of queens, MyrdemInggala, to marry a wanton nymphet and cement a queasy alliance. There are plots and counterplots, strange names and personalities galore, treason and friendship, and revelations of evolution. An Earth human descends from the Avernus, the orbiting station of observers who transmit the pageantry back to an Earth that has surrendered space in favor of genteel maturity. He is tor-

tured, questioned, befriended, and sickened. The Queen's lover arrives from the devastated front to save her. One chancellor leaves in disgrace, his life's work in a bonfire's flames, to join an enemy who thinks to conquer Borlien. Another emerges from an anatomist's lab. And the reader never gives a damn.

Aldiss here reminds me of Jack Vance at his worst and least empathic. For all the richness of imagination that shows in names, scenes, incidents, and history, there is no involvement for the reader. There is too much of manner and preciosity, and not enough of humanity. Perhaps there is simply too much authorial cleverness.

Let's switch the pace again: Here's Manly Wade Wellman, with **What Dreams May Come**, a tale of John Thunstone, friend of John the Balladeer, poking into a strange little English town where every July 4th they overturn the Dreamer Rock. The town is Claines. It is almost wholly owned by the strange Gram Ensley, who also owns the hillside which bears Old Thunder, a figure limned by turf cut away to reveal the chalk beneath. The Dreamer Rock is a supine megalith which, when John prods it with his silver sword-cane, delivers an alarming tingle.

John moves into a small boarding house run by a middle-aged woman with an eye for an unattached man. The help is a local girl who claims to be a white witch. At night, the walls fade away, and John finds himself sitting on a rock in a paleolithic countryside. He has the spells to escape, though, and he does, returning once with a flint-tipped spear and a second time with blood upon his sword.

There is clearly a mystery to Claines, centering on Old Thunder and Dreamer Rock and Gram Ensley. But what is it? John pokes and prods, and he discovers the truth. Almost, he comes to grief, and perhaps he saves the world. The story is very much in the Wellman style, folksily told, peopled with real-seeming characters, without wind and stodge, and with such deftness that we barely miss the Appalachian ambiance we may be more accustomed to from him. I recommend it heartily.

David Brin's **The Practice Effect** is less ambitious than Brin's last novel or two. It is, in fact, light and frothy, a very Analogish confection, with a good measure of satisfaction, delivered with the author's usual skill.

You know, don't you, that practice makes perfect? Well, what if it were really so? This is Brin's premise, and he gives us Dennis Nuel, a young man sent through a zievatronic reality-probe to an alternate world in which things never wear out. They just get better with use; only when unused do they deteriorate, back into whatever their initial condition was. Brin works out the implications thoroughly and imaginatively. Drab and ragged clothes grow luxurious with wearing and admiration, and a fundamental occupation of his society is the slave or free "practicer" who keeps things up; closets are worse than useless. Tools change from flint knives to keen-edged sabers with use. Walls grow stronger with battering. The practice effect only works on inanimate matter, else one could turn any man into a leader or any rag, bone, and hank of hair into a beauty simply by admiring their qualities. And then there would be no ambitious bandit lords or stolen princesses to give Nuel his chance at heroism.

And what a chance it is! He's an engineer and scientist. He knows how to make some pretty nifty gadgets, and

how to take supreme advantage of the practice effect. He can actually turn a horse-trough into a . . . Aw, find out for yourselves. Buy it. Read it. And enjoy.

Laurence M. Janifer's **Reel** is a bleakly poetic piece of work, and it may be the best thing Janifer has ever done. He gives us the planet Three, named the Reel, a world devoted to conning suckers, a world of games and flesh, a world with no law but profit. He gives us Christie Chesson, a tourist from Earth who runs out of money and is obliged to take a job servicing other tourists. He gives us Alex Yonge, son of a casino master, who meets Christie, decides he loves her, and determines to save her. He gives us Wyss Diamond, a mystery figure bent on gaining control of the Reel by protection-racket tactics.

Alex is a fairly ineffectual fellow, young and innocent despite his upbringing on the Reel. He knows better than to grasp after Christie and challenge his world's profit-first ethos, but he does it anyway. He does it even when Diamond comes after the Yonge casino and kills Papa Yonge, for then he has control, or so he thinks. Christie too is ineffectual, for she comes from a world that pretends to decency, and she cannot cope with her situation. Her mind teeters on the brink. Ultimately, even Diamond is ineffectual, for hard as he is, ambitious and ruthless and direct, a profit-minded soul for the Reel, he fails. Alex and Christie live and thrive, though perhaps they would rather not.

Janifer never tells us that the Reel is changed by the social upheaval that Diamond sparks. He does, however, tell us that the upheaval is great, for the book is cast as a series of testimonies by Alex, Christie, and others, collected by later investigators. Too, Janifer's chapters alternate with "chapters" that are brief quotations from Plato, Goncharov, Blake, Dostoevski, and so on, commenting on his text and on life. Upgrading the excerpts from epigraphs to chapters seems a mite gimmicky and pretentious, but let that pass. As comments, the excerpts work. They also label *Reel* as a work of art for any who might mistake it for a failed potboiler.

Sadly, such labels may be necessary. I wish it weren't so, and I wish Janifer had been content to leave the labels off.

Brian O'Leary is an astronaut turned consultant and writer (*The Making of an Ex-Astronaut*). Richard Duprey is a novelist, playwright, and teacher of creative writing at Stephens College in Missouri. Together, they have written **Spaceship Titanic**, a tale of what happens when, 90-odd launches in the future, the first passenger-carrying space shuttle goes aloft. The payload is an ex-astronaut politician, a Saudi prince, antique royalty, industrial magnates, a novelist, and the winners of a special lottery. They are to christen space for everyman (if everyman can afford the steepish fare).

All goes well as the authors follow the prescribed formula for disaster epics. They introduce the sweaty, befoibled cast, describe the shuttle and its mission, and stress the shuttle's safety record. But at T plus one minute fifty-one seconds, one engine loses thrust. Fumes gather in the tourist-class cabin. Passengers panic and die. Heroism abounds. The pilot freezes into catatonia, and the stewardess (a trained astronaut, of course) takes the controls.

And so it goes. It's a short disaster epic, not too long, not too difficult. The writing is sometimes downright clumsy, but as the tale develops it acquires some momentum. The book is perfectly read-

able. But as a novel, it's nothing special. Its greatest strength is that it is a *hymn*, a hymn for the future, and the authors make sure that we don't miss this interpretation. At the very end, they have a drunken trumpeter toot "Nearer My God to Thee."

E. C. Tubb may be setting himself up for another indefinite series with **Stardeath**. Ships are being lost in hyperspace, especially the big liners, and disgraced captain Kurt Varl is recruited to lead a mission to find out why. His ship has the latest of drives and weapons, and in its bowels is a machine that can imitate the psychic emanations of human beings. Varl uses the gadget to make his ship seem much larger than it is, with many more passengers. He thus sets himself and his crew up as bait, and they find the answer: the monsters of hyperspace!

There are nice touches, as when Varl and his ship punch through to a new space beyond the hyperspace, which may just be the entrails of some cosmic beast, complete with immune system. By and large, however, it suffers badly from defects endemic to the old pulps. One is that the characters are barely as thick as the paper they are printed on. Another is the idiot plot in which disasters are avoided either by the dumbest of dumb luck or by suddenly realizing that hey! this gadget can do two things! And there are the idiot heroisms, and the ending, a blind escape that leaves lots of room for sequels.

For all its unending repetitiveness and cheating of hope, the Dumarest series is much, much better. *Stardeath* promises only cheap melodrama and constant anticlimaxes. That is, it's the worst of space operas.

The late Mack Reynolds must have died before he had a chance to polish up the manuscript of **The Lagrangists**, for it suffers from a thousand tiny errors. Certainly he never had the chance to proofread the galleys, nor did anyone else, for there are a million typos that do his memory no honor. The story itself is not so bad. It takes place in Reynolds' familiar future of a socialized America, with Universal Credit Cards and Negative Income Tax, with the U.S. going strong on an L-5 colony. Yet the man behind the colony, Professor George Casey, is a target for assassins, and he must be protected. Enter Rex Bader, the unemployed last of the private eyes. He becomes a research aide cum bodyguard.

Who are the villains? The possibilities are endless. Energy barons are jealous of the prospect of cheap power from solar power satellites. Religious fundamentalists don't like the idea of challenging the heavens. The legitimized Mafia is jealous of its resort interests. The Soviets want to get their own L-4 colony built first. We see the last two coming, for Reynolds shows us a Mafia dona looking for hit-men and Soviet agent Ilya Simonov getting his instructions. Rex has his job cut out for him, and when he succeeds, it is only because Professor Casey has changed the rules of the ball game.

The characters are only a little thicker than Tubb's. The melodrama is as pervasive. The plot, in its way, is just as much a set-up. But I enjoyed the book much more and I call it better. Why? Reynolds was far more thoughtful than most writers. He had something to say.

Christopher Rowley's **The War for Eternity** is your basic wish-fulfillment military fantasy. Fenril is an ancient world with its own intelligent species, the Fein, and an immortality drug. Cen-

turies past, human refugees, capitalists fleeing a socialist Earth bent on appropriating everything of value it can see, reached the planet and learned to live in its highlands. They discovered the drug and made it a part of their culture. Then came the second wave of colonists, decadent merchants who shipped the drug home to Earth. Now Earth is dependent on the drug. It wants more, and it will have more. It sends a warship, manned by genetically engineered brutes, to socialize Fenril and put the Fein on reservations. They will clear the planet of its giant trees, which the Fein call sacred to the Arizel, which seem to be the spirits of their ancestors, and they will establish a new, agricultural culture, slaved to Earth.

It doesn't work. The Fein and the highland humans who live with them are heavily armed to resist raids from the lowland merchants, and they object mightily, if fruitlessly. When the Earthly brutes begin to drop nuclear bombs on the trees, the planet itself takes a hand. I don't think I give away too much if I say that the Arizel are real, not myths. I suspected as much early in the tale, for Rowley's characters mention them with a suspicious concreteness and their very name seems a clue. Arizel is a partial anagram of Azriel, the angel of death.

I call the book a basic military fantasy. It is, but it is also rather better than that epithet may make it sound. Rowley knits into his tale a wealth of characters, many of unusual depth and quirkiness. Too, he makes his tale of many smaller tales, and thus he brings his world alive. He comes close to overdoing it at times, but he doesn't quite. The book overcomes the bad impression of its shoot-'em-up beginning, and it ends as a surprisingly satisfying read.

Frontier Worlds is a new anthology from Paul Collins's editorial shop at P.O. Box 66, St. Kilda, Victoria 3182, Australia; if you order the book, the freight is free. A. Bertram Chandler has the introduction and a Grimes yarn, "Grimes & the Odd Gods," in which Grimes carries Bishop Agatha Lewis to the planet Stagatha, where the heathen natives run around nekkid and the Bishop will have nothing whatsoever to do with the actress. The Bishop has other varieties of hell in mind. I swear I've seen this one somewhere else lately, but I can't place it, so let it go; the book's copyright page is no help.

Of the book's nine other stories, eight are pedestrian efforts of no great charm. The best is the last, Cherry Wilder's "Cabin fever," in which a snowbound family befriends an alien and reaps surprising benefits. I wasn't entirely satisfied with the ending, for there seemed to be a clue missing, but all that went before was very nice.

Nicholas Falletta is an executive editor in Harcourt Brace Jovanovich's college textbook department. Daily he deals with English and math textbooks, and presumably daily as well he goes home to play with his hobby. What's the hobby? On the evidence of his book, **The Paradoxicon**, it is paradoxes, visual illusions, puzzles, and brain-twisting logic-busters. *The Paradoxicon* offers us 25 essays on accessible paradoxes, arranged alphabetically from ambiguous figures to Zeno's paradoxes. This arrangement and the plentiful illustrations make it a browser's delight. The clear discussions go into each topic deeply enough to satisfy most readers and seem just the stuff to turn a teenager—or a college student—on to the joys of thinking. Buy a copy. You'll enjoy it.

Two months ago, I mentioned Mike Ashley's *Illustrated Book of Science Fiction Lists*. At the time, I thought this was the last thing in the literary world to be copied. But here we are already: Maxim Jakubowski and Malcolm Edwards have put together their own version, surely quite independently (there's not been time to do a copy). It's **The** (Unillustrated) **SF Book of Lists**, and while it covers a lot of the same ground, it breaks its own as well. There's a list of 17 major authors who have never appeared in *Astounding/Analog*, another of milestones in bad SF, another of 22 famous opening lines, another of editorial boobs and interferences. There are the unpublished novels of R. A. Lafferty, lawsuits, plutocrats, bestsellers, various lists of stories with specific themes, and much, much more.

The big problem with the book, and it's an enormous problem, a gigantic bugaboo, a colossal annoyance and irritation and source of endless exasperation, is that the book is useless to anyone *except* the browser. It doesn't have an index. It doesn't even have a table of contents!

A few days ago, I had an interesting letter from a woman in Fort Worth, Texas. She's blind, but she gets *Analog* on floppy discs, and she tries to get as many novels as she can on tape or disc. She'd like more, and *just this once* I'll volunteer to forward to her letters from anyone in the Fort Worth area who might like to meet her and read aloud or otherwise assist her interest in SF. I won't tell you her name or address; for the sake of her privacy, let her make the contact. Send your letters to me, and I'll dump them all in a 9 x 12 envelope or two and send them on. My address is Box 705, RFD 2, Belfast, ME 04915.

And if this gives anyone else ideas, I am not, dammit, a contact agency. Put an ad in *Locus*.

As any pilot knows, viewing our home planet from even a few hundred meters up immediately makes obvious a great deal about its surface which can only be deduced with difficulty, if at all, from ground level. Since 1972 the Landsat satellites have been electronically providing very high resolution images of the Earth from 917 *kilometers* up, and those images, suitably processed to yield artificial color photographs, are spectacular, beautiful, and endlessly fascinating in both the large patterns and the remarkably fine details they reveal. In 1981 Charles Sheffield collected 70 of these into a most impressive large-format book called *Earthwatch: A Survey of the World from Space*, published by Macmillan. EARTHWATCH offered a very wide range of views of 185-kilometer regions all over the globe, including both highly developed and wild and remote areas, all accompanied by Sheffield's thoughtful and perceptive commentary. Now he and Macmillan have provided a no less impressive companion volume called **Man on Earth: How Civilization and Technology Changed the Face of the World**. The format is the same as in the earlier book, but the emphasis is different, as the title accurately indicates. The books are expensive—you can't print color pictures of this quality cheaply—but Analog readers who can afford them will find many hours of fascination in a close study of either or both. ■

● Life must be lived forward, but can only be understood backward.

Kierkegaard

brass tacks

Dear Stan Schmidt,

This is a partial answer for Robert Goldich of Annandale, Virginia for his September "Brass Tacks" letter (looking for books on space to read to toddlers): a place to start based on what worked for us. It won't work with all; it didn't with our older one and did only partially with one of three nieces. But our youngest, Pete, is ten and delighted to find an Asimov robot story in his fifth grade reader, even more that Mom had a slightly different (older) version checked out of the local library at the time. Which brings up a couple of points:

First, your local library—use it. They have or can get more books than you can ever afford. It leaves your budget for the ones you want most, or, they can't get. Don't limit yourself to rockets and space too soon. The important thing is to get him interested. He'll point the way from there by his own detours to where he can best go. If he loves reading, he can get there. Even before he is ready for their pre-school story hour (and if they don't have one, help them start it—mothers of squirmer ages need that hour a week off and will share the story reading to get it.) Check out picture books for him about as many unfamiliar peoples, places, insects, dinosaurs as you can to cultivate his natural curiousity. What they don't have they can borrow through their state library. Ours is delighted to, though there is often quite a wait. j629.4 is the section for rockets and Pete had found it by the time he was three.

But don't push it; my brother and I both made that mistake with our oldest daughters. Some find it late (his second waited for sixth grade and *Little Fuzzy*—H. Beam Piper), some not at all.

Our library has a couple meant for

ten-year-olds he dearly loved at three (we have Sonneborn—*The Question and Answer Book of Space* from one of their discard sales, but there are better and more recent down there now). Incidentally, it doesn't hurt to scout local church and library annual sales. Ours sells the slow circulators for 10¢/paperback, 25¢/ hardback each August, including outdated encyclopedia and dictionaries. Don't neglect the color plates in them, especially the Colliers anatomy and anthropology sections.

Even before that we started him on dinosaurs and "bug" books which lead into dragons, strange animals that do exist in other places and could in stranger places. Try the Golden Press series of paperbacks—*Spiders and Their Kin, Fossils, Whales, Insect Pests*—the stranger the better. He should love yellow and black garden spiders by the time he can say "spider."

Try mythology for bedtime—*your* version of what you can remember shaped to fit him. Ours still asks for Thor stories. Icarus led into Michelangelo and directly to invention and crude semi-schematic drawings of potential robots to do his chores for him about kindergarten.

Share your enthusiasms, basically, for if you can get across to him that you enjoy finding out more without getting technical you can keep exploring together. Your favorite authors aren't likely to mind if you simplify their stories to tell him, and his own imagination can outdo any illustrator. That way they are old friends who can be trusted when he finds them on a shelf and discovers the pieces you left out, or books they've written since.

So far, people like Asimov, Heinlein, Piper, even H.G. Wells are a good antidote to the peer pressure that forms about third grade to counter learning, of any kind.

Good luck,

MRS. G.E. LEDERHOUSE
Poland, Maine

Dear Stan,

M. David Stone, in his article "Searching for Terrestrial Intelligence" (*Analog*, July 1983), raises an interesting question, but unfortunately fails to avoid the emotionalism that he so decries in others.

During my graduate studies in physical anthropology at the University of Chicago I not only studied the great apes, but had the fortune to meet some of the people working in ape language studies. One of them had worked with Sarah (who was known for enticing new people at the facility into approaching her cage, and then trying to bite their fingers). Another woman was repeating the Washoe experiment with an orangutan.

One thing that all investigators have in common is great dedication and a large investment in their results. Teaching an ape to communicate is much like raising a young child, calling for endless patience and time. It often requires the investigators to be with the subject during most of its waking hours. Naturally, all this is expensive. This is what I mean by "investment." Ape communication investigators are understandably quick to defend themselves against what they see are attacks on their work. This is not criticism, but a an acknowledgment of the great difficulty of their work, which is generally unappreciated by outsiders.

On the other side of the coin, not all critics of ape language studies are uninformed and unwilling to listen to the evidence. The man who taught Nim Chimpsky signs concluded that the Clever

Hans effect accounted for Nim's responses. Anyone who has seen films of signing apes has noted their lack of precision in forming the signs. There is a lot of room for boosters or cynics to read their own interpretations into the data.

What disturbs me most about Stone's treatment of the skeptics is his focusing on only three representatives. Rumbaugh has published extensively on chimpanzee behaviour and communication in *Science*, not to mention his and Sue Savage-Rumbaugh's continuing feud with David Premack over this issue. The Caldwells were also chosen out of many, one must assume because they provided easy targets. Forgive me, David Stone, if I presume to much, but that is the way it appeared to me. It is easy to set up straw men and a much-used tactic in emotional issues. The Creationists often use it.

I put in that last sentence deliberately, to point out that when the label "creationist" is hung on a point of view, it immediately acquires the most unsavory connotations. Yet Stone's discussion of the separation between apes and people uses this phrase (page 59). In fact, the idea of the "pyramid of being," in which *Homo Sapiens* forms the pinnacle, is as much a concept of early evolutionists. The argument also smacks of the *ad hominem* fallacy.

My studies have led me to the personal conclusion that the apes show the beginnings of most of our most significant abilities, but that the gulf between those beginnings and the realization of five million years of evolutionary development is vast. We have gone our separate ways since we left the forests.

Disturbing also is Stone's use of rumour as evidence on page 61. How can unconfirmed (and second hand?) reports have a place in any serious discussion?

To sum it up, Stone's idea of chimpanzees as people has merit. A major problem whenever we discuss ourselves or our near relatives, as Stone points out, is our inability to be objective. The need to gain emotional distance is a prerequisite to an objective discussion of the problem. It is very hard to do so when, to paraphrase what a well known British zoologist said as he sat beside two gorillas on a forested mountain in Africa, there is nothing like looking into the eyes of a gorilla and seeing a fellow being looking out.

MARK FAGAN

Toronto, Ontario

The Author Replies:

Dear Stan:

Mr. Fagan seems to have read a significantly different article from the one I wrote.

To begin with, he seems to have missed the major thrust of the article. It was not primarily about the question of personhood for apes. It was about the nature of the debate that surrounds ape language research and related fields. These two questions, I admit, are intimately intertwined. Nevertheless, I did not argue for personhood for apes. The most I did was to argue for the plausibility of such a position.

In discussing the debate itself, I defy Mr. Fagan to show where I decried emotionalism. I happen to subscribe to the view that science is above all a human enterprise, subject to all the emotions, politics, and petty jealousies found in any human enterprise. As I said, quite clearly I thought, whatever is going on in the debates over ape language studies, it is certainly not the disinterested intellectual exercise that science occasionally pretends *to be.*

Mr. Fagan mentions his graduate studies in Anthropology. I would suggest that if he is now or ever has been

immersed in any active field of research, he should already be well aware of this aspect of the scientific process. He should also be aware that this particular debate is nastier than usual.

My point is that it is precisely the emotional pitch of the argument that betrays the nature of the issue. The debate is emotional—on all sides—because it is rooted in the very bedrock of one's view of the universe. It is fueled primarily by a profound difference in world views—as profound as the difference between Ptolemaic and Copernican world views, or Creationist and Evolutionist, or Classical and Quantum Physics. In short, the debate has all the markings of the early stages of what Thomas Kuhn has called a major paradigm shift.

In that context, it's interesting to look at Mr. Fagan's comments.

It is not clear to me what Mr. Fagan means by "investment." His explanation clouds rather than clarifies. If he means financial investment, then I couldn't disagree more. Ape language research is not particularly expensive. It is certainly much less expensive than typical experimental research in particle physics, astronomy, or biomedicine for example.

On the other hand, if Mr. Fagan means emotional *investment, then I fully agree. Most—not all—ape language researchers have a tremendous emotional investment in their charges. This point was driven home to me by Ann Premack, who pointed out that many ape researchers treat their apes like retarded children, with all the emotional investment that implies. (Ann Premack's husband is David Premack, who created a language of plastic tokens for his chimps. Ann has worked with chimps and knows most if not all other researchers in the field. She is also the author of* Why Chimps Can Read, *which I recommend highly.)*

Mr. Fagan then refers to Herbert Terrace, "the man who taught Nim Chimpski." Interestingly, Terrace's work is a prime example of what happens when the researcher doesn't make an emotional investment in his chimp. As such, it is open to a great deal of criticism. Instead of having a few researchers intimately involved in the teaching process over a long period of time, Terrace had dozens of researchers moving into and out of the chimp's life in quick succession. There was little time for a stable emotional bond to form between Nim and any individual researcher, and if one did form it was soon broken.

We know the disastrous effect these conditions would have on a human child's ability to learn, but Terrace apparently started with the Cartesian world view that such things as emotional bonds don't matter to a "mere" animal. His results are rooted in his unstated assumptions.

Fagan is absolutely right about the lack of precision in apes who sign. But I wonder if he's ever spent time around a child learning to speak, and noticed the lack of precision in the child's use of words. (Yesterday I had conversation with my five year old son in which he talked about doing strange things with chop sticks on his lips. The conversation made no sense until I realized he was talking about Chapstick.)

And of course the whole point of Premack's language of plastic tokens and Rumbaugh's language of symbols mediated through a computer is precisely that they are not subject to easy misinterpretations or "reading into" the data.

Mr. Fagan confusedly misidentifies Rumbaugh as a skeptic rather than a major proponent of ape language re-

search. But let that pass. More important, he takes me to task for focusing on only three skeptics. I hardly know how to answer that, except to point out that in writing an article, there are length considerations to worry about. The real question is not how many or how few skeptics I focused on, but how hard did I have to look for them, and how selective did I have to be in choosing them? The answer to both questions is, Not at all. The skeptics I covered were chosen primarily because they are representative. I could just have easily chosen Terrace, Noam Chompsky or any other critic that I'm aware of. My argument would remain the same.

Mr. Fagan also seems to have missed the point about the Caldwell quote. This has less to do with the Caldwells than with other people's reactions to the quote. In my experience, those who don't accept ape language studies as meaningful almost never see the absurdity of the statement until it is pointed out to them, and sometimes not even then. Those who do accept the studies almost never need to have the absurdity pointed out. It is this correlation that I find meaningful. It suggests to me that something very significant is going on here at a deep psychological level.

As for the Caldwells themselves, of course they know better. That's just the point. The fact that they could put this statement on paper in spite of knowing better, says something significant to me about the Caldwells' world view.

Mr. Fagan also takes me to task for using rumor as evidence. He would be right to do so if I had been arguing for personhood for apes. As I've already pointed out, though, I was only arguing for the plausibility of such a position. In that context, rumors circulating in the research community are perfectly acceptable subjects for discussion—as evidence of plausibility. *Here again, if Mr. Fagan has ever been immersed in any active field of research, he should be aware of the importance of such unofficial channels of communication.*

Mr. Fagan talks about a vast gulf between ape and man, and says that his studies have led him to this conclusion. I suggest that far from being a conclusion, this "vast gulf" is an a priori assumption based on Mr. Fagan's world view. Otherwise, how do we explain how other people can read the same evidence and come to diametrically opposed conclusions?

Roger Fouts has worked with Washoe from the beginning. I asked him in an interview about the fairly common comparison between a chimp and a two year old child. Fouts said it was a bum rap—for the chimp. His conclusion is that the overlap between man and ape is much greater. I suggest that Fouts's overlap, no less than Fagan's vast gulf, is ultimately based on a priori assumptions. For each of us, the reading of the evidence is structured by the world view we start with. Mr. Fagan looks at the evidence, and is struck by the differences between man and ape. Roger Fouts looks at the evidence, and is struck by the similarities.

I happen to agree with Fouts, but that, mostly, is beside the point. It says more about my world view than it says about the evidence. And that, finally, is what the article was about. ■

● Simple style is like white light. It is complex but its complexity is not obvious.

Anatole France

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a calendar of analog upcoming events

21–24 June
DEEPSOUTHCON 22 (Annual Southern SF conference) at Read House, Chattanooga, Tenn. Guest of Honor—Joan D. Vinge, Artist Guests of Honor—Doug Chaffee and Bob Maurus, Fan Guest of Honor—Jerry Page, TM—Karl Edward Wagner, Special Guests—Somtow Sucharitkul, Timothy R. Sullivan. Registration—$15 until 1 June, $20 thereafter. Banquet (limited to 150)—$10. Info: DeepSouthCon 22, c/o Irv Koch, 835 Chattanooga Bank Building, Chattanooga TN 37402. 404–767–7360.

22–24 June
National SF Research Association meeting (academic) at University of Missouri—Rolla. Info: Wayne Cogell, G-7 Humanities/Social Sciences, University of Missouri—Rolla, Rolla MO 65401. 314–341–4131.

29 June–1 July
INCONJUNCTION 4 (Indiana SF conference) at Airport Hilton Inn, Indianapolis, Ind. Guest of Honor—Joe Haldeman, Fan Guests of Honor—Roger Sims and Fred Prophet, TM—Bob Tucker. Registration—$12 until 15 June, $15 at the door. Info: Inconjunction 4, Box 24403, Indianapolis IN 46224.

29 June–3 July
WESTERCON 37 (Westcoast SF conference) at Marriott Hotel, Portland, Ore. Guest of Honor—Harlan Ellison, Artist Guest of Honor—Alex Schomburg, Fan Guests of Honor—F.M. & Elinor Busby, TM—Ed Bryant. Registration—$30 to 15 June, $40 at the door ($9 supporting at all times). Info: Westercon 37, Box 16155, Portland OR 97216. 503–761–8768.

2–6 July
10th International Conference on Computational Linguistics at Stanford, Calif. Info: Martin Kay, Xerox PARC, 3333 Coyote Hill Road, Palo Alto CA 94304. 415–494–4428. kay@parc.

6–8 July
GULFCON '84 (Dr. Who conference) at Riverview Plaza, Mobile, Ala. Registration—$25 until 31 May 1984, $28 thereafter. Banquet $15 (limited to 75). Info: GulfCon 84, Box 16966, Mobile AL 36616.

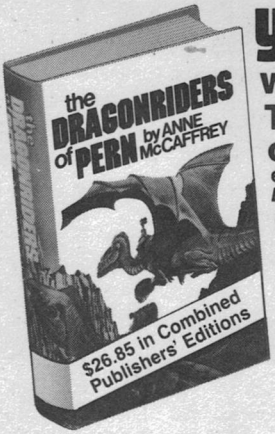
9–12 July
National Computer Conference (IEEE) at Las Vegas, Nevada. Info: AFIPS, Box 9658, Arlington VA 22209. 703–558–3613.

13–15 July
ARCHON 8 (St. Louis area SF conference) at St. Louis, Mo. Guest of Honor—L. Sprague deCamp, Artist Guest of Honor—Jack Gaughan, TM—C.J. Cherryh. Info: Archon 8, Box 50125, St. Louis MO 63105.

13–15 July
MAPLECON 6 (Ottawa area SF conference) at Carleton University, Ottawa, Ont. Guests—Larry Niven, Richard Pini. Registration—C$15. Info: Maplecon 6, Box 3156—Station D, Ottawa, Ontario, Canada K1P 6H7.

30 August—3 September 1984
LA CON II (42nd World Science Fiction Convention) at Anaheim Convention Center, Los Angeles, Calif. Guest of Honor—Gordon R. Dickson, Fan Guest of Honor—Dick Eney, TMs—Robert Bloch & Jerry Pournelle. Registration—$40 until 31 December 1983, $50 until 15 July, $75 at the door. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition, the works. Join now and get to nominate and vote for the Hugo awards and the John W. Campbell Award for Best New Writer. Info: LA Con II, Box 8442, Van Nuys CA 91409.

—Anthony Lewis



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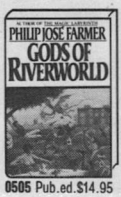

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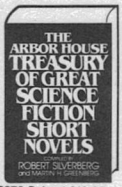

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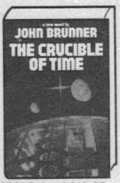

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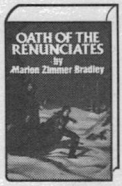

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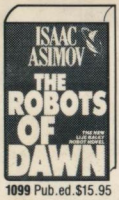

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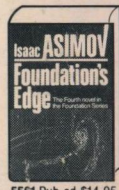

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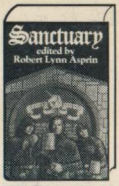

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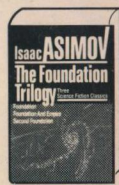

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