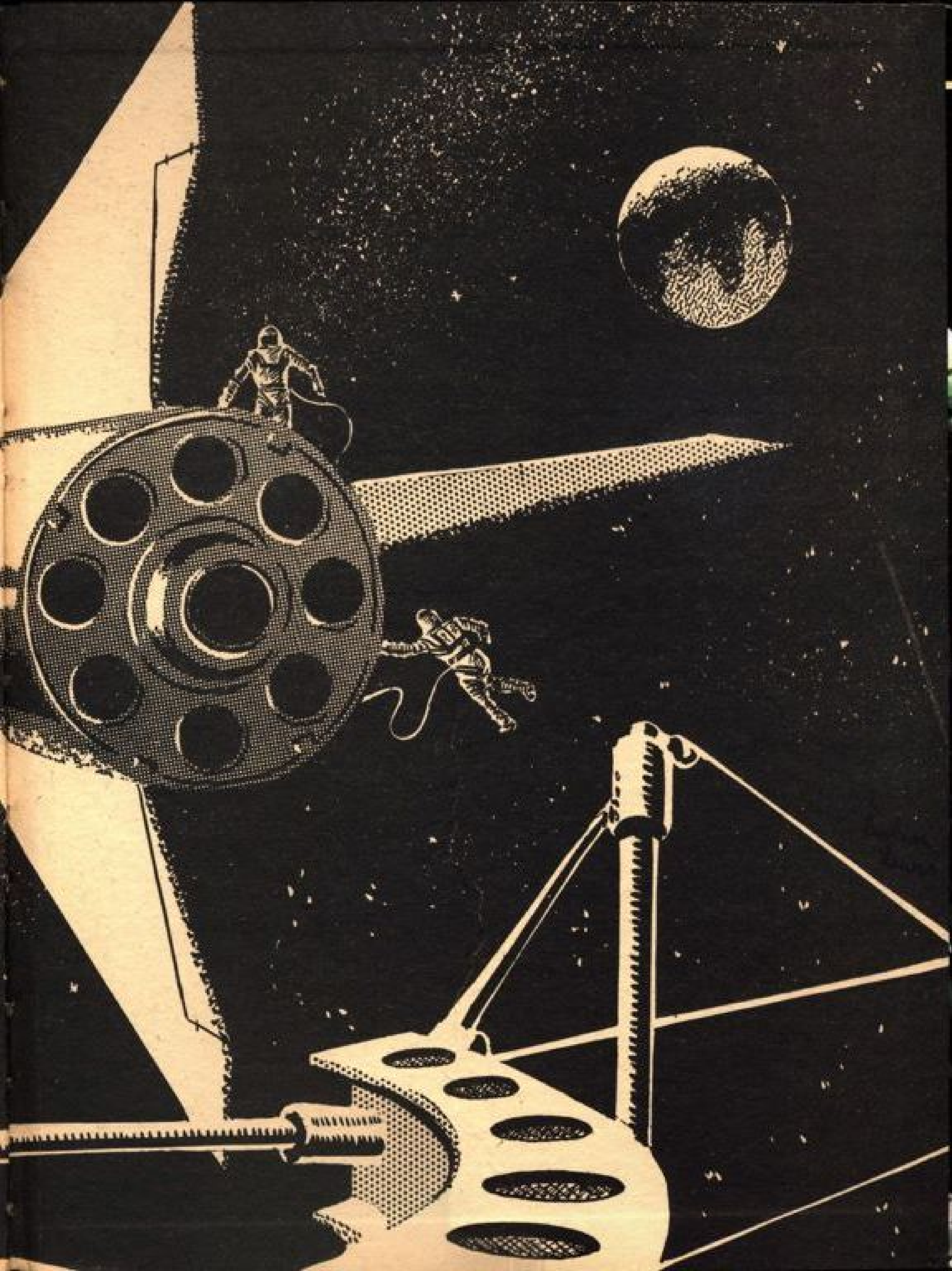
Authentic BOOK of SPACE

Foreword by ARTHUR C. CLARKE

COASTING IN SPACE

This spaceship hangs high above the Moon and is moving at fast speed although it looks quite still. The jets are silent and dark, for the rocket motors have been turned off and the ship is on a coasting course that will bring it over one of the great, dry lunar seas. Then the pilot will switch on the engines and the ship will slowly turn so that its jet points to the Moon. Down it will come, tail first and a screaming roar pouring from its jets. Like a gigantic beetle the ship will settle down on the airless surface of the Moon.



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The AUTHENTIC BOOK OF SPACE

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SCIENCE FICTION AND SPACE FLIGHT

by

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NOT all of science-fiction, by any means, is concerned with space-flight, but this subject is undoubtedly the commonest theme in imaginative literature—and the one which the public automatically thinks of when it hears the phrase "science-fiction" used. There is a good reason for this, of course. No other subject has quite the same appeal, or is so precisely in tune with the vaulting imagination, as the conquest of space. It is also a very interesting, though little-known, fact that most of the scientists who laid the foundations of astronautics have used fiction to propagate their ideas. This was true of Ziolkovsky, Goddard, Valier, Ley, Oberth and von Braun. Today, not a few of the names on the contents pages of the science-fiction magazines conceal the identities of men actively at work in the field of rocket engineering.

It would be very interesting to carry out a survey among today's rocket researchers in order to discover what first introduced them to the subject. In most cases, it would be safe to bet, the answer would be science-fiction. And as far as the initial imaginative spark is concerned, it matters little whether the science-fiction is accurate or not. I was brought up on Edgar Rice Burroughs' Martian stories—about which the less said, as science *or* literature, the better. But I shall always be grateful to the late Mr. Burroughs for making me realise that there *were* other places besides Earth.

Astronautics undoubtedly owes a considerable debt to science-fiction. Most of the ideas which will be used by the space-explorers of the next century have already been discussed, dissected and described in the vast literature of the subject. Nothing like this has ever happened before. There was no widely-read fiction about aeronautics to make people familiar with the insides of airplanes, or the sensations they would experience on a flight, before such things came into existence. But today everybody knows what a space-suit is, and expects to go floating around inside the cabin as soon as the rockets are switched off.

The public has, therefore, been prepared for the conquest of space as it was never prepared for the conquest of the air. I sometimes think that the indoctrination has been a little too thorough. When the year 1975 comes up, and the Moon still seems an awful long way off, a lot of people are going to be somewhat disappointed and the rocket engineers will be accused, in no uncertain terms, of dragging their feet. There is some danger that space-travel may be over-sold, because scientific progress happens so much more easily in fiction than it does in real life. The hero of the average space-opera never has to sit twiddling his thumbs for months while the next appropriation is voted on, or someone trumps him with a higher priority . . .

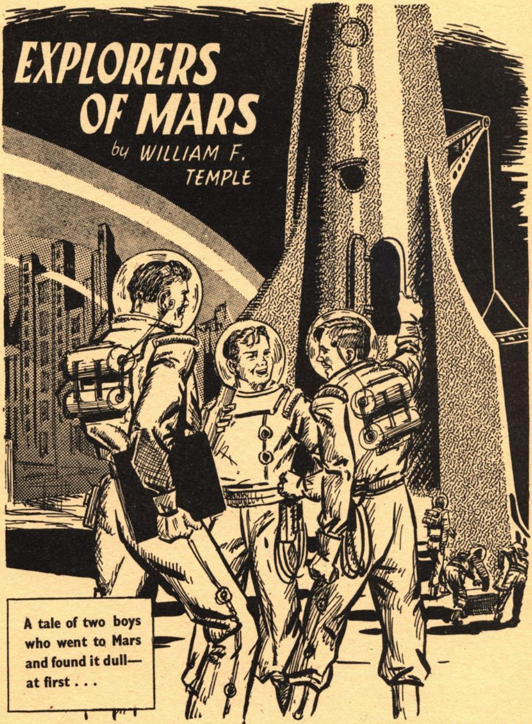
There is also some danger that science-fiction may lead the public (which will have to foot the bill, after all) to expect too much of the planets. Although the Moon has now been de-populated, some optimistic authors still place humanoid life-forms on Mars and Venus. Sometimes they even allow the explorers to leave their ships without protective equipment, just as if they were back on Earth. Let's stop kidding ourselves and face up to the facts. All the planets are pretty weird places, and will have correspondingly weird life-forms—or none at all. And the familiar fictional phrase "Oxygen content low, but breatheable" isn't going to be uttered aboard any spaceship that sets down upon the planets of *this* sun.

What will happen to the space-travel story when the planets are actually reached? Will it become extinct, like stories about the first release of atomic energy? Certainly not—the authors will just raise their sights somewhat and concentrate on the stars. (Most of them are already out there, anyway, and some have scarcely deigned to set foot in this Galaxy for years.) Yet even when we have reached Pluto, there will still be plenty of scope for fiction about the worlds of this solar system.

For the crossing of space is only the first task which confronts our descendants. When they get to Mars and Venus, then the real work will begin. They will be faced with the problem of building new homes for mankind, of laying the foundations of new nations and cultures, of changing atmospheres and climates on a planetary scale. Science-fiction needs science to nourish it: it could only have experienced its present growth in a society such as ours.

So we can be sure that, out of the unimagined technologies which Man will develop in his battle against strange and hostile worlds, countless new themes for science-fiction will arise. It is the one form of literature which will never, as long as the universe endures, be in danger of running out of ideas . . . .

ARTHUR C. CLARKE.



Illustrated by John Richards

The day the *Discovery* landed, gently on its tail but with the terrifically hot gases of its braking rockets scorching and blackening the green Martian plants for a hundred yards around, Chief Engineer Stokes told his sons: "You'll be the first boys to set foot on Mars. There's glory for you!"

Glen and Barry were pleased by the thought, but not nearly so pleased about being called "boys." Glen was sixteen and Barry would be seventeen tomorrow. Therefore they knew quite well that they were young men.

The area chosen for landing was judged to be one of the most important spots on Mars. Yet it was quite unexplored. At different points on the small red, green and yellow planet were three earlier expeditions, still prospecting, mapping, and excavating. One of them had even sent a party on motor sleds across the northern polar cap, at this season nearly three hundred miles in diameter.

Even before any ship had reached Mars it was known that the famous Martian canals were not an optical illusion but actually existed. Up in the space-station, which circled endlessly in an orbit a thousand miles above Earth, astronomers peered at Mars through the great telescope which could detect far more detail on the planets of the solar system than any telescope on Earth.

For even the 200-inch telescope on Mount Palomar was made short-sighted by the constant wash of air currents over it. But the space-station 'scope was far above the air and could use its full power of magnification.

Through it not only the canals could be seen but also the Martian cities. These stood alone at wide intervals, always near the banks of a canal. The astronomers could say only this: that the cities were entirely covered by some glassy substance, probably transparent, which shone in the sun. They would dearly have loved to have watched them during the Martian night, to see if they lit up. For that would mean that the cities were inhabited.

But because Mars is further out from the sun than Earth, the astronomers could see it only in the sunlight coming from behind them. Therefore they always saw the day on Mars, but never the night, which was always on the far side from them.

No ships were ever seen on the canals, nor any vehicles crossing the red or yellow deserts, nor any aeroplanes flying in the almost cloudless skies. And no one ever reaped the wide belts of green plants. If there were any Martians, they were real stay-at-homes.

The only way to meet them seemed to be to go there. And so the world waited with eagerness for the first report from the first expedition to reach Mars.

It was disappointing. The Martian cities were quite wonderful—from outside. The streets and buildings could be seen through the thick transparent domes covering them. But there seemed no way into them. No doors were visible. And the glassy substance had, so far, resisted all attempts to break through it.

If there were any Martians, then they remained in hiding. The streets were ever deserted. It was judged that the Martians had either died out altogether or had abandoned this planet. For the cities were never lit at night, and there was never the slightest sign of life or movement, of Martian or machine, within them.

The city near where the *Discovery* landed was one of the biggest and stood at the junction of five canals. It had been named Lowell City, after the famous American astronomer who devoted most of his life to studying Mars from his observatory at Flagstaff, Arizona.

For three days now the expedition had been trying to break into it. Thermite blowlamps no more than slightly blackened the Glassite—as the Earth party called the mysterious transparent material. A mechanical hammer had broken its shaft trying to batter through. Dynamite left the Glassite unscathed.

Something like a small atomic bomb might have done it, but that would also have wrecked the entire interior of the city.

So now the party was attempting to tunnel under the great curving Glassite wall.

Glen and Barry stood at the tunnel entrance watching the piles of red, sandy earth appearing in endless procession on the conveyor belt.

They had not expected to be bored after only three days on Mars, but they were. They had nothing to do, and nowhere much to go. Several times they had walked entirely round the outside of Lowell City, peering in at all angles. But the Glassite reflected too much light for them to be able to see clearly the intriguing streets and houses. They had examined the green plants—which were all the same—under their microscope, but there was nothing startlingly novel about them: they were about as exciting as cabbages.

Indeed, their father told them: "I believe the Martians grew these for eating purposes, as we grow cabbages."

And both lads hated cabbage. Their opinion of the Martians dropped a few points.

The Martian air was as thin as that at the summit of Everest. Well wrapped up, you could survive without a spacesuit—but only just survive. To walk you needed to take a couple of deep breaths for every step. That was no fun.

It was no fun to be trussed up in a spacesuit, either, with a quartz and metal helmet jammed over your head. Then you could breathe all right, but the suit hampered your movements—even despite the lesser gravity, which was only two-fifths of that of Earth's and let you walk with long, bouncing steps.

Kicking a football about was tame. It was like kicking a toy balloon—the ball was too light and moved too slowly. Anyhow, they didn't want to play—they wanted to work, to do something useful.

Glen said to Barry, through the telephone wire joining them: "D'you think Dad would let us go down there and help with the digging?"

"No," said Barry, flatly. He'd known their father for nearly a year longer than Glen.

"Let's ask, all the same."

"If you want to."

C.-E. Stokes was in the ship's cabin poring over a map of the locality. On the desk at his side a two-way radio, every now and then, announced a report from the second engineer with the digging party. Captain Waite was down in the tunnel, too, supervising.

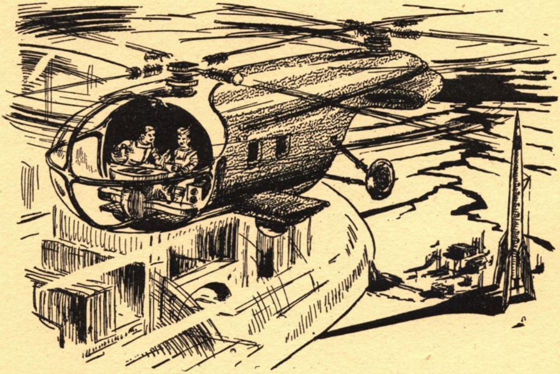
"Father," said Glen, "we're tired of having nothing to do. Can we help somehow in the tunnel—even if we only carry the loose earth away?"

"The conveyor belt does that," said his father, sensibly.

"Well, we can handle picks and shovels——"

"No," said C.-E. Stokes. "I know the waiting is tedious, but once we're through into the city I can promise you plenty of exploring."

"When will that be, Dad?" asked Barry.



"The day after tomorrow, maybe. Maybe sooner."

It seemed a long time to wait, especially as Martian days are quite thirty-seven minutes longer than Earth ones.

"Oh," said Barry.

"Why not play a game of canasta?" suggested C.-E. Stokes, and his sons' groans of disgust were drowned by the voice from the loudspeaker. "We're running into some rock here, Mr. Stokes. Looks pretty tough. We may have to blast."

"I'll be right there, Jack," said C.-E. Stokes through his microphone. Turning to the boys, he said: "You see? It's not going to be too healthy down there. The ground's rotten for tunnelling—too sandy. The tunnel might cave in, especially if we have to keep blasting. I absolutely forbid you to go down there—got that?"

They nodded a little sullenly.

"Good," said C.-E. Stokes, as he put on his helmet and disappeared into the airlock.

"Well, that's that," said Glen, with a sigh. He flopped disconsolately into his father's seat and stared gloomily at the map. Presently he began to get interested in it.

"Look," he said, "there's another city only about sixty miles away. Why hasn't anyone taken a look at that? It might be easier to get into."

"I doubt it," said Barry. "The only difference in the cities that anyone's noticed so far is in their size. Lowell City is one of the biggest. *That* city is only a tiny one—why, it hasn't even been given a name yet."

"What does the size matter? It's not been visited—it may be different in some other way."

"We'll have to wait and see. If we get held up here, it's on the cards that Dad will fly over in the 'copter and take a look at it."

Glen looked up with his eyes bright with mischief and excitement. Barry knew that look—it had led him into trouble more than once.

"Why don't we go over and do the job for him? You've got your 'copter pilot's licence."

"No," said Barry, firmly. "You know Dad wouldn't let us. Besides, the 'copter's a special one, designed for Mars. I've only flown 'em on Earth."

Glen said: "Dad, Jack and Mr. Thomson have all flown it here. It goes like a dream. Why, Dad himself said a child could handle it. Didn't you hear him?"

Barry didn't answer.

"Dad wouldn't mind," pursued Glen. "We can be back easily within a couple of hours. We'll leave a note to say where we've gone."

Barry said nothing.

"You're afraid!" said Glen, suddenly, and that did it, as he knew it would.

"Come on!" said Barry, grimly.

Everyone seemed to be down the tunnel. The roar of a great drill came from its mouth, drowning the buzzing of the two-seater helicopter as it took off, its vanes spinning incredibly fast to support it in that thin air.

Glen had brought the map with him and they sat there in the glass-enclosed cabin, high in the sunshine, comparing it with the real map laid out some five hundred feet beneath them.

"We follow this canal," said Barry, tracing it with a forefinger. "Turn left at the next junction, and take the second right beyond that."

Barry opened the throttle and the helicopter moved forward. Soon it was going quietly at its cruising speed of seventy miles an hour.

Nearly an hour later, Barry said, suddenly: "Did you leave the note for Dad?"

"How could I?" said Glen, blithely. "You told me to come on, and I came on. There wasn't time. You should think about these things—you're too impet—impetuous."

"So it was my idea all the time, eh?" Barry regarded his young brother unkindly. "You know, I ought to tip you out right now. It would save me from an awful lot of trouble in the future."

"Oh, not just now, Barry. I want to see this city. Look—there it is, just coming up over the horizon."

They flew lower, following the canal towards it. It was a much narrower canal than any of those meeting at the junction by Lowell City, and this city looked like a toy compared with Lowell. Even so, it was quite six times the size of St. Paul's Cathedral.

"H'm," said Barry. "Glassite again. Doesn't look any different to me."

He landed the helicopter gently within twenty feet of the city wall. They donned their helmets, climbed out and ran to press their noses against the Glassite.

Beyond, they could dimly see the shapes of the same kind of buildings. Unlike Lowell, none of these was over three storeys, and the streets were much narrower. It was little more than a village.

They began to hurry round its circumference. Unlike the Lowell City district this area was largely yellow, sandy desert, which did not support plant life. It was loose underfoot and not easy to hurry on.

They kept hoping that at any moment around the bend would appear the outline of a door or some sign of a way in. But the Glassite remained obstinately smooth and featureless.

About halfway round Barry began to run out of breath, and grabbed Glen's arm.

"Hold on," he said, panting. Then he remembered that Glen couldn't hear him. In their haste after getting out of the 'copter they'd not paused to connect up the telephone wire again. He remedied this.

"Why are you holding me?" asked Glen. "We haven't gone all the way round yet."

"I'm out of breath," expostulated Barry.

"Now I know I should have told Dad about you smoking that cigarette yesterday," said Glen, darkly. "You've ruined your wind."

"Oh, pipe down!"

Glen turned to peer through the wall again, shading his eyes. Barry looked round at the landscape. It was all one spreading yellow desert, with the straight thread of the canal drawn across it. The sky was a very dark blue. A shining spot moved slowly across it—Phobos, the nearer of the two moons, only 5,800 miles up and very small: in the last hour in the helicopter they had travelled nearly twice its diameter.

Near to where the canal met the slightly curving horizon a rare white cloud hung low, alone in the sky—a mere pinch of cottonwool.

Barry was thinking how desolate but peaceful it all was, when——

CRASH!

The bright desert, the blue-black sky, the cloud and Phobos all seemed to jump madly together and then sway like a painted backcloth in a draught. It was all very peculiar, especially when Barry found he was lying on his back in the sand regarding the scene. The sound of the explosion—or whatever it was—had penetrated his space-helmet almost as though it were made of paper, and his ears were singing. He was vaguely aware of Glen sprawling beside him.

Everything gradually settled down, and he could hear again. Glen was saying (the telephone wire had held): "What on earth—I mean, Mars—was that?"

Barry asked: "Are you all right, Glen?"

"Of course. Gosh—look at that!"

Glen pointed to the sky immediately above them. Drifting over the top of the city came a billowing yellow cloud. Particles came dropping gently from it. They were grains of sand.

"Sandstorm," said Barry. "They sometimes happen on Mars."

"But what caused it? There's no wind."

"I don't know. Something must have happened on the other side of the city. Let's go and see."

Slowly, cautiously, they began to walk round the base of the great Glassite wall. This time, for once, Glen was not in the lead.

"Where *can* they have gone?" C.-E. Stokes asked for the third time in his distraction.

The second engineer, who didn't know the answer either, said: "Oh, don't worry, they're just having a look around. They'll be back soon."

"But why didn't they *tell* me? They may have crashed somewhere——"

"No, Mr. Stokes, the 'copter's foolproof, and Barry's a good pilot."

"If they've gone and broken their necks I'll larrup their hides off when they get back," said C.-E. Stokes, with more force than logic.

He had been upset to begin with. When the rock had been blasted away, the rest of the tunnel was extremely easy going. They'd reached the floor of the city in no time. And it was Glassite again; the whole city seemed to rest on a solid foundation of it. Baffled, he had returned to find his sons had vanished without trace. Now he was really upset.

He searched the horizons with the telescopic attachment he had just screwed to the face-plate of his helmet. The landscape was flat—there are no mountains on Mars—and he could see nothing moving anywhere.

"I'll give them another half hour," he said. "If they're not back then, I'll ask the captain to get up a search party. Five of us—one to follow each canal."

Privately, he blamed himself for persuading the captain that it was more important to carry extra fuel than a reserve helicopter. It meant that the search party would have to go on foot.

He went back to the radio to see if any message had been received from the boys. It hadn't.

Barry was still in front, so he saw it first. His gasp went along the 'phone wire to Glen, who, half-frightened, yelped: "What is it?"

Barry pulled him gently forward so that he could see. The sand cloud had mostly settled now, and it was easy to discern the crater which had appeared plumb at the foot of the city wall—and the smashed 'copter lying near it, on its side, and with all four vanes broken off short. It was easy to see that the 'copter was far beyond repair.

And they were all of sixty miles from the *Discovery*.

Glen was wholly frightened now. So was Barry, but he didn't show it. "It'll be a long walk home," he said, jauntily. And he knew there wasn't enough air left in the twin cylinders they carried on their backs to last them for even a quarter of the walk home. He also knew that there was no hope of their father reaching them in time, for he would have to walk, too.

He could see the 'copter's radio set, blown clean out of the cabin, and lying—just splinters and a tangle of wire—in the sand. That was their last link gone. Through it they might have contacted the ship and given their position. Then Captain Waite could have taken up the *Discovery* and landed it here. He would have been angry with them for causing such a waste of precious fuel. But he would have come.

But now—nobody could know where they were. Perhaps everyone was still working in the tunnel and hadn't even noticed their absence.

Glen hadn't fully realised the position. He had gone to examine the crater. He had barely peeped into it when something else caught his eye.

"Look!" he shouted, pointing at the city wall.

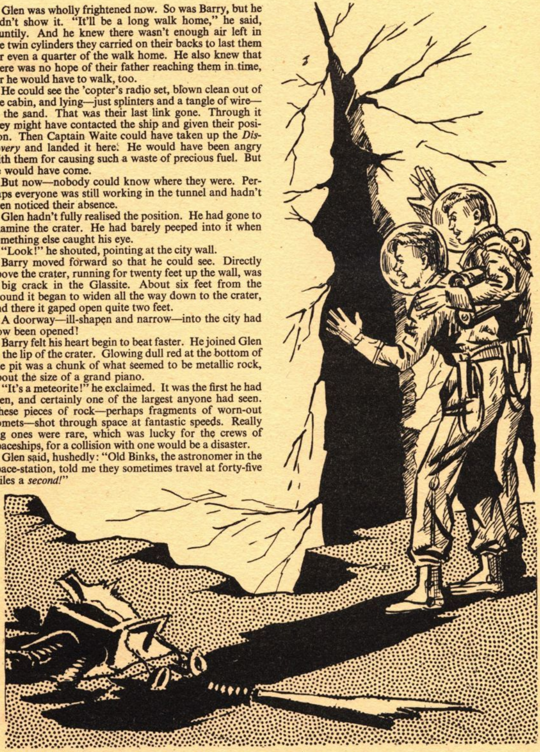
Barry moved forward so that he could see. Directly above the crater, running for twenty feet up the wall, was a big crack in the Glassite. About six feet from the ground it began to widen all the way down to the crater, and there it gaped open quite two feet.

A doorway—ill-shapen and narrow—into the city had now been opened!

Barry felt his heart begin to beat faster. He joined Glen at the lip of the crater. Glowing dull red at the bottom of the pit was a chunk of what seemed to be metallic rock, about the size of a grand piano.

"It's a meteorite!" he exclaimed. It was the first he had seen, and certainly one of the largest anyone had seen. These pieces of rock—perhaps fragments of worn-out comets—shot through space at fantastic speeds. Really big ones were rare, which was lucky for the crews of spaceships, for a collision with one would be a disaster.

Glen said, hushedly: "Old Binks, the astronomer in the space-station, told me they sometimes travel at forty-five miles a *second!*"



"This must have been a slow one, or it would have buried itself much deeper and done more than just crack the Glassite," said Barry. "Well, never mind the 'copter for now. Let's go in there and have a look round."

And he pointed to the fissure.

"You first," said Glen, cautiously.

In that order they entered the ancient Martian city, the first explorers of Mars to do so. It was as light inside as outside, but they felt scared all the same. Where were the Martians who had built this place? In their houses, peeping at them through the glassless windows? Or—dead?

They almost tiptoed down the first narrow street. It was paved neatly with blocks of faintly pinkish stone. There were no pavements, because no traffic had ever troubled this village. There were no drains, because it never rained under the great Glassite roof.

Telling Glen to wait outside, Barry screwed up his courage and entered one of the houses. It was coloured a gay yellow outside and somehow looked more cheerful than the other, nearby houses.

And there was nothing to be afraid of. The house was empty. But it looked as though the inhabitants had but recently gone out. It was beautifully furnished with soft carpets, low pink stone tables (wood seemed unknown on Mars—probably there were no trees anywhere), couches with bright cloth coverings. Small shining machines stood in odd corners, and Barry could only guess at their use. Radios? Television sets? Heaters? Vacuum cleaners? Perhaps they were gadgets that meant no more to him than a refrigerator would to an Elizabethan if he were suddenly confronted with one.

There would be time later, he thought, to investigate them.

And then a cold tremor ran down his spine as he remembered that there would *not* be time—at least, not for Glen and himself.

Covering the walls of some rooms were mosaics of coloured stone, pictures of Martian scenery: the canals, the plantations, distant shining cities. And there were pictures of Martians.

They were handsome, kindly-looking people—very human, apart from a pair of strange tendrils which sprang from their heads just forward of their rather large ears. Mostly they seemed to be smiling gently or looking thoughtful. They did not glare or frown at the artist, as far too many Earth people did. They wore plain, single-coloured robes which fell in classical lines.

They looked such nice people that he brought Glen in to see them.

"Where are they now?" asked Glen, and Barry could only shake his head in puzzlement.

They went on exploring, in and out of the houses. They found a large power house which once, perhaps, had supplied light and heat to the city. It contained many wings with huge, dissimilar machines set in rows in each.

In one wing, Barry said: "You know, Glen, I think these may be air-producing machines. Mars has lost most of its air. I expect it became too thin for the Martians and they retreated into these cities and pumped them full of air. The red deserts are full of oxydised rocks—that is, rocks crammed with oxygen. I think these machines crushed and heated the rocks and obtained the oxygen from them, mixed it with nitrogen, and so made air."

"If they were comfortable here, why did they leave?" asked Glen.

ALL ABOUT MARS

More is known about Mars than about any other planet. For a very full account, see *The Planet Mars*, by Gerard de Vaucouleurs (Faber and Faber 10s. 6d.). There is still controversy about some of Mars' features, but most astronomers are agreed upon the following.

The planet has no large bodies of water, such as seas and lakes, and there is about only one fortieth of the atmospheric water vapour of Earth. Martian atmospheric oxygen would seem to be about a thousandth of Earth's, but there are clouds of some sort—probably sand or mist—that move at speeds up to 25 miles per hour.

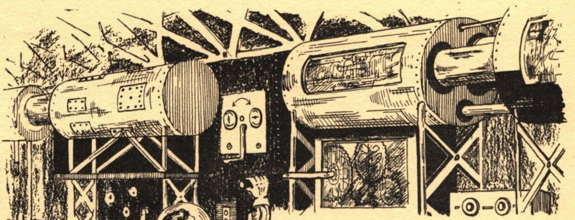
The whole surface area of Mars is about the same as that of Europe and Asia combined. On the other hand, its density is very high—only Venus's is greater—and is nearly four times the density of water. But the gravitational pull at the surface of the planet is such that a weight (on Earth) of 100 lbs. would weigh only 40 lbs. on Mars. And its atmospheric density is about only a fifth of that at the summit of Mount Everest.

There are two distinct polar caps, and these appear to be made up of ice and snow. They melt in the Martian summer and increase in bulk during the winter. The rest of the surface seems to be composed of a bright, brown, igneous rock and its dust—similar to felsite. There are green areas also, but these are probably not made up of plants like those on Earth, though some regions may possess plants similar to Earth-type mosses and lichens.

Mars has two moons, Phobos and Deimos. The first is 5,800 miles away from the planet and is ten miles in diameter. Deimos is 14,600 miles from Mars and has a diameter of only five miles.

Mars' mass is 0.11 of Earth's mass. Its radius is 2,100 miles. Its density is 3.96. It rotates on its own axis every 24 hours 37 minutes, and travels once round the Sun in 1.88 years at a speed of fifteen miles per second. The mean distance of Mars from the Sun is 141.5 million miles, and its mean distance from Earth is 49 million miles. The Martian surface gravitational force is 0.38 of Earth's, and a spaceship would have to reach a speed of 3.1 miles per second before it could escape from the planet.

Mars has figured a great deal in fiction, but for a highly accurate fictionised account of the colonisation of Mars, see *Sands of Mars* by Arthur C. Clarke (Sidgwick and Jackson, 8s. 6d.).




Barry shrugged. "Perhaps they began to die out, didn't have enough children. Perhaps they became so few that the last Martians left in these small cities gathered for company in the big ones, like Lowell City. Who knows? We may learn later."

He kept moving levers and pressing buttons in this wing, hoping that the big air-making machines—if they really were such—would start, and this city would again fill with air, and then it wouldn't matter when their own small cylinders became empty. They could stay in here, and in time Dad or the crew would be bound to find them.

Whatever he tried, he could get no response from the machines, and despite himself, tears of disappointment began to gather in his eyes.

"Come on," he said, rather roughly, to Glen.

By his reckoning they had about three hours of air left each. He walked on dejectedly.

All at once the narrow streets converged on an open space as big as Oxford Circus. In the centre of it was a small, square lake. The water was glass-smooth. Moored at one side was a craft of odd design. It was cigar-shaped and built of a pale, dullish metal like unpolished aluminium. There were round Glassite ports fore and aft. In the curving top was cut a strictly rectangular gap and, curiously, the boys peered into it.

About a yard down, at one end, was a narrow platform. Below it, in the well of the craft, was a bench beside a panel on which was set a single switch.

"A motor boat of some kind," Barry guessed. He knelt and looked hard into the murky water. "Can't see any screw, though."

"Maybe it's a spaceship," said Glen, hopefully.

"Don't be silly—how could a spaceship get out through that roof? No, it's a boat, all right. Seems too large for this little lake—I don't get it. I wonder how it works?"

He started to climb down the short ladder into the well. Glen, feeling the telephone wire pulling, was forced to follow. The boat rocked slightly at their movements. Barry sat on the bench and examined the switch.

"Don't touch it," warned Glen. "Something might start up."

"Why should it? We can't get anything else to work in this place."

So saying, Barry pulled down the switch.

Swiftly, two sections of the pale metal rolled out from concealed slots at opposite edges of the well and closed neatly and tightly above their heads, shutting them in completely. Pale shafts of daylight continued to come through the small round ports.

"Oh, dear, now you've done it!" wailed Glen.

"Keep your hair on," advised Barry. "Simple enough to open them."

Quite confidently, he flipped the switch up. But Martian technicians seemed to have had very strange ideas. They were capable of using the same switch for a series of different operations, which was all right if you knew just what you were doing. And Barry didn't.

The shutters didn't open, but glowing tubes of light suddenly lit up the well, which had become an enclosed cabin.

"Gosh!" said Barry, and hastily pulled the switch down again.

Immediately, the ship began to sink.

This time Glen simply clutched hold of Barry, speechless.

"It must be a sort of diving bell," said Barry, with an effort. "Don't worry, Glen. The lake can't be very deep."

The craft stopped sinking, became motionless. The water was dark outside—the daylight couldn't reach down here.

"We're on the bottom," said Barry. He looked around the small cabin, seeking other controls—he was getting a bit scared of that switch: it seemed to do what it liked and never what he expected. He spied a wheel for'ard, like the driving wheel of a car, but smaller. He turned it this way and that, and nothing seemed to result.

So he had to come back to the switch. He took a deep breath, and pushed it up.

The craft moved forward without a sound, gathering speed. And this time he held on to Glen, waiting for the crash when they hit the end of the lake.

It didn't come. They continued, smoothly. Very soon, to his astonishment, since he had touched nothing, the craft performed a gentle left turn. Apparently some kind of automatic pilot had taken over control.

"It's a submarine, Glen," he said, knowing that at last he was right.

"Where's it taking us?" Glen's tinny voice through the 'phone was trembling.

"We'll find out soon enough."

Weak light began to filter through the ports. It grew brighter.

"We're surfacing," said Barry, with relief.

In a few moments strong sunlight was streaming in through the ports. As if this was the cause—and perhaps it was—the strip lighting went out, and noiselessly the two shutters overhead rolled back.

Both boys gazed up at the dark blue sky, where gleaming Phobos still moved steadily towards its setting. Then, together, they mounted the narrow platform and looked outside.

The craft was proceeding along the exact middle of the canal which ran past the city they had just left. It was doing nearly thirty knots, and the city was receding fast behind them.

"I think," said Barry, "this is how the Martians used to travel about the planet. This boat acted as a submarine only when they wished to leave or enter the city. There must be a tunnel from the bottom of the lake which passes under the Glassite wall and joins the canal—under the surface. No wonder they didn't bother about airlocks in the city walls when they already had a simple and convenient airlock of that kind."

Glen said: "I'm sure they were very clever—but are we going the right way? Why did the sub. turn left instead of right? Perhaps we want the opposite direction."

"Let's have a look at the map."

Glen produced it from the flap pocket of his spacesuit. They studied it.

"I see," said Barry, almost at once. "This canal carries on in the other direction past the city for only a few miles. Then it comes to a dead end. I don't suppose anyone ever went that way, so they set the controls to steer the boat this way only. The point is, are we going to turn left at the next traffic lights? We must if we're to reach Lowell City by canal."

Glen had an idea.

"That wheel," he said, pointing to it. "I wonder if it really *is* a steering wheel?"

They tried it again, and it was. They found they could steer easily in any direction. When they came to the next junction Barry cornered like an old hand, and the boat—which they had now named the *Skylark*—drove smoothly up the new canal. Presently came a right turn, and then they were on the big canal which ran past Lowell City.

By then they were discussing how the *Skylark* worked. Barry's theory was that the boat took in water through the nose and heated it with a small atomic pile, and a jet of steam, rushing out deep under water at the stern, drove the *Skylark* along.

Glen was hanging dangerously over the stern trying to spot some trace of a jet when Barry called out: "There's Dad!"

Ahead, on the canal bank, a figure was gesticulating frantically to them. Despite the spacesuit which masked him, they knew it was C.-E. Stokes, all right—the wild arm-flailing was familiar and meant that their father was in no gentle mood.

They were still doing about thirty knots. Barry wanted to switch off the engine. He knew of only one switch—which he now called "Old Faithful." He pulled it, and Old Faithful lived up to its name. The boat began to slow, and Barry guided it to the bank. Even so, they overshot their father by fifty yards, and he came hurrying after them.

"That won't improve his temper," said Glen, gloomily. "Now for it."

But the storm, when it broke over them, was quite a short one. C.-E. Stokes complained that he had trudged nearly ten miles along this bank, and four other people were out looking for them, and their conduct was disgraceful, thoughtless, and quite unforgivable. Then he forgave them and said how glad he was to see them again.

"You don't know how glad we are to see *you*, Dad," said Barry, and told him the whole story—most of it as they were giving him a lift back to Lowell City.

C.-E. Stokes became more and more excited as the story unfolded. At the end of it he was silent for a moment. Then he told them of the failure of the tunnel, and added: "You've given me new hope. I believe all these cities were built on the same general plan. That means there's a lake at the centre of Lowell and a tunnel to it from this canal. I think this old boat is the key that's going to unlock all the cities on Mars!"

It is history now that this was so. The entry into Lowell City was made in the evening of that same day.

Lowell was even more wonderful than its small neighbour which is now known as Glenbarry City. But there were no Martians in it, and it became certain that all the Martians had long ago left Mars.

"Why did they go, Dad?" Barry asked.

"Well, son, their planet was dying, losing its air. There were no prospects here. I think they were a proud, strong people and they resented being caged up in these big glass cases, like tame animals. So they packed up and left."

"Why didn't they come to Earth?"

"Earth is already overcrowded. They must have seen that and feared they wouldn't be welcome."

"Then where have they gone?"

C.-E. Stokes stroked his chin. "The planet Venus is a young planet. It's perpetually covered with clouds—we've never seen its surface. Maybe, under those clouds . . . One day one of our spaceships will reach Venus. My guess is that that will be the day we meet the Martians."

Barry thought a while. Then he said: "I hope I'm on that ship."

THE END

death rides the spaceways

by Forrest J. Ackerman

A fact article by America's most famous science fiction film personality

A piercing scream rent the stygian gloom, a woman's terrified voice crying out in sudden fear and echoing and re-echoing in the dark.

"Wendayne! What's the matter?" Her husband's voice, shrill with concern.

"Over here!" her breathless response. "By the six rockets. I——" Her voice broke off. "It's something terrible. I think I've," sound of gulping, "stumbled onto a corpse!"

"A corpse! *Here?* Hold it, I'll be right there."

There was a click, and the ray from a flashlight sprang into being in the man's hand. He directed the beam

A space candidate takes the strain of artificially increased gravity pulls.

toward the area of the six rockets. First three horizontal ships came into sight, then two tall cylindrical shapes poised for flight, and finally one great rocket hovering in mid-air. The beam moved a foot to the right and revealed the frightened face of the beautiful Wendayne, her red-rouged lips drawn into an "o" of terror, hands clutched to the temples of her prematurely greying hair, eyes pointed downward at a ninety degree angle.

Waveringly the light travelled down the trembling woman's trim figure till, accompanied by an oath, it reached her ankles—and the thing of horror upon which she had inadvertently trod.

"My God!" The exclamation involuntarily wrung itself from the man's pale lips. "Bob Karnes! And we saw him alive not more than ten minutes ago!"

But if the hideous caricature of a man at their feet had ever been alive, it was difficult to believe now. Like nothing so much he looked as an Egyptian mummy, exhumed after 3,000 years from his ancient tomb and then, anachronistically, clad in a spacesuit! For the cold, dead figure wore the standard equipment of protection against alien atmospheres and interplanetary vacuums of all those who brave the starways.

But now the pliant rubber fabric was gashed and rent, the glass visor of the helmet smashed and jagged. This was a spacesuit destroyed by an explosion or caught in a collision with a meteor.

And the man inside—— The flesh had instantaneously been ripped from his body, as though attacked by a million soldier ants, the terrors of the jungle, or a school of pirhannas, the peril-fish of the South American waters that can devour a full-grown man in a matter of moments. His hands were bony claws, his eyes sunken hollows, and his white ribs could be counted.

Death in Space is violent and not pleasant to look upon.

Fortunately my wife—Wendayne Ackerman—and I were not looking at the real thing, but a cleverly constructed, life-like, life-size reproduction of cinemactor Robert Karnes, who meets a literally meteoric end in the scientifilm *Riders to the Stars*. This is a technicolor production based on an original novel by Curt Siodmak, also responsible for such memorable s.f. movies as *Trans Atlantic Tunnel*, *Floating Platform No. I*, and *The Magnetic Monster*.

Riders to the Stars is the dramatic story of a nerve-wracking, near future and a perilous preliminary step that may have to be taken on the star-way leading to the conquest of space. It poses the not impossible problem: supposing even the toughest alloy, say vanadium, should prove inadequate to shield rockets from some invisible iron curtain in the sky? Supposing, as in the picture, test rockets should hurtle heavenward at 3,000 miles a minute, only to repeatedly tumble back to earth—their structures crystallised and shattered.

The Siodmakian theory is advanced that meteors in space may be surrounded by some chemical coating which protects their core from disintegration by the merciless cosmic rays. To test the theory a "pure" meteor, one whose protective shell has not been burned away by friction from passage through our atmosphere, has to, in effect, be captured.

Fearing the establishment of an Iron Curtain in the sky if the free world doesn't establish a space station first, the Office of Scientific Investigation drafts a number of technical experts to engage themselves with the problem. At first the men, in complete ignorance of their eventual mission, are treated like candidates for some future school of Space Cadets. They are subjected to a variety of tests, both psychological and physical, the former being surreptitiously performed to test for claustrophobes, irritability quotients, etc. The body tests call for super-human endurance of heat, gravity and other travails of the Centrifuge.

Finally, the choices are narrowed down to three men for three rockets.

Take off! The trio of meteor hunters rise almost simultaneously to a height of approximately 150 miles.

Robert Karnes is the first to spot a quarry. Calculations indicate it is oversize for his scooper, but he recklessly attempts to capture his prey. In the endeavour his ship is blown up and he becomes the dehydrated dummy upon which, later lying discarded in the dark on the sound stage at the Hal Roach Studios, my wife stumbled.

Yes, it's going to be tough to be a space explorer—but even filming a space movie is a risky proposition. One man lost his life during the production of *Riders to the Stars!* Another had his right hand blown off. Another——

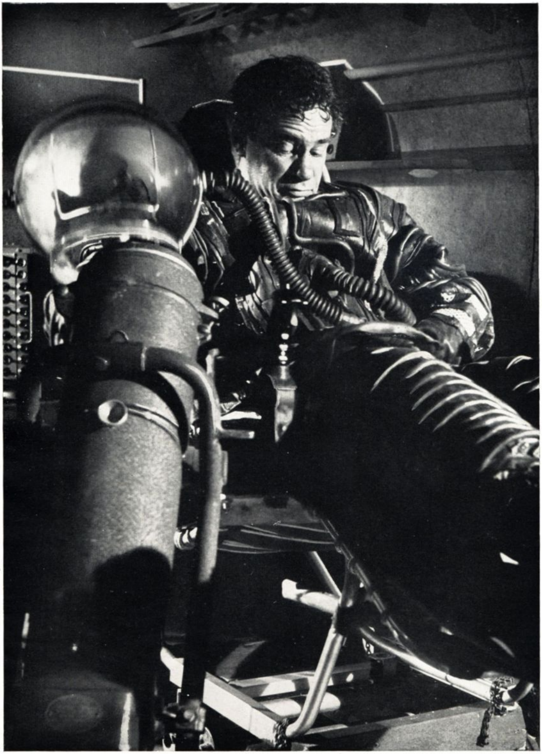
Producer Ivan Tors, during a special interview in his office at "A-Men" Productions, said: "I would like to salute a brave and loyal man, Robert Orlando, who truly gave his life in a cause 'above and beyond the call of duty.' No one connected with the making of our picture would have asked it of him. But the Pentagon had lent us one of their official pressure suits and an expensive duplicate had been made from it. This was stored in a warehouse overnight, and the warehouse caught fire. Mr. Orlando, who was nearby, and who knew the value of the suit and how production would be delayed if it were destroyed, ran into the blazing building, and was overcome by smoke, rescued by firemen, rushed to the hospital—but died the following day. I greatly regret this tragic accident."

A second bad accident was soon to follow. Just a few months before, while Master of Ceremonies at a radio awards show, where plaques were given to outstanding contributors to scientifilms, I had had the pleasure of meeting an electronics engineer named Maxwell Smith, who, for the edification of the audience that night, put on an electrical stage demonstration. Later hired as technical expert for *Riders to the Stars*, one of his jobs was to operate the first radio-controlled miniature rockets ever used in any scientifilm. An acetylene tank simulates rocket exhaust, and the day before shooting the first rocket sequences Smith got an idea for colouring the gas. Faced with a deadline, he took his work home with him, to his basement lab.

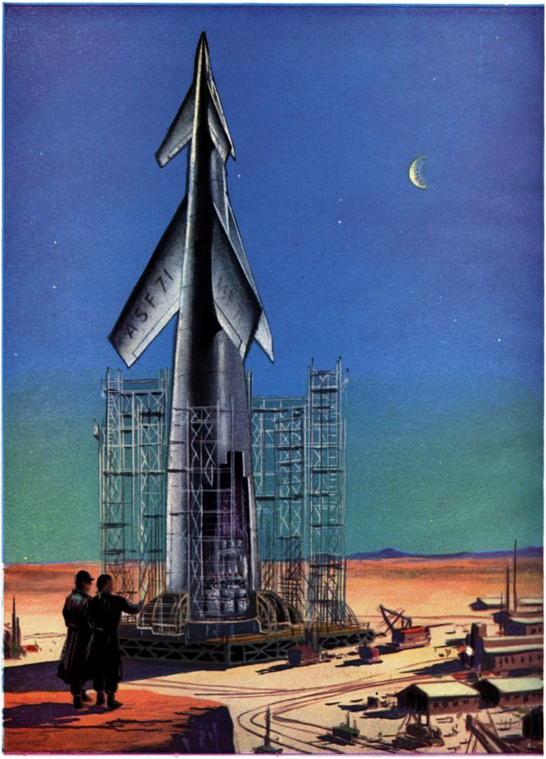
At three in the morning a terrific explosion rocked Smith's neighbourhood. Lights popped on in nearby houses, owners hastily donned dressing robes and ran out into the cold night air, now acrid with the smoke of chemical fumes. Moans were emanating from the shaken Smith home.

The fire department was quickly summoned—and an ambulance. When the débris was cleared away and the unconscious man rescued, it was discovered that the force of the explosion had blown his right hand off. He was bleeding from multiple wounds. Sharp bits of metal had

Continued on page 33



Checking the Equipment before Blasting Off for Space!



The Constructional Stage of a Three-Step Orbital Rocket

FROM EARTH ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ TO THE STARS

The passage of humanity from Earth to the stars will be long, tedious and expensive. There will be many stages, each taking many years and millions of pounds. But each one will be yet another step towards the ultimate goal—the stars, and the planets that must revolve around them. You who read this book will not live to see this goal achieved. Neither, probably, will your grandchildren nor *their* grandchildren. But it is almost certain that you *will* see some of the early steps.

To begin with, man must get into space. So far the best that the rocket engineers have been able to do is send a missile up to a height of 250 miles. That is not very high; it is not even higher than the end of Earth's atmosphere. It just so happens that the fuels available to the rocket researchers are not powerful enough to carry a single stage spaceship out into space in such a way that it will not fall back to the ground. To do this the rocket must reach a speed of 17,500 miles per hour. There is only one way that this can be accomplished with the fuels we already have—in a three step spaceship.

Somewhere out in a desert man will one day soon begin to build a rocket made up of three parts, each part smaller than the one below it. The completed set-up will cost something like fifteen hundred million pounds. That is a lot of money. Finding it is the main obstacle to the conquest of space. If the money were available, say engineers, the spaceship could be built within a year or two. All the materials are available, all the required knowledge has been gained. Now we need the money to put them together.

Most of the constructional and operational details have already been worked out. The three-stage spaceship will be about 270 feet tall and 70 feet in diameter. It will weight just over 7,000 tons, of which more than 6,000 tons is fuel and only about thirty-five tons is cargo and men. When the ship blasts off from Earth on its first journey into space, the massive motors will develop a thrust of 14,000 tons. To do this they suck up fuel at the rate of over 60 tons a second. All in all, the first stage of this ship uses 5,250 tons of fuel—and the whole lot is burned up in eighty-four seconds. At that time the ship will have reached an altitude of nearly thirty miles and will be travelling at well over 5,000 miles per hour.

Now we see why the ship has been made in three parts. When all the fuel in the lowest part has been burned up, an automatic device separates the lower part from the rest of the ship and it drops back to Earth by parachute. At the same instant, the motors of the second stage come to life and carry the top two parts higher still.

The second stage weighs something under 1,000 tons, of which 770 tons is fuel. This fuel is used up at the rate of about six tons a second, and it develops a thrust of rather less than 2,000 tons. The motors continue working until all the fuel has been used; this takes 124 seconds. Once more, at this stage, an automatic device separates the lower step, which drops back to earth by parachute.

Now the third stage—the final, into-space part—roars away. It starts at an altitude of almost forty miles and is travelling at that height at more than 14,000 miles per hour. The motors develop a thrust of 220 tons and this, operating for eighty-four seconds, raises the velocity to the point at which the ship can escape from Earth's gravitational pull.

But we do not want to send the rocket out into space. We want it to remain in a permanent orbit around the Earth. So, when the vehicle reaches a height of 1,075 miles, the motors are switched on again for a very short time to raise the speed to 15,840 miles per hour. This speed would keep the spaceship forever circling the Earth under the same forces that make the Moon circle the Earth—but only if the ship is pointing in the right direction when the motors are restarted.

In order to have the ship's nose facing the correct way, *viz.*, along a course circularly parallel with the Earth's surface, a system of three gyro flywheels is set in action just before the final burst of power. By means of sight-fixing on the stars, these gyros make it a very simple matter to align the ship correctly. Then the motors are turned on for a few seconds and the first artificial moon is born.

But we have placed this ship in this permanent orbit mainly for convenience, not because it is going to stay there. For one thing there are very few men in it and less equipment than scientists need for their observations. For another, more important, thing the men have no food and very limited oxygen supplies.

This first rocket is rather like the first contractor's lorry that arrives at a building site with the fundamental equipment for construction work. When it reaches its orbit and is safely speeding along its path of no-return, the men inside it will don spacesuits and open the airlocks. Piece by piece they will shift out girders and welding units and struts and bars. These things they will simply place outside the ship. Since everything they touch has the same velocity as they have, all those things will remain beside the ship—even though they are hurtling along at nearly 16,000 miles per hour.

When the payload of equipment has been dumped in space, the men will return to the ship, start up the gyros to dip their nose and set the motors roaring into life. They will bring the ship back to Earth for more supplies. Behind them they will leave the first building units for the first permanent artificial satellite, which we will discuss later.

In a great sweeping curve the ship skims back to Earth. But the ship does not merely swoop down and down like a gigantic airliner, dropping through the atmosphere and the clouds and coming to rest on a futuristic airfield. That is the way it happens in comics, perhaps; but this is reality!

Even if the pilot ran the motors for only a second or two when leaving the orbit, just enough to start the ship on its way, and then turned them off—the ship would hit Earth. Any object, of whatever size or kind, falling onto the Earth from a very great distance will meet the surface at a speed of 25,000 miles per hour or just under, and this, of course, is far too great for a safe landing.

So our ship will return to Earth using a manœuvre known as "braking ellipses." When we said that the motors will be set roaring into life, we did not mean in a forward direction. What the captain of the ship has to do is *decrease* the speed of the ship so that it will tend to fall out of the circular orbit of the satellite station. He does this by a slight burst on the forward-pointing rocket tubes, and that tends to push the ship backwards, *i.e.* slows it down. The actual decrease necessary is about a third of a mile a second.

The motors are then shut off and the ship gradually falls in a great curve towards the Earth. As it does this its speed again increases and becomes even greater than the original orbital speed. But when the ship is low enough to be in Earth's atmosphere, air resistance very quickly slows it down; this happens about an hour after leaving the satellite orbit. The ship is now behaving very much like an aeroplane at a height of fifty miles. After about 15,000 miles, the air resistance will have slowed the ship's velocity down to about 6,000 miles per hour, and it will have dropped to a height of something like thirty miles. Dropping lower and lower, the ship moves slower and slower, until at a height of 15 miles it is down to 750 miles per hour. When it finally lands, much like a modern jet plane, its speed will be in the region of 65 miles per hour, and there will be no difficulty at all in bringing it to a stop.

But it may not be possible for the crew to get out of the ship immediately, nor for ground staff to approach the vessel. This is because the rush of air past the ship during its last few thousand miles raises the temperature of the hull considerably. It has been calculated that at a height of about 40 miles, the temperature of the ship's hull will be something like 1,000 degrees Fahrenheit. And when it lands its temperature will be in the region of 450 degrees Fahrenheit. It will have to stand on the tarmac for quite a while to cool down.

Let us pass on now to the next stage in the journey from Earth to the stars. You can read all about the artificial satellite in the words of the men who designed it on pages 80 to 82. Let us here assume that the satellite has been built. It will serve as a space base for the construction of another type of ship—the kind shown on the cover of this book.

Such a ship is called a space-to-space vessel because normally it never lands. It is built in space, travels to another part of space, and there releases a space-to-planet vessel for the actual landing. But we can assume that this type of ship would also be suitable for landing on the Moon, since the force of gravity on the lunar surface is very small in comparison with that of planets. Our next step, then, is to reach the Moon.

Initially, scientists will probably want to send a manned rocket around the Moon and back again before actually attempting a landing. In this way, they will gather a lot of very useful information about the Moon that cannot be obtained in any other way. This survey ship will be built beside the space station and will leave for the Moon from that orbit. It will weigh about 260 tons, and will slowly pick up speed until it is travelling at about 6,900 miles per hour. About half an hour will be required for this velocity to be reached.

When the ship reaches a point some 217,000 miles from Earth, the gravitational attractions upon it of the Moon and Earth will be equal. The ship will then begin to fall towards the Moon. About four and a half days have now passed, and the ship will be turned round by gyro wheels. After passing round the Moon, the ship will increase speed and begin the journey back to Earth, decreasing its speed after a time so as to enter the satellite orbit again.

If the observations of the survey ship prove satisfactory, the next stage is to land on the Moon. For this, three ships would be needed—one containing the spacemen, another to carry extra fuel, and the third to act as the landing and return rocket. All three ships will start off from the satellite orbit, the two unmanned ships being controlled by radio by the spacemen in the third rocket.

When the ships get near the Moon, they will go into an orbit around it. The spacemen will climb out of their rocket, remove the nose from the landing rocket, and transfer the extra fuel tanks to it. They then take the landing rocket down to the Moon's surface tail-first, and using the tail jets to slow the ship down—for there is no atmosphere on the Moon that would help brake the rocket's fall.

When they have completed their duties on the Moon's surface, the spacemen will leave behind the empty fuel tanks, take the landing rocket up again into the orbit near the other rockets that are still floating along up there. They will climb back into the first rocket—the "manned rocket"—and return to the satellite orbit round Earth, leaving the landing rocket circling round the Moon ready for the next expedition.

The landing rocket will weigh only about half as much as the manned rocket when complete with fuel, for it has not so far to go. Whereas the manned rocket will use up 173 tons of fuel, the landing rocket will need only 66 tons during their first flights. The total fuel used by these two ships during the whole operation will be 240 tons and 100 tons respectively.

Now we pass on to interplanetary flights. Here we are up against a number of new problems, the biggest being the enormous distances involved. Though we could get to the Moon and back in a little over ten days, we cannot do that where, say, Mars is concerned. Assuming that the science of space flight is still in its infancy when the attempt to reach Mars is made, we can take it for granted that the ship used will have only the bare minimum of power available. In this case, the journey to Mars would take at least 260 days. Then, once on Mars, the spacemen would have to stay there for at least 450 days before they could leave again, for if they took off before this time had elapsed they would arrive back at Earth's orbit to find that the Earth was no longer there!

Thus the shortest time in which a minimum-powered visit to Mars and back could be made is getting on for three years. The problems of keeping the spacemen alive during all this time are quite great. Certainly it means that they will have to be provided with a fairly massive ship. The kind shown facing page 68 could be used.

This is a space-to-space vessel similar to, but larger than, the Moon rocket, and it carries within one of the spheres a space-to-planet ship. It leaves from the Earth satellite orbit and, after traversing the vastness of space, goes into an orbit around Mars. It stays in that orbit until it is time to leave.

Continued on page 34

The BLUE CLOUD

. . . by Mary Dogge

a story of the future

A thick blue cloud was forming in the sky. It was a thunder cloud. It was full of cracking sounds, and a man stood watching.

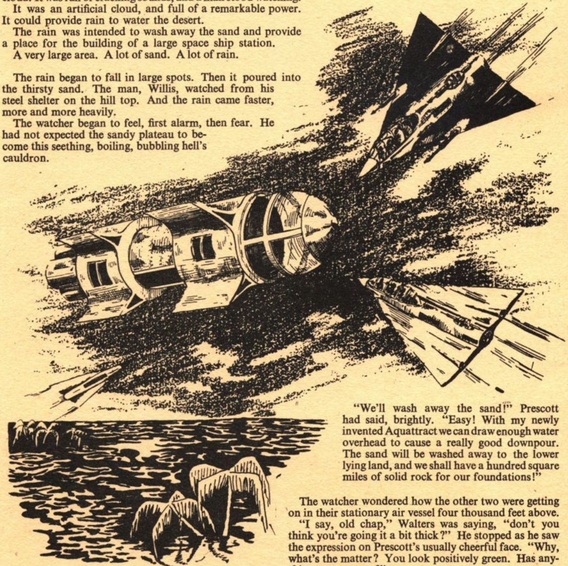
It was an artificial cloud, and full of a remarkable power. It could provide rain to water the desert.

The rain was intended to wash away the sand and provide a place for the building of a large space ship station.

A very large area. A lot of sand. A lot of rain.

The rain began to fall in large spots. Then it poured into the thirsty sand. The man, Willis, watched from his steel shelter on the hill top. And the rain came faster, more and more heavily.

The watcher began to feel, first alarm, then fear. He had not expected the sandy plateau to become this seething, boiling, bubbling hell's cauldron.



"We'll wash away the sand!" Prescott had said, brightly. "Easy! With my newly invented Aquattract we can draw enough water overhead to cause a really good downpour. The sand will be washed away to the lower lying land, and we shall have a hundred square miles of solid rock for our foundations!"

The watcher wondered how the other two were getting on in their stationary air vessel four thousand feet above.

"I say, old chap," Walters was saying, "don't you think you're going it a bit thick?" He stopped as he saw the expression on Prescott's usually cheerful face. "Why, what's the matter? You look positively green. Has anything gone wrong?"

"I can't open the controls box," gasped Prescott. "There's enough water round this Aquattract to wash away the whole Sahara. And its still accumulating. Here! You have a go. There'll be international complications over this if we don't get it stopped quickly. I only have rights for this plateau—not the whole continent!"

"But surely you don't think that . . ?"

"Yes I do," interrupted Prescott, impatiently. "If we don't get this Aquattract stopped it will just go on attracting water indefinitely. Can't you see what will happen then?"

In the Congo, a missionary said to his wife: "What an extraordinary thing, dear. I've never known a tropical storm to stop so suddenly. Why, it was just as if someone had soaked off all the water with blotting paper!"

"Perhaps these atomic energy experiments they keep doing might have something to do with it. When man starts interfering with nature you never know what might happen."

Back over the one-time desert Prescott and Walters were preparing to bale out. They had struggled for two hours. But they could not open the controls.

The rain fell in torrents. It fell in sheets.

The whole project had become a race against time. "There's only a certain amount of water in the world," murmured Walters, coming with irritating slowness to the speculation which had harrowed Prescott's mind for the last ten hours. "What will happen to the rest of the world whose water we've stolen?"

In the south of France a group of vine growers gesticulated in their anxiety. "I tell you I've never known the winter rains to stop so suddenly," said one old man. "Something's gone wrong with the weather and it spells ruin for us."

Prescott and Walters had a bigger worry.

What would happen if the Aquattract started evaporating the Polar Ice Caps?

It would mean a watery grave for a large part of the civilised world.

After the Drought.

They were very wet. While the Aquattract went on relentlessly making it rain, their radio was bombarded with enquiries.

Prescott sat with a beatific smile on his face.

"They don't know anything is wrong yet. Shall we tell them?"

"No, we'll fix it before then," said Walters.

They had, after all, the Company's prestige to maintain. It was the Company's project. They would manage it by the skin of their teeth.

It was no picnic parachuting down onto that seething, foaming mass of sinking sands which the desert had become. It was making a gamble with death—but then, so was remaining in the Aquattract.

But they managed it. They landed on the wet, slippery surface of the rock plateau.

Inch by inch they fought their way towards the shelter on the hill. It was like crawling under a million taps turned full on.

But they got there and fell, exhausted, into the steel shelter as Willis, the watcher, opened the door.

"Nothing wrong with the parachutes, anyway," said Prescott. Then he turned to Willis and said: "Call the Air Force—any air force. We're drowning the world, nearly."

Willis pipped out messages. Then he gave tongue: "In this Atomic Age, when man has conquered space, you—YOU have to start a flood. And call in the Air Force."

Prescott said: "We opened our box, started it—then closed it, and then we couldn't open it again. With the same key, mark you."

They sat and brooded. Then Walters said: "Our key got bigger. It wouldn't fit. That means only one thing. It was made of inferior metal. It was a copy. Why?'

Walters jumped to his feet. "A duplicate!" he shouted. "A cheap copy that was taken by someone who wanted to see how our machine worked."

He paced up and down, then turned suddenly. "I see it all now," he said. "Carter in the Packing Room!"

Willis narrowed his eyes. "Tell me more of Carter," he said.

Carter was five feet high and had several more years of serious growing to do. He was, perhaps, the keenest man on the staff. He packed boxes. They would not let him do anything else. But he was keen. And he would work his way up.

He had shown a great desire to examine the new Aquattract. But it was a top secret. It was kept locked. The controls were only accessible if you had a key.

"So Carter made a duplicate key when we weren't looking!" said Prescott. "With wax and much ingenuity on the Company's key cutter."

He stared into the rain-washed horizon.

"So he could say to his friends, 'I've seen inside the Aquattract'—and swank in his heart."

"Then where's the real key?" asked Willis.

"We'll ask him," said Prescott.

The fighters hurtled across the sky and shot down the Aquattract. The blue cloud still went on pouring out water.

"Warn everybody. World broadcast," said Walters. "Tell them things will soon be normal. Any day now."

"Wait till I get Henderson," said Prescott. "I'll have him fry Carter in oil for this. This is what comes of teaching science to the keen and stupid."

Carter admitted to having the key under his pillow. It was stolen from Prescott's desk. Prescott had not thought that anyone might do that. He did not see the point of stealing a key without the thing it unlocked.

But Carter wanted to admire the new metal.

"What's the damage?" asked Walters, as Willis received messages.

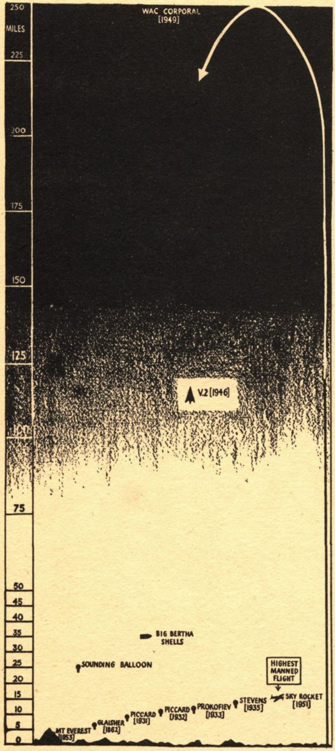
"Polar ice caps still intact," said Willis. "No damage elsewhere. But we seem to have cleared rather more of the desert than we meant to!"

They looked out over a vast, rocky plain. Big enough to build a city.

They had found a good place to build. When they had finished paying compensation to the French vine growers and explained that they had risked their lives in landing on the rock, the Company was quite pleased with the result.

They had washed clear a city of buried gold.

THE END



MAN'S SLOW ASCENT

When, on February 24th, 1949, the rocket researchers at White Sands, New Mexico, sent one of their missiles to the record height of 250 miles, the most recent high-point was reached in man's slow ascent through the atmosphere. Though the marvels of science have for long made man comparative master of the Earth's surface around him, the stretch of air above him has always been a hard barrier to conquer.

Attempts to reach record heights go back to 1783, when the Montgolfier brothers made the first manned balloon ascent, but did not get very high. Then, in 1862, Glaisher and Coxwell took up a balloon to a height which they claimed was 37,000 feet. It was not until 1931 that this record was broken. In that year Professor Auguste Piccard and a colleague, utilising the newish metal, aluminium, went up with an oxygen filled balloon to 51,775 feet—a height of nearly ten miles.

Piccard, with another colleague, went up again the next year in a similar balloon and got a little higher—54,789 feet (just over ten miles). The year after that, 1933, the Russian Army sent up a balloon in charge of Commander Prokofief. This attempt reached 62,320 feet. Another Russian team ascended in 1934 and perished in the attempt, though they reached the new record height of 72,178 feet. America entered the battle of the atmosphere in 1935, and sent a balloon with Captain Stevens and Captain Anderson to a height of 72,395 feet (some 14 miles).

That is about as high as manned balloons have gone, but unmanned meteorological balloons have ascended much higher. Sounding balloons have been sent up to heights of 25 miles.

With the advent of powered flight, a new weapon became available for the conquest of the atmosphere, but it was not a very effective one—as history shows. One of the highest flights occurred in 1932, when the British Air Ministry sent Captain U. F. Unwins to a height of 45,000 feet. In 1936, R.A.F. Lieutenant F. D. R. Swain broke this powered flight record by ascending to 49,967 feet. The next year, Flight Lieutenant M. J. Adam flew to 53,937 feet. Then in October, 1938, the Italian Stratosphere Experimental School sent up Colonel Pezzi, who reached 56,016 feet. That height remained the record for a good many years, and it was not until the development of modern military aircraft that serious challengers came into being.

Many modern fighting 'planes, and also the jet-engined airliners, can cruise quite comfortably at 40,000 feet. In a number of cases, the absolute ceiling—highest attainable height—has not been released by the military authorities, but we can safely bet that Colonel Pezzi's record has been broken quite often. The present record for manned powered flight rests with the American airman, William Bridgman, who, in 1951, took up a rocket-powered aircraft, the Douglas Skyrocket, to a height of at least 80,000 feet (its actual maximum ceiling has not been released).

Only three other man-made objects have climbed higher than this into the atmosphere. During the 1914-18 war, Germany had a massive gun called "Big Bertha" and the shells from this weapon rose to 34 miles at the maximum trajectory point. Then, in the 1939-45 war, German scientists at Peenemunde developed rocketry to the point where it became feasible (though hardly economic and rather futile) to send enormous semi-guided missiles across the English Channel. These are the notorious V-2 weapons, and they topped their trajectory at about 60 miles.

Using captured weapons, the rocket scientists at White Sands (who included the original Director of Peenemunde) improved the performance of the V-2 until a rocket that was substantially similar soared to a height of 114 miles over the dry American desert.

That was in 1946, and since then a number of similar high points have been reached. But it was not until the researchers constructed a two-stage rocket that a substantial increase in altitude was attained. This was done in 1949. A small rocket, called a WAC Corporal, was attached to the nose of an improved V-2 in such a way that it would be triggered into flight as soon as the V-2 reached its maximum height. When the V-2 got to something like 115 miles, the little WAC Corporal zoomed off on its own and soared to a height of 250 miles. This is officially the highest point yet reached by a man-made object, though it is rumoured that rockets have gone even higher, their flights being currently marked "secret."

So it is that 166 years elapsed between the first attempt to conquer the atmosphere and the present altitude record. Even now, we are nowhere near getting into space. At 250 miles we have hardly left the surface of the Earth in comparison with the millions of miles that separate us from the planets.

But progress has been rapid of recent years, and there are incentives to space travel now that did not exist before the last war. It is fairly safe to predict that, although man's ascent of the atmosphere has been slow to date, it will speedily increase in pace during the next decade.

SCIENTIFIC CROSSWORD

CLUES

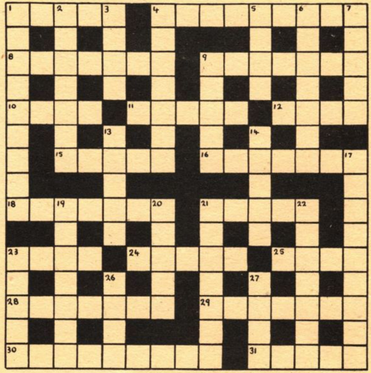
ACROSS

1 Turns tail to the Sun.
4 Aberrant, artificial or natural
8 Crazy about the Moon?
9 Vegetable colouring matter
10 Ellipse
11 Star in Orion
12 Celestial bodies, eyes right!
15 30 across cannot do this with meteors
16 Space engines
18 Island universes
21 King of Saturn?
23 Mercury's climate is this
24 We'll need these for space sickness
25 Hydrous silica
28 Girls and gravity do it
29 Makes you think and act
30 Vessel with room?
31 Vista disturbance

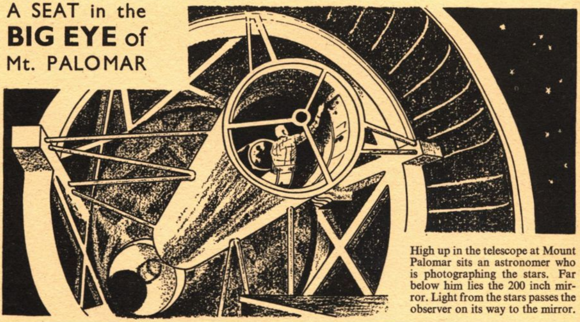
DOWN

1 Guncotton dissolved in ether
2 Of this world
3 Nips the babies
4 May threaten man
5 No racecourse on the Moon
6 Stargaze
7 Ratios of perpendiculars to hypotenuses
9 You can't 6 unless it's this
13 Not much use in space!
14 Bounder
17 Moon or filling station
19 Square cap for clerics
20 Split off by chemistry
21 You have to do this in space
22 Submarine king of the eighth planet?
23 Play the leading role all over the sky
26 First men on the Moon will get it
27 More use to a shark than to a space-to-space rocket

Solution on Page 101



A SEAT in the **BIG EYE** of Mt. PALOMAR



High up in the telescope at Mount Palomar sits an astronomer who is photographing the stars. Far below him lies the 200 inch mirror. Light from the stars passes the observer on its way to the mirror.

THINGS IN THE SKY

Many people think that there is in the sky nothing but stars, the Sun and the Moon. Others know that there are also planets. But very few people realise how many different kinds of things there are in the sky. Yet, though our naked eyes may not be able to see them, there is quite a number of interesting objects in the universe, objects that have been revealed to us by large, modern telescopes.

There are the planets, like Earth and Mars and Venus. These are massive globes of solid matter that do not shine by their own light, only by the light from a sun that is reflected by the planet into our telescopes. Around our Sun circle nine planets—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. Astronomers believe that there are millions more planets beyond the solar system.

Then there are the stars, the most familiar sight in the night sky. These are all like our Sun, and our Sun is one of them. Stars shine by their own light; they are rather like gigantic fires, very hot, very bright, and almost completely gaseous.

When million upon million stars all stay close together in a great wide group, we get what is called a galaxy or nebula. Our Earth, the Sun and the whole solar system is a tiny part of the galaxy of the Milky Way. And this is only one galaxy. Beyond ours there are thousands, maybe millions, of others. Some are compact, taking the form of spirals; some are diffuse, looking like vast clouds of gas spreading lace-like across many millions of miles of space. Each galaxy seems to be complete in itself, and this has led to their being called "island universes."

One very interesting thing about the galaxies in the universe is that they all seem to be rushing away from a central point! Some of them are moving at terrific speeds, and the farther away they are, the faster they are going. It is as though the whole universe were once concentrated at a point—which then exploded. The universe looks like an incredibly enormous explosion that is still going on. This is why some astronomers refer to an "expanding universe." The most interesting question this phrase raises is: Into what is it expanding? What, in fact, is beyond the farthermost galaxy? No one knows. And, unfortunately, it seems unlikely that we ever will.

In between the galaxies there is virtually nothing. Just a very thin gas made of hydrogen atoms and myriads of tiny bits of "cosmic dust." But on the outskirts, so to speak, of the galaxies we find globular clusters of stars. These consist of several thousand stars much more closely packed than those in a galaxy.

Similar clusters are sometimes found inside a galaxy, but these always have only a few stars—some five or six hundred—spread over a fairly large area. These are called open clusters, and the Pleiades form an example in our own galaxy.

Another fairly familiar sight, at least to astronomers, is the comet. These are hazy clouds of gas with a bright nucleus and a faint tail stretching over thousands of miles of space. They move in highly eccentric orbits under the Sun's attraction, coming into the solar system and then going right out again—not coming back for many years.

Shooting stars, a phenomenon common in the autumn, are not stars at all. They are meteors—lumps of solid stony or metallic matter that, winging their way through space, collide with our atmosphere. The friction of their passage through the air burns them up and makes them appear like falling stars.

On the next two pages you will see how some of these things in the sky look when seen through the Telescope!

Below is Saturn, one of the most beautiful planets in Earth's solar system. Altogether there are nine planets revolving around the Sun, but only Saturn has this remarkable system of rings. They are made up of many millions of tiny solid particles as big as grains of sand. When viewed edge-on from Earth they are almost invisible because they are so thin. Among the stars there are very many other planets.

Compact masses of stars such as the one above go by the name of globular clusters. They consist of many thousands of individual stars, occupying a fairly small region of space. Such celestial bodies always occur outside the Milky Way. They form a kind of border to the star system which our Sun belongs to and to which the Milky Way forms a perimeter

Through the Telescope

Out in sunny California, near the peak of the tall Mount Palomar, stands the observatory shown at the left. Inside it are some of the best astronomical instruments in the world, but the pride of the men who work there is the 200" telescope, largest and most powerful of its kind. With it the astronomers can see other galaxies that are nearly 400 million light years away. To print this distance as miles would need more noughts than this book could hold.

The largest objects seen through the telescope are galaxies, another name for which is nebulæ. Such types as the two shown below have been called island universes. They contain many millions of stars spread out over an area of five thousand million square light years, in the form of a spiral.

Our galaxy is probably of the spiral type. It certainly takes the form of a disc. In this photograph, which is a part of the Milky Way, what we are looking at is the edge of our galaxy, the rim so to speak of a big stellar wheel. Because we are looking across a diameter we see a great many stars.

This striking photograph shows the flaming head of a comet. These are rare sights in the sky. The one shown here has not been seen since 1910, and will not be on view again until 1986. Although a comet travels at great speed, it is so far away that to the eye it seems to be stationary. On average the head is ten times the size of Earth, and composed of clouds of glowing gas surrounding particles of bright matter. The comet's tail may be millions of miles long, but it does not contain much material. The comet is really a part of Earth's solar system.

HARDSHIPS IN STARSHIPS

Life on star journeys will not be all fun says

Alan U. Hershey

Man has always looked to the stars with wonder and curiosity. In recent years, as his knowledge of the twinkling, inscrutable points of light above him has increased, he has also looked at them with longing. To-day, it will be granted by most men as an undoubted fact that it is only a matter of time, perhaps a century, perhaps a millenium, before the first leap to the stars is made.

In the interim, of course, will come the exploration of the Solar System with its attendant tremendous advances in knowledge in all branches of science. Also in the interim will probably come the unification of the race, with its inconceivable implications in regard to social change.

And so, the earth which eyes the stars and builds the Starship in that future time will be an earth we do not know. Its people will have different values and their ideas of the social problems connected with a voyage to the stars will probably differ most markedly from ours. But since we can only conjecture with what we know, it is on that basis that this article is written.

The primary problem of star travel is the tremendous distances which are involved. Even if a spaceship could approach the speed of light, which is considered a limiting velocity in the universe, it would take a man's lifetime and more to reach the nearest stars.

Writers of fiction have thought of four possible methods to approach the solution of this problem: the interstellar drive—a very vague type of mechanism to go from one point in space time to another point instantaneously; suspended animation; immortality—in essence; and the simple passage of time and human generations aboard the ship.

Suspended animation and simple time passage will be the only two types considered here, the other two possibilities being rather far-fetched in terms of present thinking.

The environment of the space voyagers, or the ship itself, would be the second great problem. With either solution of the distance problem, the ship would have to be very large to hold several hundred colonists, since this would probably be the smallest number of people necessary to maintain any level of civilisation comparable to that of Earth. There would be several ships starting out for the same destination, not merely one, since the investment in resources would have to be protected. The spaceships would have to be built in space because of the enormous mass involved, and landings on planets would be accomplished by means of life-boats.

The ships would have to be designed to maintain life, and two of the major requirements would be food and oxygen. The simplest and most permanent method of supplying oxygen would be through plant life. Food could also come through this method, along with storage of supplies.

In the suspended animation method of travel, a way would have to be worked out to awaken the colonists as they approached their destination. With this method of travel, there would be no particular social problems aboard the ship. The problems would all be after landing.

The third great problem in the star voyage would be the social problem. In the suspended animation type of approach, the major question for the social scientists to answer would be: "What type or types of person are potentially capable of colonising a new world?" A subsidiary question would be: "What type or types of person would be willing to leave their mother world with little hope of ever seeing it again?"

In the ordinary time passage type of flight, the social questions become far more complex and difficult to solve. This becomes so because of the time factor.

Question: What type or types of person would be willing to spend their entire life aboard a star ship with no hope of ever living on the surface of a planet again?

Question: What type of person could live in a comparatively small group with no possible change of scene, raise their children under such conditions, and die without ever seeing the promised land?

Question: Could children and grandchildren who had spent their entire lives on a space ship, with no conception of life on the surface of a planet, successfully adjust to a planetary life?

Question: How would it be possible to assure that such children, unacquainted with Earth and its culture, could successfully re-establish a continuation of that culture on the surface of a strange world?

On the somnambulistic type of trip, the answer to the type of individual to choose would be rather restricted. Who would like to leave the earth forever and would do so willingly and even eagerly? The broad category would be those who were failures upon earth, the socially damned. Thus it was that America and Australia were initially colonised. Thus, possibly, the stars may be colonised.

Are such people capable of colonising a new world? Evidently they are, since they have done so before. Give a failure new conditions to live under, including a new society which he participates in establishing, and it seems probable that he will succeed.

Will a society established under these conditions tend to resemble that of Earth? This is begging the question. There is no necessity that it should do so, since there is no real connection with Earth, many light years away. Secondly, even if it did to begin with, it would soon change, since the living conditions would be very different. A pioneer civilisation with unlimited land and wealth there for the taking would be bound to be different, especially with little or no culture contact.

In the time passage type of flight, the selection of personnel would be more difficult. The ordinary, gregarious type of person who thrives on chatter, back-slapping and social amenities would probably not work out. The confinement and the lack of social turnover would be soul destroying. The socially frowned upon human type of failure, who might work out well on the somnambulistic trip, could get into a gigantic amount of trouble under the rigid conditions of discipline, authority and law aboard the spaceship. Probably the person best suited for this type of trip would be the introvert. Not being a man of action, he would take no action against authority. He might grumble and gripe, but he would do his job, as long as he was allowed to follow his bent in his own time. There would have to be a surfeit of escape mechanisms available for such people so that they could follow their customary way of life. There might be something of a problem as far as procreating was concerned with such a group, but this might be compensated for in various ways, one of which would be the selection of couples—if people still married then—who were already expecting a child.

Assuming a voyage of sixty years, such as Heinlein did in his "Universe," this would mean that the children of the original voyagers would be approaching old age before the end of the trip and the grandchildren would be approaching middle age.

There is little or no likelihood that introversion is hereditary. It is generally considered to be largely a matter of background. Thus, the spaceship children and grandchildren will probably be "normal" individuals, largely of the usual gregarious type. Since these new individuals would never have known any other kind of life to use as a basis of comparison, they would work out quite well in the second and third generations.

The major problem on this type of voyage would probably be the settling down on a planet. In terms of our present concepts of longevity, all the original voyagers would be dead or half dead on arrival. The living colonists would be people whose whole universe always had been a ship travelling through space. Agoraphobia could conceivably be quite a problem. A tremendous amount of psychological insecurity would be likely for a group brought up in a small, enclosed space, once turned loose on the immensities of distance of a planet.

One possible approach to compensation for this in advance would be to get these space ship dwellers used to the immensities of space by sending them out into it from the ship during the voyage. Thus, there would be frequent space suit drills from early childhood.

It is conceivable that another type of problem might arrive when the ship arrived at its destination. Given a group of individuals satisfied with their environment, they are apt to be rather reluctant to change it. Why leave the ship? Why not go on and on forever? "It was good enough for my father and my grandfather, and it's good enough for me." This is a rather strong possibility, but once again could be compensated for in advance, by not making too good a ship. In other words, a ship which would operate efficiently for possibly 150 years, to give the colonists some leeway in finding a planet, but would definitely not operate indefinitely.

A fourth great problem in any starship voyage would be justifying the voyage on Earth. What would the people of Earth get out of such a voyage? Would it solve any over-population problems? Definitely not. Would it supply new material wealth or needs to Earth? Definitely not. Would even communication with the colonists be possible, once they arrived? Probably not.

The only justification would have to be in terms of intangibles, which, after all, is the way man usually justifies any action he takes. A step outward into the Universe will have been taken. Perhaps some day man could be found in every nook and cranny of the Universe! And that old, nagging curiosity about the stars twinkling up there in the sky will have been partially satisfied.

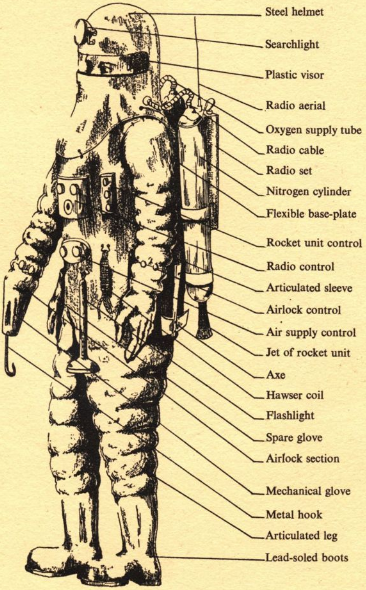
This article has mentioned four possible ways in which a sky ship voyage could be made. There is a fifth, however, which would obviate every difficulty which has been mentioned heretofore. Is it possible? Is it practical? Who knows what another millenium will bring?

What is the ideal star ship? What kind of vessel will present a minimum of psychological problems? What kind of vessel could solve the major problem of relieving over-population—transportation?

A planet, of course. The day may well come when our remote ancestors will literally move the earth.

A SUIT FOR SPACE

Below is shown an impression of the kind of suit the well-dressed spaceman will wear. This garment is suitable both for wearing in space itself—such as when the spaceman is outside his ship doing repairs—and on planets where conditions are such that men must be protected from them, which includes *all* the planets that revolve around the Sun. The main body of the suit is made of metal-impregnated plastic that is completely air-tight and flexible. The helmet is strong steel with a very tough plastic visor that gives an all-round view of the surroundings. At the cuffs are diminutive air-locks which enable the wearer to replace the gloves by a variety of instruments such as hooks, spanners, etc. Heavy boots enable the wearer to retain his balance in low-gravity conditions.



. . . . and what it's like up there

Up in space, conditions are a very great deal different from what they are at Earth's surface. It is probably safe to say that no one on Earth has yet experienced anything very like space conditions—though a number of research establishments have developed instruments that approximate *some* of these conditions.

To begin with, of course, there is no apparent gravitational force. Although the force of gravity that all material things possess does not end at any point, it certainly grows weak at great distances; and a ship which is in a circular orbit—or any other kind of orbit if the motors are off—experiences no gravitational force at all. The nearest we on Earth get to this state is when we try to sit on a chair that is not there, or when we dive into a swimming pool, or when we commit suicide by jumping off a tall building.

You can see then that out in space the human body will feel all the time as though it were falling! Perhaps this feeling would wear off after the person had been in space some time. No one knows.

But there is no doubt that *everything*, as well as the human body, would appear to be weightless. Objects could be placed in mid-air and they would simply stay there. No shelves are needed on spaceships! All drinking would have to be done through a straw, because liquids would not run out of their containers; you could turn a bucket of water upside down without spilling a drop—and if you gently pulled the bucket away, the water would hang in the air as a liquid ball. All you'd have to do then would be to stick a straw into the ball and suck!

Walking would be impossible. If you moved your legs the way you do in walking on Earth, you would shoot up into the air and bang your head on the ceiling. The only way to move around in space is by floating and pulling yourself along by your hands—and gently at that. Of course, this apparent lack of weight comes in very useful when building operations are under way. One man could move the heaviest girder merely by giving it a slight push; his main problem would be to stop it flying away from him and being lost in the dark recesses of space.

When spacemen want to sleep, they will simply lift their feet off the floor and lie suspended in mid-air. Getting upright again will not be so easy. They will have to thresh about with their arms and legs until they can reach a strap or a bulkhead. Most likely they will tether themselves to the wall before going to sleep.

Another odd thing about space is that everything on the ship retains the velocity of the ship unless it is given a hefty push in some other direction. If you open an air-lock and place something outside—a dead animal, for example—it will just sail along beside the ship until the latter alters course. In the same way, a man can step outside the ship and paint the hull or do whatever he wants to do, with no danger of being left behind. Usually, though, he will rope himself to the ship just in case—to be left behind in space would not be pleasant; the unfortunate man would drift on and on until he came into the gravitational field of a planet or star, and would then be dragged down to crash on the surface—unless he was burned up in the atmosphere first.

As shown in the drawing opposite, his space suit will probably have its own little jet motor attached, so that he can rocket himself around at will—but not for very great distances. Also, his boots may have electromagnets in the soles; this will enable him to walk about inside or outside the ship, the magnetic attraction taking the place of gravity.

And, naturally, there is no air in space. Although space is not, as popularly supposed, a vacuum, it is still very nearly such. Certainly there are not enough air particles to support any kind of life, let alone a man's. So his spacesuit will have to incorporate oxygen bottles that will keep his helmet constantly supplied with this life-sustaining gas. And the spaceship itself will have to have some kind of apparatus for regenerating the air inside it. On long journeys through space the air will have to be used over and over again.

Another consequence of there being no air in space is that there also is no sound. Sound, normally, is simply a disturbance of air, though sound will also travel through almost any medium, such as water, wood, bone, etc. But it must *have* a medium. In space there isn't one. So space is characterised by sheer silence. On Earth, two men in spacesuits could probably talk to each other—just as two people on each side of a door or window can speak fairly easily. But two spacesuited men in space could not do this. They could shout for all they are worth inside their helmets, yet not even a whisper would pass across to the other man. To look after this side of things, spacesuits will have built-in radio transmitters and receivers.

Lots of people look upon space as being cold. This is not true. Space is neither cold nor hot, nor any degree of warmth in between. Space has no temperature. Only something material such as metal, wood, air, etc., can have a temperature. But the spacesuited spaceman will have a temperature. Outside his ship he will be exposed to all the radiations of the Sun, and he will be liable to burn. Thus his suit will be very bright in order to reflect as much radiation as possible, and it will incorporate a temperature-regulating device.

We have no space to go more deeply into space conditions, but enough has been said to show that the conquest of space involves something entirely new in human experience.

HOW BIG IS SPACE?

by

Frank Wilson, B.Sc.

ANYONE who travels around this world may think that he covers pretty large distances, and of course, relatively speaking he does. But again, relatively speaking, he hardly moves. When ordinary terrestrial distances are looked at from the point of view of the whole universe, they seem to be mere inchings.

After all, our nearest celestial neighbour, the Moon, is a quarter of a million miles away, and that is more or less equivalent to going round the Earth completely just once. Our nearest planetary neighbour is Venus. Its mean distance from Earth is 26 million miles. If you went right round the Earth 14,000,000 times you would just about have covered that distance. Then, at the limits of the solar system, there is Pluto—2,350 million miles from Earth on average. You'd have to go round the Earth a hundred million times to approximate this distance.

The time factor, too, is a guide to these distances, which cannot really be understood until they have been traversed. A ship that left Earth at 25,000 miles per hour would take five days to reach the Moon. The trip to Venus would require nearly five months, and the one-way journey to Pluto could not be accomplished in less than twelve and a half *years!* More likely, the Plutonian cruise would take nearly seventeen years.

But even now, with these distances so great that the mind has difficulty in conceiving them, we have got nowhere near the really *big* distances. Not until we begin to consider the stars are we handling really respectable distances.

Take our nearest stellar neighbour, called Proxima Centauri. This star is so far away that light, travelling at 186,000 miles per *second*, would take more than four years to reach it from Earth. In round numbers, the distance of Proxima Centauri is 25,000,000,000,000 miles. This star could suddenly die—and we would not know about it until more than four years later. When you look up into the sky at night, some of the light that hits your eye may be coming from stars that have long ceased to exist. People go searching all over the world in the quest for very old things. Yet they could save themselves the trouble simply by looking at the sky. It is a fact that in the case of many stars the actual light that enters your eyes began its journey long before man appeared on Earth, long before the Earth was formed even, long before our Sun came into existence, maybe.

One of the remotest stars in the Milky Way stysem is called Betelgeuse. This is so far away that light would take 296 years to reach it from Earth. Of course, strictly speaking, Proxima Centauri is not the nearest star to Earth; the Sun is. The Sun is some 93 million miles from Earth, and its light takes eight and a half minutes to reach us. You see the sunset eight and a half minutes after it has actually occurred!

So far we have been dealing with our own system of stars, called the Galaxy of the Milky Way. But there are many other galaxies. Each galaxy contains millions upon millions of stars which, though appearing incredibly far apart to us, are yet clustered together into what has been called an "island universe." And each galaxy is many millions of miles from the others.

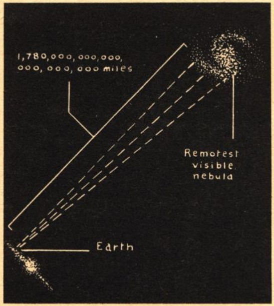
The galaxy nearest our own is called Andromeda, and this is on the other side of a piece of space that light would take 750,000 years to cross. Astronomers consider that very close! These galaxies can be seen in all directions around Earth, and they are all rushing away from what seems to be a central point. It is as though the universe is a gigantic explosion—*that is still going on!* Their velocities are enormous, and increase with increasing distance. Thus a galaxy at a distance of 72 million light years (*i.e.*, light would take that long to reach it) travels at 7,300 miles a second; and a galaxy at 150 million light years travels at 15,000 miles a second. The biggest-in-the-world telescope at Mount Palomar can photograph galaxies that are between 300 and 400 million light years away. That marks the limits of the known universe at present. But when we say "known" we are using the word very loosely. We don't even know if those galaxies still exist; they may have gone out of being anything up to 400 million years ago!

And distance is not the only aspect of size in the universe. Mere diameter is often so astounding as to be almost unbelievable. Most of us think, for instance, that our Sun is pretty big. It has a diameter of about 900,000 miles. Yet astronomers have found at least twelve other stars whose diameters are larger than Earth's *orbit*. In other words, you could put the Sun and Earth inside them and yet keep their respective distances, and even the very smallest of the stars, whose diameters have been measured, is many times larger than the Sun.

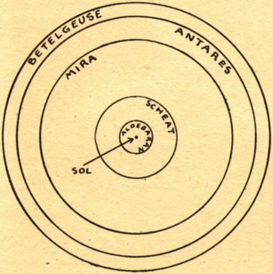
When we come to consider galaxies, we naturally find even larger diameters. Here, our own system is not to be scorned, for its diameter is about 78,000 light years. The Andromeda galaxy mentioned above has a diameter of 65,000 light years, and some others are even bigger.

Whether the universe is finite or unbounded no one really knows. There are a number of conflicting theories about this point. One question that springs to mind is how far out do the galaxies extend? We can see them up to 400 million light years away. Are there any more farther out? No one knows for certain, but there is every reason to suppose that there are. Suppose, then, that the farthest galaxy is x million light years away. What is on the other side of that? And how far does whatever it is, extend?

These are imponderables. But we have at least enough knowledge to be sure that if the universe is not infinite, then it is at least pretty vast!



Above is a diagram showing the enormous distance between the galaxy that contains Earth and the remotest visible nebula. It is a great credit to man's skill and ingenuity that he can construct instruments that will pierce space to a distance of 400 million light years. **Below** is shown to scale the relative sizes of various stars. On this scale the Sun is a mere point, and a circle representing the *orbit* of Earth would lie between Scheat and Mira. Betelgeuse, one of the largest stars known, is almost as great in diameter as the orbit of Mars. Most of the larger stars are red or orange, whereas our Sun is yellow. Also, the larger stars are very tenuous. Betelgeuse, for example, contains less matter than a fairly good vacuum!



DEATH rides the SPACEWAYS

(*Continued from page* 16)

pierced his lung, "shrapnel" mangled his right leg, his left arm muscles and nerves were severed.

He was given no chance of survival. Nevertheless, three surgeons operated simultaneously for six hours—and he pulled through. Maxwell Smith, graduate of the Massachusetts and California Institutes of Technology, victim of a leaking valve, martyr of a space movie.

But I spoke to Max a couple of weeks after the accident, and he had assumed a remarkably philosophical attitude toward it. "You know, Ackerman," he said, "all my life I worked with my hands—from here on in I'm going to use my *head*."

Still, the end was not yet on the mayheming misfortunes that plagued the picturisation of *Riders*. In one hair-raising episode William Lundigan, his strength waning, is ordered to return to earth. He is over the North Pole as he receives instructions to decelerate, and fires a nose rocket once.

Suddenly a meteor approaches. Lundigan decides to take a crack at trying to capture it. Against orders he switches off automatic operation and accelerates. He is rapidly using up his fuel. At a speed of 300 miles a *second* he "inches" up on the celestial speedball, which is about fourteen inches in diameter and revolves slowly around its axis.

He falls behind the meteor, moves in cautiously, activates the scoop, secures the meteor!

Returning to automaticomputer, he is told when he reaches altitude eighty miles. He will hit atmosphere in thirty seconds. He opens glide-wings.

The rocket temperature increases to 130 degrees . . . 140 . . . 190 . . . 210 . . . 220!

Blinded by sweat, his vocal chords scorched, Lundigan rasps: "I can't take it any more—too hot—burning up—get me out of here!"

And at this point a model rocket caught fire and special effects man Harry Redmond came squealing to studio nurse Lucille Damewood with a blistered right hand. Lucy treated Red for second degree burns while I looked on and made sympathetic noises, wondering how long it would remain safe just to be a *reporter* on a space film!

The *fourth* accident happened when star Richard Carlson, who had survived a tussle with The Magnetic Monster and the frog-horror of The Maze and the Bradburian Thing that Came from Outer Space, took a tumble. He was rather far above the floor, "floating" in free fall, when the invisible piano wire supporting him snapped in two. I didn't wait to learn whether he intended to sue for non-support.

My Pal George, who gave us *Destination Moon, When Worlds Collide* and *The War of the Worlds*, just 'phoned, inviting me to take a trip to Mars with Chesley Bonestell over at Paramount Studios, where they're filming Willy Ley's *Conquest of Space*, but I'm not getting out of bed till Lloyds of London answer my urgent cable: WILL YOU INSURE LIFE OF REPORTER WHO FREQUENTLY COVERS FILMING OF SPACE MOVIES?

THE END

FROM EARTH TO THE STARS *(Continued from page 20)*

During the trip the crew lives in one of the massive spheres, where also are laboratories. They will carry out observations throughout the journey, examining the chemistry and physics of space. In the region of Mars they will spend some time in orbit, observing the planet and its two moons.

When these observations are complete and the crew has decided where to land, they will go to the sphere at the other end of the ship and get out the space-to-planet vessel. They may first land on one of the moons, say Phobos. From this vantage point they can make even more detailed survey of Mars before going on to land on the planet.

The actual landing on Mars will be much the same as when a spaceship lands on Earth. True, the Martian atmosphere is much thinner than Earth's, but this simply means that the ship will have to spend more time coming down.

The rocket ship that actually lands on Mars will be very large, and it will probably be so supplied with fuel that it can make several trips to and from the space-to-space ship in the orbit above the planet. For, remember, these spacemen have to stay where they are for about fifteen months, and they will have to build themselves some kind of shelter from the elements. (They will, at least, be free from trouble by wild animals, for such can hardly be expected to exist on Mars.)

Thus they will bring down from the space-to-space vessel prefabricated domes and equipment for setting up man's first base on a planet. Under these air-tight domes—the Martian atmosphere has too little oxygen to support active life—they will live out their time until Earth and Mars are in the right positions for the return journey to be made. But they will not be idle, of course.

During their stay on the planet, the spacemen will carry out many investigations, collect many samples of rocks and soil for later analysis on Earth. They will bring back to their home planet the information that future expeditions will need. On the basis of this information, mining equipment will be taken to Mars, together with other material for setting up a permanent base there. The tiny domes of that first expedition will form the nucleus for a future colony. Whole families will be taken to Mars, and the children will live and die there, giving rise to other children who will never have seen the planet from which their grandparents emigrated.

The Martian colony will build and service ships that will push on across space to the other planets. Both Saturn and Jupiter are too large, probably, for ships to be able to land and take off again. Man's acquaintance with them may be limited to landings on their moons. It is just about possible that we shall be able to send spaceships down onto Uranus and Neptune; these planets are about half the size of Saturn and Jupiter, and it is fairly likely that when space flight science is well advanced, the right design of ship will be available for these operations.

But certainly we shall be able to land on one of the moons of Uranus and Neptune. Here indeed, say upon Triton, moon of Neptune, will probably be set up man's last outpost in the solar system. It will be a jumping-off place to the stars. The plate facing page 70 is an artist's impression of the kind of base there will be on Triton. This is a cold, cheerless world, only 3,000 miles in diameter and about 2,800 million miles from the Sun. It is so cold that no water can exist naturally; it will all be frozen. Even carbon dioxide will probably exist in solid form. So men outside the base-domes will have to wear heated spacesuits, and the domes themselves will need a plentiful supply of warmth.

Up in the space above Triton, scientists will build the most gigantic vessel ever seen—the first starship! The parts and equipment, some of it flown perilously and tardily from Earth or Mars, will be assembled in an orbit around the moon. Its construction will take many months, maybe even years, and its cost is something that no one today would even hazard a guess at. Pretty certainly it would have to be a joint enterprise of all nations, including the new states on Mars and Venus, the Moon and Mercury.

But somehow, no one doubts, the money will be found, and the prodigious amounts of materials will be accumulated. Piece by piece, the starship will grow in the dark sky on the rim of the solar system. The starship will almost certainly be the most ambitious project that mankind has ever undertaken. Before we look at it in detail, let us consider what it will have to do. Let us see just what is entailed by a journey to the stars.

The stars are a long way away. The nearest star is so far away that light takes three and a half years to cross the distance between it and Earth—and light travels at 186,000 miles per *second!* This works out at some 15,000,000,000,000 miles. And, as far as we know, this particular star probably has no planets circling round it. So there is no point in travelling to it. The chances are that the first starship will have to travel very much farther before it finds a world on which human beings could live.

The ship will set out from the solar system and speed away into the black void of real outer space. It will travel for many years before reaching the first star. Even if the ship can move at an average speed of 6,000 miles per second—and interplanetary ships will be hard put to make an average of only 6 miles per second—the starship will take some hundreds of years to reach the nearest star. And then the people aboard may discover that there are no planets attached to that star. Then they will have to turn the ship and start off for the next nearest star. After a few more hundred years they may reach it and find that it *has* planets, but that none of these planets is suitable for human life. So they must travel on and on among the wide-spread stars in their search for a new world.

All this means that the starship can be no ordinary vessel of space. Nor can the people aboard be a mere handful of crew and passengers. Starships will not transport individuals or groups but *colonies*. And they will have to support these colonies of maybe several hundred or a thousand people for centuries.

It is a project that awes the imagination. Consider it. Some few hundreds of people climb aboard the ship and wave goodbye to the planet that gave them birth and breeding. The ship glides on and on through space.

Continued on page 68

The First Stage of the Rocket is Fuelless and is Dropping Back to Earth by Parachute

From Earth's New Satellite, Man Sets Out on his Conquest of Space


HARTNELL
TUBBY
POP
OLD GROWLER
SPACE SHIP Nº2213
By Jon J. Deegan
"GO TO FELLIK – FOURTH PLANET OF VEGA FOR PRELIMINARY OBSERVATION," SAID THE INTERPLANETARY EXPLORATION BUREAU, AND THAT MEANT ANOTHER JOB FOR SPACESHIP Nº 2213, NICKNAMED "OLD GROWLER" BY HER IRREVERENT CREW.
WE KNEW FELLIK MIGHT BE INHABITED, BUT THIS FOOTPRINT IS HUMAN....
...AND WE'RE THE FIRST TERRANS TO REACH THIS SECTOR OF SPACE!
THEN IT MUST BE A RENEGADE SPACE-MAN, POP, ANTHROPOID ALIENS JUST DON'T EXIST OUTSIDE THE VIDEO SERIALS!
I HAD BETTER REPORT TO THE SHIP AND SEE WHAT CONTROL THINKS ABOUT THIS!


X3 CALLING CONTROL 2213, WE HAVE FOUND WHAT APPEARS TO BE A HUMAN FOOTPRINT AT APPROXIMATE MAP REFERENCE P 450. ONE TOE IS MISSING. — REQUEST GUIDANCE!
NO RECORD OF ANY WANTED MAN WITH MISSING TOE IN THE FILES. YOU ARE AUTHORISED TO USE SPEED-GAMMA PISTOLS IF NECESSARY - - -
- - - - AGAINST ANY HUMANS YOU MAY ENCOUNTER. STANDARD RULES APPLY CONCERNING OTHER FORMS OF INTELLIGENT LIFE. NO FURTHER SPACE PARTIES WILL BE SENT OUT UNTIL YOU HAVE MORE INFORMATION. USE YOUR DISCRETION IN PROCEEDING. THAT IS ALL —— OUT!
HEY POP!! TAKE A LOOK AT THAT!!
HOLY MOSES! IT MAY NOT BE HUMAN, BUT IT COMES NEARER THAN ANY LIFE FORM I'VE EVER SEEN!


WELL! WHAT DO YOU THINK OF THAT! IT THINKS THAT WE LOOK FUNNY! ANYWAY, IT'S GOT A SENSE OF HUMOUR. DO YOU SUPPOSE YOU CAN COMMUNICATE WITH THAT THINGUMMY OF YOURS, POP?
TUBBY! DON'T REFER TO THE ERRIKSEN BASIC STELLAR VOCABULARY TRANSMITTER AS A THINGUMMY! YOU'LL ANNOY POP!
IF YOUNG HARTNELL WILL DRY UP, I'LL TRY IT! ODDS ARE THAT THIS IS AN ANTHROPOID RACE SO HE MAY UNDERSTAND!— "WE ARE MEN OF SCIENCE. WE COME IN PEACE!"
THAT TOOK THE GRIN OFF HIS FACE! BETTER REPORT TO THE SHIP FOR ORDERS!

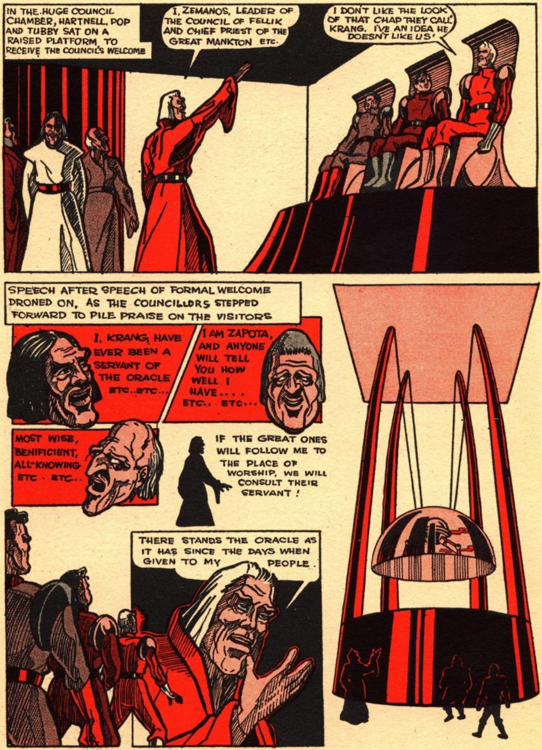

INDIVIDUAL WHO APPEARS NATIVE TO FELLIK HAS BEEN SEEN— PRIMITIVE TYPE PROBABLY ERRIKSEN VOC Nº III!
CONTACT SPECIMEN AND COMMUNICATE WITH HIM.— REPORT BACK AFTER THE USUAL INTERVAL.. THAT IS ALL.— OUT!
ALL RIGHT SLEEPYHEADS! THAT MEANS US. WE'RE GOING AFTER OUR MONKEY FRIEND!
COME ON TUBBY! A BRISK TROT WILL HELP TO TRIM YOUR FIGURE DOWN A BIT!
GET YOUR BREATH, BOYS, WE'VE FOUND THE INHABITANTS!
WHAT A MEATSAFE! THAT'S WHY WE MISSED THEM FROM THE SHIP.— THEY LIVE UNDERGROUND

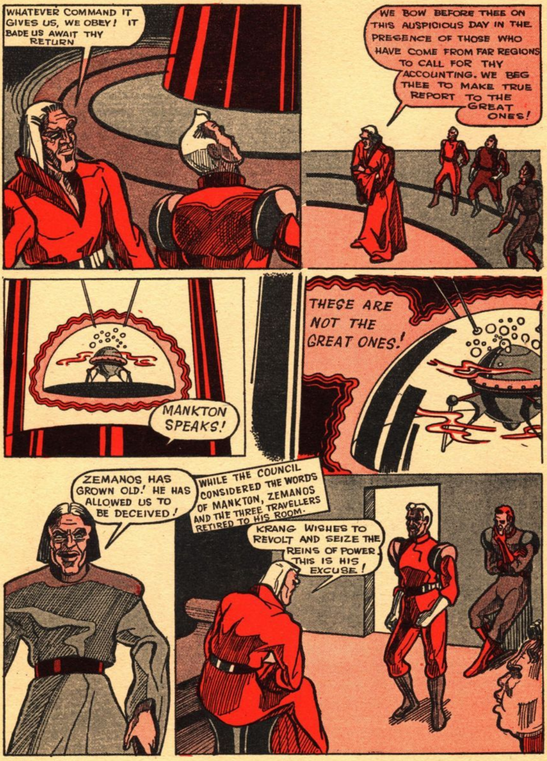

I CAN'T BELIEVE THAT SUCH PRIMITIVE TYPES COULD BUILD A PLACE LIKE THIS!
ONE UP TO YOU, POP! JUST TAKE A LOOK AT THOSE BOYS WAITING FOR US IN THE HALL AT THE BOTTOM OF THE STAIRS. THEY LOOK LIKE A DIFFERENT RACE!
A THOUSAND WELCOMES O GREAT ONES! WE HAVE AWAITED YOUR COMING FROM THE DAY WHEN YOUR SERVANT WARNED US OF YOUR RETURN
MY NAME IS ZEMANOS. I BEG YOU TO ENTER OUR DOMAIN.
IF IT IS YOUR PLEASURE, WE WILL CALL THE COUNCIL WHEN YOU HAVE REFRESHED YOURSELVES AND THEN GO TO THE TEMPLE WE HAVE BUILT FOR YOUR SERVANT, MANKTON THE ORACLE.


SINCE YOU WERE LAST HERE, A THOUSAND AND A THOUSAND AND MORE TIMES HAS THE PLANET REVOLVED AND WE HAVE EVER OBEYED THE COMMANDS OF MANKTON!
I PRAY YOU TO FOLLOW ME, AND THE ORACLE WILL MAKE REPORT THAT WHAT I SAY IS TRUE!
THIS SOUNDS LIKE A BAD CASE OF MISTAKEN IDENTITY TO ME, TUBBY!
THE PLACE OF WORSHIP LIES DEEP BENEATH THE SURFACE, O GREAT ONES. WE WILL DESCEND!
I'VE CHECKED THE AIR DOWN HERE ON MY METER, AND IT'S BREATHABLE, SO WE CAN TAKE OUR HELMETS OFF!
THIS IS MY HUMBLE DWELLING AND I WILL BE HONOURED IF YOU WILL ENTER....
.... AND EAT WITH US. THIS IS MY DAUGHTER, JERETA, GREAT ONES. IF YOU WILL BE SEATED, SHE WILL BRING FOOD AND DRINK!


I HAVE OFTEN WONDERED WHAT THE GREAT ONES WOULD BE LIKE. I AM GLAD YOU HAVE COME
YOU MUST WONDER WHY WE ARE HERE ON FELLIK AND NOT ON THE PLANET WHERE YOU LOOKED FOR US. FOR THY SPACE SHIP LAST CALLED ON MY PEOPLE ON A FAR DISTANT GLOBE
WHAT IS THE HISTORY OF YOUR PEOPLE, SINCE WE-ER- LAST VISITED YOU. THEN?
WHEN OUR SCIENTISTS PREDICTED THAT LIFE WOULD BE WIPED OUT ON THE PLANET BY THE NEAR APPROACH OF ANOTHER WORLD, WE CONSULTED MANKTON, WHO HAD BEEN LEFT TO US MANY GENERATIONS EARLIER BY YOUR PEOPLE, HE GAVE US INSTRUCTION IN THE BUILDING OF A SHIP SUCH AS THAT YOU CAME IN, AND TOLD US TO CHOOSE THE WISE AND FAITHFUL AMONG US AND TAKE HIM TO A DISTANT STAR, ON THE FOURTH PLANET OF WHICH WE LANDED, AND THUS WE CAME TO FELLIK!
POP! THIS MAP SHOWS THE PLANET THAT THIS RACE USED TO LIVE ON.- IT'S EARTH!!!
THE GREAT ONES SEEM DISTURBED! PERHAPS THE MUSIC OF MY PEOPLE WILL SOOTH THEM. MY DAUGHTER IS FAMOUS THROUGHOUT FELLIK FOR HER PLAYING

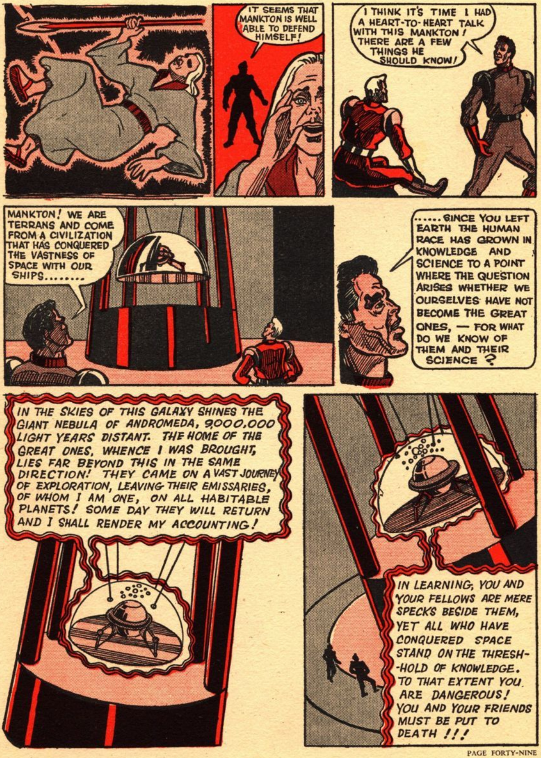

DOES THE PLAYING OF JERETA FIND FAVOUR WITH THE GREAT ONES?
WOW! MY EARDRUMS! YES JERETA, THE GREA— ER— WE HAVE NEVER HEARD MUSIC QUITE LIKE THAT BEFORE!
NOW MAY I SUGGEST WE PROCEED TO THE COUNCIL HALL? EVERYTHING IS READY FOR THY WELCOME!
SUITS ME! SOMETHING TELLS ME. THIS FRUIT IS NOT DOING MY WAIST-LINE ANY GOOD.
HEY POP, DON'T YOU THINK WE'D BETTER STRAIGHTEN OUT THIS "GREAT ONES" MALARKY? IT MAKES ME BLUSH!
I THINK WE'D BETTER PLAY IT THIS WAY! AT LEAST WE'RE WELCOME AS "GREAT ONES"!
BEHOLD THE HALL OF COUNCIL! THE HEADS OF OUR PEOPLE AWAIT YOU WITHIN!


IN THE HUGE COUNCIL CHAMBER, HARTNELL, POP AND TUBBY SAT ON A RAISED PLATFORM TO RECEIVE THE COUNCIL'S WELCOME
I, ZEMANOS, LEADER OF THE COUNCIL OF FELLIK AND CHIEF PRIEST OF THE GREAT MANKTON ETC.
I DON'T LIKE THE LOOK OF THAT CHAP THEY CALL KRANG. I'VE AN IDEA HE DOESN'T LIKE US'
SPEECH AFTER SPEECH OF FORMAL WELCOME DRONED ON, AS THE COUNCILLORS STEPPED FORWARD TO PILE PRAISE ON THE VISITORS
I, KRANG, HAVE EVER BEEN A SERVANT OF THE ORACLE ETC..ETC...
I AM ZAPOTA, AND ANYONE WILL TELL YOU HOW WELL I HAVE.... ETC.. ETC...
MOST WISE, BENIFICIENT, ALL-KNOWING ETC · ETC...
IF THE GREAT ONES WILL FOLLOW ME TO THE PLACE OF WORSHIP, WE WILL CONSULT THEIR SERVANT !
THERE STANDS THE ORACLE AS IT HAS SINCE THE DAYS WHEN GIVEN TO MY PEOPLE.


WHATEVER COMMAND IT GIVES US, WE OBEY! IT BADE US AWAIT THY RETURN
WE BOW BEFORE THEE ON THIS AUSPICIOUS DAY IN THE PRESENCE OF THOSE WHO HAVE COME FROM FAR REGIONS TO CALL FOR THY ACCOUNTING. WE BEG THEE TO MAKE TRUE REPORT TO THE GREAT ONES!
MANKTON SPEAKS!
THESE ARE NOT THE GREAT ONES!
ZEMANOS HAS GROWN OLD! HE HAS ALLOWED US TO BE DECEIVED!
WHILE THE COUNCIL CONSIDERED THE WORDS OF MANKTON, ZEMANOS AND THE THREE TRAVELLERS RETIRED TO HIS ROOM.
KRANG WISHES TO REVOLT AND SEIZE THE REINS OF POWER. THIS IS HIS EXCUSE!


SECRETLY, I HAVE LONG WONDERED IF THE WORDS OF MANKTON WERE JUST! PERHAPS THE PEOPLE OF FELLIK MIGHT BENEFIT IF HE WERE DESTROYED
AFTER ZEMANOS HAD MADE THIS REVOLUTIONARY STATEMENT, THEY RETURNED TO HEAR THE COUNCIL'S VERDICT.
THESE WANDERERS ARE ENEMIES OF MANKTON! THEY HAVE BEEN EXPOSED, - AND ZEMÄNOS IS IN LEAGUE WITH THEM!
THE SITUATION IS GETTING OUT OF HAND! USE YOUR GREAT POWERS OR WE ARE LOST!
TURN UP YOUR THROAT AMPLIFIER AND GIVE 'EM A TALK, POP! THAT SHOULD IMPRESS THEM!
BE SILENT AND HEAR ME, PEOPLE OF FELLIK! WE HAVE JOURNEYED FROM FAR WORLDS TO WITNESS THE MIRACLE OF MANKTON! BUT KRANG WISHES TO DICTATE TO YOU! WHO RULES FELLIK? KRANG OR MANKTON? LET US HEAR THE ORACLE'S WORD!
DO NOT LISTEN TO HIM! HE SEEKS TO CONFUSE US WITH WORDS! THEY MUST BE DRIVEN AWAY!
THE STRANGER SPEAKS TRUTH! LET US HEAR WHAT MANKTON SAYS!
THESE TRAVELLERS SHALL BE SENT BACK WHENCE THEY CAME! THEY SEEK TO SEIZE THIS PLANET FROM THE PEOPLE OF FELLIK!


NOW WILL YOU LISTEN TO THE WORDS OF KRANG? ZEMANOS AND THE STRANGERS CONSPIRE TO DESTROY US!!
I WONDER WHICH SIDE ZEMANOS IS REALLY ON? HE COULD BE PLAYING A DOUBLE GAME!
WHO CARES! THIS WAY WE GET AWAY FROM THESE BEETLE-BROWED TYPES AND BACK TO THE SHIP
THOUGH I'D LIKE TO KNOW MORE ABOUT THOSE 'GREAT ONES' THEY MUST HAVE INTERSTELLAR FLIGHT'
I BRING DROBNO. HE WANTS TO HELP THE WISE ONES TO OVERTHROW MANKTON!
THERE ARE MANY AMONGST US WHO DOUBT THE ORACLE! DEEP IN THE SECRET CAVERNS OF FELLIK LIE BOOKS THAT SPEAK OF FREEDOM AND JUSTICE. WE HAVE READ THESE AND THEY ARE FINER THAN THE DICTATES OF MANKTON!
IT IS SAID THAT THE BOOKS WERE BROUGHT FROM THE OLD PLANET NOW WILL I BREAK THE SPELL OVER MY PEOPLE .....
...WITH MY SPEAR I SHALL BREAK THE CRYSTAL IN PIECES!


IT SEEMS THAT MANKTON IS WELL ABLE TO DEFEND HIMSELF!
I THINK IT'S TIME I HAD A HEART-TO-HEART TALK WITH THIS MANKTON! THERE ARE A FEW THINGS HE SHOULD KNOW!
MANKTON! WE ARE TERRANS AND COME FROM A CIVILIZATION THAT HAS CONQUERED THE VASTNESS OF SPACE WITH OUR SHIPS........
......SINCE YOU LEFT EARTH THE HUMAN RACE HAS GROWN IN KNOWLEDGE AND SCIENCE TO A POINT WHERE THE QUESTION ARISES WHETHER WE OURSELVES HAVE NOT BECOME THE GREAT ONES, — FOR WHAT DO WE KNOW OF THEM AND THEIR SCIENCE?
IN THE SKIES OF THIS GALAXY SHINES THE GIANT NEBULA OF ANDROMEDA, 9,000,000 LIGHT YEARS DISTANT. THE HOME OF THE GREAT ONES, WHENCE I WAS BROUGHT, LIES FAR BEYOND THIS IN THE SAME DIRECTION! THEY CAME ON A VAST JOURNEY OF EXPLORATION, LEAVING THEIR EMISSARIES, OF WHOM I AM ONE, ON ALL HABITABLE PLANETS! SOME DAY THEY WILL RETURN AND I SHALL RENDER MY ACCOUNTING!
IN LEARNING, YOU AND YOUR FELLOWS ARE MERE SPECKS BESIDE THEM, YET ALL WHO HAVE CONQUERED SPACE STAND ON THE THRESH--HOLD OF KNOWLEDGE. TO THAT EXTENT YOU ARE DANGEROUS! YOU AND YOUR FRIENDS MUST BE PUT TO DEATH!!!


AS THE FATAL WORDS OF THE ORACLE BOOMED THROUGH THE HALL, HARTNELL REALISED THEIR DANGER
WE DON'T KNOW WHO HEARD THAT, POP! WE'D BETTER GET OUT OF HERE WHILE WE CAN!
WAIT, O WISE ONES! KRANG'S MEN HAVE HEARD THE ORACLE COME WITH ME TO THE UNDERGROUND PASSAGES!
DOWN LONG WINDING PASSAGES THE THREE MEN RAN, LED BY JERETA, TO THE PLACE WHERE THE OLD BOOKS, RESCUED FROM EARTH, WERE HIDDEN FROM KRANG!
WE'VE BEEN FOLLOWED! I CAN HEAR FOOTSTEPS IN THE TUNNEL!
SO, WE HAVE FOUND THE ENEMIES OF MANKTON AND THE FAITHLESS DAUGHTER OF ZEMANOS! TAKE THEM TO THE ORACLE!
DEATH HAS BEEN DECREED FOR YOU, AND IT IS FITTING THAT MANKTON HIMSELF SHOULD EXECUTE IT! GO AND PIT YOUR PUNY WITS IN BATTLE FOR YOUR LIFE!


I HAVE BROUGHT YOUR HARNESS TO AID YOU IN YOUR FIGHT, WISE ONE!
WELL, I DON'T THINK A SPEED-GAMMA WILL HAVE MUCH EFFECT ON THIS BOY.. HE ISN'T EVEN ORGANIC. BUT I'LL TRY ANYTHING!
SPEED GAMMA'S NO GOOD, TUBBY.—I'D BETTER REPORT TO CONTROL, IT MAY BE OUR LAST CHANCE!
USE ALL MEANS IN YOUR POWER TO DESTROY THIS ROBOT.— HE REPRESENTS A THREAT TO OUR RACE THAT CANNOT BE OVER-ESTIMATED!!
CALLING CONTROL 2213. WE ARE CAPTIVES OF NATIVES RULED BY AN ALIEN IMPOSED ROBOT. ETC.
THE ONLY WAY THAT I CAN SEE IS TO CUT THE SUPPORTING CABLES SO THAT MANKTON CRASHES DOWN!
IT CAN'T BE DONE, POP! THESE CABLES WE'RE BUILT TO LAST IT WOULD TAKE MONTHS TO CUT THEM.


THIS DOESN'T LOOK VERY HOPEFUL! THE GREAT ONES CERTAINLY BUILT THEIR EMISSARIES TO STAND UP TO ANY ATTACKS! WE'LL HAVE TO THINK OF SOMETHING!
I'VE GOT AN IDEA!
I DON'T UNDERSTAND HARTNELL! WHY MUSIC AT A TIME LIKE THIS?
IT'S GOING! - AND KRANG IS UNDERNEATH IT !!!
HARTNELL EXPLAINED — "I GOT THE IDEA WHEN I REMEMBERED AN OLD PARLOUR TRICK, — BREAKING A GLASS BY THE RESONANCE OF A TUNING FORK. IF JERETA CAN FIND THE RIGHT PITCH AND HOLD IT LONG ENOUGH, IT MAY SHATTER THE CRYSTAL OR WHATEVER HOLDS MANKTON TOGETHER!
WELL, IT WORKED! AND NOW THE PEOPLE OF FELLIK CAN LIVE WITHOUT FEAR OF MANKTON! AS FOR THE GREAT ONES— WELL, TIME WILL TELL!
THE END

He was certainly an odd boy. But he was also a fine—

Playmate

by Leslie A. Crouch

I was in the kitchen hunting for matches to light my pipe when Bobby came bouncing through the door, letting the screen shut with a shattering bang. Without seeming to even pause in his rush he got out all in one long breath: "Hey, Mom, can I have Dickie for supper tonight?"

Betts paused at her task of trimming a pie before popping it in the oven.

"Who's Dickie, dear?" she asked.

Bobby snuffled, slyly helping himself to a cookie. "He's the new boy who moved in next door, Mom."

"Is he a nice little boy?"

I snorted a bit to myself at this. I don't cross Betts; it doesn't complement the happiness and tranquillity of a home to tell a woman how to raise your son. You just let 'em go their own way, and watch the offspring go his.

"Sure he's a nice boy." I sensed the disdain in his voice.

"What's he like, son?" I asked.

"Oh—I dunno—he's, well, he's jus' diff'rent."

We let it go at that. Betts would have carried the matter further, but, catching her eye, I shook my head. She desisted, smiling a little.

It was comfortable on the veranda. There was a little breeze blowing and I was sitting there, feet cocked up on the rail, half asleep. Betts came out and picked up a magazine. Only the slight sound of her flipping the pages disturbed the tranquillity of a hot summer afternoon.

"Hey, Mom! Where's the oil can?"

Our small son came tearing around the side of the house, yelling his request in that impatient tone all small boys seem to have some sort of a proprietary interest in. He mounted the steps and asked again before we had had a chance to answer.

"I think there's one in the cupboard under the kitchen sink," I supplied the information.

"Gotta be thin oil," he stipulated.

I grinned. "Three-in-one there. That thin enough?"

He rumpled his hair with a grimy hand. "I guess so. Dickie needs it."

Betts smiled. "What does Dickie need it for, dear?" she asked.

"Don't call me 'dear'!" he scowled. "That's baby talk."

"I'm sorry." She sounded hurt. "What do you need the oil for, Bobby?"

His voice came back to us as he vanished into the house.

"It's for Dickie. *He squeaks!*"

I frowned about the garage. I'd got tired of sitting about, doing nothing, so I'd wandered down here to the combined garage and work shop, thinking maybe there might be something I could putter a little time away on.

It was pretty messy. Various items that collect about any home, no matter how well managed, had collected in a hodgepodge that was without rhyme or reason. I thought I might tidy up a little.

I was well into things, shirt sleeves rolled up, when I heard voices. Unconsciously, as one will do when busy, I listened. It was Bobby, and apparently he had brought the other boy with him.

"Pop's got a bench back here. We can fix you there, maybe," I heard him say.

I grinned, thinking how funny the ungrammatical speech errors of small children are at times. I wondered, briefly, what might be broken that needed fixing.

I had hung up a basket, and was bending down for a rake when a definite denial from the direction of the bench broke in on my wandering thoughts.

"Heck, no," I heard this new voice exclaim. "Not that one. It's too large."

"No it ain't," Bobby's voice replied.

"It is, too. It'll stick way out and get in the way."

"Pop uses bolts too long. He cuts 'em off and polishes the end."

"Well—maybe—all right. Be careful though. I won't be able to pick anything up if it isn't just right."

Then I heard the various tiny clickings denoting tools in use, to be followed by the thin rasp of a hacksaw.

Not believing in interfering with the activities of boys at play, I went on with my work and quickly forgot the incident.

The roast certainly smelled good. But then, Betts is a wonderful cook. She teases me sometimes about that being the only reason I married her.

I helped her bring it in: she carried the platter, and I carried the carving utensils.

"Where's Bobby?" she asked, setting it down.

"Oh, somewhere about. Down in the basement, I think."

"Will you call him, dear?"

I did this and I could hear his footsteps and those of his new friend clattering up the stairs. The faucet went on splatteringly.

"Get another towel, Bobby," Betts called.

"Phooey!" Bobby answered. "Only need one. Dickie doesn't wash!"

I almost laughed at the horrified look on my wife's face. I turned to the window, thrusting hands into pockets. Cleanliness is almost a fetish with her and I knew how Bobby's remark must have needled her.

She marched—that is the only word—toward the kitchen.

"Oh dear," I heard, a second later.

When I turned, she was standing behind her chair at the table, a funny look on her face. It wasn't a frightened one. It was sort of, well, amazed, dumbfounded, perhaps. I couldn't place it, and I can't yet when I think back. She looked at me, and gave the queerest little shrug, helpless like.

Then Bobby and his friend came in.

We all sat down and I had carved the roast and was passing the plates around before I got a chance to look at the new boy closely. I'd thought there was something a little out of the ordinary about him when he had come in. His walk had been rather stiff, as though his knees wouldn't bend properly.

When I saw his face I was astounded. Never had I seen one like it before.

It had human lines, yes. The texture of the skin, if skin it was, appeared normal, outside of a certain hard appearance, a harshness, that was altogether alien. That is the only term I can use—alien. The mouth opened, but it wasn't pliable like a human mouth. It was supposed to be that, I know, but it still was something else.

I watched him as we ate. He drank his milk as Bobby did, only differently. That is, he didn't seem to swallow it, he just appeared to pour it down. He'd place the glass to his lips, tip it, and the fluid would pour down, steadily, quickly, and the whole glassful would disappear in one smooth flow, without halt or apparent discomfort.

Exactly as though he didn't have to swallow, but just poured it straight down, I thought to myself. As though he had no gullet!

And the way he ate. This was something even stranger. He didn't place the food in his mouth and chew it, with pauses now and then. He fed himself like an automaton. Each piece was cut from the meat, each forkful of potatoes, each bite of bread, was an evenly spaced motion as though controlled by a mechanism. Each portion was of the same size. And this went on until his plate was empty, without the slightest sign of hesitation, except to take another glass of milk, which was poured down the same way as the first.

He didn't chew his food, either, as far as I could see. I know it must sound as though I am a very imperfect host, to watch a guest in such a fashion. But I think that if you were in the same position, you would have done the same. As I have said, he didn't appear to chew his food. His mouth would open, receive the portion brought up by his fork, close—and that was all. Absolutely no motion of working jaws; no sign of swallowing.

When the main courses were finished, we had ice cream, a favourite of Bobby's. This is something I have to eat with some circumspection, as it bothers my teeth at times. Betts can eat it without a thought in the world. But she still doesn't take it the way Dickie did. He shovelled it in the way I'd stoke my furnace on a cold night. I could picture the inside of his mouth becoming iced up and needing some sort of defrosting. But it didn't seem to bother him a bit. He held out his plate for a second helping, which went the same way as its predecessor.

Finally the meal was over. Bobby, as is his wont, was impatient to get away. His friend seemed just as eager. As they left the room I again noted the stiff, rather awkward, yet albeit somehow graceful, stride of his.

I looked at Betts. She was staring at me with eyes big and round.

"What's the matter, dear?" I asked.

"That boy, Al. He isn't normal."

That was an understatement, I told her.

"Oh, I know what you mean. The way he eats. But that isn't all."

I lifted my eyebrows.

"When I went to the kitchen to see about him not washing, what do you think I saw?"

I stuffed my pipe and eyed the bowl appreciatively.

"I saw him oiling himself!"

I lit up. The pipe drew swell. After a full meal, the good rich tobacco tasted wonderful.

"Al, did you hear me? I said he was oiling himself!"

"Oh sure, he was oiling himself. What's wrong with that?"

I got up, pushing the chair back with a muted rasp. I stretched. Feeling like a short siesta, I started for the front porch. Then it was that the intelligence of her words struck me. I did a quick double-take.

"He was doing—WHAT?"

She smiled, smugly. "Oiling himself, Al."

I leaned on the table. "Easy now, Betts, old girl. Easy now. Maybe you ate too much—maybe the heat——"

"Heat nothing. He was leaning against the table and he had a can of oil and he was squirting it in his hands and rubbing it on his neck and wrists."

I sat down. Looking at her, I wondered.

"No, I'm not crazy," she said. "And I'm not cracking up. I'm just telling you what I saw."

I thought it over. I was pretty sure she was mistaken. She had seen something, but to her it had looked entirely different. Betts is a highly imaginative person, what with reading those science fiction magazines and stuff. But I looked at her closely, as it still didn't sound like her.

I rose. "C'mon. We'll look up Dickie and get to the bottom of this."

They were building something in the back yard. It looked like a house, or maybe it was supposed to be a boat. They had two or three old piano crates, and with some scrap lumber from the loft over the garage, were nailing it all together.

Bobby was busily banging away with a hammer. I imagined the nails he was using, with his habit of using ten where one or two would do. I could hear his friend hammering away on the other side, out of sight.

"How ya doin', Dickie?" Bobby yelled as we came up.

"Fine," Dickie replied.

"Ya usin' the hammer?"

"Nope. Do it faster without."

"Don't it hurt your hand?"

"Naw!"

"I wish I could drive nails with my hand."

"It's easy. Ya just double up your fist and give the nail a whack on the head——"

We didn't hear the rest. We moved around the packing cases and stared.

Dickie was standing there, nails sticking out of his mouth. He'd take one in his left hand, hold it to the wood, and bang! bring his fist down on it and drive it home. No hammer—no nothing. Just his bare hand,

doubled into a fist, and he was driving those nails home with the regularity of a slow trip-hammer.

Betts, fainting, knocked the pipe from my mouth. I carried her into the house and started fussing over her.

After she had recovered, we held a consultation. Then we went over to our new neighbour and rapped on the door. When it opened we faced, not some strange creature, as I think we half expected, but a perfectly normal woman, somewhat harassed looking, wiping her hands on a flowered apron.

"I'm Al Hason," I introduced myself. "We live next door——"

"Oh!" She seemed to be expecting us, by the look on her face. "Please come in."

She ushered us into a nicely furnished parlour and called to someone named John. Her husband, I suspected.

"This is Mr. Robeson," she introduced us. To her husband: "They live next door."

He drew in his breath and lines of weariness grew about his mouth.

"We've been sort of expecting you," he said, sitting down. "But not so soon."

My eyebrows raised.

"I guess," he patted his wife's hand where it rested on his shoulder, "I guess you've met our son."

"Yes," Betts answered. "Our little boy had him at our place for supper."

Mrs. Robeson sat down and started to wring her hands.

"Oh dear. So now you know! We have had to move so often—people just can't understand."

I started feeling uncomfortable. I ran my finger around inside my collar and wished we had left well enough alone.

"Oh, I'm so sorry," Betts said. "But really, he seems such a nice boy. He is so quiet and well mannered. We—er——" she stumbled.

"Yes, I know just what you mean, Mrs. Hason." Robeson rose to his feet, started pacing up and down the small room. "You can imagine what we feel like, living with him for almost seven years. We know even less about him than you do."

"Perhaps a doctor——" I muttered and was sorry immediately. He heard me.

"A doctor?" He smiled slightly. "I had the same idea a long time ago. We took him to the best and found out nothing. After looking him over for a time, they wanted to put him on display before other men of science. They wanted to experiment on him. We couldn't allow that. After all, he *is* our son."

I agreed, mentally, and verbally.

"He was born to us in a normal way, as far as we know, and as far as the records show," Mrs. Robeson took up. "He seems to grow, but from what we were told, we cannot understand how. Nothing seems to hurt him. He never gets cut, or has shivers, or gets colds. He's never been ill, and he eats anything he desires."

Robeson laughed, somewhat bitterly, I thought. "Don't forget the oil, my dear."

She smiled. "Oh yes, the oil. I forgot—if he doesn't oil himself quite frequently, especially during wet weather, he stiffens up so he can hardly move. He doesn't require as much as he used to, though."

"No, not since he started eating more fats and oily foods," her husband added.

"What did the doctor say?" I asked.

"Oh, they used a lot of long words that meant nothing to us. What it all boiled down to was that they didn't know either. We were as much in the dark after leaving as we had been before."

"But haven't you any kind of an idea of what he might—er—be, or what might be the matter with him?"

He shook his head. "There is nothing wrong with him, Mr. Hason. He is just too perfect. Consider that he has never been ill. He never has a cold, or has any pains. He apparently can't be easily hurt. He can't be shocked, I know that. I've seen him do things around electricity that would kill an ordinary man. He doesn't even seem to feel the juice. If he does, he doesn't let on. He is strong. His flesh seems too hard to give. Why, I've seen him drive nails with his fists. He is smart. He's a regular prodigy. So you tell me what is wrong with him!"

I didn't answer that. There wasn't any need. Any remark I might have made would have been superfluous to say the least.

"Did you ever try other doctors?" I suggested.

"No, and I'm not going to. And why? Because they'll be the same as the first. They wanted to X-ray him, stick needles in him, even operate on him. I don't want that. After all, queer as he might be, he *is* our son. We can never have any more children, so he's all we got, and by God, man, for better or worse, I'm going to keep him!

"What will those men do? Put him on display like a freak, maybe. Take him all over for people to stare at. I won't have it. It wouldn't be fair to him. Maybe he is a genius. If he is they'll burn his brain out with questions and he'd be just another dumb guy like his old man. No, sir, I'm going to give him his chance to grow up and then maybe he'll amount to something."

He stopped. Running his fingers through his hair, he suddenly smiled.

"I'm sorry. Guess you think I'm a little nuts. But we've had to move a lot of times just because people got nosey and started saying things. It gets under a man's skin after a while."

I figured it was time we were leaving and I suggested it to Betts, tactfully.

"Don't worry about it," I said, as I shook hands with him at the door. "We won't say anything. We have a son, too, you know, so we understand. Our boy seems to like him, and that's enough for us."

That night, before retiring, Betts and I went in to say goodnight to Bobby, as was our rule. He was sitting up, looking out of the window at the moon, which, big and silvery, was just coming up out of the east.

He turned as we entered.

"What are you thinking about, son?" I asked, mussing his hair. Kids have the funniest, and sometimes the most astute, philosophies, and I never tire of hearing them.

"I was just thinkin' 'bout Dickie, Pop."

"And what about Dickie?" Betts asked.

He looked at us, his eyes big, his face a little sad.

"I was thinkin' how Dickie was so lucky. He can't ever get hurt, or be sick, 'n' he told me today he won't die for hunnerds 'n' hunnerds of years 'cause he's not like us. He's got no tonsils to get sore and have to be cut out, 'n' his teeth won't ever get bad, 'n' he knows millions and millions of things I don't know. Oh, he's awful lucky 'n' awful smart, Pop. I wisht I was like him."

I looked at Betts.

"What is he like, Bobby?" I asked him.

He looked thoughtful. "I guess I can tell you," he said. "He asked me not to tell people, but I guess it's all right to tell you 'n' Mom. It *is* all right, ain't it, Pop?"

"If you think it is, son," I said. "If you say it's all right, then it's all right."

He thought this over. His fingers picked at the bed clothes. Finally he sighed.

"Well," he began, "Dickie hasn't got insides like us, Pop. He's diff'rent. He says he's got wires 'n' glass things 'n'—'n' water, only it ain't water—'n' it's all kinds of colours 'stead of blood. He don't have to eat but he says he likes to 'cause he likes the taste of things."

I felt Betts' hand close over mine and grip tight. Was this another childish game, another bit of make-believe?

"Dickie says he can tell only some kinds of kids 'bout him, 'cause he says mos' kids are like grown ups: they won't believe, 'n' they would only think he was crazy 'n' try to shut him up. But he says some kids are diff'rent, 'n' those he can tell. He says when they grow up they will be his friends 'n' then he won't be alone 'n' he can do things for people with their help."

"Are there others like—well, like Dickie?" I heard Betts ask.

"Oh yes. Dickie says there are lots more. He says he knows ten right in this city."

"How did he meet them?" I asked.

"He didn't meet them!" was the somewhat surprising response. "Dickie doesn't have to meet them. He says he jus' thinks—'n' one of them thinks back at him 'n' they talk—inside here." He touched his forehead. "He says when he gets bigger 'n' stronger he can think longer 'n' meet more like him. But he says he knows there are lots more like him 'cause sometimes he dreams 'bout them."

He lay down. Facing the moon, he said: "I wish I was like Dickie, 'cause then I could do all kinds of wonderful things. Dickie says when he gets big he will rule the world 'n' he 'n' his people will not let there be any more war or let people kill each other or be bad. Gee, Pop, why can't I be like him?"

His eyes closed. We waited for a few moments, then left the room and closed the door softly behind us.

In the hall we stood silently, looking at each other.

"What do you think, Al?" Betts asked.

"I don't know, Betts. If it's all made up then the answer is simple. If he's right, then, somewhere, a new race is springing up. What is creating it I don't know, and whether it is good or bad is equally uncertain."

She sighed. "I prefer to think it's just a game he is playing."

. . . But as I lay in bed that night I wondered. And in the many nights since then I've begun to worry. It's not that I'm afraid, or maybe I am. I don't know. It's the uncertainty. The dread of something you cannot understand—something you know you are powerless to stop.

You see, the neighbour boy continues to play with Bobby. And just the other day I saw them by the garage. They were building something. And Bobby was pounding the nails in with his fist . . .

THE END

. . . RADIO IN SPACE . . .

by David McIlwaine

Editor of "British Radio and Television"

RADIO is making the world smaller, so they say. During the next century there is little doubt that it will help to make the *solar system* smaller, and will eventually reduce the apparent size of the universe itself. Interplanetary flight without radio—and that includes TV and radar—is unthinkable.

The possibilities of interplanetary radio are enormous, but there are rules to the game—rules which science fiction authors frequently ignore. For example: radio waves travel at the speed of light, which is 186,000 miles a second. Because of this limitation a radio signal from a planet to a spaceship ten million miles away would take some fifty-four seconds to reach its destination, and an answering signal would need a further fifty-four seconds to get back. A two-way conversation would be punctuated by a lot of two-minute gaps.

Over a distance of 50 million miles the time delay between message and reply would be ten minutes. And the optimistic operator who transmitted a signal to a ship in the region of Alpha Centauri, our nearest star, would have to wait eight years for an answer!

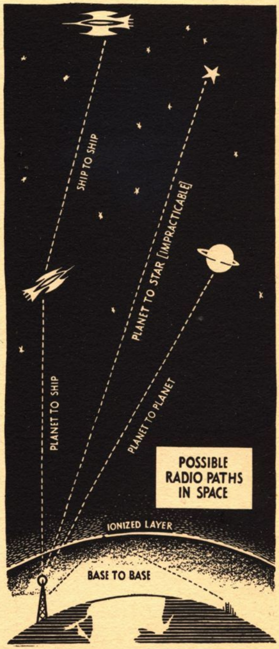
This presupposes, of course, that no faster means of communication will ever be discovered, and since the speed of light is generally accepted as the highest possible velocity, it rather looks as though *interstellar* radio communication is impracticable. Glib talk of extra-dimensional radio contact, or communication via time, has no roots in the practical technique of radio as we know it today or as we can visualise it in any future logically projected from the here and now.

Within the circumference of the solar system, however, radio communication *is* practicable, and falls into three categories: from planet to planet; from ship to planet, and vice versa; and from ship to ship.

For obvious reasons spaceborne radio gear will have to be as compact and lightweight as possible; consequently there is a limit to the transmitter power and receiver sensitivity that can be incorporated in the equipment carried in the ship. On the other hand, no such limits exist on planetary installations. The transmitters can be as big as desired, with complex beamed and phased aerial arrays covering a large area. Power from atomic turbines will easily supply the millions of watts of electrical energy required to fling radio waves across the enormous distances between the planets.

Receivers, too, can be large and complex, designed to give maximum gain for optimum reception of weak signals.

Provided the planetary installations are powerful enough, the smaller equipment of the ship will be able to function satisfactorily. The spaceborne receiver will pick up signals of maximum power, while the small, spaceborne transmitter will transmit to ground receivers of extreme sensitivity.



Ship to ship communication will, however, be limited because low power equipment will be communicating with low power equipment, but there would seem to be little necessity for radio contact between ships over enormous distances, so that this does not constitute a problem.

While transistors—crystal valves—will certainly be used for radio reception, enabling compact, multi-stage circuits to be designed with a minimum of power supplies, the familiar vacuum valve with its heater and inbuilt electrodes must necessarily form the basis of the power valves required to handle the megawatts of energy needed for transmission purposes.

There will be one big difference. In the vacuum of space there will be no need for a glass or metal envelope to preserve a vacuum around the valve electrodes.

This means that the design of transmitting valves for use in space will be revolutionary. The electrodes can be built into the circuit, and since transmissions will probably be in the microwave bands, radio transmitters will comprise one integral plumbing unit, with waveguides and valves machined together for maximum ruggedness and stability.

In the event of a valve breakdown—for example, a burnt-out heater, or a fractured electrode—it will be possible for the ship's electronic engineer to enter the airless radio-equipment compartment and change the faulty electrode—or even repair it!

This ease of maintenance and servicing will apply particularly to the large planetary installations where the transmitting valves may need to be as big as a room. These stations will not be located on the ground, where atmosphere with its ionised layers would complicate matters enormously, but will rotate in satellite orbits around the mother planet.

The orbital radio station will consist of a saucer-shaped array of parabolic aerials capable of projecting a narrow radio beam at a predetermined target, each aerial linked by a waveguide to the transmitter and receiver at the centre of the structure. Messages will be relayed at relatively low power between radio satellite and ground, the satellite itself being either a robot, or manned by a small crew of technicians. Duty engineers will be able to rotate the structure in order to orientate the aerial array at the desired target, and will enter valve chambers to carry out repairs when necessary.

There are several good reasons why the frequencies chosen for interplanetary communication will be extremely high, *i.e.*, in the microwave bands of centimetric or millimetric wavelengths. For one thing, equipment is smaller and more compact, and aerials in particular can be stacked in multiple arrays to secure good beaming and power, without taking up a great deal of space. These features are particularly important for spaceborne installations.

Another, perhaps more important, feature not generally realised is that microwave operation is essential if any satisfactory form of TV communication is to be achieved over interplanetary distances. The nature of a vision signal is such that the carrier frequency in its modulated condition spreads into adjacent parts of the band to form "sidebands." With a high-definition, full-colour, and possibly 3-D vision signal, the amount of frequency space taken up on normal channels by the modulating waveforms or sidebands would be considerable, and the

transmitter and receiver circuits would need to be extremely "flat" or unselective to avoid distorting the TV signal.

At microwave frequencies, however, the amount of channel spread becomes a negligible percentage of the carrier-wave frequency, and receivers can be made selective, restricting the bandwidth, reducing random noise, and improving amplification. In this way terrestrial eyes will one day see the alien landscapes and terrain of other planets in the solar system, and the necessary techniques are being used and developed in an embryonic form at the present day.

In the early days of lunar exploration, radio communication between moon and earth will be in Morse code. It is unlikely that equipment of adequate power for radio-telephone contact will be transported to the moon for many years. Telegraphic communication is reliable and economical in terms of power, and the first men in the moon will have been trained as wireless telegraphists.

Ships will, of course, carry radio-telephone equipment, but they will almost certainly be out of speech range after the first 100,000 miles. Therefore, Morse will be a must.

Speech-modulated transmissions will become possible when more power is available to supply the additional frequencies—or sidebands. And vision, which is merely a more complex form of speech so far as the radio carrier-wave is concerned, will require still higher power. It is safe to predict that the source of energy will be atomic.

Other systems of communication will, of necessity, be used to build up what must eventually be a vast interplanetary radio network: teleprinter links—using the pulsed Murray code; hellschreiber methods of letterpress transmission; radio picture circuits and other adaptations of present-day methods. It is not inconceivable that some future development of the electroencephalograph may eventually produce a method of transmitting thought itself by radio—a process which, even at the present time, would seem to be far more amenable to technological treatment than the elusive phenomenon known as telepathy. Thought-modulated radio and vision channels may well prove to be the ultimate perfection in physical communication systems.

So far we have dealt solely with the problem of transmitting information from point to point in space, but this is only one part of the vast field of radio services. Just as important, if not more so, is radar, which might be defined as the potential sixth sense of a spaceship.

Radar is an incredibly precise kind of electronic measuring instrument, and in combination with electronic computors it will take over most of the complexities of astronavigation. Orbits and trajectories will be adjusted automatically as the ship's equipment analyses and computes the information derived from the radar system.

Basically a radar installation consists of a transmitter, which sends out pulses of short duration and high power, a receiver to pick up returning pulses reflected from a surface or object within radio range of the ship, and an interpretive unit, where the relationship between the outgoing and incoming pulses can be displayed and measured. In this way the distance of a ship from a known target, or above a planetary surface, can be accurately computed.

This is basic radar, where the equipment is spaceborne and behaves as a kind of sense organ. There is a limit to its usefulness, because the power needed to obtain adequate reflections or echoes from inert objects—such as planets, asteroids, etc.—increases enormously as the range lengthens. Its main field of application would be within orbiting distance of a world or body where accurate indication of range or altitude was needed.

Navigational radar generally employs a number of high-power transmitters—usually three—located at the apexes of a triangle and casting an invisible network of intersecting pulses over a wide area. The network forms a grid reference system of great accuracy. On an interplanetary scale, with radar master and slave transmitting installations spread throughout space in fixed orbits, it would be a simple matter for any spaceship carrying relatively compact receiving equipment to pin-point its position exactly and automatically compute and effect the correct trajectory to reach its destination.

In addition to this type of navigational radar network, the simple homing beacon will find unlimited application in the building up of safe spacelanes between the planets and satellites. A small battery-powered beacon, orbiting around a planet or a fuel dump or any rendezvous point, would act as an automatic responder to spaceborne ship's radar, switching itself on when pulses are received, then amplifying them and retransmitting them so that the ship could use them as a direction-finding signal and home straight onto the beacon.

It is not likely that radio interference will be encountered to such a degree that all forms of radio and radar services will be obliterated—at least, not within the limits of the solar system, excluding the zone surrounding the sun. There may, however, be certain areas where a high level of interference may seriously affect communications and navigation—for example, in the vicinity of planets having considerable atmospheric turbulence and ionisation.

But it is reasonable to suppose that by the time man has cast his radio net over the greater part of the solar system, the problem of interference will have been solved for ever.

Interstellar radio and radar may encounter insuperable difficulties so far as static interference is concerned, particularly in the vicinity of "radio stars"—those dark points of space recently identified because of the radio noise they generate. The ether within light years of a radio star might well be a zone of strong radio noise, impenetrable to the most powerful signal that man could ever produce. Such an obstacle could hinder the full exploration of space—for exploration without communication is a long and hazardous process—but who can doubt that man, even if stripped of the miraculous power of the radio wave, will, nevertheless, choose to plunge obstinately into the noise barrier of a dark star, using his old human skills and senses, to chart the last remaining zones of the cosmos?

And, finally, the last remaining triumph of radio, and a favourite of science fiction authors—transar. Man can already send sound and picture through space; will he one day be able to transmit matter itself? Will the people of the far distant future travel to the planets via radio beams? Will transar supplant rockets and orbits as a mode of transportation?

Your guess is as good as mine. But there is nothing within the scope of present-day knowledge to suggest that such a thing might ever be possible.

TOUR of the SOLAR SYSTEM

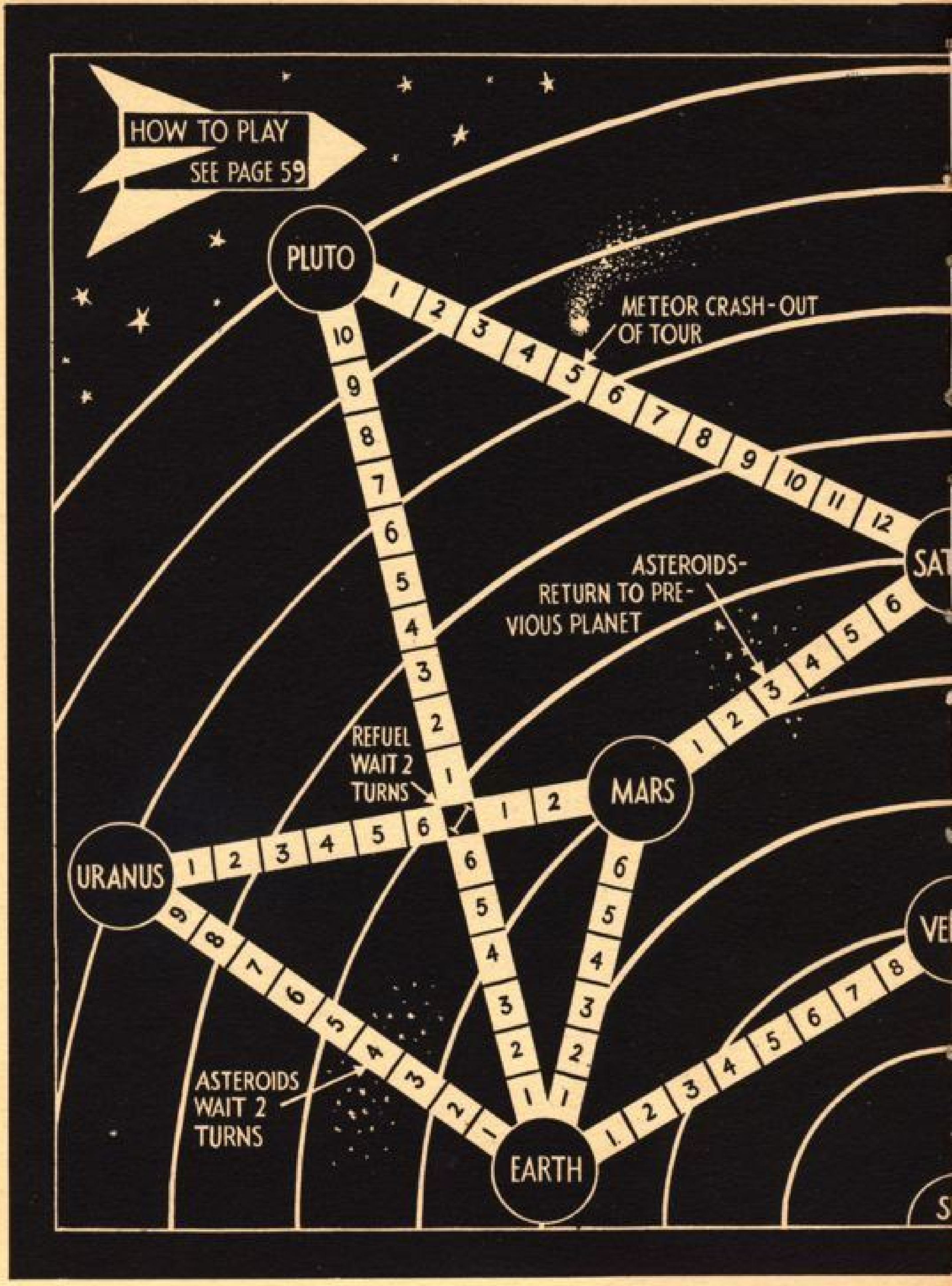
How to play the game on the next two pages

The materials you need to play the *Tour of the Solar System* game are the usual dice and counters. Each player throws dice in turn and moves his counter forward the number of spaces the dice turn up. Each player must throw a six before he can begin to move. And he must start from Earth, though he may travel along either of the four routes that lead from that planet. The whole aim of the game is to reach each of the planets and then get back to Earth.

Thus, there is more to this game than mere skill in throwing dice. You have to decide which routes you are going to take to each of the planets so as to cover the whole system in the shortest possible time. You should write down the name of each planet as you reach it so that you will not forget where you have been!

Remember that the numbers on the spaces do not mean that you must travel in one direction; the numbers are inserted to help you count out your moves.

Any number can take part in the game, and play should continue until all but one of the players has toured the system; that player then drops out and the rest play again, and so on, until just one player has beaten all the rest.


HOW TO PLAY
SEE PAGE 59
PLUTO
METEOR CRASH-OUT OF TOUR
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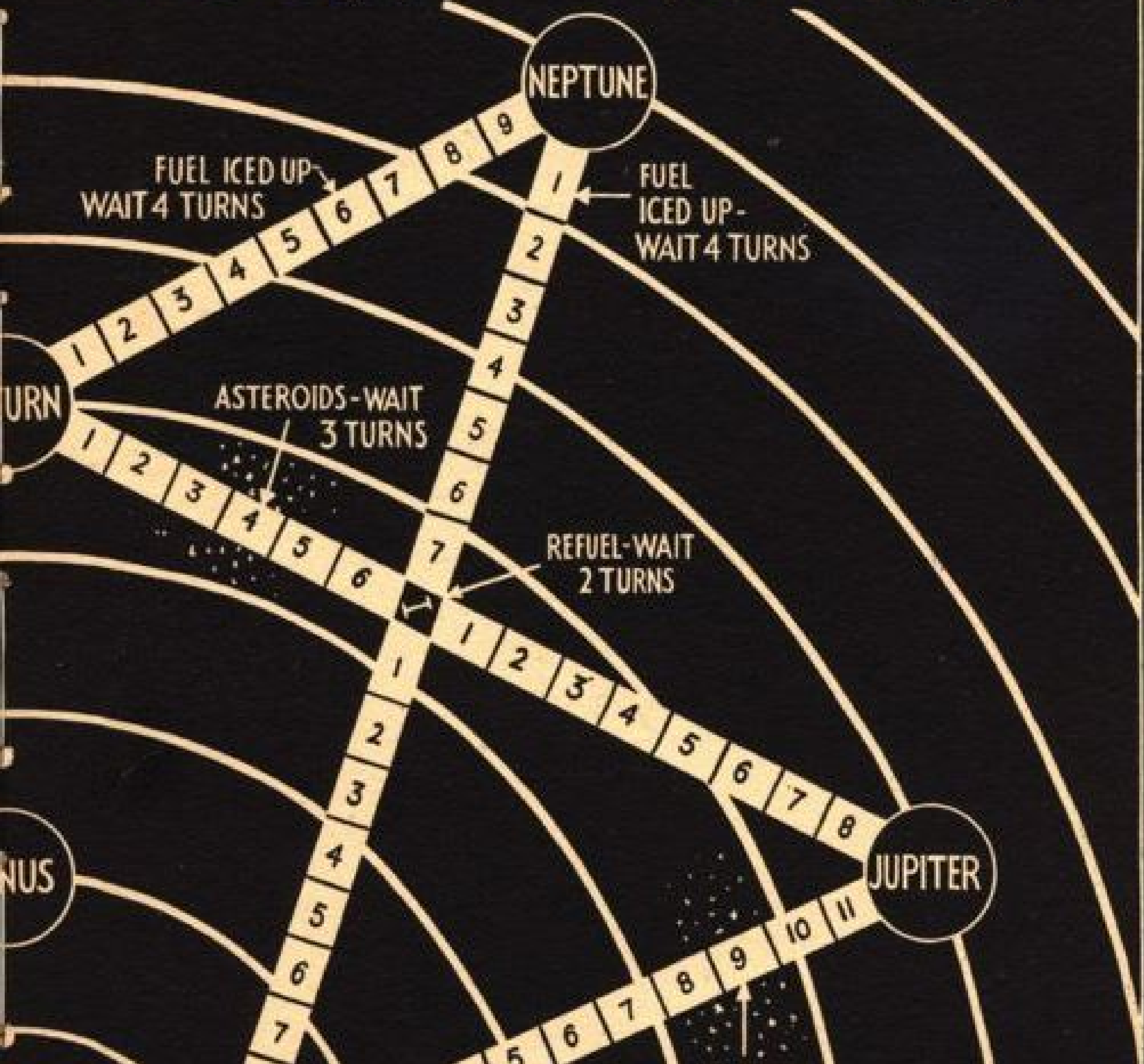
TURNS
MARS
URANUS
ASTEROIDS
WAIT 2
TURNS
EARTH

TOUR OF THE SOLAR SYSTEM



OUR FRIENDS THE ALIENS

by H·KEN BULMER

Our star, our sun which gives light and warmth and life to our planet, is only one small star spinning round along with millions of its fellows of the Milky Way galaxy.

Around this weakly yellow star, buried inconspicuously in a star cluster some three-fifths of the way from the centre of the galaxy, our scrap of moist rock and dust pursues its yearly circles. We have to face the fact that mankind inhabits a triflingly tiny mote in the inconceivable immensities surrounding it.

Don't be one little bit ashamed of that.

It has been estimated that there are about a hundred thousand million stars in our galaxy, and that light takes about one hundred thousand years to travel across its diameter. Figures like these, of course, cannot be comprehended by the human brain. But what we can imagine, projecting our thoughts out from the Earth to a point remote from the whole galaxy, is the entire picture of the galaxy, like a majestic spinning lens of light. A whirling dinner plate, or grindstone as Herschel envisaged it, spreading out its millions of glowing suns, its vast patches of nebulous luminosity and its mysterious swathes of dark and dusty black clouds.

The very fact that we can, sitting comfortably in our chairs before the fire, allow our thoughts to roam untramelled and free so very far from the planet of our birth must be an indication of some spirit, some force within us that will never rest until we have actually set foot upon the farthest bounds of our universe.

Around many of the millions of suns composing our galaxy or stellar universe, which is the term sometimes used to denote the Island Nebula formation, there must be considered other planetary systems to exist. And, because it would be insanely egoistical to think that *homo sapiens* living on Earth is the only life anywhere, there must be other peoples, other civilisations, growing and flourishing on these planets.

Just as in the past of our own planet civilisations and empires have risen and decayed, so must other races have grown and fallen on the unknown alien planets throughout the galaxy. As the galaxy spreads out its great Catherine wheel arms the stars on the rim would be the first to have planets cool enough to support life as we know it. Down in the hub the stars are clustered thickly; their planets would be the last to become of a temperature suitable for our carbon-oxygen life to evolve. The position of our sun, then, is of importance. We are some two-fifths of the way in from the rim. That means that we might expect many of the suns out from us to have habitable planets, whilst those in from us, towards the hub, are not yet ready.

However, another factor enters the picture just about this point. How do planetary systems originate in the first place?

Among many conflicting theories, one of the most widely held was that two suns came close enough together for a cigar shaped filament to be drawn off, which, cooling and condensing, broke up into circling planets. The sizes of our planets uphold this theory, with the exception of Mars, which is a lot smaller than the God of War should be. Other astronomers put forward the idea that it would need a binary star, meeting with another star, to break up and form a planetary system. Other scientists believe that the stars and planets formed independently of each other, condensing from the primal hydrogen that filled all space, sweeping great channels through space and growing gradually over periods of millions of years.

It will be fairly clear from this that we must expect to find planets more frequently where there are more stars if we adopt the first two theories. The last theory would mean that planets might be found anywhere.

Now—if there are so many planets, and if these planets are populated by other civilisations who have evolved in much the same way that we have here on Earth, we must expect to find decaying civilisations between us and the rim and primeval races beyond us and into the hub.

Why has Earth never been visited by any of our neighbours?

Here it might be as well to discard the superman complex, and realise that other peoples will probably have just as much drive and ambition as has man. It is very nice and convenient to envisage a race that is content to sit under the trees all day, drinking some strange and alien beverage, possibly indulging in telepathic high jinks, with not a thought for the wonder and mystery of the stars spread out in the night sky above them. There may very well be such alien races. There are very probably, also, races living on planets that have a perpetual cloud sheath so that they never see the stars and, therefore, the first drive to find out just what those little chips of light really are never materialises. Venus is such a planet.

There may very well be such alien races. But it is a certainty that there are also aliens who live on planets where the stars are visible, who do not sit dreaming under trees all day. These are the people we might expect to come calling on us. And—to make the argument even more cogent—we may expect people living around suns near to us to be in a similar state of advancement as are we. For us to recognise them as a life form they would probably have to evolve under a G type sun.

Since the end of World War II very many millions of pounds have been spent on ways and means of raising a person off the ground and keeping him off—circling in an orbit around Earth. The satellite space station is no longer a dream of fancy but a grimly sought-after weapon. Disregarding the suicidal reasons for much rocket construction, there is a strong hope that some man alive today will set foot on the Moon in the not-too-distant future. Say thirty or forty years' time. Perhaps we could give a nearer time if we knew all that was going on among the astronautical experts.

Eventually, *homo-sapiens* will be able to reach out and explore all the planets in our system. It will take time, lots of time, but the day will come when someone stands on Pluto—or any other even farther out planet—and looks away from the sun and says: "Next stop—the stars."

How to reach the stars? Travelling at the speeds which will probably be reached in going from planet to planet of the solar system it would take many years to reach even the nearer stars. So many years, in fact, that second and third generations might arrive with only parental information of Earth.

When the shaggy brute that was man first reared up on his hind legs and found himself fighting for domination of a world he was at a serious disadvantage when compared with the magnificent fighting animals sharing that world with him. He had no sabre teeth. He had no steely claws. He had no pinions to launch himself at his quarry. He had very little physical capacity to survive. However, he did have the trick of using his brain to think with as well as to control his bodily functions. So he used fire as a servant and weapon. He extended his own strength with stone clubs and arrows.

When he needed to drag logs he eventually got around to the idea that wheels would make the job easier. When he wanted to get somewhere in a hurry he climbed on the back of another animal and made it run for him.

Then he translated all that into terms of steam and iron and coal. Next he harnessed up nuclear energy.

All in all, it seems that when man wants something he will find a method of obtaining it. In this case he wishes to travel vast distances and he comes up smack against the basic building brick of the Universe.

If light were stationary it would have no mass. Only because photons cover one hundred and eighty-six thousand miles in one second do they exist at all. If you speeded up a spaceship to that velocity it would acquire infinite mass. The speed of light is always constant no matter how fast you travel with respect to it. That brings up some rather incredible paradoxes which cause scientists to shudder when they consider their basic laws. Relativity demands that we accept that an object is longer when in motion than it is when at rest. But the big thing that our somebody on Pluto has to face is that light is the one thing in the Universe which is constant.

You can't go faster than the speed of light.

You can't keep warm in a damp cave. You can't kill a sabre-tooth tiger with your bare hands. You can't run fast enough to catch an antelope. You can't go faster than thirty miles an hour. You can't fly. You can't go faster than sound. You can't...

But—light is the Universal basic. It's a different *sort* of problem from all others before it.

Whatever the problem may be, one thing is clear.

Mankind will one day wish to travel to the stars and discover for himself what's been holding up his neighbours arriving here. It may well be that extra-terrestrials will in the meantime visit Earth. Or, it may be discovered that you just can't go faster than light and that is the reason for the non-appearance of our stellar neighbours. But *homo-sapiens* will make his way out to the planets of other suns by some system or other—if he has to stock a huge ark and hope that third and fourth generation crews will eventually make planetfall.

He may discover a way round the speed of light, via the fifth dimension or any other at the moment purely hypothetical curving of space. Space warps may well be drawing board enginering by the time we stand on Pluto.

All that lies in the future. We, sitting before our fire, projecting our imaginations outwards, will not see it happen. We can only dream our dreams, and envisage ourselves as a part of that glorious future of Earth, taking a vicarious pleasure in mankind's achievements. No—we'll not be directly concerned at all.

Except in one thing.

There is one thing that must begin *now*, with us, or all that bright promise will be useless. When we do eventually get around to visiting our neighbours of other suns, let's make sure that we go as friends.

How do you say "Hello" to a Martian?

It is not an easy matter says William F. Temple

Member of the British Interplanetary Society; Author of **The True Book of Space Travel, The Four-Sided Triangle.** *Former Editor of the* **Journal of the British Interplanetary Society.**

Few people can have read space stories without coming across a description of the first meeting between Earthmen and Martians; and many and varied are the methods used to enable the two races to converse with each other. The commonest method is little short of cheating—for here the author supposes that Martians can at least speak, even if they *do* have tentacles and purple spots all over their bodies. Since the Martians have the right kind of anatomy for speaking, they also have their own language, and all the Earthmen have to do is learn it.

There is nothing new in this method, of course. Every explorer who has happened upon a primitive tribe has used it. He thumps himself on the chest and says "Man" several times. The native cocks his head and then finally points to the explorer and repeats "Man." The explorer nods and looks happy. Then he points to the native and tries to look as though he is asking a question. The native replies with his own equivalent word for "Man." From that beginning it is merely a matter of time and persistence before the two people can converse as well as they need.

Now that is all very well for darkest Africa—or any other place where the natives have vocal chords. But Martians *may* not have these structures that seem to be essential to speech. (Of course, we are not limiting this discussion to Martians—who probably do not exist anyway—but are considering *any* alien race.) They may not be like men at all. They may be like birds or lizards, or fish. Not only do these types of creatures not have vocal chords, but they may be deaf too. What happens in a case like that?

Well, you could try mouthing the words and hope that the alien creatures would learn to lip-read by linking up the shape of your lips with the thing you are pointing to.

But you probably would not get very far that way. It might be better to use a graphic means of communication—pictures and diagrams. This assumes, naturally, that the alien can hold a writing or drawing instrument.

Perhaps the first thing you would do is draw a simple map of the solar system, a set of circles representing the orbits of the planets with the Sun at the centre. You point to yourself and to the third planet from the Sun. Then you point to the Martian and to the fourth planet from the Sun. If the Martian has any sense worth speaking of, it will not be long before he sees what you are driving at. After that, the pair of you simply have to increase your "vocabularies" of pictures.

If you had landed on Mars you could have drawn your pictures in the desert sand, and the Martian, if he were a lizard, could have used his tail to draw diagrams. And you would both be under a clear sky, in which case the Martian would be aware of the Sun and possibly of the planets. But if you had landed on a planet like Venus you might find that there is no land at all, that the planet is one enormous ocean, that the sky is always opaque with clouds, and that the creatures of the planet are fish. This is no place for drawing a picture of the Sun in sand!

Perhaps you would go down in a diving suit—your spacesuit would probably do—and try to communicate with the goggle-eyed fish by gesturing at them. Ordinary fish might have difficulty talking back, but something like an octopus could wave its tentacles about. Still, perhaps this approach is too simple.

Quite a number of fishes on Earth normally "talk" to each other in a crude kind of way—for sound travels perfectly easily in water. Whales, for example, can be heard bellowing from miles away. So you might be able to use a sound language for the alien fish-men after all. Dr. Hans Hass did a roughly similar thing in the Red Sea not long ago. He played a record of the "Blue Danube" beneath the surface and the fish for miles around came and danced to it—in a fishy manner, of course, and not with ballroom technique!

Now there is another method that authors sometimes use to get over the language problem, and that is telepathy—thought-reading and thought-sending. For a very long time hard-headed people laughed at the idea of telepathy, but strictly controlled scientific experiments are indicating that it really is possible. Professor C. D. Broad of Cambridge University, Professor H. H. Price of Oxford University and the late Dr. C. E. M. Joad of London University have all stated their convictions that telepathy is "an experimentally established fact."

But it's being a fact does not make it very useful, and everyone concerned will readily admit that telepathy has not yet been brought under real control. Nobody can switch it on and off, as it were, and either speak or not speak. So, before we could communicate telepathically with alien creatures, we would have to find some way of making telepathy as easily controlled as ordinary speech.

Even then, we come up against the difficulty that the thoughts of the aliens may be of a different *kind* from those we have ourselves. It is hardly likely, for example, that dogs think in the same kind of way as we do; their world is not so much sight and sound as *smell*. If we want to get into telepathic communication with dog-like creatures, we will have to train ourselves in thinking concretely in terms of smell.

Should the aliens be something like bats, we may have to do our thinking to them in the form of mental sound images. For the bat senses the world as a pattern of echoes of the high squeaking noise it emits constantly when in flight.

So much for telepathy. But there may be other ways in which aliens normally communicate—ways which to us are quite meaningless or unobservable. They may talk at such a high pitch that we cannot hear what they are saying, let alone understand it. The human ear can pick up sounds that occur only in a fairly narrow range of pitch; sounds that are higher or lower do not register. Or the aliens might use some language that utilises light. We could see it only if the light were of a wavelength within the normal visual band. If the aliens used infra-red or ultra-violet light, we should not be able to see what they were saying.

You can see now, perhaps, that conversation with aliens is not likely to be as simple as some authors would have us believe.

Professor Lancelot Hogben thinks that we should start looking into the question now by sending radio messages out into space in the hope that some intelligent race will pick them up and answer us. It is possible that aliens are already trying to communicate with *us*—the Northern Lights, the "radio stars," and various cosmic noises *may* be messages from space.

If they are, the aliens probably think that humans are too dumb to understand, for nobody is trying to decode them or answer them. And how *could* we try to answer? What kind of language should we use? Professor Hogben has devised a scheme for this purpose, based on numbers—which all intelligent creatures should be able to understand. The language is known as "Astraglossa," which means "Star-Tongue."

Professor Hogben's idea is that we should set up a radio station that will continuously send out dot and dash pulses in the form 1, 2, 3. A radio receiver would be constantly alert for a repetition of this signal, an indication that a race in space had picked up the message and was sending it back as a sign that they understood. Then we modify our transmitter to send out the message: $1+2+3=6$, using groups of dots to represent the plus and the double bar. In this way, the Professor thinks, could be built up quite a complicated system of communication. The only drawback is that, even if the alien race were in the vicinity of Earth's *nearest* star, we would have to wait eight years between sending out a message and getting an answer, for that is how long the radio wave would take to cover the double distance. Obviously, we are not going to get on speaking terms with star people very quickly!

Then, of course, there is the question of speed of thinking. We all know some people who think much more quickly than average, and other people who think much more slowly than average. The rates are close enough together to make both intelligible, even if sometimes a little boring. But suppose a person tried to communicate with you by saying one word—or perhaps even one syllable—every day or every week. You probably would not realise that he is talking at all. You would think he is merely making noises!

And there is no reason why some alien races may not be very slow or very rapid thinkers. Creatures who live on frozen planets might be sending us a radio message in the form of one dash a month. Who is going to recognise the sense in that? An alien who lives in a fiery inferno may have thought processes that proceed with the speed of light. His radio messages would be composed of words tumbling so closely one upon the other that they would be meaningless to even the most alert listener. Similarly, our own messages, if sent out in the way envisaged by Professor Hogben, might fall on sluggish or lightning-speed minds, and so be ignored.

There seems to be little doubt about it—the only practicable way to get in touch with the races of other planets is to go there in person. And even then—well, you see what I mean!

BRITISH ASTRONAUTICAL PIONEERS

are second to none says

HARRY HARPER

first Air Reporter, doyen of aviation writers, author of more than twenty flying books, member of the British Interplanetary Society and author of Dawn of the Space Age.

Modern science develops at such a speed that the wonder of yesterday becomes commonplace today, while what we are wondering at today will, no doubt, be taken just as a matter of course tomorrow.

This strikes me forcibly when I take down from my bookshelves again a slim volume which I was putting together in 1947 under the title of "Dawn of the Space Age." That was in our immediately post-war phase, when the development of such a rocket as the V.2 seemed to be opening up before our eyes a vista of coming wonders which was almost dazzling. What, in fact, had appeared no more than possibilities in pre-war days now seemed converted into definite probabilities.

I remember peering into the future with Kenneth Gatland as he helped me with some of the technical aspects of my book—which was, incidentally, the first to expound in a popular but accurate way the problems of future space travel.

Well, 1947 does not seem such a long time ago, from any ordinary viewpoint. Yet today, when I re-read that book, it seems in many ways as out-of-date as do, now-a-days, some of the aeronautical books I was writing in flying's early days.

Aeronautics and astronautics have, incidentally, one thing in common. This is the thorny path that had to be trodden by the earliest pioneers. Their efforts, instead of being encouraged, were not merely ridiculed, but often definitely obstructed. When, for example, that old air friend of mine, Sir Alliott Verdon-Roe, was carrying out some of his earliest experiments on an open stretch of ground near London, the local authorities threatened to prosecute him for being a public nuisance, or a public danger, or something equally unpleasant, while the thorny path of our astronautical pioneers is illustrated by the experience of Mr. Eric Burgess, of the Manchester Interplanetary Society, not long before the outbreak of World War Two.

Gatland

It was after having established a technical research committee that this Society, of which Mr. Burgess was President at the time, decided to carry out some experiments in rocket design and construction. To facilitate these, and to make sure that there should be no question of any risk to the public, an experimental station was established far out on a wild and lonely stretch of moorland. But just when what looked like being an interesting series of tests was about to begin, the blow fell. Police officials, descending suddenly on four of the leading members of the Society, served summonses on them. From these it appeared that, quite without any of them being aware of it, these members had, in the construction of experimental rockets, been guilty of several alleged contraventions of the Explosives Act of 1875.

The summonses called upon the members to appear at the Manchester City Police Court, and when the case came on, its novelty caused very considerable attention to be attracted to it. In the opening statement for the prosecution it was pointed out that the summonses had been taken out against members of what was known as an interplanetary society.

"Inter—— what did you say?" asked the Magistrate, with an expression of great surprise. His face registered even greater astonishment when he was told that the object of these persons in the dock was to send projectiles up to heights never attained hitherto, and eventually if possible, to reach the Moon, Mars and Venus.

This statement caused an amazed silence to fall upon the Court. After which the legal pundits on either side found themselves involved in a complicated and lengthy argument as to the precise meaning, according to the strict letter of the law, of the words "making" and "manufacturing."

This, of course, provided an ideal opportunity for an almost interminable legal wrangle. In the end the Bench seemed doubtful as to the validity of the defence, and after a great deal of further talk it was decided that the case should be adjourned.

At the next hearing the problems which cropped up seemed even more difficult to follow, ranging as they did from Newton's Third Law of Motion to jet reaction, and from thermal efficiencies to questions of delayed combustion and instantaneous explosion.

The case went dragging on, with renewed arguments on one side and the other, and without there being any chance, so far as could be seen, of a definite conclusion ever being reached. It came as a relief, therefore, when it was decided that the prosecution would agree to withdraw their summonses on receiving an undertaking from the Society that they would not, in future, use in the propulsion charges of their rockets certain chemicals which, according to the Act which had caused all the trouble, it was illegal to employ for any such experiments as the Society was conducting.

On this not very satisfactory note the whole business was allowed to drop. But so far as one can see, and according to the strict letter of the law, it still remains uncertain whether or not an interplanetary rocket can be regarded just as a "firework."

One thing certainly needs to be said emphatically. In


Burgess

our great post-war era, with the world developing its scientific resources in every possible direction, no old-fashioned rules or enactments should hinder in any way the experiments of scientists, chemists and other technical research workers.

Practical tests with big experimental rockets, as apart from such researches as our British Interplanetary Society undertakes, have now become such an elaborate and costly business that they have, at present at any rate, been left to Government departments, which can rely on official funds for carrying out their work. Actually our British Interplanetary Society is, in regard to astronautics, playing the same part as does our Royal Aeronautical Society in aviation. It does not undertake the building of rockets. Nor does the Aeronautical Society build aeroplanes. The Interplanetary Society is a scientific research body, reinforcing the experiments of the Government.

Even today, if private research should develop into full-scale experiment, it would still apparently be restricted in more than one direction by the provisions of the now obsolete Explosives Act. These would not only prohibit, unless waived, the use of certain liquids and chemicals in rocket propulsion, but would also insist on experimenters obtaining the sanction of the local police for any rocket firing they might wish to undertake, while the design of such rockets would have to be approved by the Secretary of State or his advisers. Not only this, but the actual filling of rockets would need to be carried out only in premises licensed previously under the Explosives Act.

In America, in contrast to all such red tape, rocket research has received every possible encouragement from the authorities, not being hampered in any way by the dead hand of repressive legislation.

But even though in this country conditions were discouraging, there were enthusiastic space-flight pioneers who refused to have their ardour quenched. One of these was Mr. P. E. Cleator. In spite of the difficulties confronting rocket research workers, he was the moving spirit in the formation of the pre-war British Interplanetary Society. It was as far back as October, 1933, that this pioneer Society held its first official meeting, Mr. Cleator being appointed President, with Mr. C. H. L. Askham as vice-president, and Mr. J. L. Johnson as secretary.

Though officialdom proved so unresponsive to space-flight ideas, this was certainly not the case with our British Press. The newspapers gave prominence to the early work of the Society, and this had an effect which was definitely beneficial, seeing that it attracted public attention to the significance of space-flight research, and emphasised that in this new scientific field, as in others, it would not do for us to lag behind.


Greenwood

In the years following its establishment, and up to the outbreak of World War Two, the Interplanetary Society was carrying out investigations which included the design of sounding rockets to obtain data from high altitudes, the preliminary design of a full-scale space vessel suitable for a flight to the Moon, and the evolution of rocket machines for commercial purposes in the transport of urgent loads, and more particularly of mails.

After the war, with its tremendous scientific and technical progress, the whole of our British Astronautical movement, outside officialdom, became focused in the post-war British Interplanetary Society, which has now gone ahead with such strides that its membership, at the time of writing, has increased to 2,700.

Included in this membership are experts in the fields of aeronautics, metallurgy, meteorology, chemistry, specialised engineering, wireless and radar. Its *Journal* keeps research work well to the fore, while it can now boast its own London headquarters at, 12, Bessborough Gardens, S.W.1.


Professor Baxter

Among our present-day British research workers many names spring immediately to one's mind. There is L. R. Shepherd with his work on interstellar flight. There are Messrs K. W. Gatland and A. M. Kunesch with their researches and papers on inter-orbital vessels. There are Messrs. H. E. Ross and R. A. Smith with their work on artificial satellites, including a design which many believe is the only one so far produced which is in strict accordance with scientific laws (*see page 80-82*).

Then there is the valuable work on the biological factors of space-flight by Messrs. H. Bowman and C. R. Armstrong; Mr. S. W. Greenwood's brilliant exposition of the mathematics of space-flight; Mr. A. C. Clarke's work on electro-magnetic launching; Prof. A. Baxter and J. Venn's investigation of rocket motor engineering; and Mr. D. F. Lawden's researches on the dynamics of trajectories.

Although much attention has, naturally, been attracted by the work in astronautics done in America since the war, it is well to bear in mind that Britain has a team of research workers, guided and inspired by the Interplanetary Society, and amplifying what is done by Government departments and stations, which is now second to none, anywhere, in this fascinating and all-important field.

THE END

Colours of the Stars

Though an uninformed person looking up at the night sky might claim that all stars are white, yet he would be quite wrong, for very many stars are brilliantly coloured. Indeed, of the brightest stars, more than half of them are coloured!

Our Sun, for example, is yellow; Aldebaran is orange; Beteleuse is red; Rigel is bluish-white and so is Regulus. Other orange stars are Arcturus and Pollux.

The explanation of this is relatively simple—at least where broad considerations are concerned. We know from common experience that a poker or an electric fire element glows red; that a low-powered lamp—such as a carbon-filament type—gives off yellow light; that very hot coal is often orange; and that the ordinary electric lamp emits a white light. If we also know a little physics, we know that the colour of these various things depends, not upon what they are made of, but upon their temperature.

Very hot bodies appear white, and the colour drops down through orange and yellow to red as the temperature falls.

Thus, we can see that the colour of a star is a guide to its temperature. Of course, the colour cannot tell us the absolute magnitude of the temperature—only the relative hotness and coldness of the stars. A white star, for instance, is always hotter than a yellow one, and a yellow star is always hotter than a red one. The coolest of the stars are very dark red.

Astronomers, however, can use the colour of a star to give its actual temperature very accurately. They are not so much concerned with whether a star is, say, red; but *how much* red? By using their eyes, they can form only very rough judgments. But by using the spectroscope—the instrument that splits light up into its constituents—they can study with great precision the light emitted by a star. And at the same time, the dark lines seen in the spectra give indications of the star's constitution.

Further, it was long ago discovered that there is a direct connection between colour and magnitude of stars. This is a rather complex and somewhat mathematical affair, for practically all stars appear as points—even the largest telescope cannot resolve them into discs so that their diameters can be measured.

But there are various ways in which the size of a star can be induced from accurate observations. One of them is by measuring the colour of the star. Thus, merely by studying star colours, the astronomer can measure the temperature, size, and get some idea of what the star is made of.

FROM EARTH TO THE STARS *(Continued from page 34)*

The passengers will not behave like the passengers of a liner or a train—just passing the time until they get to their destination. They will settle down to live—and die—on the ship. The ship will be their world for the rest of their lives. There will be children born on the ship who will grow up knowing no other way of existence. To them, the idea of walking about on a planet will seem strange and unreal. They will not understand what their parents mean when they speak of the blue sky and the bright yellow sun; they will have no real conception of forests and seas, and bird songs and cities, and railways, and aeroplanes and ships.

For year upon year they will live out their lives within the metal hull of their floating home. They will grow to maturity, marry and have families, and in their time they too will die and leave the task of taking humanity to the stars in the hands of their grandchildren. About thirty generations will come into being before the destination is reached. As century moves upon century, the tales of Earth will become more and more legendary, more and more vague and fanciful, embroidered by sentiment, distorted by prejudice. In the end it may be that Earth will be forgotten; the legends may be looked upon as fairy tales, with no basis in reality.

We can imagine the men and women of that far future, so many millions of miles away from Earth, so many years away from their origin, wondering how they came into being and why.

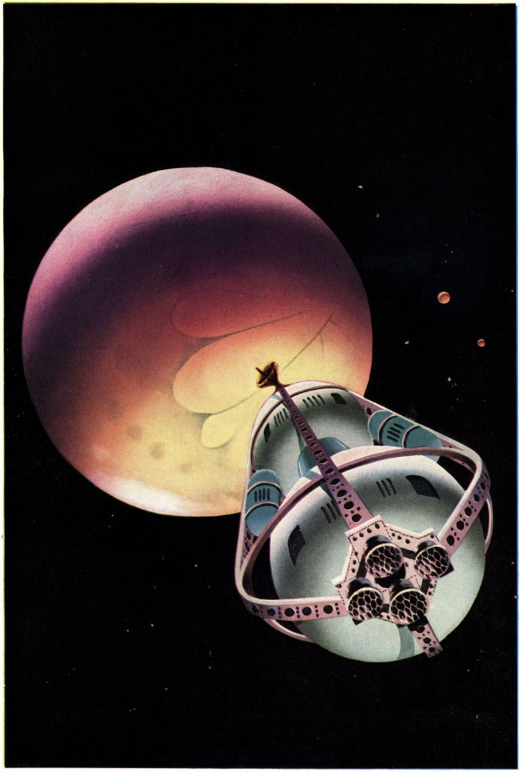
It will be the task of the ship designers and planners to reduce that possibility to the minimum. This can be done by stocking the ship with films and books, and other kinds of enduring records that can be handed down from generation to generation, preserving the knowledge of technology, customs and ways of life that we have here on Earth.

But the biggest task of all, of course, will be to design the ship in such a way that the passengers will still be alive ten centuries after the ship takes off!

There is only one way to do this, and that is to make the ship a miniature world. The starship must not be looked upon as a vessel so much as a complete cosmos in itself. This means that every necessity that is found on Earth must have its counterpart on the ship. Usually, passengers are prepared to go without a few things when they are travelling—but not when the trip lasts several lifetimes!

Thus, the starship will have roomy living quarters for all aboard, with room for expansion when the children come. There will be a privacy such as is not known on any other kind of vessel, even the luxury Atlantic liners. There will be a system of working, whereby the passengers can earn money to buy themselves luxuries from the shops and from each other; this means some kind of a bank, with currency-issuing powers. There will be some kind of legal system to deal with the disputes that are bound to arise between the passengers. There will be facilities for religious ceremonies in the various denominations. There will be recreation facilities to keep the passengers occupied in leisure moments.

And, behind all these, will be the great fundamental



Man Approaches his First Planet — Mars

Man's Last Outpost in the Solar System — Triton, Moon of Neptune

services of food, light and power. No one is yet sure how the food will be produced, but it is fairly certain that it will have to be as natural as possible. The ship could neither hold enough food for all the people for all the journey, nor could it preserve it. Thus, it is considered that the starship will have farms much like those on Earth. For these, a substitute for sunlight will have to be found. Farming also means that the water system will have to be carefully planned and controlled. Once the ship has left the solar system there is no chance of its taking on any more water—or anything else for that matter. So there will have to be devices that will purify used water so that it may be put to work again growing crops and quenching the thirst of animals and men.

Air is another important problem. Though it would not be beyond the reach of technology to provide a system for purifying used air, this cannot replace air that has been combined in the body. The total air breathed in and breathed out will gradually get smaller and smaller unless there is some way of uncombining what has been combined. The only way we can see of doing this is to make sure that all animal refuse and even animal bodies are, so to speak, ploughed in. There will be no possibility of ordinary burial in the starship. When people die their remains will have to be converted back into usable materials—an aspect of life that is very different from what we know on Earth.

This will lead to the remarkable situation where, several hundred years after they are dead, people will still exist—as particles of air and as nutriments in the soil. This will be a very abstract and advanced kind of cannibalism.

Light and power will probably be made along with the force that drives the ship, and this is unique. Naturally, no ordinary fuels could be used, for, apart from their comparative inefficiency, they are too bulky to be carried in sufficient amounts to last the trip out. The fuel for the starship will take the form of ordinary matter of almost any kind. This matter will be converted into highly charged particles—ions—which will be sent in a steady, continuous stream from the rear of the ship.

While the ion-drive ship is slow to accelerate, the duration of the journey is such that after only a very small fraction of it the ship will have picked up a speed far in excess of that of chemical-fueled rockets. Remember that the acceleration is continuous; the ship gets faster and faster as time goes on, with no extra expenditure of fuel. The greatest advantage of the ion-drive engines is that they can be fed on practically anything. When parts of the motor wear out—as they undoubtedly will—they can be used to feed the replacements. And when anything else in other parts of the ship fall into disuse, say movie projectors or air-purifying plant, these too can be fed into the engines to provide ions to keep the ship moving forward. So, not only is there a continuous supply of fuel, but the ship is not cluttered up with useless bits and pieces.

As far as we know today, the ion-drive engine is the only practicable means of getting to the stars.

We can see, then, that the starship is no idle undertaking! It is quite certain that it will not be built and supervised by one country alone. The whole world will have to contribute to its gigantic cost—dearer than anything else the world has ever known—and to the supply

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Double Stars

★ ★

If you look at the sky through a telescope, you often see two points of light very close together. Some people have called all such pairs double stars.

But the closeness of the points of light might be due to two different things: the stars themselves may be actually close together, or they may be far apart and only their *images* are close together. Since there is no real relation between the stars in the latter case, there is no need for a special term to describe them. Double star, or binary star, should be applied only to those cases where the actual stars are in close juxtaposition.

This is the case when two stars are near enough to each other to affect each other gravitationally. They revolve around a common point, which is the effective centre of gravity of their combined gravitational fields. Photographs of the pair taken at intervals show the relative positions altering—proof that the stars are revolving one around the other.

But this has been done for only a few binaries, since with many of them the period of revolution lasts more than a hundred years. One catalogue of binary stars lists more than 17,180 of them.

Double stars are very useful for the astronomer. If he can measure the relative orbit of each star around the common centre of gravity, he can calculate the masses of the two stars.

Many years ago, the astronomer, Bessel, was studying the star called Sirius and saw that it moved across the sky in a wavy line. He suggested that there must be a companion star to Sirius that he could not see. Some years later, Alvan Clark, using the new eighteen inch telescope, actually found the companion star and showed that it had properties which had been predicted by Bessel.

One very important discovery made by observing double stars is that only a very few stars have less than one fifth of the mass of the Sun, and that even fewer have more than ten times as much mass as the Sun. Of course, this does not mean that many stars are not a great deal bigger in *size* than our Sun.

It is interesting to conjecture what life would be like on a planet belonging to a binary star component—with *two* suns in the sky. It might be that there would be no night on such a planet!

Do you want to emigrate to Mars?

It's not going to be all fun and games up there, says

E. C. TUBB

After the rockets reach the Moon the next obvious goal will be the planet, Mars. Unlike Venus, Mars has a transparent atmosphere and we know more about it than any other planet in the entire Solar System, excluding, of course, our own. Mars then is the logical place to establish the first extra-terrestrial colony.

It won't be easy though.

For one thing the air is very thin, about a thousand times as thin as our own at sea level, and far too rarified to support animal life as we know it. Plants could live there though, and probably do. They would be stubborn plants if they existed at all, sprouting like mushrooms as the polar ice melted and then dying to dormant seeds or spores during the long, cold winter.

For it does get cold on Mars. The atmosphere is too thin to conserve heat, and there are no clouds to act as a warmth-retaining blanket during the night. There can be no long twilight, for dusk depends on a thick atmosphere and one containing plenty of minute particles of dust to scatter the light. On Mars night falls with startling abruptness, the evenings are super-cool, and by dawn lead will have hardened and mercury frozen into a solid.

But not so at the poles. During the summer the north pole will be the only comfortable spot on Mars. Here the Sun shines for ten months of the year and obviously it will be well above freezing point. A summer day on Mars is equivalent to a November afternoon here—bearable, even if nothing like the tropical heat we usually associate with deserts. Winter is something else. Then the pole is dark and without direct heat save for the thin, bitterly cold winds sweeping over it.

Water is the second big problem for our colony to solve. For Mars is arid almost beyond our imagination. It has been estimated that there is more water lying beneath the Sahara desert than is to be found on all Mars. One of our desert cactuses would die of drought in a day out there. Animals as we know them would dry out into lifeless husks within hours.

The temperature we can tolerate; we find similar extremes on Earth, at the poles and in Siberia, extremes of cold, that is. We shan't have to worry about excessive heat, but the thin air and dehydrating conditions will force the colonists to live in domed, insulated dwellings.

They will settle near the pole, of course, both for what water is available and for the weak heat of the summer Sun. They will either bring the domes with them, or construct them from the materials at hand—treated and tamped sand, perhaps, similar to the adobe huts of the Indians in New Mexico. For light and power we can assume a small atomic pile, situated well away from the settlement as protection against stray radiation, for shielding is heavy, and on rocket ships weight is important.

Air of course is the main problem. Unless men can breathe, all other problems are not worth solving. At first, perhaps, liquid oxygen will be imported from Earth, and chemical processes will remove the carbon dioxide and freshen the air for rebreathing. But that is only a temporary solution and other ways will have to be found. Hydroponic tanks will help, growing specialised vegetation in baths of nutrient solution so that they can refresh the air by their carbon dioxide-oxygen cycle. Hydroponics too will supply some of the essential food the colonists must have, for it is unlikely they will be able to eat the local produce; certainly there wouldn't be enough of it to provide the staple diet.

Yeast will do that. Edible yeast, growing in culture vats, needing only water and sugar, will provide all the food the colonists will need, but yeast vats will not provide air.

The desert will.

The redness of Mars is almost certainly due to the ferric oxide in the weather-crumbled rock which covers the entire planet. As the old rocks were broken and weathered so they soaked up oxygen from the air and changed from black and grey and brown to red and yellow, blue and orange. One hundred and forty-three tons of ferrous oxide absorb sixteen tons of oxygen—more than a tenth of its own weight. How many tons of oxygen must there be locked up in the sand of Mars, just waiting for our colonists to use? For they will use them. Without that precious gas the colony will never be able to become other than a base camp supplied from Earth.

But men aren't machines, and they need something more than fuel—food and water—to maintain their health. Vitamins can be imported, mental health can't, and it will be that which will prove to be the most serious problem of all.

Living together as they must, cooped up in small, heavily insulated dwellings, without privacy, without any of the small comforts which we take for granted, psychological troubles will be a certainty. Tempers will be short, and arguments frequent. There will be quarrels over food, water, living accommodation. Men, despite themselves, will alter from what they were to what their conditions have made them. And there will be no escape.

A man will work outside on the water lines or oxygen reclamation plant. He will wear a pressure suit, without which he would die of dehydration or asphyxiation. He will talk to others by intersuit radio, or be spoken to by central control. He will have nothing to look at but the limitless vastness of the barren desert, an undulating sea of crumbled rock marred by the long indentations of the age-old subsistences known as the "canals." At night he will see the heavens coated with the burning glory of unshielded stars, and sometimes, if he is lucky, he will be able to see the two small moons of Mars, Phobos and Diemos.

So much for the scene. What about the living quarters themselves? Cramped conditions and endless labour to provide the essentials of life. With time the conditions may alter, more domes would be constructed and a surplus of food and water, air and equipment built up, but that would bring its own troubles, for, with the easing of continuous labour, would come boredom, and with it nostalgia.

For Mars is so far away from home.

There can be no walking back, or catching a boat or 'plane, if the conditions prove too hard. Once on the planet the colonists will have to stay there, and the wrench from their normal lives will have to be adjusted too. It won't be easy. A man can adapt himself to almost any set of conditions—but the adaptation cannot last too long. Unless the conditions are altered to suit more nearly his accustomed environment, then he will begin to break beneath the strain. Not all at once, and it will be probable that most of the colonists won't understand what is happening to them. Quarrels will turn into fights, ill health will appear where it shouldn't, and terrible fits of depression will cloud their emotions and intellect.

They will begin to long for Earth, spend hours just thinking about the things they may never see again. Rain and green fields, snow falling and a clear, blue sky. The sound of waves on a sea shore and the wonderful sensation of being able to walk for miles without having to wear a pressure suit. They will remember all the luxuries they once enjoyed, smoking perhaps, drinking tea, swimming and being able to use an unlimited supply of water. They will think of these things and then they will remember what they are and where they are—and some of them will want to go home.

Nostalgia will grip them, making them dislike the work they must do, numbing their high spirits and making them wish they had never come to Mars at all.

It is then that the colony will meet its greatest danger.

For, to survive, a colony must be stable, be self-sufficient and grow. That means women and children, the making of a new life on a new world, and to be happy the colonists must be adapted and at peace with their surroundings. While they still think of all they have left behind them and long for the home planet, then the colony will begin to dissolve and fail.

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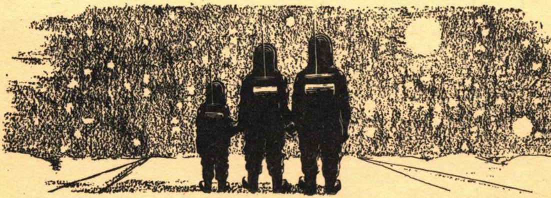


POSSIBLE LIFE-FORMS ON OTHER PLANETS

A shortened version of a lecture given to the Cambridge University Interplanetary Society by

H. J. CAMPBELL

Before we can go very far with a discussion on possible life forms on other planets, we should have a fairly clear idea about the essential characters of life. Life is very difficult to define and most good definitions of it are difficult to understand. We must tackle the problem more by description than by definition.

We learn in elementary biology that we recognise life by its possessing or exhibiting the features of growth, respiration, nutrition, reproduction, sensitivity and movement. Not all living things exhibit all these features, but most living things exhibit most of them. (We shall now use the term "organism" to mean any living thing.)

But elementary biology is concerned only with life as we know it—a phrase we will have to repeat quite frequently. And, for the moment, let us be similarly concerned. Life as we know it can exist only within a limited range of environmental conditions. These conditions include light, temperature and nutritive substances.

Light is important in a life-system such as ours, because the animal-type organisms are parasitic, in the widest sense, on the plant-type organisms, and these latter cannot photosynthesise in the absence of light. (Photosynthesis is the process by which plants that contain chlorophyl build up complex compounds such as sugars and proteins from simple substances such as water and carbon dioxide, under the influence of sunlight.) If the Sun rose for the last time tomorrow, we should all be dead within a few months, not from cold but from starvation. During the last sad months, the last survivors might subsist on certain fungi (such as mushrooms) which need no light. But the fungi too would ultimately perish, being dependent in the long run on light-built foods.

So we can be fairly certain that life as we know it does not exist on one hemisphere of the planet Mercury, since that hemisphere never sees a ray of sunshine, being turned perpetually away from the Sun.

Temperature has to be considered for its effects on reaction kinetics (roughly, the speed of chemical reactions). Active life as we know it can occur only in the so-called biotemperature band of from about -10 to 60. (All temperatures are given in Centigrade.) Below this range, molecular reaction kinetics slow down and finally cease. Above this range, the speed-up of reaction kinetics becomes so great that molecules disrupt, but even before this stage is reached proteins coagulate (i.e., clot)—as often happens in human patients with high fevers; the cerebral proteins coagulate and vital functions such as respiration cease.

Now some bacteria and some primitive plants can withstand fairly long exposure to temperature extremes. However, these hardly represent active life—and indeed, under these extreme conditions, they appear to be dead. This is important, for while there is no doubt that these lower organisms can *resist* extremes of temperature, there is no evidence that they can carry on normal living processes such as growth and reproduction. We can therefore conjecture that if the extreme conditions were sufficiently prolonged, the species would become extinct. In other words, even bacteria and primitive plants will be unlikely to *evolve* outside the biotemperature band.

Looking now at the known planets, the planets of the solar system, from the point of view of temperature, we can rule out Mercury as a home of Earth-type organisms because the whole of the temperature range on its sunlit side lies above 400, and on its dark side the temperature is low enough to solidify oxygen.

Venus has a temperature range of from -25 to 100 and so might not be inimicable in its higher regions to life as we know it. Mars' temperature ranges from -70 to about 30, and so this planet too might support the kind of life we know. Jupiter, Saturn, Uranus, Neptune and Pluto have temperatures ranging from -130 to -220; life as we know it could not exist on them.

So from temperature requirements, the only known planets capable of supporting life as we know it are Venus and Mars. We could say that the coldest parts of Venus approximate our tropical temperatures, and that the warmest parts of Mars approximate our sub-Arctic temperatures.

Now let us consider oxygen, as the most important nutritive substance. Life as we know it depends on oxidative respiratory processes. In order that a man might live normally, his environment must contain a concentration of oxygen of the order of 5.5 times ten to the eighteen molecules per cubic centimetre. Fluctuations may occur, with effects of varying severity, but death will ensue if the oxygen pressure falls below 65 mm. Hg. or rises above 400 mm. Hg. This is for a man—or a woman! Extending the ranges to all homoiothermic (warm-blooded) animals, the minimum pressure is about 50 mm. Hg. For poikilothermic (cold-blooded) animals it may fall to below 1 mm. Hg.—down to zero in the case of some lowly invertebrates.

Looking again at the known planets, we may once more rule out Mercury and the giant planets; the first because it has an extremely rarified atmosphere of heavy gases only; the latter because they have deep dense atmospheres of ammonia and methane. Any oxygen present on Uranus and Neptune is probably in the form of a solid. Pluto probably has no atmosphere at all, but if it has, then it consists of helium or neon.

This leaves us once more with Venus and Mars. Both of these planets have atmospheres containing traces of oxygen. That of Venus is mostly carbon dioxide, and there is twice as much of this gas in the Martian atmosphere as in our own.

We are now in a position to say that from the points of view of light, temperature and oxygen pressure, the only known planets capable of supporting animal life as we know it are Venus and Mars, but that such life would be of a lowly poikilothermic kind. Similar arguments apply to vegetal life. Plants need oxygen, though not necessarily in gaseous form, and it could be that both Venus and Mars harbour plant life of a kind we know.

The green areas on Mars are tempting in this respect, but recent observations of these areas in the infra-red wavelengths indicate that seed plants and ferns cannot cause this green colouration. It is thought possible that lower forms may exist on Mars.

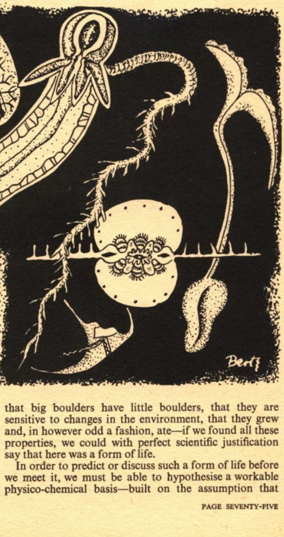
Where unknown planets are concerned (and there ought to be a few millions of them in our galaxy) life as we know it will exist only on those where conditions fall into the fairly narrow range we have outlined here. But there are probably several hundred such planets and it is highly likely that some of them at least will support human life, more or less as we know it.

It may be that, now, some readers are thinking of the anærobic bacteria, which need no oxygen. You may be remembering that peculiar alga that lives in water near the boiling point. You may be considering the fascinating zoophytes that seem to live quite happily in total darkness.

We must, of course, admit the existence of these organisms in the pattern of life as we know it. But if you think about each of them, you will come to see that each of them exists under conditions where only one of the three vital factors is distorted out of the normal range. And you will notice that in the places we have designated as being inimicable to life as we know it, at least two of the vital factors are out of true. We are suggesting that, given a normal range of conditions in the beginning, a species may evolve in such a way that it can exist under conditions where one factor has shifted out of the normal range. Astronomical arguments are available to indicate that in the "inimicable" planets, conditions did not change one factor at a time.

Let us now go beyond the limits of elementary biology, beyond the realm of facts; not into fiction, exactly, but into the enchanted imagery of controlled imagination, logical speculation, scientific conjecture. Let us now deal with life as we do not know it, but as it might be—*possible* life forms.

If, on an alien planet, an object resembling a boulder should roll towards us and begin communicating ideas, we should not be unduly credulous if we tentatively assumed that the boulder was alive. If, later, we found



that big boulders have little boulders, that they are sensitive to changes in the environment, that they grew and, in however odd a fashion, ate—if we found all these properties, we could with perfect scientific justification say that here was a form of life.

In order to predict or discuss such a form of life before we meet it, we must be able to hypothesise a workable physico-chemical basis—built on the assumption that natural laws are the same for all observers. Our hypotheses may be proved quite wrong, but it is the only scientific approach to possible life forms. And—it is not easy.

We find it difficult to visualise in precise terms any living system that is not founded on something similar to the carbon chains of terrestrial life. An objective appraisal of the existent knowledge of earthly life would convince most scientific minds that we know little of its fundamental mechanisms and hardly anything at all of its destinal schematics. But we *do* have considerable evidence that indicates the dependence of biological reactions on the carbon chain. As a specific example we could cite the simple molecule of glucose, a rather important biological carbohydrate, in which six carbon atoms are linked to each other. All carbohydrates, proteins and fats—compounds that constitute most of what we are made of when the water is removed (we are more than 90% water, by the way!)—are built of these carbon chains.

The only element whose chemical properties closely resemble those of carbon is silicon—and it has been postulated that somewhere in the wide universe there may be organisms in whose bodies silicon takes the place of carbon. The chains in such organisms may be of one or both of two types, the first being based on the element itself, and the second on its compound with oxygen, silica.

Another possibility that has been postulated is the addition of fluorine as a basic constituent of living things. On this system, although the basic chain link is still carbon, we find some interesting chemistry. It has been suggested that plants of this constitution would absorb hydrofluoric acid as water from the soil, and carbon tetrafluoride as carbon dioxide from the air, and free fluorine would be given off, in respiration, as our plants give off oxygen.

So far we have been dealing with the chemical bases of possible life forms, and it is not very profitable to go farther then we have gone in this direction. Indeed, some people will think we have gone too far already, and, admittedly, we are on the very borders of scientific speculation here.

But we can progress somewhat more by considering the physical side of our topic, and this we can best do by basing our discussion on energy relations.

But first, it may be as well to point out the main difference, the *distinguishing* difference, between plants and animals, for it is with such distinction that we shall have to deal when considering the impact of physical factors.

Green plants are able to manufacture their own energy-supplying foods inside themselves. This they do mainly in their leaves, where carbon dioxide from the air and water from the soil are brought into proximity where sunlight can shine on them. Under the action of the sunlight, catalyzed by the green pigment chlorophyl, the water and carbon dioxide combine to give sugars and other complex substances. These photosynthesized foods are either used at once or stored—potatoes and carrots are examples of such stores. But sooner or later, these compounds are turned into energy either by the plant itself, or by an animal that eats the store.

For animals are quite unable to manufacture food in this way. They require their energy-sources to be ready-made, in the form of sugars, proteins, fats, etc. Similarly with non-green plants, such as fungi.

Terrestrial organisms fall into two broad classes on the basis of energy relations—energy fixers and energy dissipators. All organisms need energy in order to do those things by which we recognise their possession of life—growth, reproduction and so on. Some organisms—the energy fixers—obtain their vital energy from extra-terrestrial sources; in the main, these are photosynthetic plants. Other organisms—the energy dissipators—obtain their vital energy from terrestrial sources; in the main, these are animals and non-photosynthetic plants.

Of course, energy fixers also dissipate energy, but in far smaller amount than they fix it. The American botanist, Loomis, estimates that only 15% of the material formed in a plant by photosynthesis is used up in the plant's respiration—so 85% of it is available for dissipation by you and me.

And there is a kind of dynamic equilibrium in operation. This ensures that the quantity of energy fixed over a reasonable lengthy period is equal to the energy dissipated in that time, thus preventing a plethora or dearth of organic material.

If Einstein is right in claiming that material laws are the same for all observers—and he does seem to be—then whatever chemical form life takes on other planets, it will have to comply with these energy relation laws. This enables us to assign a number of general features to life on other planets.

We can see at once that it cannot be solely of the energy dissipator type, for such organisms need ready-made compounds as a substrate for their dissipative activities. Suppose that this alien life form is solely of the energy fixer type, that is, that they approximate to our green plants. They will build up energy, stored in the chemical bonds of photosynthesised compounds. They will reproduce and multiply. They will die. But they will not decay. If these processes continue for a long time without the appearance of energy dissipators, they will be brought to a stop by lack of the material bases of energy fixation; the elements used in the formation of the, so to speak, capacitor substances will all have been utilised—will all be locked up in the complex synthesised compounds that are useless for green plant metabolism.

If life is not to become extinct on this imaginary planet, then energy dissipators, organisms similar to our animals, must appear. These will break down the fixed compounds and return the basic elements to the soil and atmosphere.

Thus we can predict that whatever chemical form this alien life assumes, it will be divided into kingdoms roughly equivalent to our plant and animal kingdoms, and will be involved in a material cycle whereby elementary matter is kept constantly available and energy is constantly dissipated.

The origin of life on Earth is a topic that has been discussed, quite hotly at times, ever since man realised that there must be an origin. Two main theories emerge from the very few scientifically tenable ones. These are known by the names panspermy and spontaneous generation. For our purposes one of these—panspermy—reduces to an extension of the other. We are not so much concerned with how life arose on Earth, as with how it might arise anywhere in the universe.

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BACKGROUND TO THE ROCKET

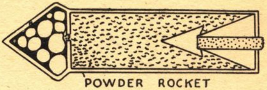
by Frank Wilson, B.Sc.

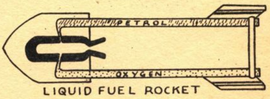
Though the word rocket has only recently come into more or less everyday use, the rocket itself has an extremely long and interesting history. The enormous man-carrying spaceships of the future, the pretty-big experimental rockets of the present, and the small powder rockets of the past seem to have little in common, yet they are all members of one big family—projectiles that do not need air to fly in.

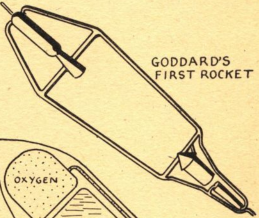
Most authorities believe that it was the Chinese who first discovered that if you burn something fiercely in a tube, the tube will move away from the gases that issue from it. This was sometime around 1200 A.D., more or less coincident with the discovery of gunpowder. All sorts of wars have always been going on in and around China, and even towards the middle of the eleventh century the Chinese rockets were putting fear into the Mongolians, who were at the gates of Kai-Fung-Fu. The main advantage of the rockets was not so much the killing of enemy soldiers, but the setting fire to his equipment and the scaring of his horses. However brave a regiment of cavalry may be, they are useless if their horses bolt *en masse*. And that is what happened in the Chinese spots of bother. Since then, horses have been trained to meet rockets with indifference, and their use as weapons for this purpose has been largely superseded—even before the more or less complete abandonment of cavalry as a fighting force.

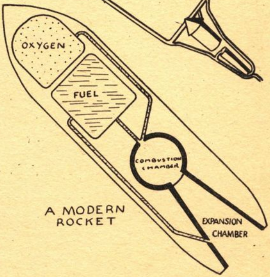
Nevertheless, the gunpowder rocket had many other, more peaceful uses. As soon as it was discovered that its erratic flight could be controlled by attaching to it a stick seven times as long as the rocket itself, the powder rocket became a useful tool for signalling and for carrying ropes to stranded ships. Coastguards all over the world have rockets as a normal part of their equipment, and there can be no doubt that they have saved a great many lives.

But the powder rocket still occasionally found military uses, right up to about 1830 when the discovery of rifled gun barrels was made. This really put the rocket on the shelf as a weapon of war, but earlier, in India, the British Army had to contend with enormous iron-tube rockets hurled by the Rajah of Mysore. The high effectiveness of these weapons interested Colonel William Congreve, who made improvements in rocket design such that a missile weighing forty-two pounds could be flung over a mile and a half towards the enemy, its incendiary head wreaking great damage. Congreve's rockets became normal army equipment and were used to much account in the wars with France. Copenhagen was practically destroyed by rockets in 1807, when British warships bombarded the city because of its alliance with Napoleon. And when British troops stormed America, they poured hundreds of rockets onto Baltimore—a proceeding that has been immortalised in the line about the "rocket's red glare" that occurs in the American national anthem.









When the rocket was abandoned as a military weapon, it spent a good many years in the background of human affairs until its present rather sensational return to fame—or infamy. Germany takes the credit for keeping the rocket alive after its abandonment by the world's armies—as also for its latest developments. It appears that a great deal of the German rocket work was done not so much to advance the science of rocketry as to get publicity. Thus, Opel, the car manufacturer, brought prominence to the rocket when he fitted a few of them to a car and made the thing accelerate to sixty miles per hour in only 200 feet. But the experiments were dangerous and ill-controlled, and the serious researchers were rather worried about the whole thing—for they knew that a rocket driven car at that time was an impossibility. In 1928, Opel made a rocket-driven vehicle that reached the maximum speed of 135 miles per hour—and blew up to pieces. The man behind all this hazardous, and not very useful experimenting, was Max Valier, who had interested Opel in rockets. Valier killed himself with a home-made rocket in 1930.

The reason why Valier's rockets added nothing to the scientific study of this type of vehicle was that they were powder devices; that is what made them dangerous too. Yet as far back as 1923, Hermann Oberth had written a learned treatise about rockets, in which he showed that powder-driven missiles were no good, and in which he also proved mathematically that a rocket flight to the Moon was a practical possibility. Oberth had shown, without having to place half his neighbourhood in peril, that powder, of however perfect composition, just had not the power to lift a rocket away from Earth. It burned too slowly to produce an exhaust of high enough velocity to raise a rocket's speed to 25,000 miles per hour—the velocity needed to escape from Earth's gravitational pull.

Thus it was that the German Rocket Society, which was formed in 1927, devoted itself to research on rockets that were powered by liquid chemical fuels. The requirements were that the fuel should burn much faster than gunpowder, but not so fast that an explosion resulted—as occurs when, say, nitroglycerine "burns"; and also the fuel had to be of a kind that would "burn" in the absence of air, for there is no air in space. So the Germans worked on liquid fuels, and developed two types of fairly advanced rockets with high performance figures.

In America, round about the same time, Professor Robert Goddard of Clark University, Massachusetts, was trying his hand at designing rockets, but he was only concerned with solid fuels because he was not particularly interested in reaching the Moon—only in exploring the upper atmosphere. But he soon found that no solid fuel available was powerful enough to send a rocket really high up. Like the German workers, he turned his attention to liquid fuels, and to such good account that he claims the honour of sending up the very first liquid fuel rocket—on March 16th, 1926.

Both the German and the American pioneers used petrol and liquid oxygen as fuels—the latter supporting the combustion of the former. And the use of these materials introduced many problems into rocket design. In the old days, any old tube could be filled with gunpowder and a light applied to one end. Not so with the liquid fuel devices. For one thing, liquid oxygen cannot be kept in whatever container comes to hand. It must be kept under very high pressure or it becomes gaseous, *i.e.*, explodes. Thus the tank containing the liquid oxygen had to be very stout. With the petrol there was not this difficulty; petrol can be kept at ordinary room pressure indefinitely.

But there had to be some means of bringing these two fluids together, since they could not be mixed previously. That meant some kind of pump system. Then there was the question of the place where the liquids burned. The intense heat and pressures caused by the combustion of these fuels made it necessary that special firing chambers should be constructed. And when a material was found that would stand up to the burning conditions long enough for an experiment to be completed, there was the question of the most efficient design to be settled. All these problems kept rocket researchers busy—and frustrated—for many years.

By this time, scientists in several parts of the world as well as Germany and America had become interested in the scientific study of rockets. Rocket societies sprang up in England and France and some very high talent was put into solving rocket problems. Many and varied were the early experimental models. When it was found that the hardest steel practically vaporised under the impact of the burning fuels, all sorts of other materials were tried out. In the end, the only feasible thing seemed to be to rig up a cooling device around a firing chamber of some orthodox material. A glad idea was the use of the liquid oxygen itself for this purpose.

Yet, despite all this work by some of the finest brains in creation, the early rockets made by the American and German researchers did not equal in performance the old powder rockets that Congreve had designed for teaching Napoleon a thing or two! That is, if by "performance" we mean distance travelled, and neglect the direction. For Congreve's rockets had traversed a distance of a mile and a half, and it was not until 1935 that Goddard devised a rocket that covered that distance. But—Goddard's rocket went upwards.

That was the key to the difference between the liquid fuel rockets and the old type powder missiles. And, when the Nazi regime came to power the German leaders saw this difference very clearly. The German Rocket Society was closed down and all its papers made State property; its members were drafted into government service—on rockets for war.

So opened the second military phase in the rocket's history—a phase which is still with us, unfortunately.

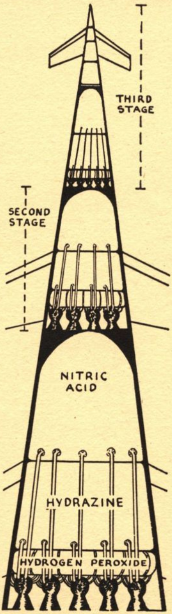
Of course, Germany was not the only power that was militarily interested in rockets, but it was certainly the one with most data, with most trained and experienced men, and the one that went wholeheartedly into rocket research. Almost every adult person in the world has probably heard of the V.2 which fell in large numbers upon London during World War II, but this was by no means the only German rocket development; indeed, it came comparatively late. There was the "Natter," a manned aeroplane driven by a rocket motor using oxygen, hydrogen peroxide, alcohol and hydrazine hydrate as fuel elements. This 'plane climbed 37,400 feet in one minute! There was the M.E. 163, a small interceptor aircraft whose undercarriage dropped off after launching, and which came down on a skid-like keel. There was the series of radio-controlled bombs that could be released from aircraft and ships—known by names such as Firelily, Butterfly, Waterfall. These were about six feet long, carried 110 pounds of high explosive and were fuelled by visol and nitric acid.

But it is true that the main German efforts on rocket development were applied to the V.2. A special centre at Peenemunde was set up for its genesis, and it was not long before the rocket bomb was in production and being launched against England. Powered by hydrogen peroxide, liquid oxygen and potassium permanganate, the V.2 was hardly a serious weapon, since it could not be controlled in flight, and, therefore, could not be directed at a target; and they were notoriously unreliable at launching time. More than one V.2 doubled on its tracks and destroyed the very men who had set it off on its cross-channel flight. And its destructive effect was far less than that of a heavy bomb, mainly because it tended to bury itself and spend its force against the side of the hole. London soon got used to them and ignored them!

Though the V.2 was rather silly as a military weapon, it was a great advance in rocketry and has been the basis of most present work. A large number of V.2 missiles, captured in France, were taken to America and studied by the experts there, who later came up with modifications—a number supplied by Wernther von Braun, the German who was in charge of Peenemunde and who is now working for the Americans. Most American rockets are, therefore, derivatives of the German design.

England, too, had quite a few rocket weapons developed during the war. Indeed, anti-aircraft rocket missiles had reached production stage after seven years of research several months before war broke out, and proved themselves far superior to any anti-aircraft gun against high-flying 'planes. Britain also developed rocket shells for use against land troops, depth charge rockets for combating the submarine menace, and a great variety of ship-launched, tank-launched and soldier-launched rocket devices. It is true to say that the second world war saw a remarkable revival of the rocket as a weapon, and each of the powers involved was very well equipped with them.

The interesting thing is that the vast majority of these rockets were not powered by liquid fuels. In effect, they differed but slightly from the ancient rockets of the Rajah of Mysore!



Remember, the world's armies in the field are not in the least bit concerned with getting to the Moon, and the backroom boys who must keep the armies supplied with new gadgets have to stow away their private ideas and concentrate on what is practical and warlike. This being the case, the scientists had to admit that, providing certain disadvantages of the solid fuel rocket could be overcome, it would be a much more feasible and economical weapon than liquid fuel missiles. Accordingly they set to work to iron out the difficulties—slow speeds, uneven burning, erratic trajectories, etc.

Gunpowder was out right at the start. It burned too slowly. On the other hand, nitroglycerine and other high explosives burned much too fast. Someone had the happy idea of slowing down the burning of H.E. by mixing it with petroleum jelly. Not only does this keep the burning within non-explosive rates, but it also stops uneven burning, and thereby keeps the rocket on a straight course. In one swoop, the solid fuel rocket became a mighty weapon. Well, perhaps not just *one* swoop, but not very many. The stick was replaced by vanes, the "lighted taper" business was replaced by a variety of firing devices, and special launching arrangements were designed.

Whether the use of the rocket in the war did more good than bad is a moot point, and one which probably has a different answer depending upon where you were born. But of one thing there can be no doubt. The general public for the first time became acutely aware of rockets as serious things rather than short-lived toys that streak up into the star-pocked night of November 5th in England and July 4th in America. Rockets, they saw, were not figments of a visionary's dream; they could kill, they were a reality.

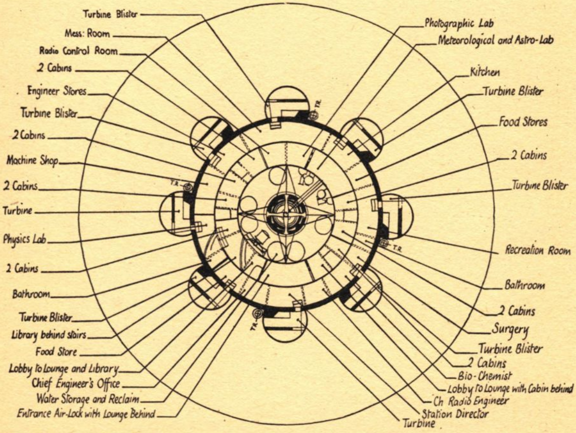
And so, in the post-war years, the public is more than ever ready to accept the idea of a rocket going to the Moon. Catering to this, the world's Press carries news of the work being done at White Sands, New Mexico, and at the Woomera range in Australia. One English national daily newspaper carried its banner headline into the realms of science fiction when it boldly announced: MAN CAN FLY INTO SPACE! on the occasion of the flight of the Douglas "Skyrocket." Well, the headline was a bit previous. But maybe not so previous as all that. The rocket has grown up!

THE END

The ARTIFICIAL SATELLITE

by H. E. Ross and R. A. Smith

Condensed from a paper in the Journal of the British Interplanetary Society



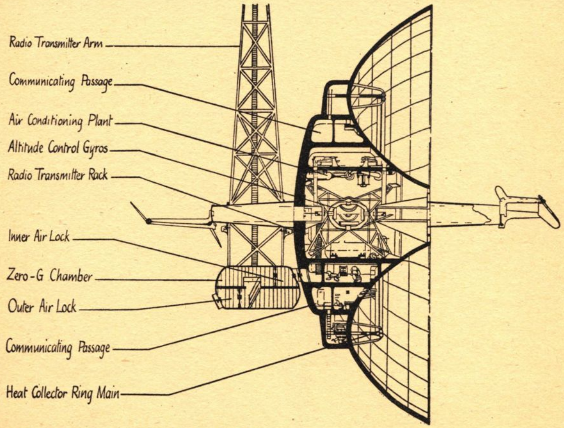
The satellite (shown in full on page 36) consists of three principal parts: (1) the "bowl"; (2) the "bun"; (3) the "arm." The bowl is a 200-foot diameter mirror; in this version a parabolic annulus, but other forms are possible. This mirror is used to collect and concentrate the sun's rays onto a system of pipes situated at the focus of the mirror. These pipes contain a fluid—let us say water or mercury—and they connect with eight turbo-generators situated round the circumference of the "bun" behind the "bowl." Boiling of the liquid by the trapped solar energy operates the turbines, which in turn generate electricity for the station's various services. About 3,900 kilowatts of energy is intercepted by this aperture mirror, so that we might reasonably expect that some 1,000 kilowatts would actually become available for use.

The "bun" behind the mirror constitutes living quarters, laboratories, workshops, etc. Since it is highly probable that entire absence of gravitational datum is undesirable physiologically, and certainly would be a considerable nuisance when moving about, it is necessary to rotate the inhabited part of the station. The bun living quarters being in this case conveniently integral with the solar mirror, the whole of this part of the structure is made to rotate in order to provide a pseudo-gravitational effect. Since the living quarters are in this design arranged as two concentric galleries, in effect a two-storeyed building, the *g* will differ in the two levels. However, with the bowl—and bun—rotating once in seven seconds, the *g* three feet from the floor of the two galleries will be 1*g* in the outer and 0.43*g* in the inner—which is probably a satisfactory compromise. In any case, manifestly it would be a simple matter to arrange for single-storey accommodation at the expense of compactness.

Control of the "attitude" of the station as a whole, which, if nothing else, must at least rotate about a diameter once per year, in order to keep the bowl facing the sun, is achieved by the "box" of six electrically powered gyros situated at the hub of the station. A photo-electric servo link between the mirror and these gyros could make the station automatically self-compensating in this respect.

The arm behind the bowl mirror normally does not rotate. At one end of this arm is a chamber with two air-locks. This chamber serves the dual purpose of a no-gravity laboratory and means of entrance to and exit from the space station. The far end of the arm carries radio aerial arrays which provide communication with Earth, and can also be used for diffusing television or other radio services beamed to the station. The radio array would normally be gyro-stabilised to hold a constant direction in space irrespective of any change of attitude of the station. Furthermore, automatic control would be incorporated to lock the Earth-Station-Earth beams. In addition, an overriding manual control would allow re-orientation of the various units of the arrays independently and at will. This, among other uses, would permit communication with and navigational assistance of a spaceship in transit between Earth and the station, and *vice versa*.

It is not necessary to describe in detail all the points of the layout, most of which will be apparent upon inspection of the internal schematic, but the *strobotelescopes* are worth some explanation.



The strobotelescope, developed by us, consists of a telescope with a built-in coelostat and an exterior plane mirror, or system of mirrors—which latter accessory enables the instrument to be sighted in practically any direction of a celestial hemisphere without the whole telescope being turned bodily.

As will be seen from the drawings, two such instruments are incorporated at the axis of the station, the barrel of one serving as the bearing of the lattice arm. It should be understood that the exterior mirrors would be capable of being rotated equatorially and adjusted in polar angle at will, in order to sight in the direction required, and that the mirror head entire would be fitted with a self-compensating mechanism that, normally, would keep the head pointing in the required direction. In essence, the latter requirement simply means that the mirror head would be synchronously driven counter to the revolving barrel of the strobotelescope on which it is mounted.

In operation what actually happens is that the light impinging on the exterior mirror system is reflected down the barrel of a normal telescope—which may be either reflector or refractor, as convenient—and then passes through the coelostat unit and eyepiece to the eye of the observer—or, alternatively, to a photographic plate. Since two strobotelescopes are provided, and since each can be sighted at will, virtually in any direction of a celestial hemisphere, practically any part of the whole star-sphere can be studied at any time without changing the attitude of the station.

The functions which this particular station could perform are fairly self-evident upon inspection of the internal layout drawing, but a few remarks may be enlightening. To begin with, the strobotelescopes—which might have apertures of the order of 40 to 60 inches—could be used for meteorological study of the Earth. Indeed, a great deal might be learned about the brewing of Earth's weather by the especially comprehensive, if long-range, inspection which this artificial satellite can afford. Again, since the strobotelescopes would be operating under practically ideal conditions—not peering through a quivering and slightly opaque atmosphere, but situated in airless space—very high magnification indeed could be used at all times, and true spectra of the sun and stars would be obtained. This is, of course, not possible when an atmosphere intervenes, a fact which especially clouds with uncertainty the determination of the constituents of the atmospheres of the other planets of the solar system. Against this we should bear in mind that in order to obtain a stationary image and sight in various directions without re-orienting the barrel of the strobotelescope, it has been necessary to introduce several more reflections than is normal to astronomical telescopy, so that some sacrifice in image brightness, etc., is unavoidable. Moreover, the mirror head mechanism and the coelostat must both be precision jobs. However, for some special occasions the bowl should be brought to a standstill, the station oriented to sight a strobotelescope direct upon the object, the exterior mirror system swung clear of the line of sight, the coelostat removed, and an ordinary telescopic view or photograph obtained.

A function of the photographic laboratory is obviously that of providing a recording service for other laboratories. Of course, the Physics laboratory would, among other things, investigate cosmic-ray and solar-radiation phenomena, and it will be noticed that a biochemist has been co-opted to conduct research into the effect of various radiations upon living organisms. In addition, the scientist would have the unique advantage over his terrestrially-located colleagues in that he can use the no-gravity chamber for a whole new range of experiments.

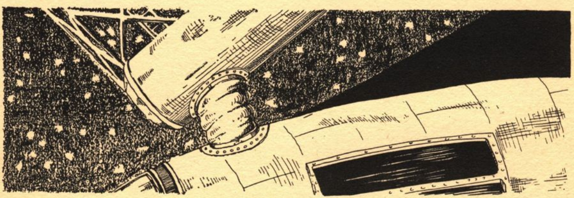
Besides the foregoing, we can envisage that, apart from any ordinary radio relay services which the station's adequate gear might provide, there would be opportunity to conduct a number of highly interesting experiments in connection with the reflection and refraction of various radio frequencies by the Earth's atmosphere.

Upon further consideration, a number of uses for such a station as this will become apparent—for example, that with vacuum "on tap" it is an admirable site for "atom-smashing" machines like cyclotrons and betatrons, which not infrequently fail under terrestrial conditions through developing a leak in the evacuated chamber.

The staff suggested for the station is as follows:—
One Station Director, 1 Deputy Station Director, 1 Chief Mechanical Engineer, 3 Assistant Mechanical Engineers, 1 Chief Electrical Engineer, 3 Assistant Electrical Engineers, 2 Astronomers, 2 Meteorologists, 2 Physicists, 2 Biochemists (one an M.D.), 2 Cooks, 4 Orderlies.

As a point of interest, it may be mentioned that the two galleries which together comprise the living quarters and work rooms of the station, if "unwound" and laid out flat, would be equal to a single-storeyed building no less than 450 feet long by about sixteen feet wide by ten feet high. The domestic accommodation alone, apart from the laboratories, etc., include a mess room, kitchen, recreation room, surgery, library, personal cabins and two bathrooms, and this should be entirely adequate for the staff of twenty-four which we have in mind. This may seem an unnecessarily large number but is, in fact, not excessive when it is realised that a twenty-four-hour radio service is being catered for, and that a good deal of highly exacting maintenance will probably be needed.

THE END



USEFUL INFORMATION

PLANET	ESCAPE VELOCITY	DISTANCE FROM EARTH	DIAMETER	SURFACE GRAVITY	MASS
Mercury	2·2 miles per second	93 million miles	3100 miles	0·27	0·04
Venus	6·3 „ „ „	26 „ „	7700 „	0·85	0·8
Earth	7·0 „ „ „	—	7900 „	1·00	1·0
Mars	3·1 „ „ „	49 „ „	4200 „	0·38	0·11
Jupiter	37·0 „ „ „	473 „ „	86700 „	2·64	317·0
Saturn	22·0 „ „ „	795 „ „	71500 „	1·17	95·0
Uranus	13·0 „ „ „	1674 „ „	32000 „	0·92	14·7
Neptune	14·0 „ „ „	2697 „ „	31000 „	1·12	17·2
Pluto	6·5? „ „ „	3534 „ „	3600 „	0·90	0·7

COSMIC RAY PARTICLES

PARTICLE	SYMBOL	MASS	LIFE secs.	CHARGE	DECAY
Electron	e^-	1	stable	—	
Gamma ray	γ				
Hyperon	Ω°	2184	$3{\cdot}3 \times 10^{-10}$	N	$\Omega^\circ \rightarrow p^+ + \pi^-$
Hyperon	Ω^+	?	?	±	$\Omega^+ \rightarrow p^+ + (?\pi^\circ)$
Hyperon	V^*	?	?	?	$V^{*-} \rightarrow \Omega + L^-$
Meson	$\mu^\pm$	210	$2{\cdot}3 \times 10^{-6}$	±	$\mu^\pm \rightarrow e^\pm + 2\nu$
Meson	π°	266	10^{-14}	N	$\pi^\circ \rightarrow 2\gamma$
Meson	$\pi^\pm$	276	$2{\cdot}6 \times 10^{-8}$	±	$\pi^\pm \rightarrow \pi^\pm + \nu$
Meson	ξ°	550	10^{-14}	N	$\xi^\circ \rightarrow \pi^+ + \pi^-$
Meson	$\xi^\pm$	530	10^{-11}	±	?
Meson	τ°	1000	?	?	$\tau^\circ \rightarrow \pi^+ + \pi^- + \pi^\circ$
Meson	$\tau^\pm$	970	$10^{-8} - 10^{-10}$	±	$\tau^\pm \rightarrow \pi^+ + \pi^-$
Meson	θ°	971	10^{-10}	N	$\theta^\circ \rightarrow \pi^+ + \pi^-$
Meson	$K^\pm$	990	10^{-9}	±	$K^\pm \rightarrow \mu^\pm + 2\nu$
Meson	$\chi^\pm$	1000	?	±	$\chi^\pm \rightarrow \pi^\pm + \nu$
Meson	η	?	?	N	$\eta \rightarrow K + L$
Proton	p	1836	stable	+	
Positron	e^+	1	stable	+	

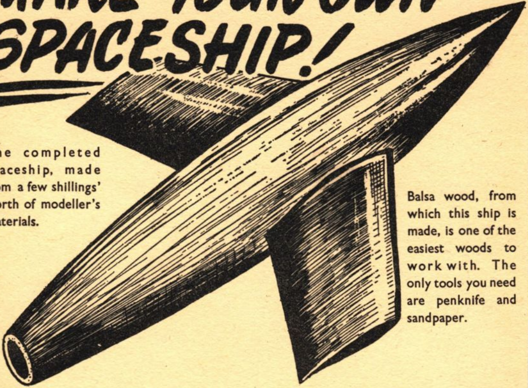
NEAREST STARS

STAR	DISTANCE
Proxima Centauri	4.3 light years
Wolf 359	8·1 „ „
Lalande 21185	8·4 „ „
Canis Major	8·7 „ „
61 Cygni	11·0 „ „
Ross 614	12·6 „ „

WEIGHTS ABOVE EARTH'S SURFACE

HEIGHT	WEIGHT
0 miles	1 lb.
1 „	15·99 ozs.
5 „	15·97 „
10 „	15·92 „
50 „	15·60 „
100 „	15·25 „
500 „	12·69 „
1000 „	10·24 „
4000 „	4·00 „
8000 „	1·78 „

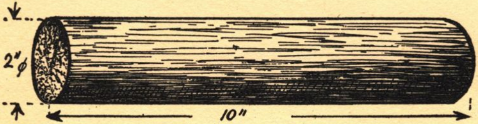
MAKE YOUR OWN SPACESHIP!



The completed spaceship, made from a few shillings' worth of modeller's materials.

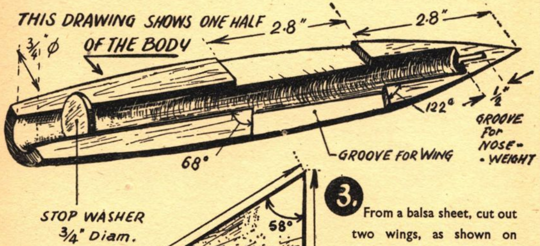
Balsa wood, from which this ship is made, is one of the easiest woods to work with. The only tools you need are penknife and sandpaper.

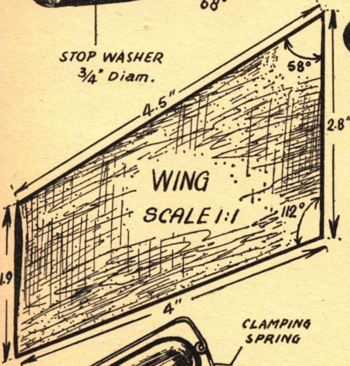
1. Start with a 10" × 2" cylinder of balsa wood, and shape it out to form the main body of the spaceship. When doing this, make the diameter of the tail 1",



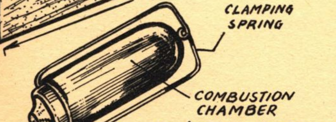
and make the widest part—where the rings will go—2" in diameter and 2·8" from the nose. Then cut the shaped body right down the centre, along the dotted line.

2. You now have two halves. Carefully ream out a central channel from each half, stopping one inch from the nose; this helps to make the block even lighter. Now make a smaller groove, extending ½" towards the nose, large enough to take a small bolt which will act as a nose-weight. Then, in the positions shown below, cut out grooves for the wings. Make disc ¾" in diameter from balsa sheet and glue it into the central groove 1" from the tail.





3. From a balsa sheet, cut out two wings, as shown on the left. Glue them into the grooves on one half of the body. Then glue the other half on top and bind up with elastic bands for a few hours. Polish carefully with fine sandpaper and then varnish all over, or paint the ship if you prefer. Fix a strip of asbestos tape into the tail and insert a Jetex motor. The motor is supplied, with directions, by all model-makers' shops. Your ship is finished!



THE JETEX-MOTOR

Magnitude of Stars

Though many people are aware that astronomers refer to the brightness of a star as its "magnitude," not so many really understand what this is. They are especially confused by the fact that as brightness increases, magnitude decreases!

Dividing stars into magnitudes goes back as far as Hipparchus, the Greek astronomer who, in 150 B.C., classified the stars he could see into six sections depending on how well he could see them. This, obviously, was a rather rough and inaccurate way of sorting out stars. Even so, it was not until 1850 that a really better system was devised; this delay was mainly due to the absence of light-measuring instruments until that time.

Then, the English astronomer, Pogson, put forward a scheme in which stars' brightnesses were expressed as ratios—each magnitude being 2.512 times brighter than the one following. By using the newly developed light-measuring devices, it was possible to assign numbers to the brightness of different stars, taking a certain level of brightness as a standard.

By using the ratio figure of 2.512, which is the fifth root of 100, the old Hipparchian system was more or less preserved, only more accurately. This had the advantage of not requiring a revolution in nomenclature and the scrapping of traditional catalogues. It also ensured that stars of the first magnitude were shown to be 100 times as bright as stars of the sixth magnitude—which they are in reality.

Richardson of Mount Wilson Observatory put the matter very clearly when he said: "To have a better conception of the meaning of magnitude it may be remembered that Altair, the brightest star in Aquila, the eagle, is almost exactly a first, the north star only slightly dimmer than a second, and that a candle at a distance of about two-thirds of a mile would appear as bright as a first magnitude star." (*Astronomy*, Chapman & Hall, 1947.)

These figures represent the *apparent* brightness of the stars; they do not indicate the *absolute* brightness. Apparent brightness depends upon its absolute brightness and upon its distance. Absolute brightness is not dependent upon distance.

The absolute magnitude of stars is found by observing their temperatures and sizes. It can also be calculated from the star's apparent magnitude and distance (or parallax).

FROM EARTH TO THE STARS (*Continued from page 71*)

of raw materials for its construction. Probably, the starship would exhaust the mineral wealth of even the richest country, for many millions of tons of steel and alloys would be required.

Nor, probably, could any one country call upon enough first class brains to plan the venture. Project Starbound will tax the abilities of experts in almost every field of endeavour, and they will need many years—maybe even centuries—to bring their plans to completion.

It is safe to say that when the project becomes a feasible thing, several thousand of the world's biggest experts will have to spend their full time on the planning. They may have to spend their lifetimes, and train others to take their place when they die. No doubt there will be training schools for men to learn how to plan a starship, and it may be that several generations will pass by before even the "keel" of the starship is laid. No one will grumble at this long delay. Remember, where a starship is concerned, there is no turning back! Everything has to be right the first time.

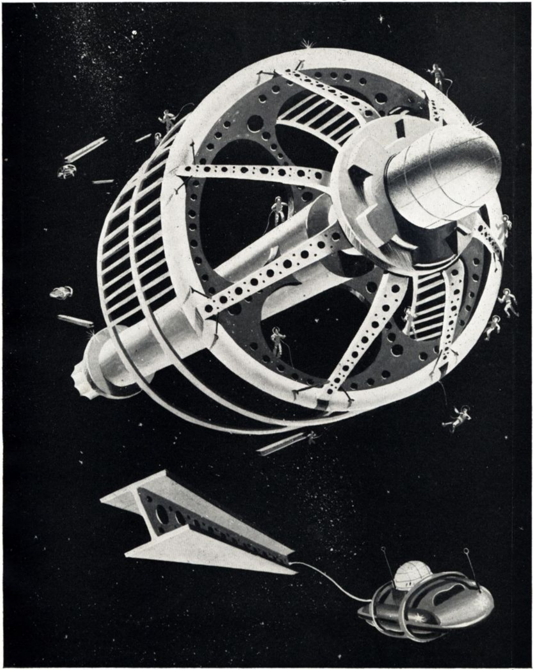
Of course, there are bound to be mistakes and errors of various kinds. But the task of the experts will be to keep these down in number and to see that they do not involve vital things. If an error results in the passengers not being able to have hot baths, for instance, no great harm will be done; but if an error means that the air supply is inadequate after, say, a century, then the whole project will be ruined.

Some people believe that man will not try to reach the stars—this being so huge a project—until there is some real necessity for him to do so. There are a number of ways in which this necessity could arise. Once the available planets in the solar system have been colonized to capacity, there will be no room for populational expansion. Choked populations are usually the first stage in the decline of a culture, and mankind will run a real risk of extinction if this happens. The stars and their planets offer a way out. Even if the population problems are somehow solved—and they may be, by eugenics—there is still the probability that in the extremely remote future the Sun will no longer be in a condition to support life on the solar planets. Once again, the stars and their planets hold out the hope of perpetuating humanity.

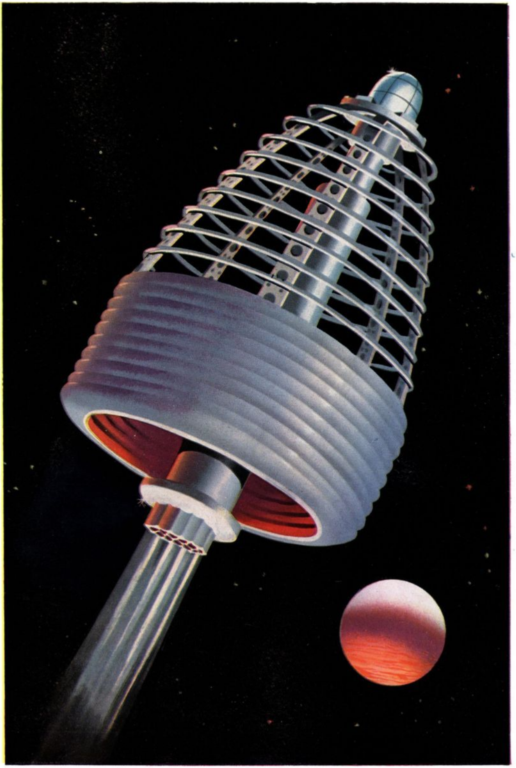
This view that the star trip will be made only in case of necessity may well be true, and it has a lot to support it. No doubt there are many men who would like to make the trip just for the adventure and thrill of it. But as we have pointed out, this is not something that a few men can undertake. When mastery of the air was the goal, one or two men could sink their personal fortunes and lives in making it come true. Where the conquest of interstellar space is concerned, the whole world must dig into its pockets and manpower.

Even so, the experts have little doubt that one day man *will* set out for the stars. Whether he ever gets there is another matter. Should the trip be made because of the risk of extinction in the solar system, and should the trip fail for some reason—that would be the end of humanity in the universe. Most of us are too sentimental or homocentric to admit that dour situation!

THE END



A Skeleton of Man's First Starship in the Making



The First Starship, Man's Most Ambitious Project, is Completed

POSSIBLE LIFE FORMS

continued from page 76.

The theory known by the name of panspermy was put forward by the Swedish physicist, Arrhenius, and claims that life came to Earth in the form of something like bacterial spores pushed through space by the light pressure of the Sun's rays. This is quite possible, though the invading micro-organisms would have to have been much more primitive than bacteria, which are some way from the bottom of the evolutionary scale. The Sun's light exerts a pressure of 2 lb. per square mile on Earth's surface, and mathematics show that the light pressure is sufficient to act in a counter-gravity manner on small particles.

So life on Earth may have originated from something that came from space. Life on other planets may originate in a similar manner. But these things from outer space had to originate themselves, somewhere, sometime. *That* origin is the one to which the theory of spontaneous generation applies.

As applied to Earth—and life in the universe *may* have begun on this planet—the theory claims, quite simply, that since life exists here it must have an origin, and that it must have originated from inorganic—that is, non-living—matter. This seems irrefutable.

But Pasteur's fame and the antisepsis that Lister gave to medicine are based on the observed *fact* that if you remove all living things from any medium and protect it from their entrance, no living thing will appear in it. When science came up against this apparent impasse between theoretical necessity and experimental fact, it was rather at a loss.

It is still like that today, though experiment has to some extent come out on the side of spontaneous generation. Experiments have shown that if a solution containing water, carbon dioxide and ammonia is subjected for lengthy periods to intense ultraviolet radiation, reactions occur, energy is absorbed and there is a synthesis of simple sugars and compounds that closely resemble simple aminoacids—basic units of protein construction.

In our imaginations, we can picture the young Earth on which there are lakes and seas containing the basic constituents—water, carbon dioxide and ammonia. At that stage of its existence, the Earth had no ozone layer in the atmosphere to screen off most of the Sun's ultra-violet radiation as it does today. So the lakes and seas were bombarded incessantly by these high-energy radiations and gradually turned into rather sickly and no doubt evil-smelling soups of sugars and protein units. Combinations and recombinations occurred until, in one place or many, a molecule appeared that was catalytically self-reproductive. This was the first living thing and all others developed from it.

Came the time when spore-forming organisms appeared. Some of the spores were carried high by the winds and tossed into regions of low gravitational force. They rode the light pressure of the Sun and were gently shoved off into space, later to be trapped in the gravitational field of another planet, there to give rise to life—panspermy.

Thus can be equated into a common system the idea of spontaneous generation and of mutational evolution.

Variable Stars

Though by looking at the Sun and by casually looking at the sky, we might think that the brightness of stars is constant, yet in fact there are several thousand stars that change in brightness from very bright to quite dull. These are called variable stars, and they are of very great importance to astronomers.

There are five different kinds: eclipsing variables, Cepheid variables, long-period variables, irregular variables, and temporary variables. Of these, only the Cepheid variables and temporary variables are of much interest.

The name comes from Delta Cephei, one of the first-known variable, which has a period between bright and dull phases of 5.37 days. Some Cepheids have periods of only a few hours, and the longest is fifty days.

The nearest Cepheid variable to Earth is about 200 light years away, but the astronomer has various means by which he can measure their distance indirectly. Many of them occur among the groups of stars known as globular clusters (see page 26) and all of these are remarkably similar in degree of brightness. Because of this, the astronomer can work out the distance of the globular cluster simply by observing the apparent magnitude of the variables in it.

Temporary variables are sometimes, perhaps more often, called novæ. These are characterised by staying for many years at a certain level of brightness, then suddenly flaring up to a much greater intensity, and finally dying down to a brightness dimmer than their original brightness. Since the beginning of this century there have been thirteen novæ observed, and astronomers believe that many more occur but are too dim to be seen readily unless one is actually looking for them.

Nova Herculis, a 1934 phenomenon, increased in brightness by about 169,000 times within a day or two, and Nova Persei, in 1901, flared up to 100,000 times its former brightness in three days. One of the most recent novæ, Nova Puppis, of 1942, rose from the seventeenth magnitude to more than three times the brightness of first magnitude.

Though novæ have been studied for several hundred years, no one yet is sure of what makes them flare up the way they do. There seems little doubt that somehow the dim star becomes unstable and cannot contain itself, as it were. Then it literally "explodes." All of us must hope that our own Sun will not decide to do this, for it would surely mean the sudden end of Earth!

The Difficult Science of Astronautics

Don't be frightened of the mathematics in this article. You don't have to understand them!

The space scientists of the future will need very good brains!

Astronautics can be said to be the science of space travel, with special application to the physical and engineering aspects. Roughly, it is comparable with aeronautics, the science of how to fly aeroplanes. But whereas aeronautics is in the main a mere extension of ordinary physical and mathematical ideas, astronautics involves completely new problems.

There can be no doubt that the kind of brains—the level of intelligence—that is perfectly satisfactory for a career in aeronautics, falls far below the standard required in an astronautics expert. The space scientists of the future will have to be better by far than any applied mathematician engaged in present-day ventures, and the men who train *them* will have to be paragons of physical prowess—in the non-muscular sense!

Since it is hardly likely that the general level of human intelligence will change sufficiently to supply enough men for the varied jobs of the future space travel programmes, it will probably be necessary to make men specialise acutely, narrowing down their mental application to a small field of enquiry. In the early days of aircraft it was possible for any single man to master the greater part of the science of all branches of the subject of aeronautics, so that he became an all-round expert. That cannot be done where space travel is concerned. Even today, before space travel has got under way, the experts have chosen special fields and kept to them. How much worse it is going to be when the first spaceships actually blast off and up crops a whole host of unexpected problems.

Of course, the world will not be entirely unprepared. It will not be a question of hundreds of specially-trained men being needed overnight. The men who work on the first spaceships will have spent their lives in the aircraft industry, in radio and electronics, in aviation medicine and so on. At the present time there are very many projects being undertaken which are indirectly linked with space travel. Today these projects are applied to quite different things, such as assisted take-off of aircraft, guided bombs, atmosphere-exploring rockets, etc. Nevertheless, the basic training and experience will be of inestimable value when the world finally gets around to building a spaceship, and these men will be given the job.

That is all very well, but it could hardly be put under what we mean here by astronautics. It is simply aerodynamics applied to rockets. The *real* astronauticists will be the men of the future who tackle the big problems of flying to the outer planets, avoiding the sucking drag of Jupiter's mighty gravitational field, designing new and more efficient spaceships and rocket engines and launching devices. Even the pilots of the future will probably have to know far more than the most accomplished expert of today. Anyone who knows anything about the flying of aeroplanes over long distances knows that a fair amount of mathematics enters into it. But this is nothing to the mathematics that the spaceship pilot or navigator will have to master. Below we give you some examples of the kind of mathematics regularly to be found in scientific papers on spaceship routes; don't be frightened of them, you do not have to understand them!

Take the case of a spaceship that leaves Earth and goes to the orbit of Mars by the so-called spiral path. Its changes in speed are shown by the equation:

$$\Delta S' = \sqrt{2K(1-\sin\phi)}\ \left(\frac{1}{p_1}^{\frac{1}{2}} + \frac{1}{p_2}^{\frac{1}{2}}\right)$$

which, as you see, is far from simple! Or consider the apparently simple example of the amount of fuel used up when a spaceship is given a push. This is shown by:

$$\mu^{-\frac{1}{2}}\, c \log \frac{m}{m'}, = u\,(p^{1-\frac{1}{2}} - p^{-\frac{1}{2}}) \sec \phi$$

which seems a lot of bother just to find out how much is left in the tank! And these are some of the easiest equations involved in astronautics. Let us show you some of the more advanced kind, without going into what they mean:

$$\frac{dp}{p} + \frac{dh}{h(1+h^2)} - \frac{Kdp}{p^2 S'^2} = 0.$$

$$\frac{p \sin\psi}{p_1 \sin\psi_1} = e\ \left(1 - \frac{pl}{p}\right)$$

$$V = \left(\frac{\mu}{a}\right)^{\frac{1}{2}} \left\{\sqrt{2}(z+u^2)^{\frac{1}{2}} - 2\,(z+1)^{\frac{1}{2}} + 1\right\}, z > 1$$

$$U \log R = \int_0^T \left\{\Sigma\left(\ddot{x} + \frac{\delta V}{\delta x}\right)^2\right\}^{\frac{1}{2}} dt.$$

$$\frac{d^2}{dt^2}\left[\frac{\ddot{x} = \delta V/\delta x}{\{\Sigma(\ddot{x} + \delta V/\delta x)^2\}^{\frac{1}{2}}}\right] +$$

$$\frac{\left(\ddot{x} + \frac{\delta V}{\delta x}\right)\frac{\delta^2 V}{\delta x^2} + \left(\ddot{y} + \frac{\delta^2 V}{\delta x \delta y}\right) + \left(\ddot{z} + \frac{\delta V}{\delta z}\right)\frac{\delta^2 V}{\delta x \delta z}}{\{\Sigma(\ddot{x} + \delta v/\delta x)^2\}^{\frac{1}{2}}}$$

Perhaps these will be enough to give you an idea of the kind of mathematical minds that spacemen of the future will have to possess. It also tends to give the lie to the fanciful stories in which robot pilots steer the spaceships. It is not likely that for many years to come electronic brains capable of solving such equations as these will be built small enough to be carried on a spaceship. There is no way out. The pilot—the human brain—will have to be able to solve equations like these, and still more advanced ones

Anyone at school today who wishes to become an expert astronauticist must make up his mind to put everything he has got into the study of mathematics and physics. Judging from the letters received from young people by the British Interplanetary Society, there are a great many youngsters who are dying to work on some aspect of space travel science and who are not too sure of the way to go about it. One thing is certain: they will have to work at their studies far harder than the entrants to most other professions. And the process of "weeding out" the duds will be far more severe than that of the most selective public school.

But not the *whole* of astronautics is too difficult for the average brain. In the column on the right, we give you some examples of simple space mathematics that anyone can do. And a lot of amusement can be got from the application of these mathematics to problems that crop up in arguments.

Used in conjunction with the information on page 83, they will enable you to work out all sorts of interesting things about the planets and satellites of the solar system.

SIMPLE SPACE FIGURING

To calculate the Escape Velocity of a planet, *find the square root of the surface gravity times the diameter.*

Example: Escape velocity of Jupiter:—

Jupiter's surface gravity is 2·64 times that of Earth. (Note: Earth's surface gravity is reckoned as equivalent to 0·006094 miles per second per second.)

Jupiter's diameter is 86,700 miles.

$\therefore$ Jupiter's escape velocity =

$$\sqrt{0{\cdot}00609 \times 2{\cdot}64 \times 86{,}700}$$
$$= 37{\cdot}35 \text{ miles per second.}$$

To calculate the Orbital Velocity at any height above a planet's surface, *find the square root of the surface gravity times the radius squared divided by the height above the planet's centre.*

Example: Orbital velocity of a space station 22,000 miles above Earth's surface—

Earth's surface gravity is 0·00609 miles per second.

Earth's radius is 3,950 miles.

Station's height above Earth's centre is 25,950 miles.

$$\therefore \text{Station's orbital velocity} = \sqrt{\frac{0{\cdot}00609 \times 3950^2}{25{,}950}}$$
$$= 1{\cdot}914 \text{ miles per second.}$$

To calculate the time to complete a circular orbit at any height above a planet's surface, *multiply the height from the planet's centre by* 6·292 *and divide by the orbital velocity at that height.*

Example: Time of revolution of a space station 22,000 miles above Earth—

Station's orbital velocity is 1·914 miles per second.

Station's height above Earth's centre is 25,950 miles.

$$\therefore \text{Time of revolution} = \frac{6{\cdot}292 \times 25{,}950}{1{\cdot}914}$$
$$= 85{,}350 \text{ seconds}$$
$$= 23{\cdot}70 \text{ hours.}$$

CONSTANTS

Speed of light............... 186,000 miles per second.
Miles in a light year............... 5,678,000,000,000.
Gravity at Earth's surface
32·17 feet per second per second.
Absolute zero temperature............... −273·2° C.
Astronomical unit.................. 93,000,000 miles.

CONVERSION FACTORS

Miles to kilometres........................... × 1·6093.
Miles per hour to feet per second........... × 1·4667.
Tons to kilogrammes........................ × 1016·0.

The Radio Telescope lets Astronomers listen to

Sighs from Space

★

For centuries astronomy underwent hardly any fundamental development in technique. Though masses of information were accumulated, these were all obtained by the age-old method of looking through telescopes. True, a big advance came when photography was invented, By substituting a sensitive photographic plate for the not-so-sensitive human eye a great deal more of the heavens could be brought into view. But this was still only an extension of ancient methods. Astronomers were still dependent on the light emitted from stars, and all the photographic plate enabled them to do was to see more of the same kind of things they had already seen in profusion. Even the enormous, expensive and precision-built 200 in. telescope at Mount Palomar, California, has not added any new basic ideas to astronomy. Not until radio astronomy came into existence did this happen.

This very recent branch of the star-gazing science began in 1932, when an American radio engineer discovered that the noisy hisses and clicks that came from his wireless apparatus were actually being picked up from outer space. As with many similar fundamental discoveries, no one took much notice, and it was not until just before the second world war that more work was done along these lines. Then, an amateur radio enthusiast named Reber made himself an aerial thirty feet in diameter, pointed it at the Milky Way and picked up radio waves coming from outer space.

What really made astronomers sit up and take notice this time was that Reber showed that these waves did not come from anything that could be seen in the sky. They came from regions of space that the telescope showed to be empty.

No doubt astronomers all over the world, together with physicists and radio men, would have turned their thoughts towards this exciting new phenomenon. But the war came and their time was too valuable to spend on academic work, however interesting that may be. The men who would have taken up radio astronomy—as the new branch has come to be called—were drafted to work on radar and similar problems. This, it turned out, was a blessing in disguise.

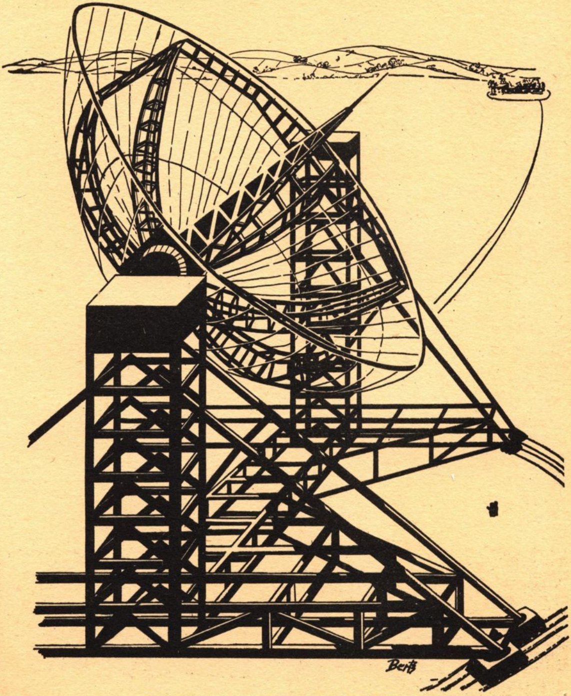
The whole world knows now what tremendous advances were made in electronics and radio generally under the stimulus—and expenditure—of the war. Devices that would have taken a decade to develop under peacetime conditions were perfected within a few years, and many other ideas might never have seen the light of day had not the needs of defence been so urgent.

A team of scientists who are now at Manchester University became so schooled and so expert at radar techniques and instrument design that, when the war was over, they were able to lay the foundations of radio astronomy on which astronomers all over the world are building today. Equipment they devised to seek out enemy 'planes and ships are now probing the skies and helping to give us greater understanding of the universe.

After the war these scientists set up a research station at Jodrell Bank, far from interference by electrical machines. This was the first radio astronomy research station in the world, and it consisted of crude huts surrounded by what looked like gigantic bowl fires. These thirty-foot diameter aerials were mounted on turntables and could be swung to face any region of the sky.

Radio telescopes are really massive receiving aerials, shaped as a parabolic curve so that all parallel rays falling upon it will be sent to a single focus. From the focal aerial rod, impulses are conducted along cables to the laboratories, where they are amplified and recorded. At Jodrell Bank, waves of about three metres length came in from the vastness of space, were carried to the laboratories and transformed into wavy lines on graph paper.

Progress was rapid, and various important bodies such as the Government and the Nuffield Foundation took great interest in the work being done. So much so that these bodies have financed the building of what will be the largest radio telescope in the world. A drawing of



Our artist's impression of the completed Radio Telescope.

this is shown on the previous page. This, rightly enough, will be the property of Manchester University. Its bowl will be 250 feet in diameter, and it will reach up to 300 feet at its highest point. The telescope will weigh 1,000 tons, excluding foundations. The bowl will be supported by steel lattice-work towers, and the whole can be turned through a complete circle on ten bogie mountings which have seven-foot wheels and are as large as express locomotives. At the tops of the 180-foot towers are gearings that can rotate the 300-ton bowl through 360 degrees. The circle at the bottom will be just a little wider than Trafalgar Square!

Automatic steering enables the bowl to follow any point in the sky with a precision of about fifteen minutes of arc. This is a triumph of engineering skill, surely.

Not only the Manchester astronomers, but star-gazers all over the world, are anxiously looking forward to this telescope being put to use to answer some of the questions that smaller radio telescopes have posed.

To begin with, the astronomers want to know where these radio waves are coming from. Of course, it is well known *how* they originate; just as we know that a glowing heater element is giving off infra-red waves, and that a white-hot lamp filament is giving off visible light rays—in each case due to movement of particles in the emitting substance—so we know that *all* particles of matter emit waves the length of which depends upon the amount of movement of the particles. And radio waves are not fundamentally different from any of the other electromagnetic waves such as light and heat (radiant). Radio waves are simply very long electromagnetic waves.

Nevertheless, they cannot, as far as we know, be generated from something that is not particulate. Yet the radio telescopes indicate that the waves coming in from space do not start out from anything visible. They come from quite definite regions—such as a part of the constellation of Cassiopeia and Cygnus—that the visual telescope shows as being devoid of stars.

The regions from which come the radio waves have been called "radio stars," and the only way to know of their existence is to point a radio telescope at them. Yet they rise and set like any visible star, coming up over the horizon in the evening, crossing the sky and dipping down again later in the night. Their course is shown by the wavy lines on the graph paper of the recording device. Also, though it may seem strange but shouldn't, radio stars rise and set during the daytime, too!

There is nothing really remarkable in this. Normally, we cannot see stars during the day because the light of the Sun is so much brighter than the light from the stars that the latter is cancelled out. But the radio telescope is not bothered by things like this. By the same token, the astronomer who works with this instrument does not have to sit up all night in a cold observatory dome. Nor does he have to twiddle his thumbs if the sky is cloudy or foggy. Radio waves penetrate fog and cloud, and he is able to keep his telescope probing the heavens continuously day and night, cloudy or fine. He does not even have to sit over it, for the automatic steerer will keep the bowl pointed at whatever region he is studying, and the recorder will take down all the information he needs on one long sheet of graph paper. He can study it at his leisure.

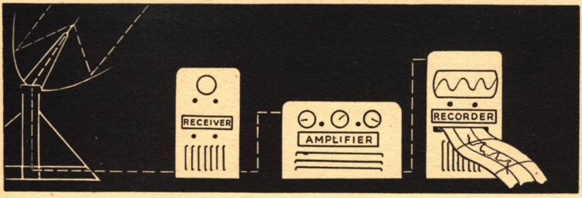
When we said that these radio waves do not come from visible objects, this was not strictly true. For all except one set of such waves it is true, and the exception is of great interest. It is the object that is called the Crab Nebula. The Crab, a vast mass of swirling luminosity, is the remains of a stellar explosion that was observed to take place by Chinese astronomers in 1054 and which is still going on! The seething, fiercely-hot gases have not yet cooled down.

The fact that radio waves are coming from the Crab Nebula is interesting because they are also coming from the point in space where a star was seen to explode in 1572. Nothing is visible at that point today, but where that star died is something that sighs, and the radio telescope picks up the sighs. This suggests that all, or many, of the spots that give off radio waves are places where stars have exploded and all visible remains have gone. There are more than fifty such spots discovered to date.

And this is important, for more than ninety per cent. of the area of the Milky Way is covered by completely dark obscuring "cloud" of a nature that nobody understands. It may be that the new radio telescope will solve that problem once and for all.

But the greatest and most fundamental problem that the radio telescope will be called upon to answer is the question of whether the universe is expanding, and if so, why. This topic leads into very deep waters indeed, so we will leave it to the astronomers—and to their gigantic new wonder-instrument.

THE END



Lunar News

Mars Mirror

MERCURY OBSERVER

Venus Times

EARTH GAZETTE

NEWSPAPERS of the FUTURE

Today the world has many newspapers. Every country has certain large newspapers which try to reflect the views of the whole country and to give news from all parts of the world. Every large town has its newspapers, which deal with local news and select from international news those parts that affect the locality. In this way several thousands of newspapers have come into being. What effect will the conquest of space have upon the Press?

We can be pretty certain that the majority of the present newspapers will remain in existence, and it is probable that the main effect of space travel will be an increase in the number of newspapers. Remember there were once no newspapers in America and now there are thousands.

Here on Earth we shall probably see the starting of the first world-wide newspaper—not published for a town or a country, but for the entire planet. What language this will be published in is a moot point, though it is to be hoped that by that time people will have been sensible enough to adopt a universal language—and one that is far more efficient than English.

As the other planets in the solar system are colonized, so they will print their own newspapers. And as the colonies spread out and establish new townships, so will local newspapers spring up on Mars, Venus and Mercury. A fairly safe bet is that the first extraterrestrial newspaper will be published on the Moon, for that body will almost certainly see the very first out-of-this-world colony. Gradually, as mankind moves farther out among the planets, more and more planetary newspapers will come into being. It is likely that foreign editions of these, or the most important of them, will be radioed to other planets to save the time of sending actual paper freight.

Nowadays in big towns like London, one can find newsagents who stock daily editions of most foreign newspapers. In the future it may well be that such newsagents as these will stock the *Martian Mirror* and the *Venus Times*, giving news of the happenings on those planets.

Then, of course, rival publishing groups will start newspapers on the planets, and we will have the same kind of circulation wars that we have now among our big national papers. One can imagine the *Lunar News* claiming a circulation of 10,000, while the *Mercury Observer* brags that its modest 5,831 is not so dusty for so small a colony. And then the *Lunar Chronicle* and the *Mercurian Star* will start up and fight their rivals, probably giving prizes of land tracts on the Moon to gain new readers.

Finally, there will probably develop a newspaper or several such that cover the entire solar system colonies, much as the *Earth Gazette* will cover the entire globe. We can imagine that the language of those remotely future days will be very clipped and precise, following modern trends. Indeed, it is on the cards that these future newspapers would be unintelligible to people of today, even though, apparently, published in the same languages.

On the next two pages is shown what the front page of such a newspaper might look like in 2155. You can see that although the type has changed, the style has changed and the "readability" has changed, there is not much alteration in the basic pattern of the news. Still there are disasters and the headlines will glory in them. Still there are trade disputes and the paper will give a prejudiced account of them. Still the advertisers will make incredible claims for their wares on the fond assumption that people are fools. Probably more than anything else, the newspapers of the future will be proof that human nature does not change, but remains as primitive as ever.

WE PRINT ANYTHING!

SOLAR

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No. 12854 | Monday, June 15th, 2155 | Price 3cr.

JUPLINER HOLED OFF IO

Meteor Freak Tragedies Maiden Trip

500 DEAD

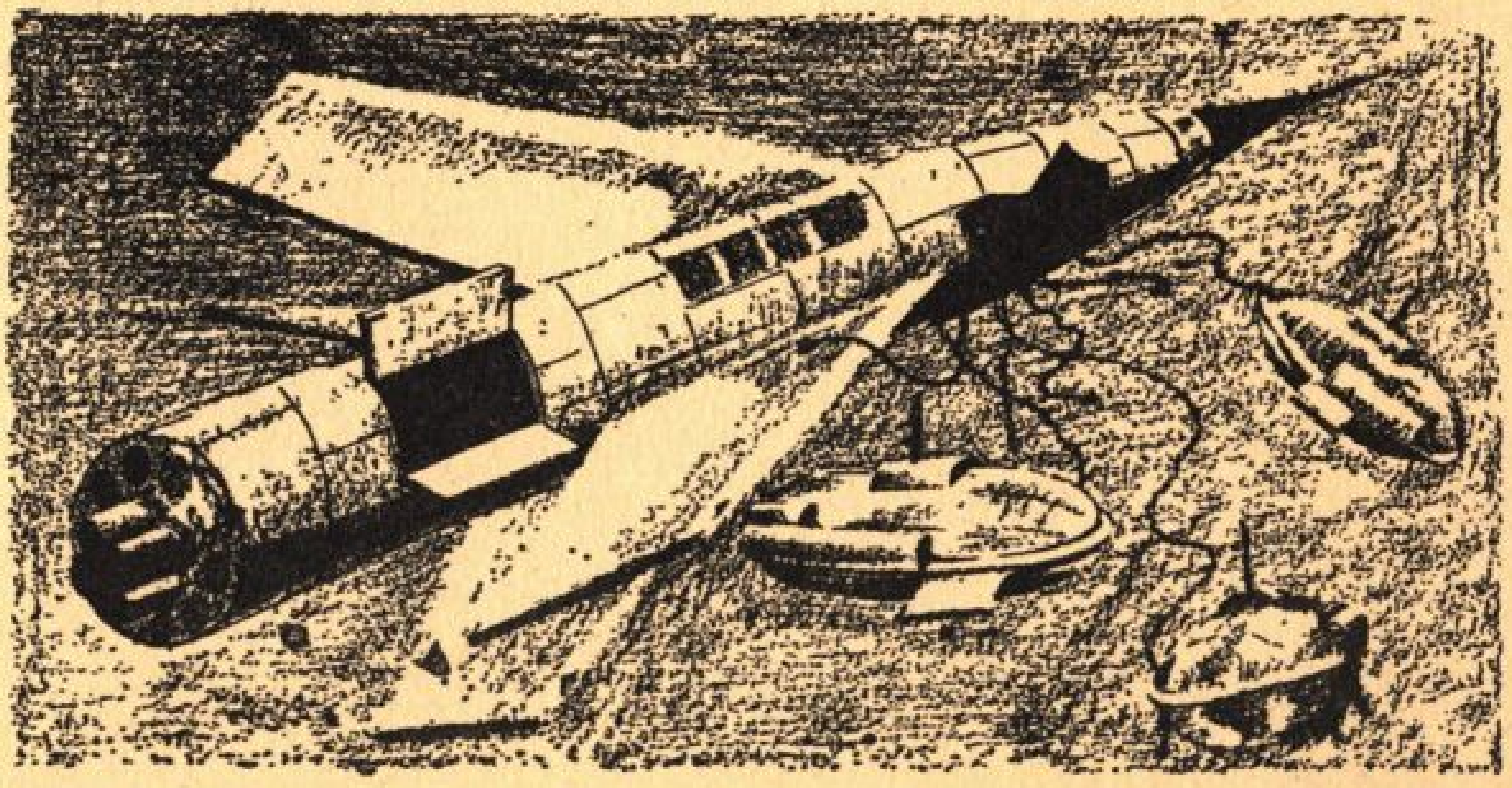
Jim Doyle,
Io, Saturday

TRAGEDY came tonight to the greatest space vessel in creation—the mammoth *Solstice*, launched by Juplines only a month ago and dedicated by the Bishop of Mars, who said at the time: "May this ship ride safely on the velvet blackness of God's space."

Streaking out of the night sped a freak meteor—freak because it shouldn't have been around at this time of the year. And straight for the majestic liner went the meteor, crashing her amidships and tearing a jagged hole in the three-inch thick hull. Air rushed out into the throttling vacuum of space and seven chambers were airless before the automatic safety mechanisms could seal off the rest.

Rescue craft were rushed from other Jovian moons—Europa and Ganymede. Mercy squads sped to the aid of the stricken vessel from Marsport and from Titan, moon of Saturn. The full force of Intersol Salvage was brought into action, and now—as you read this—space-suited men are floating around the ship off Io, welding and rivetting, cutting and sealing, in a brave attempt to get the liner into shape for the landing on Io—where she was making when the thunderbolt struck her.

Turn to page 2, col. 2



This radio picture received tonight from Io shows the extent of the damage made by the freak meteor to the pride of the Juplines biggest ship. Rescue crews were rushed from Europa, Ganymede, Mars and Titan, but arrived too late to save 500 of the passengers. The rescue work goes on.

Pay Claim By Astroes

EYESTRAIN DANGER ALLEGED

At the meeting of the Interplanetary Union of Astrogators held at Venusport yesterday, Captain Ken Davis, President of the IUA, told members that a strong claim for a wage increase would be made on their behalf. Said Ken: "The employers do not sufficiently realise the tremendous danger to our sight caused by the eye-strain of staring at pin-points of light against the pall of space." A resolution was passed by a 3.5 to 1 majority, calling upon the employers—the large spacelines—to agree to an increase of ten credits a day for all fully qualified astrogators.

NO PENSION

Speaking on behalf of the astrogators of Mars, Captain Jeff Tomas told the meeting that they must never forget that astrogators received no pension when they retired. There was laughter when Jeff pointed out that this was because no astrogator ever did retire—he always perished aboard ship before that!

"Seriously," he said, "we must press this claim so that we can lay aside something for the days when our space-jockeying is over."

The resolution will be put before the Interplanetary Federation of Spacelines tomorrow.

More meat, veg from Venus

It was confirmed in Washington today, Headquarters of the Food Allocation Council, that greater exports will be allowed from Venus of meat, vegetables and certain fowl. Most of these exports will go to Earth, but the majority of the rest will be used to feed the growing colony on Oberon, distant moon of Uranus.

LUNIES NEED NEW DOMES

Cracks in the cranium

Solar Reporter

The men on the Moon are not smiling tonight. Nor is there peace in the Garden of Tranquility, that fabulous space-house for jaded tycoons. For the domes are cracking. Not, let us rush to add, the domes of the tycoons, but the plastic canopies that protect the Lunies from the airlessness of space.

Astrogeologists, carrying out a survey of the 200-years-old Moon Base, have discovered minute cracks spreading through the yard-thick domes. Air is leaking out at the rate of nearly a hundred milligrammes a day—lunar day; 28 Earth days.

The Domes were re-covered only fifty years ago with a newly discovered silicone resin, but this seems to have been inferior to the plastic used by the pioneers. A fine blow to the conceit of modern chemists!

Since the maintenance of Lunar is the responsibility of Earth, a deputation will call upon Professor MacDonald, Terrestrial Supply Supervisor, next week, demanding action against the cracking craniums of the Moon.

Still loyal to Earth say Martians

Solar Reporter

Dwight Finkelberg, President of Mars, stated in the General Assembly early today, that no one on Mars can forget that mankind was born on Earth. "Our loyalty," said the President, "lies with that planet, and we pledge ouselves to perpetual friendship and peace with Earth." The President's speech was loudly cheered by the Assembly.

HOW TO STEER A SPACESHIP!

Navigation in Space

It is not too difficult, says
Frank Wilson, B.Sc.

Have you ever thought how marvellous it is that a ship or an aeroplane can start out from, say, London, travel many thousands of miles and then safely land at Tokio or Sydney? If you have ever made such a journey yourself you may well have pondered, in mid-ocean, how the pilot or captain knew where to take the vessel. There is nothing to see but sky and sea. As far as you can tell, any direction might lead to your destination. How is it then that the navigator on a ship or 'plane knows where to go?

Well, as you probably know, he takes a look at the Sun during the daytime, or the stars at night. In a wonderful little book called the *Nautical Almanac* he can look up the positions of the Sun and stars at any time of the year. From those positions, and from his own measurements, he can tell where he is himself.

But what happens to the captain or navigator of a spaceship? Surely the conditions here are much worse, for there the ship is, out in the blackness of space, surrounded by mere pinpoints of light! The liner or the aeroplane at least have solid ground beneath them to give some idea of what is up and what is down; but out in space there is no such thing. The vessel merely "hangs" in space, probably *millions* of miles from anything.

Actually, although the spaceman might seem to be in a most difficult position, he is really at an advantage compared with his terrestrial colleagues—for *he can see where he is going all the time!* Whereas the ship that leaves Southampton for New York has a range of visibility of only a few miles, there is no limitation at all on how far a spaceman can see. Even though his destination is a couple of hundred million miles away, it hangs there in front of him like a beckoning lamp. At least, it is in front of him if he is going in the right direction.

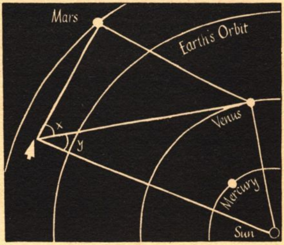
And how does he tell whether he is in the right direction? Well, the procedure is very much like that on Earth.

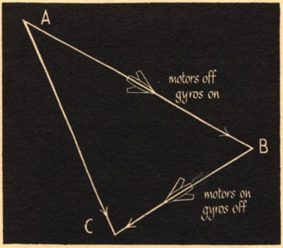
When space travel becomes a reality, there will certainly be issued a kind of *Nautical Almanac* showing the positions of the stars and planets at any time. So, the spaceman, using something like a sextant, sights, say, Venus. Any other planet would do just as well if Venus happened to be awkwardly placed. He measures the angle between Venus and the Sun, or another planet. His almanac tells him the position of Venus, so he can plot the Sun-Venus line on a piece of chart-paper.

Then he aims the sextant at another planet, say, Mars, and determines the angle between Mars and Venus. Since the almanac tells him the positions of these two planets, he can now draw the line Mars-Venus. He now knows the angle x (see the figure), the angle y, and the lengths of the lines Mars-Venus and Sun-Venus. Reasonably simple geometry now gives him his exact position in relation to these bodies.

Of course, we have assumed here that the spaceship, the planets and the Sun all lie in the same plane, and this need not necessarily be so. But the correction needed would be small and very easy to make, so there is no great problem there.

There is another way in which the astrogator could determine his position, only this would not be so accurate as the method just described. For a rough check on his position, the spaceman could simply measure the apparent diameters of some of the bodies around him—the Sun and one or two planets. The actual diameters of these bodies are well-known (and will, presumably, be known even more accurately at that date), so the astrogator can easily





determine the distance of his ship from them. Once he knows these distances, he knows where he is.

Now, all this tells him where his ship is at the moment he makes the observations, but it does not tell him where his ship will be ten minutes later. In other words, it does not tell him whether he is travelling in the right direction. True, another determination of position at a later time would help out here, but the astrogator cannot do very much in the way of navigation unless he knows his velocity. And this is not at all easy to discover from the ship alone.

A suggested method of overcoming this difficulty involves radio beacons. These may one day be set up in space much as light buoys and lighthouses are positioned on Earth today to help mariners and airmen determine their position. But the radio buoy would be more concerned with the determination of velocity.

These beacons, it is proposed, would send out radio pulses at definite intervals—probably different for each buoy, or of a different wavelength. The impulses would take the form of "pips" and these would be picked up by receivers on the ship and counted. If a ship is travelling fast *towards* a beacon, it will receive more pips per second than the beacon is actually sending out. And if the ship is moving *away* from the beacon, it will receive less than the beacon is sending out. By counting the number of pips received in a second and comparing that number with the number known to be given out by that particular beacon, the ship's velocity can be determined.

Now, suppose the astrogator determines his position and velocity—and then finds that his ship is off course. What does he do? He cannot, like a pilot, use air resistance to swing his vessel round. He cannot, like the captain, use a rudder to push water away from the ship and so turn it. Up in space there is nothing to push against.

Luckily, there is a way of overcoming this problem, too. It is based on the principle of the gyroscope. By spinning a couple of heavy flywheels inside the ship, the astrogator can turn the vessel through any angle he wishes. (These gyros will come in useful when, for example, the ship has to be turned jet-down for a landing.)

But, you say, the angle of the ship has no effect on its direction. And you are quite right. Once the motors are turned off—and spaceships will do most of their journeys with dead motors—the ship will move in a certain direction irrespective of which part of the ship is pointing in that direction—tail-first, side-first, nose-first, or any angle in between.

The reason why an astrogator will have to turn his ship when he wants to change direction is that he will have to fire the motors to accomplish the later change. It is no good firing the motors—giving the ship an impetus—if the jets are not pointing in a direction exactly opposite to that in which it is desired the ship should go. Otherwise, the ship would fly off in a completely useless direction and the astrogator's careful calculations will have been of no avail.

So the astrogator starts the gyro wheels revolving until the ship is in the required position relative to the line of travel desired, and then gives a short burst on the motors. Reference to the second figure will show the reasoning behind this.

In the figure, we suppose that our ship is travelling along the line AB, nose-first. We take sightings and discover that we are on the wrong course. We should be moving along the line AC. This means that we have to give our ship a little push towards AC. So we turn the ship by its gyros until it lies along a line such as BC. Any line parallel with BC will do, but the extent of the push needed will depend on how far that line is from A.

Now, with the nose of our ship pointing towards AC, we fire the motors for the requisite length of time. This will probably be just a second or two. There will then be two forces acting on the ship: the momentum in the direction AB and the propulsion force in the direction BC. The ship will actually move along the resultant (effective mean) of these two forces, and that resultant will be the line AC. We are on course again!

Now there is one other point that we must consider from the point of view of the astrogator, and that is: What do we mean by the velocity of a spaceship? On Earth, when we say that a vehicle is moving at, say, 300 miles per hour, we mean that all points on the Earth beneath it are being passed at that speed. Terrestrial speeds take the landmarks of Earth as reference points. But this obviously will not do in space. Arthur C. Clarke has pointed out in his *Exploration of Space* that observers on Mars might come to the conclusion that a certain ship was approaching the planet at 12,570 miles an hour; and observers on Earth, looking at the same ship at the same time, might decide that the ship was receding at 8,490 miles per hour. And both of them would be right!

This is where relativity comes in, and a discussion of the theoretical basis is outside the scope of this article. All we need to know at the moment is that it does not matter! The only important thing to remember is that the velocity of a spaceship must always be expressed in relation to some body. It does not matter which, for its velocity with respect to other bodies can be calculated.

In the early stages of a journey, the astrogator will probably express his velocity in relation to the planet he has just left. After the half-way mark, he will probably state his velocity in terms of his destination. The whole thing is merely a matter of convenience.

THE END

A few words
About our Authors
and their backgrounds

H. J. Campbell

H. J. CAMPBELL spent ten years as a research scientist working on the chemotherapy of tuberculosis, human embryology and biochemistry applied to the cause and cure of cancer. He is now a scientific journalist and Editor of *Authentic Science Fiction*. He has had published ten novels and two anthologies in addition to several hundred scientific articles and short stories in Britain and abroad. A few years ago he devised and wrote the script of a science fiction strip in a British national daily newspaper. Well-known in the New World, he has broadcast on science and science fiction in Canada and is the British representative of an American science magazine.

Still retaining his former contacts, Mr. Campbell draws upon his friends in hospitals, University departments, the Harwell Atomic Energy Establishment, and research institutions for ideas of "quirky science" to incorporate in his stories. Most of these stories have a biological slant, and Mr. Campbell is at present carrying out research on the regeneration of animal tissues. He is married, has two sons and lives in Sussex.

ARTHUR C. CLARKE worked in the Exchequer and Audit Department until he joined the R.A.F. in 1941 as a radar mechanic. He was demobilised as a Flight-Lieutenant in 1946, when he went to King's College and took a degree in physics and mathematics. He was one of the earliest members of the British Interplanetary Society, is a Fellow of the Royal Astronomical Society and a Member of the British Astronomical Association. In 1947 he became Chairman of the British Interplanetary Society, and held that position again from 1951 to 1953. He is the author of two standard works on space travel—*Interplanetary Flight* and *The Exploration of Space*—as well as several novels (including *Sands of Mars*, *Childhood's End* and *Prelude to Space*) and a great many short stories. Well-known as a lecturer on space flight in Britain and the United States, Mr. Clarke is married to an American and spends a lot of his time in that country.

Forrest J. Ackerman

FORREST J. ACKERMAN, who has been given the title of *Mr. Science Fiction*, has the world's largest collection of science fiction magazines—resulting from his thirty-odd years of devotion to this branch of literature. His home in Los Angeles, California, just a stone's throw from the Mount Palomar observatory, is crammed with more than 5,000 books and 10,000 magazines in almost every language, including Esperanto, which he reads, writes and speaks fluently.

Known affectionately as 4e, his stories have appeared in many magazines in Britain and America, and he is a columnist for several dozen publications. But his greatest fame comes from science fiction films. The chances are that if you've seen a rocket on the screen or a ray-gun on television, Ackerman had something to do with it. He helped in the production of *Donavan's Brain, When Worlds Collide, Duel on Icarus,* and several other well-known films. In 1953 American science fiction devotees awarded him by vote a rocket trophy for being the most popular fan of the year.

DAVID McILWAINE was for some years a B.B.C. engineer before taking up his present position as Editor of *British Radio and Television*. Under a pseudonym he has written several science fiction radio and television plays, one of which has been made into a film. He is a novelist and short story writer whose work has been published in America, Sweden, India and Britain.

FRANK WILSON is a professional scientific journalist who forsook the chemical laboratory for the desk, the test-tube for the pen. He is a trained logician and is the author of a number of learned scientific papers. He tried to write fiction, was unsuccessful, gave it up and now sticks to non-fiction articles—which have appeared in magazines all over the world. He is married, has two daughters and lives in Hertfordshire.

H. K. BULMER has been writing science fiction for several years and is becoming well-known for his graphic novels and poignant short stories. He is married and lives in London.

H. K. Bulmer

E. C. TUBB began writing science fiction in the late 'thirties and then the war interrupted him. After the war, his first science fiction story was published in the first British science fiction magazine. From then on his

E. C. Tubb

output has steadily risen, with sales on both sides of the Atlantic. He is a keen astronomer with a wide knowledge of kindred sciences, and he has specialised in the problems of the Martian Base. He is married and has two children.

HARRY HARPER has the honour of being the first air reporter in the world. In his young days he saw the very beginnings of aviation, and later he became absorbed with the idea of space travel. His book, *Dawn of the Space Age*, was one of the very first to deal with this topic. He has also written several books on aviation. Articles by Harry Harper appear regularly in all publications dealing with aeronautics and space flight.

WILLIAM F. TEMPLE was once of the staff of the London Stock Exchange and then served in the Royal Artillery for six years during the war. After the war he took up writing seriously and immediately began to see his stories published in America and Britain. His most famous novel, *The Four-Sided Triangle*, was made into a film, and he has written a book on space travel for children. One of the earliest members of the British Interplanetary Society, he edited its *Journal* at one time. He is married and has two children.

William F. Temple

DO YOU WANT TO EMIGRATE TO MARS?

(*Continued from page 73*)

But to fail on the red planet would be to die.

So the most important thing on any extra-terrestrial colony won't be a supply of food and water, air and power, important though those things may be. Above them, dominating them by sheer necessity, will be the psychological attitude of the colonists themselves, and the most important member of the settlement won't be the engineer, but the psychologist.

It will be his job to keep them happy. To help them to adapt enough to their environment so that the colonists do not reach the limit of adaptation and break, but will be able to adjust and accept their new life. Recreation will be important, politeness essential, for living in close proximity as they will be, with frayed tempers and strained nerves, an impolite colonist could easily arouse the terrible, primitive, hate-fear reaction lurking within us all, and brought very near the surface whenever men are facing physical strain and mental adjustment.

Such a man could cause riots, murder, disrupt the very foundations of the new colony by triggering the frustration of them all. For on Mars there can be no escape from each other, no other place to go if you don't like the man you are working with, or living with, or whom you are married to.

One of the prime essentials in selecting the personnel for the Martian colony would be to avoid any dogmatic, overbearing, arrogant or impolite personnel. The colonists, to begin with at least, must be a close-knit unit of friends, each with high empathy towards each other, and each with an innate good nature.

It may even be that a sense of humour will be the main qualification for any would-be colonist before he or she can be selected for Mars.

THE LAWS OF ROBOTICS

It is probable that the greatest amount of thought ever given to robots by one man has come from Dr. Isaac Asimov, who is a biochemical researcher at the Boston University School of Medicine, and also a prominent science fiction author.

His most famous book of robot stories is called *I, Robot* (published in this country by Grayson & Grayson at 8s. 6d.). This contains some of the finest robot stories ever written, and each one is based ultimately upon the three Laws of Robotics, devised by Asimov. These laws are:—

1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Scientific Crossword Solution

Across

1, Comet; 4, Mutations; 8, Lunatic; 9, Chrysin; 10, Oval; 11, Rigel; 12, Orbs; 15, Evade; 16, Rockets; 18, Nebulae; 21, Demon; 23, Sere; 24, Cures; 25, Opal; 28, Attract; 29, Stimuli; 30, Spaceship; 31, Scene.

Down

1, Collodion; 2, Mundane; 3, Tots; 4, Machine; 5, Turf; 6, Observe; 7, Sines; 9, Clear; 13, Sails; 14, Scamp; 17, Satellite; 19, Biretta; 20, Educt; 21, Dress Up; 22, Neptune; 23, Stars; 26, Fame; 27, Fins.

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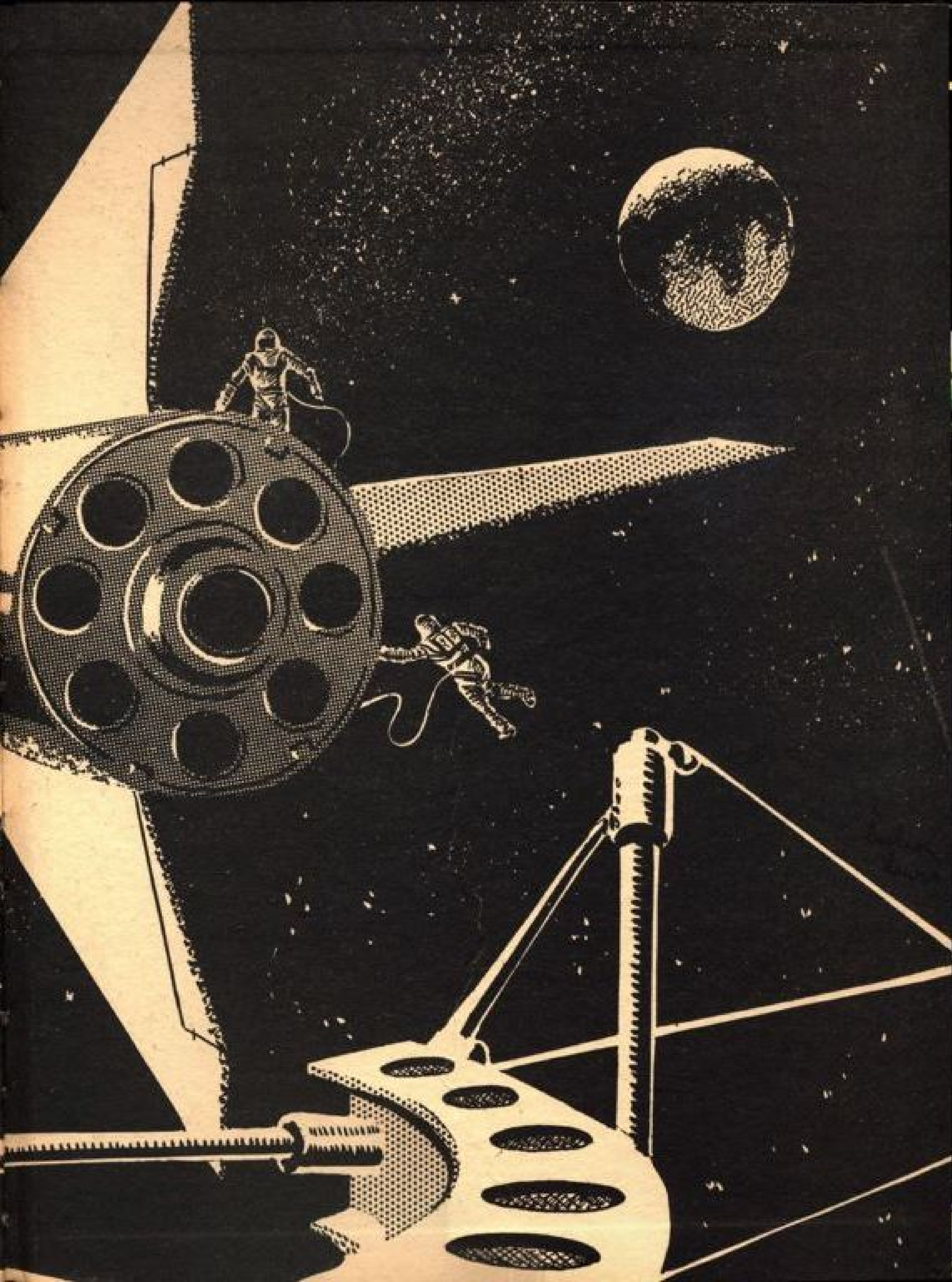
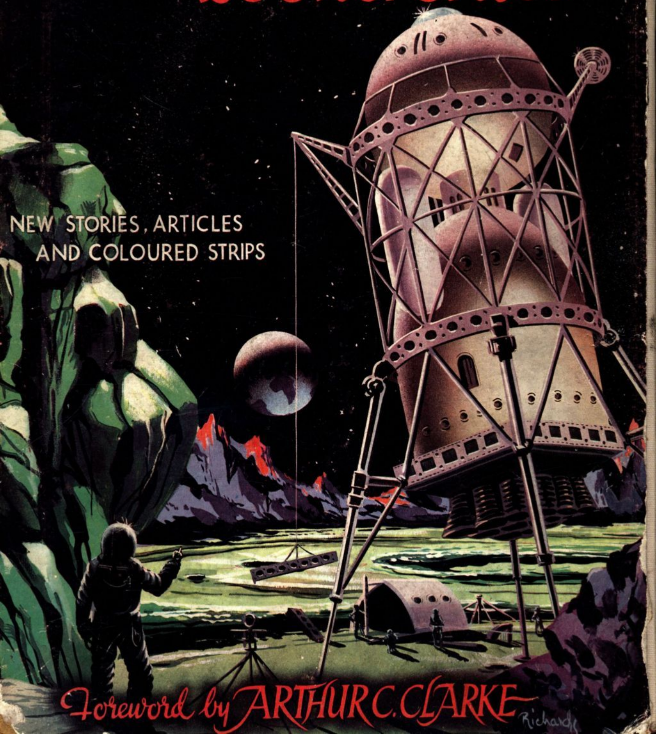
COASTING IN SPACE

This spaceship hangs high above the Moon and is moving at fast speed although it looks quite still. The jets are silent and dark, for the rocket motors have been turned off and the ship is on a coasting course that will bring it over one of the great, dry lunar seas. Then the pilot will switch on the engines and the ship will slowly turn so that its jet points to the Moon. Down it will come, tail first and a screaming roar pouring from its jets. Like a gigantic beetle the ship will settle down on the airless surface of the Moon.



Authentic BOOK of SPACE

NEW STORIES, ARTICLES AND COLOURED STRIPS



Foreword by ARTHUR C. CLARKE