

★ DENOTES SPECIAL
FEATURE ARTICLE

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Space Travel

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Front cover painting by Malcolm Smith, depicting coming Space Station

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SPECIAL SCIENCE FEATURE

Beyond Earth's atmosphere men will have to be equipped with portable living quarters; the space-suit will be an absolute necessity, providing in effect a terrestrial environment. Here are the problems to be resolved for the —

MAN IN SPACE

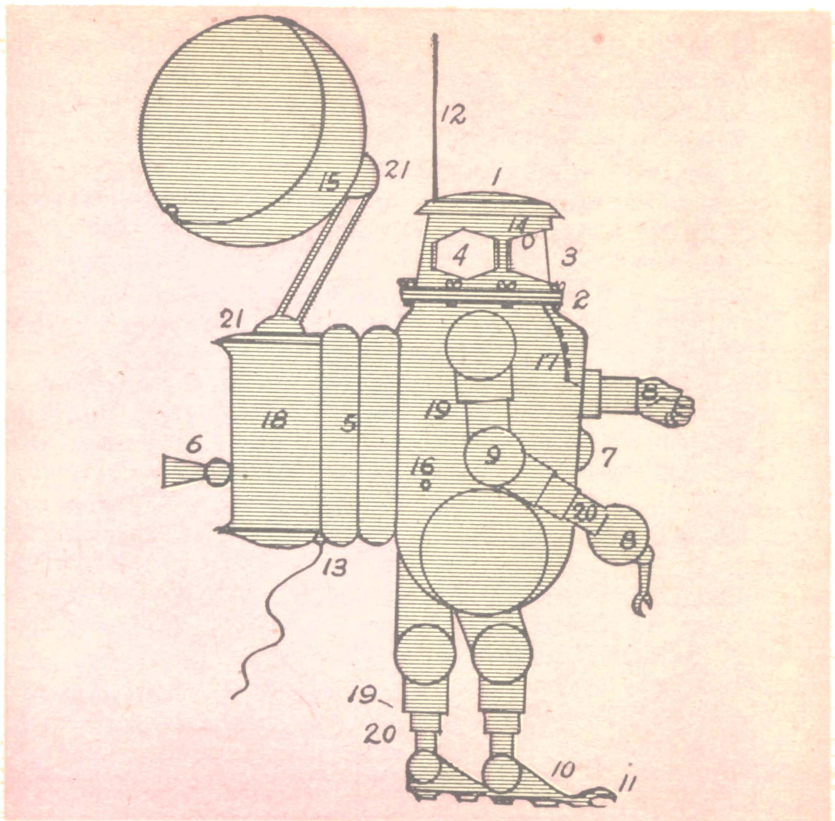
By

Guenter Schmidt, Ph. D.

TO THOSE ENGINEERS concerned with launching massive-thrust, multiple-stage rockets designed to throw things like Sputnik II and Explorer I into orbits around the Earth, the major problem of their art is communication and control. Once the rocket lifts its monstrous flame-squirting bulk from the launching pad, subsequent actions taken by it must be communicated either by complex telemetry systems or by built-in brains of the integrating-accelerometer type. As the newspaper headlines show, both systems are prone to error. No matter how carefully control systems for rockets are designed, the failure of the

minutest part can destroy the planned flight. A pair of sticking relay contacts, a vacuum tube failure under stress, a pulse of over-voltage—and the rocket is wasted.

To a rocket engineer, a man—his brain in his body—is “a kilogram of computer mounted in less than a hundred kilograms of servo-mechanisms” and the nervous system that links the two is a positive, fail-proof communication network which can't have “shorts” or blown tubes. In its first stage of growing pains, the entire art of rocketry could be simplified enormously if it were possible to mount a man in every rocket to be launched. But human life is precious, and



Above, sketch of a space-suit, which might as well describe the essentials of any "terrella" (see text). Points listed as follows: (1) Entry to suit through cover; (2) flange joint for securing helmet; (3) front port; (4) side port; (5) cylinders for air, oxygen, fuel for reaction drive; (6) reaction motor; (7) control panel; (8) glove and tool holder; (9) joint; (10) magnetic foot-pieces; (11) grip for suspension with catch operated by feet; (12) short-wave antenna; (13) hooks; (14) rear-view mirror; (15) heat dissipator; (16) jack for telephone connection; (17) breastplate hinges; (18) equipment storage; (19) leg adjustments; (20) rotating joint; (21) rotatable support for heat dissipator.

until the trip can be more than one-way, human beings won't ride rockets. Every sign points toward the nearness of this day.

There are now functioning a half dozen institutes and laboratories for "space medicine" in this country and undoubtedly there are the Russian equivalents. It is the purpose of this article to describe some of the things these laboratories have learned about the fitting of a human being into the most alien of environments that he has ever encountered—space!

Outside of the deep desire of human beings to leave the planet motivated by that strongest of forces, scientific curiosity, (and for the sense of accomplishment, adventure, and aesthetics) there is this forceful need for them to go there simply to guide the celestial steeds that carry them. The engineers' description of human beings as "computers mounted in servos" is apt; the most amazing thing about these "fleshly machines" is that they possess a power of adaptation and adjustment comparable to nothing else.

Machines, rocket guidance systems and telemetry systems, can be programmed to carry out a sequence of events, timed to fractional seconds—but, and this is the crux of it!—they cannot cope with the unexpected. But a man

can and will. No matter what the circumstances, no matter how exotic the atmosphere, no matter how strange the condition, a man can think, sense, respond, act, judge, exercise caution or daring, as the situation demands.

Right now the aero-medicine labs are agreed that men can go into space, be carried there in rockets, can survive in space, can occupy orbiting satellites, can eventually make the trip to the Moon and to the planets. How have they learned this when so far no man has actually gone into space? How do they know he will not meet as yet unknown terrors? What basically are the problems that a man in space faces? Let us consider them.

First, before we even look at the synthesis of environment that must be made for spacemen, let us examine the primary problem of acceleration. In an ascending rocket the spaceman is exposed to accelerations of 1, 2, 3, 4, 5,—possibly, depending on the design—8 and even 9 "g's." On the other hand, when the "Brennschluss" or burnout point of the rocket is reached, the spaceman endures "free-fall" or zero-gravity, i.e., no acceleration, that is, no forces on his body. His physiological reactions to these extremes of external forces have been studied here on Earth.

Already the powerful "g-forces" have been endured by experimenters. The best known is Colonel John Paul Stapp. He rode the furious rocket sled at Holloman Air Base in New Mexico. On one occasion he was accelerated by rocket to a speed of 632 miles per hour and then quickly brought to a dead stop. He took forces of *forty* g's for one-fifth of a second, and he endured forces of ten g's (the kind he might expect in riding a conventional rocket) for much longer periods. Similarly piloted aircraft nozed into dives and pulled out abruptly have given their occupants four and five g accelerations for many seconds *without serious effects*. And when a man is mounted or situated on a platform or bed at right angles to the accelerative forces, he can endure ten g's for long periods without acute discomfort. This horizontal position is desirable because it prevents the blood from being drained from the brain, the cause of "black-out." Without equivocation, it can be said with assurance that so far as rocketry and space-flight is concerned, men can stand the accelerative forces they'll meet. It must also be noted that these forces will exist for very brief times in most rockets, periods ranging from seconds to minutes—that is all.

LESS IS KNOWN about the other end of the scale, the condition of "free-fall" or zero gravity, but some information has been garnered about this condition, which is so hard to simulate on Earth, from very fast aircraft which have gone into arcing flights so that momentarily their centrifugal forces have balanced gravity, and their contents and occupants have been weightless. Subjects, while describing the experiencing as fantastic, have reported no ill effects, no more than the momentary nausea or stomach-rising one expects in a rapidly descending elevator.

Because it has been impossible to make this state of "free-fall" last more than seconds, it is hard to say with assurance that we know what the human body can expect when it is required to exist in that state for days and weeks and months, but physiology implies that there is no inherent weakness in the body that would make free-fall unendurable. A Soviet Aviation journal has reported that Laika, the dog which occupied Sputnik II, betrayed no violent reaction to her week-long existence at zero-g, at least in terms of blood pressure, pulse, respiration, food ingestion and other variables which were successfully telemetered to Earth.

But gravity of course is only one

aspect of man's environment. What of a completely simulated natural environment? Let us consider the basic needs of man; these are:

- a. temperature
- b. air
- c. food
- d. water
- e. elemental protection from
 1. cosmic rays
 2. ultra-violet light
 3. meteors

Doctor Hubertus Strughold has coined a very picturesque word to describe the synthetic environment that must accompany man into space; he calls the miniature worlds which must provide those factors listed above, "terrellas," or little Earths. Numerous "terrellas" have actually been built both here and abroad. Recently the "encapsulated" airman, Airman Donald G. Farrell of the Randolph Field Air Base endured a simulated flight to the Moon, locked hermetically in his steel shell for a week—without ill-effects.

These synthetic environments which have been constructed both for submarine and spaceship research, have supplied all the protections and needs noted except protection against meteors—that will wait!

The temperature of a "terrella" must be maintained at around sixty degrees Fahrenheit plus or minus

ten degrees. The human body and mind function best without extremes of temperature, although they will endure such extremes for considerable periods of time if necessary. Providing that temperature range in space is no problem at all. When in sunlight the inhabited capsule rather will have to be cooled; this can be done first by making sure it is reflective and secondly by equipping it with a shaded radiator designed to radiate away excess heat. While the actual control problem might be difficult, it is by no means beyond our capabilities.

When the capsule is shaded by a planet or is in the umbra of a ship or satellite, body heat alone will serve to warm a properly insulated suit. Should additional heat be required, small amounts from any energy source ranging from candle to bulb filament will do.

No, temperature control of a satellite or spaceship or space-suit is not a serious problem.

A man requires approximately two pounds of oxygen per day. In a terella of any size (such as a satellite or large space-ship) this oxygen supply will be gotten eventually from the electrolysis of water, or the reconversion of carbon dioxide, either through chemical processing or from photosynthetic processes. For the space-suit or for

smaller space vessels, oxygen can be supplied by tank, in the form of liquid. Except for small inevitable amounts of wastage, this oxygen will be re-cycled indefinitely.

It is interesting to note that a terrella will not be pressurized to Terran standards of 14.7 lbs/sq. in. pressure. The partial pressure of the oxygen in the air is about three pounds per square inch. Theoretically this would be adequate for the space-ship, but to prevent discomfort from the reduced pressure, the pressure will be maintained somewhat higher, probably in the region of six or eight pounds per square inch. Notice that this reduced pressure further simplifies the structural, the sealing, and the general engineering problems of space structures.

Carbon dioxide and moisture must be removed from the air. There are numerous ways of doing this. For large terrellas probably our familiar friend, radiation refrigeration will condense these gases to solids. For space suits, chemical means will be provided—absorbents and dessicants.

Incidentally it may be pointed out that a small amount, slightly less than two per cent, of carbon dioxide must be maintained to stimulate the breathing centers in the brain.

Men in space will not be doing what on Earth would be called "heavy labor." In fact, the labor will be that essentially of pushing buttons, and space-ship living will certainly be sedentary. As a consequence, it is safe to assume that considerably less than a pound of food per man per day is required. This food must reasonably resemble what we think of as "food." The "capsule" or "pill" type will not do. Bodies require bulk and roughage.

Possibly the only complaint spacemen will have about their food is its lack of variety. But then for psychological reasons meals in space may be quite elaborate. More of this later.

Water requirements vary considerably among humans and of course are determined in part by diet, humidity and other factors. Like air, water will be the product of a cyclic process and its supply will present no insuperable problems.

Protection from ultra-violet light, the brilliant coruscant flaring light of the Sun requires that the spaceman does not stare through an undarkened port. This is no problem.

ONE OF THE GREAT unknowns of space travel of course is the question of the in-

tensity of cosmic radiation. These penetrating radiations so akin to super "hard" x-rays, can have devastating effects on the human body provided their intensity is great enough. From the sparse knowledge so far garnered from the Explorer satellite, the Sputniks and balloon ascensions, it seems as if the concentration of these lethal rays is not great enough to prevent the effort. We have much to learn however and it may be necessary either to limit the exposure time of a man to space-ship life, or it may be necessary to provide much more elaborate shielding than has hitherto been thought necessary. Cosmic radiation remains somewhat of an unknown. Possibly only one thing can be said about it with certainty—it will not prevent space travel!

Meteors are another suspect matter. Information gotten from the satellite program in the International Geophysical Year suggests that minute meteoric density is higher than was thought as evidenced by the erosion of satellite surfaces. But this erosion took place very near the Earth and in a very limited region of space. Statistically it is improbable that large meteors will strike space-ships, satellites or terrellas of any kind. If however they are large enough and the improbable does occur—then we say—

"good-by space-ship." This hazard must be accepted as realistically as we accept the possibility of an airliner crashing. That possibility does not preclude people traveling by air.

For the meteoric dust, a double or if necessary a triple, skin can be provided, a tenuous skin whose only function is to convert the meteor's kinetic energy into volatilizing heat. It is also conceivable that a terrella might be "hulled" or holed by a meteor of pinhead size. It is simple to effect a repair of such a hole. Science-fiction writers have suggested that small balls of sealant material might continually float in the ship's atmosphere and be carried automatically to the puncture's site.

Much has been written about the psychological problems of space flight entirely aside from the purely physical ones of surviving in such an uncongenial environment. These psychological hazards have been grossly exaggerated. For one thing, an often discussed problem, that of men living closely cooped up, subject to an erosion of nerves, is unrealistic. Numerous explorers of hostile Terran areas—the Arctic and Antarctic, for example—have experienced similar situations with no ill-effects at all. Above all, it seems to me that proponents of this view entirely disregard the fantastic

pride of accomplishment that will sustain space-men. Men have endured horrors for comparatively trivial causes. One cannot underestimate human idealism.

If we concede that some psychological hazard does exist, we can point out that the tour of duty can be adjusted to accommodate this. In a similar way, the sexual problem can be relieved.

There are two conditions which one can imagine may involve psychological problems. One is that of the first pilots of space-craft. The sheer inhuman loneliness of the vastness of space will undoubtedly have repercussions on the first few men who make the great venture, although here too, pride will sustain them. The other is that of the long voyage. When men make the huge elliptical swings that carry them to the outer reaches of the Solar System, to Jupiter and Saturn, then isolation and loneliness, even among well-staffed ships, may have some weight. But again we must discount this. Crews will be picked after the most elaborate and searching tests. Pride, *esprit d'corps* — old-fashioned concepts, will make them in a little way, akin to gods.

The environmental capsule, the terrella, will not only shroud men in satellites, space-ships and other vehicles. So far as can be de-

termined—and this is quite far indeed—from the standpoint of providing a humanly tolerable environment, the Solar System is notoriously deficient. Our nearest goal, the Moon, is utterly barren, a “wasteland” of mingled beauty and desolation. Obviously for men to live there, a synthetic environment no different in conception than those terrellas we have been describing, will have to be furnished. Initially the landing space-ship itself will be the Moon-base terrella supplying the needs of its inhabitants. Eventually when space travel becomes more science than art, the permanent Moon-base will be a structure not very different from a manned satellite, except that men will leave it to gather and use the resources—meager though they seem—that the Moon provides. With an extended mastery of atomic energy, where you have matter you have energy, and certainly the substance of the Moon will provide twin sources of these basics. Campbell’s fictional “The Moon is Hell” presented a superb account of how the carbonates and silicates and other components of the lunar crust furnished Lunar explorers with their necessary substances, including oxygen and water. This carefully reasoned account is more potential fact than fiction too.

In a similar fashion men will

accommodate themselves to the planets they land on, constructing Terran environments as they did on the Moon, possibly improved by the conceivable but unproven presence of organic life. Mars and Venus may offer more than we know now. Landings on these planets will come in time.

Mercury may also be explored. The outer planets, Jupiter, Saturn and Uranus—not to mention Pluto—seem fiercely hostile to the erection of a Terran environment not because of their fantastic surface conditions which have been well described, but because of their fierce gravities. But in the long run, technology probably will surmount even these difficulties if the cake is worth the candle.

The satellites of Jupiter and Saturn of course will see human habitations also, even though temporary. And the terrella will make this possible.

THERE IS NO NEED to belabor the point. After the rocket motor unquestionably the single most important development for conquering the Solar System is the evolution of the closed ecology we have called the terrella, a cocoon which enwraps men, surrounds them with warmth, air, light—and life.

One of the most encouraging as-

pects of the development of artificial Terran environments, is the fact that they are here—here and now! In a sense they are simply hardware or plumbing, their intricacies comparatively nothing. Technologies built for other purposes have provided this major tool for the taking. The terrella already built on Earth could, with the possible exception of their weight, be used directly. Their control systems, their closed cycles of supply, their chemical balances—exist.

We might ask, “what sort of men will explore space?” “Is the jaunty folk-hero of aviation, leather-jacketed and swaggering, an authentic measure of a spaceman?” Science-fiction’s image of this potential figure also seems as improbable as that of the comic strips.

We can see now, in the engineer-pilots who are initiating the runs of our early rocket-planes, those hybrids of aircraft and spaceships, a more accurate picture of the type of man required for space travel.

The faculties of quick judgment, instantaneous reaction, and “seat-of-the-pants” flying, will be required in the ferry rockets which have to return to Earth, decelerating against atmospheric friction. Bringing the winged hybrids down to Terran landing fields will be reminiscent of landing conventional

aircraft although the speeds may be altogether different. Never-the-less, in this operation we can see a procedure which is basically not different than that of landing aircraft. And for these skills we can look to present aviation. Here the word "pilot" is not a misnomer, simply because "flight"—reaction to atmosphere—is concerned.

But what of space-travel itself? Here there is no analogy with Terran practices save possibly to compare it with the trajectory of an artillery shell. Space flight is a matter of trajectories, not pilotage. And trajectories require foresight and planning, computation and calculation. Before ever the rocket firing button is touched the course must have been mapped.

It is hard to get this concept across to people considering space travel for the first time. That is because basically they are thinking in terms of "flight" a word which really does not apply to space travel. This semantic difficulty undoubtedly will be taken care of in time. One doesn't "fly" to the Moon, nor does one "fly" into an orbit. "Shot" or "projected" or "hurled" are better terms. It will be interesting to see what sort of language is finally evolved for this action, when we have disassociated ourselves from the familiar actions of aviation.

If we can think of any extraordinary skill that a spaceman must possess, it must be an extraordinarily acute ability at three-dimensional spacial visualization. We do not say computational skill because this can and will be taken care of by computers. Spaceships will not flit and scoot about space as aircraft do in the atmosphere. The only regions in which anything akin to "pilotage" will be performed, will be around the space station where low thrusts and low velocities manageable with human skill, will be required.

Interestingly enough, another quality not often associated with space-travel, is caution. Because there is almost no room whatsoever for error or forgetfulness, because once committed to a trajectory which is impossible to alter without fuel, a spaceman will have to think of every imaginable contingency. Nothing must be forgotten, everything must be planned in advance. No move can be made impulsively because the consequences are unalterable. When atomic energy is applied to space travel the margin for error can be widened. But as long as precious chemical fuels must be used, there is no room for error at all. Fuel can come only from one place—the Earth, and that fact will not help a spaceship locked into a Sunward orbit—with-

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out fuel.

No frontier has ever stood long against determined intelligent men. Nor will space. The fact that men will have to carry their environment with them is no deterrent. In a les-

ser sense they have done that before. Sheathed in his terrella like a larvae in a cocoon, spacemen will reach the limits of our Solar System.

THE END
