FLIGHT INTERNATIONAL 10 JULY 1969 2s 6d

FLIGHT INTERNATIONAL

Walking on the Moon

Letters

No "Good" Noise

SIR,—With reference to Sensor's news item on page 1041 of *Flight* for June 26 concerning Concorde engine noise, I quote: "Concorde take-off noise level is considered to be as good as that of the heaviest subsonic jets in present-day service." Who does your writer think he is trying to fool? There is nothing "good" about the noise level of present-day jet aircraft and this subtle sort of brainwashing does not assist the serious problem of jet engine noise. The sentence would be more truthful if worded "Concorde take-off noise level is considered to be as bad as, etc."

We must face the facts that suppression of engine noise costs money in research, increased engine weight and therefore loss of specific power, etc., and no commercial firm will be prepared to make these sacrifices lightly until legislation is brought in to limit noise drastically, though the USA do seem to be making a serious move in this direction.

At the present time we are just getting bigger and better engines with the same (or let us face it, slightly worse) noise levels as the worst offenders in operation now.

What a pity that there has been nothing to follow the one shining example of a large quiet commercial aircraft in the last 20 years, namely the Britannia.

Stevenage, Herts ARTHUR C. SMITH

Captain Thain's Vindication

SIR,—A point which appears to have been overlooked in the many comments on the findings of the "Second Fay Commission" is the fact that it is only quite recently that we have been able properly to appreciate the catastrophic effect on aircraft take-off which can be caused by slush on a runway.

Any commission of inquiry, no matter how competent, sitting in 1959 to consider the causes of the Munich air disaster was bound to reach the wrong conclusion for the simple reason that the true cause of the accident—slush on the runway—was not even on the list of possible causes to which it could then have been attributed!

During the past few years, however, the work of R. L. Maltby at RAE Bedford, and John Williams at Cranfield has led to a proper understanding of the magnitude of slush drag and of its potentially catastrophic effect on take-off. The true cause of the Munich crash has thereby emerged.

Since the potential danger of runway slush was not recognised in 1958, even by the most experienced authorities, and since Captain Thain can now be seen to have been dismissed for completely the wrong reason, would it not be a gracious gesture on the part of BEA to reinstate or compensate him appropriately instead of attempting to justify his dismissal on the paltry grounds that he was sitting in the wrong seat?

Esher, Surrey G. R. M. GARRATT, *Wg Cdr (Rtd.)*

Disservice to General Aviation

SIR,—I wonder whether members of certain flying clubs realise how damaging to the cause of general aviation is any tendency to reach for the telephone and get in touch with the lay press after incidents involving light aircraft.

To see the June 23 issues of *The Times, Daily Express,* and *Daily Mirror,* to name only three papers, all carrying lengthy stories involving a forced landing by a light aircraft at Sidcup is an indication of some Press agentry of a rather "eager beaver" nature.

It is pointed out that if one uses these mass media to communicate at length to the public that when the fan stops motorists are going to be narrowly missed, the aircraft is going to narrowly miss a public house (out of opening hours, I trust) and that the aircraft is going to "thud into the top of a grass verge before landing upright in a field," the public is going to gain an increased impression that light aircraft flying is dangerous. Furthermore, they are going to think that sooner or later they are going to be hit by a light aircraft.

If one relates this to a situation where there might be pressure from a local authority, or a land developer, or others interested in closing an airfield to use the land for other purposes, it is obvious that the pressure will be increased if it is backed up by hostile public opinion.

There will always be incidents involving any flying activity, but it is clearly laid down in regulations who *needs* to be informed, having due regard to the seriousness of the incident. The Press is not listed as a necessary authority to be so informed.

We are now in an era in which general aviation in this country needs, more than anything else, to be regarded as matter-of-fact transport, divested of all derring-do. I submit that general aviation would be best served if the lay Press were left to get their own news of light aircraft accidents rather than have it proffered.

Royal Aero Club ROBERT LEES
London SW1

The Cost of Space

SIR,—The ludicrous figure quoted by Mr Willmott (Letters, June 5) for the supposed daily cost of space travel is of course *nine times* the daily fraction of the US Gross National Product! The true cost is one half of one per cent of the GNP.

Mr Willmott suggested £8,000 million a *day* as the figure, while the May 1969 edition of the *National Westminster Bank Review* gives the sum devoted to space research by the Americans in the 1969 Budget as £1,750 million a *year* of which only 70 per cent is in any way connected with reaching and exploring the Moon. To put this expenditure in perspective, the *Review* points out that in the same year Americans will also spend £33,750 million on defence, £20,420 million on health and welfare, and £12,920 million (i.e. *nine* times the spending on space) on alcohol, tobacco and cosmetics.

Those living on the borderline of starvation stand to gain rather more from the unique opportunities being rapidly opened up by the new views from space for the understanding and management of the Earth's plentiful but ill-used resources, than they do from the first or last of these other items of expenditure.

Basildon, Essex ANTHONY M. BUDD, *Associate Fellow of the British Interplanetary Society*

Combating Supplemental Power

SIR,—There are considerable—and perhaps unconsidered—dangers in any future international charter airline organisation which may be set up (*Flight,* June 12). In any such organisation, the American supplemental carries would exercise disproportionate power and influence.

Unlike most European charter companies, which tend to be either small units with weak finances or subsidiaries of scheduled IATA members, these US supplementals have the backing of wealthy finance and insurance groups. They have evolved their own concepts of charter operations, such as affinity travel, which are not necessarily suitable for European conditions.

To a very considerable extent they are in effect subsidised by US military operations. Over the last five years,

Walking on the Moon

SINCE THE INVENTION OF THE TELESCOPE 360 years ago, the science-fiction addicts have never had it so good. The faces of the Moon and planets were revealed for the first time, but not in such detail as to deter those writers who would set their adventures in tropical vegetation bordering the Martian canals or facnciful castles in the lunar Appenines. But advances in astronomy have overthrown earlier hopes of hospitable havens in the solar system. When the first astronauts step ashore on the Moon, it will not be with the prospects that the hardships of longer voyages to other planets will be offset by easier conditions when they get there.

There is only one Earth in the solar system. Every other body is either too hot or too cold, has too little or too much atmosphere (and, in any case, invariably unbreathable), or has no defined surface to offer even a transient base for manned flights. While the Moon is hardly a holiday resort, it is thus hardly less convenient than any other body in the Sun's family. It is also close at hand—a mere three days journey— and so is very suitable for man's first steps into the cosmos.

What are the impressions of the first astronauts, as the comforting noise of their retro-fire engine dies away and they are engulfed in the airless silence? Not loneliness,certainly. No explorer in any other human endeavour has ever had such a large audience. Through the commonplace marvels of television and communication satellites, the actual moment of man stepping onto another heavenly body for the very first time is brought to every fireside viewer in the world. It is estimated that one in every three of the world's population is witnessing the event.

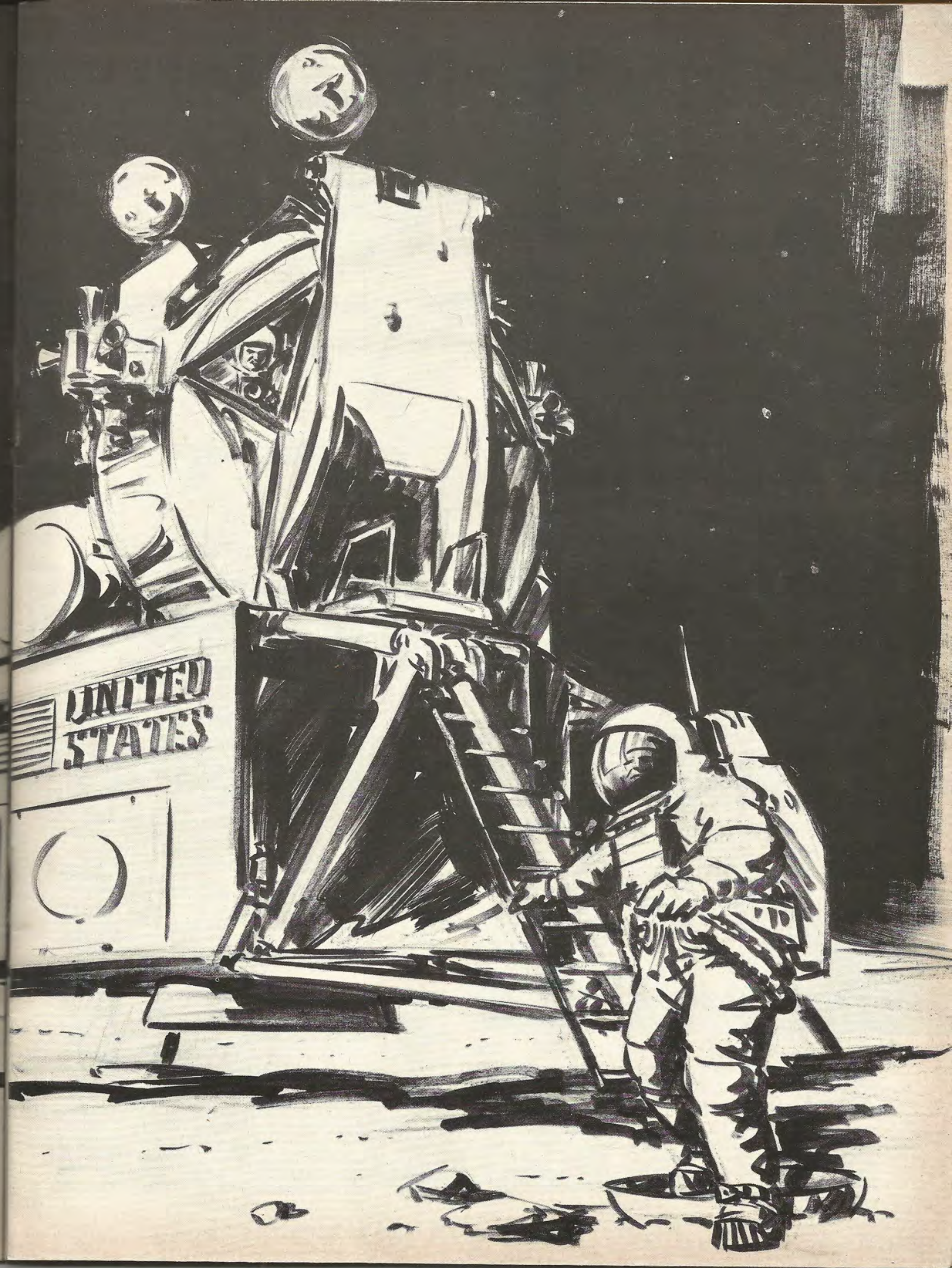
Thanks to the efforts of generations of astronomers, geologers, physicists, chemists, and to the data returned by American and Russian spacecraft which have crashed or soft-landed on the Moon or circled around it (with and without men aboard), we now have a very good idea of the nature of the Earth's satellite. Even so we are really only just beginning to get to know our neighbour world; just as the forbidding aspect of Antarctica proved to be rewarding only on close inspection, so the Moon will open up its secrets only to determined exploration.

As the astronaut climbs down the latter to the surface, three thoughts are uppermost in his mind: as awareness of history in the making, coupled with a large measure of concern—even unconscious apprehension—about the serviceability of his craft; there is no rescue service to the Moon. As his lunar overshoe meets the surface, he may perhaps recall the long-and widely held theory which held that the Moon was covered with a layer of dust, many feet thick. This fear was finally dispelled only with the relatively recent soft-landings of the American Surveyors and Russian Lunas. The technically comprehensive but subjectively limited voices of these spacecraft described the ground, at least in the areas in which they landed, as having the texture of damp sand. So the all-American shoes (which, it now seems certain, will be first on the Moon) will make little more than a small impression on the lunar soil. The depth of the layer is assessed as a by-product of the effort needed to push Old Glory into the ground.

The first impression is of the complete stillness and the startling contrast between sunlight and shadow. The gentle hiss of air into his helmet from the life-support pack, interspersed with the conversation of the other astronauts and the mission-control centre back on Earth, provides a comforting background to drown the silence as the astronaut gets down to his first tasks. The stillness is permanent. Old Glory lies limp in the absence of any zephyr breezes, and apart from the rare impact of a meteoroid, or the probably rarer action of a possible volcano or Moonquake, no movement is seen. The dominating aspect is, however, the contrast between light and shade. The area chosen for the first landing is flat, with

By MICHAEL WILSON

Drawing by GORDON HORNER


UNITED
STATES

Top, the 14-mile diameter ring-plain Triesnecker is the centre of one of the most remarkable rill systems on the Moon. These rills are about 1 mile wide. In the background are the highlands of the Central Bay, so named because it occupies the centre of the visible face of the Moon. The picture was taken from Apollo 10

Below, a different feature is the great Alpine Valley visible from Earth with binoculars. The valley is 4-6 miles wide and is 75 miles along; its origin is unknown. The difference between the rocky highlands and the smooth area of "sea" is striking. The picture was taken by the American Lunar Orbiter 5 on August 14, 1967, from a height of 153 miles

WALKING ON THE MOON . . .

little or no slope, so simplifying the approach and landing. The nearest large-scale feature is the crater Moltke, but even this is some 25 miles away and visible only as a low ridge. The shallow depressions or craters in the ground, which are at once both the large and small-scale characteristics of the Moon, are half-filled with the deepest shadows, and these are emphasised by the low angle of the Sun (between 4° and 12°) which is necessary for the best lighting conditions during the landing approach.

Matching the austere darkness where sunlight does not directly illuminate the ground is the darkness of the sky, more black than ever seen on Earth, where man-made illumination and the faint auroral airglow prevents the night sky from ever being quite dark. In this sky hangs a hard-white Sun (no rosy sunsets or sunrises are ever seen to stimulate poetic Moon visitors) with stars visible to the naked eye within about 20° of it. The stars do not shimmer as they appear to do on Earth, but appear as steely points, remaining undimmed down to the horizon. High in the sky hangs the Earth, a fascinating spectacle of greens and blues and whites, and four times the size of the Moon as seen from Earth. While the Sun and stars make their slow way across the lunar sky, traversing it in 14 days instead of 12hr, the Earth remains apparently fixed. And cutting diagonally through the firmament is the magnificent assembly of ten thousand million stars which we call the Galaxy or Milky Way, picked out with unusual clarity.

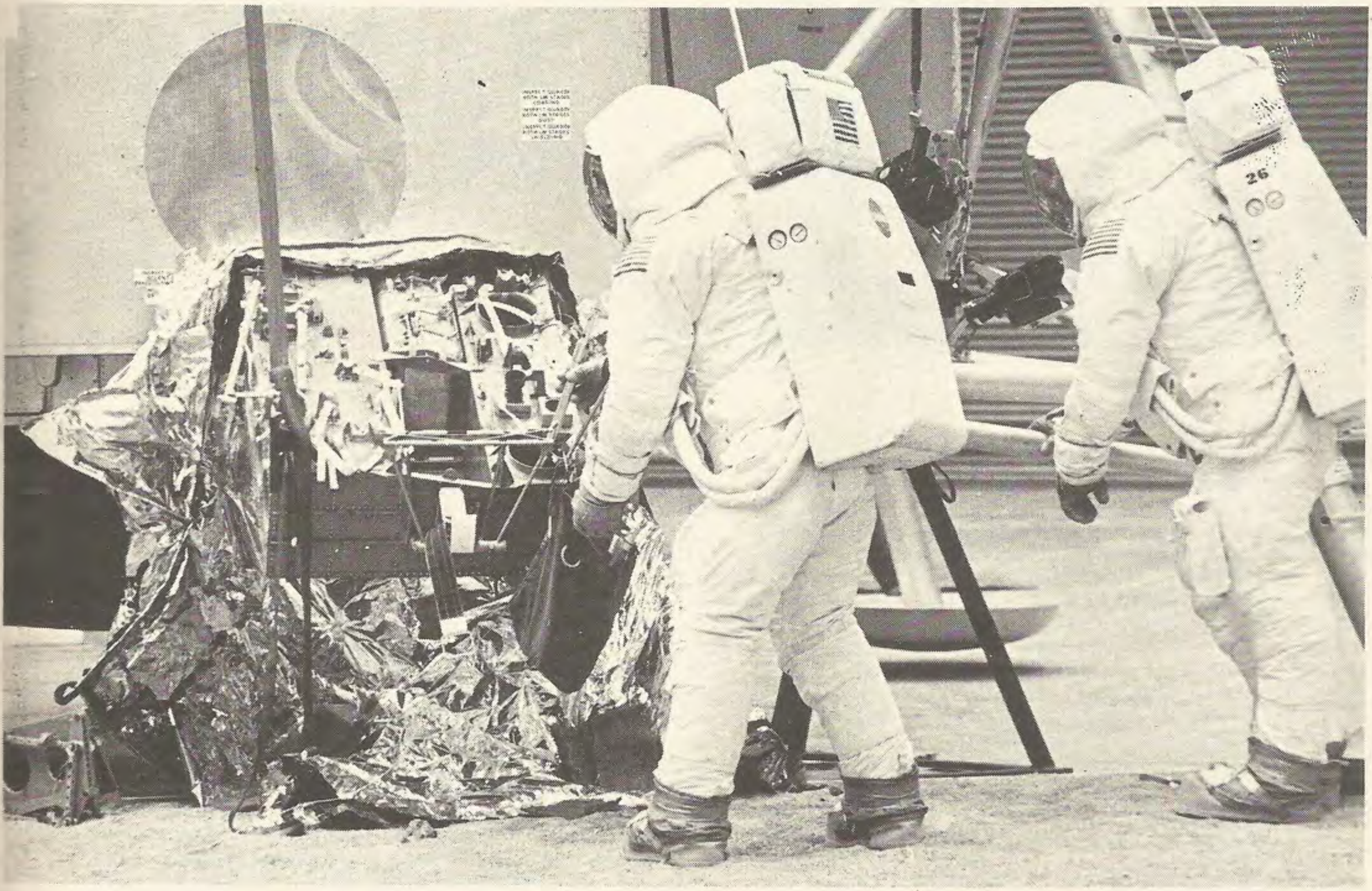
Many of the Moon's phenomena, subjective and real, are a direct result of its total lack of atmosphere. The surface pressure corresponds to a very hard vacuum such as is difficult to reproduce in the laboratory. On Earth we are insulated by a complex environment reaching 100 miles above us; on the Moon the astronaut is at all times immersed in interplanetary space.

The Moon has long since lost any atmosphere which it may once have possessed. Its diameter of 2,160 miles and average density of only 3.33gm/cu cm combine to give a mass of only 1.2 per cent of that of the Earth. Consequently the gravitational acceleration of only 5.3ft/sec^2 enables a body or particle with a velocity in excess of 7,750ft/sec to escape entirely from the Moon's influence. Molecules of oxygen—necessary for advanced forms of animal life—have an average velocity of about 1,500ft/sec at 0°C, or 1,850ft/sec at 100°C, and at first sight it seems that any oxygen present on the Moon could not escape. But the distribution of velocities in any atmosphere is such that, at any given time, a large fraction of the molecules have velocities greater than the minimum necessary for escape, and these consequently vanish into space. The proportions of molecules having higher velocities than the average remains unchanged by the addition of more molecules having these velocities, and so a continuous leak away from the Moon occurs.

Although the molecules of other gases except hydrogen are heavier, and consequently slower, they too are lost in the same way. Another atmosphere-stripping mechanism is that due to the solar wind. Particles of ionised gas, known as the solar wind, stream continuously from the Sun into space at speeds of around 500km/sec. The energy of collision of these particles with molecules would be quite sufficient, over the aeons, to effectively denude the Earth's neighbour of any atmosphere it may have had. The Earth is spared a similar fate because it possesses a magnetic field which deflects the stream of charged particles, or ions, well away from contact with the atmosphere.

Left, commander of the Apollo 11 mission, Neil Armstrong undergoes a rehearsal of activities using a scoop to collect quantities of simulated soil. Initially a 2lb contingency sample will be secured in case a sudden return to the orbiting spacecraft is required. Later, 50lb of soil (from the surface and down to 12in below the surface) will be collected and stored in vacuum bags. The chest-mounted box is the remote-control panel for the back-mounted life-support system

Below, Astronauts in Moon-walk garb. The backpack contains a portable life-support system, with a smaller, oxygen-purge unit (a back-up unit for emergencies). Two umbilicals from the pack connect with the front of the suit and carry oxygen, water and electrical supplies. The apparent debris on the spacecraft is the insulating foil surrounding the bay in which the lunar-surface science experiments are stored



By contrast, the Moon has virtually no magnetic field to shield it.

Owing to the rapid curvature of the Moon's surface, the horizon is only 1.5 miles away from the astronauts. Because of the size of some craters and the relatively shallow hills surrounding them, it would be quite possible to stand inside a crater without being aware of it. As it is, the surface around the first landing area is flat and, except for the multitude of small depressions, featureless.

One of the important aims of the first flight is to assess the ease of walking with the unfamiliar adjuncts of greatly-reduced gravitational field, and a heavy and constricting space-suit and life support system. Despite exercise with special rigs which simulate the effects of lunar gravity, walking on the Moon is a totally unfamiliar experience and needs a lot of practice to master. While gravity is reduced to one-sixth of its Earth value on the Moon, inertial forces remain unchanged, and moving around will take some getting used to.

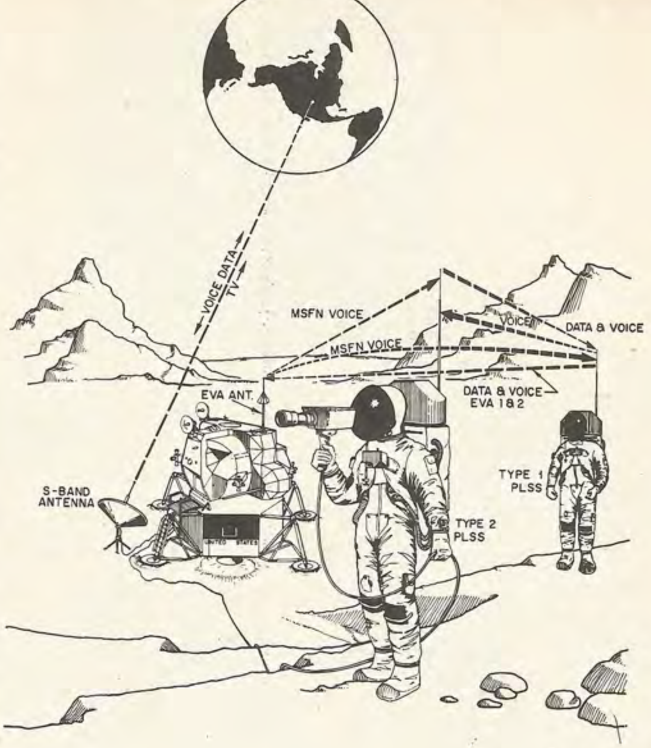
If the tendency to extrovert activities of the crews of previous flights continues, the astronauts may feel tempted to make 10ft jumps. But any attempt to set up new sprint records will fail sadly, for reasons which have been explored only comparatively recently, and which have to do with the dynamics of human locomotion. Examination of the movements of the human body while walking shows that the centre of gravity is raised and lowered by several inches during each step. As the weight of the body is supported by one foot in contact with the ground, the other foot is brought forward and placed in position, ready to provide a horizontal reaction as soon as the weight is transferred to it. The speed of locomotion therefore depends on the length of stride and the number of strides which can be made in a given time. The latter in turn depends on the time taken to transfer the body weight from one foot to the next, and this is a function of gravity. The pendulum clock provides an analogy, where the amplitude of movement of the pendulum and its periodic time correspond respectively to the stride and the time taken to transfer the weight. The periodic time of oscillation of a pendulum is inversely proportional to the square root of the gravitational potential; as gravity decreases, the period of oscillation increases.

The atmosphere in which life evolved on Earth provides more than just a breathable environment for higher forms of biology; it is also an insulating blanket and a shield against physiologically dangerous radiation and meteoroids. Short-wave electro-magnetic radiation (such as gamma rays and

WALKING ON THE MOON . . .

Below, unsung but vital: personnel at Mission Control Centre, Houston, Texas, keep close watch on the many complex spacecraft systems, noting deficiencies often before the astronauts do. Their job is to monitor, discuss, warn, advise, reassure. Emphasis is on tact and humour

Right, a complex communication system of TV, voice and telemetry is required to maintain contact between walking and circling astronauts and Earth. A small black-and-white TV camera will be used with Apollo 11 surface activities; all other TV will be in colour. The 210ft aerials at Parkes, NSW, and Goldstone, California, receive the transmissions over a 240,000 mile link. MSFN denotes manned space flight network; EVA, extra-vehicular activity; and PLSS, portable life-support system



x-rays) and high-energy atomic particles (electrons, neutrons, protons and the nuclei of heavier atoms, such as those of helium) have the property of ionising, or removing electrons from, living tissues, resulting in the breakdown of vital body compounds such as enzymes and nucleic acids. Both immediate and long-term effects of exposure to ionising radiation can be substantial injury or even death.

Such radiation and particles are present in cosmic rays, which may (from the medical aspects) be regarded as emanating from two sources, the Sun and the Galaxy. Those from latter are of constant intensity and are not regarded as biologically dangerous, at least for flights of reasonably short duration. But the main hazard to astronauts arises from high-intensity radiation coincidental with the appearance of transient objects, known as flares, on the face of the Sun. Large flares are spectacular areas of disturbance which, while occurring quite infrequently even at times of maximum solar disturbance (the 11-year cycle of which peaks in 1969), appear quite suddenly and unpredictably.

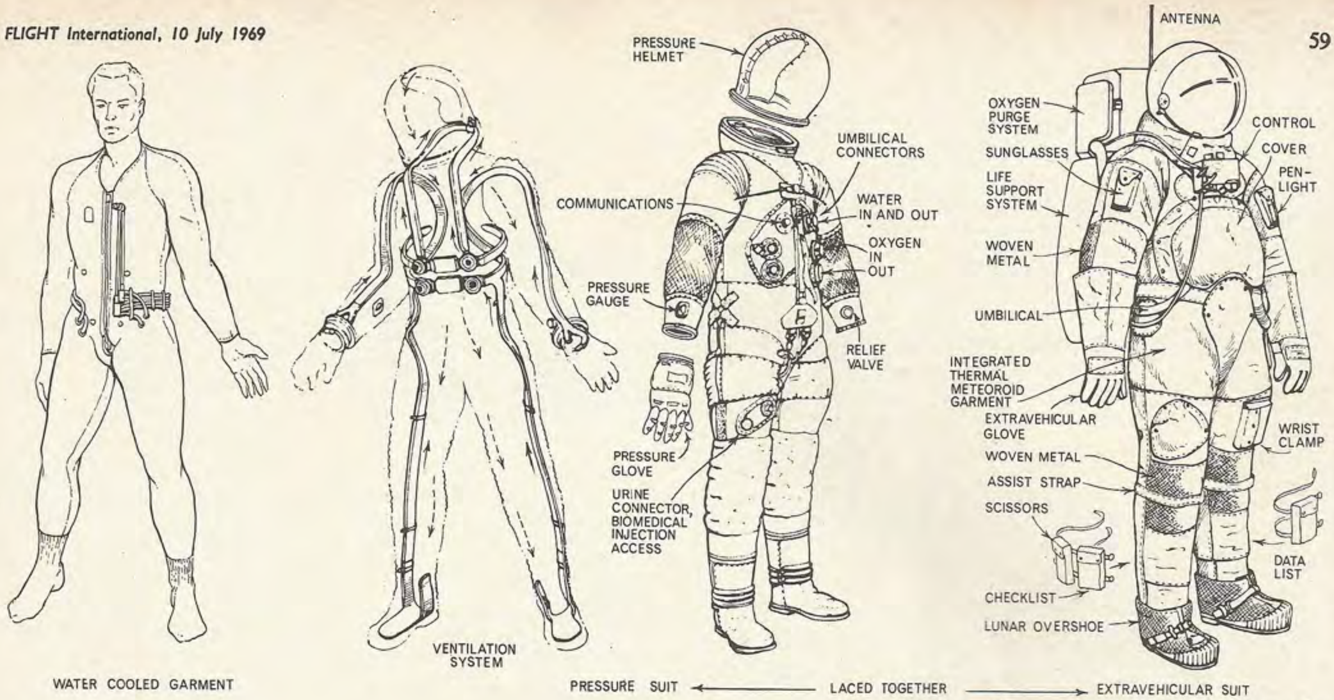
Shielding which reduces the level of radiation on the body to an acceptable level has to be provided both en-route to the Moon and during exploration. This is achieved by installing equipment inside both the transit and expeditionary spacecraft in such a way as to protect the astronauts as far as possible. Outside the spacecraft, astronauts are unprotected, and since the radiation intensity of a flare can reach a maximum in only 5min-10min, care has to be taken to avoid being caught in the shower, as it were, by a hurried return to the spacecraft. Future expeditions using tractor or crawler vehicles capable of moving 20 miles or more from the parent spacecraft will have to carry some sort of metal umbrella to ward off cosmic rays for the 6hr or so during which their intensity attains dangerous levels.

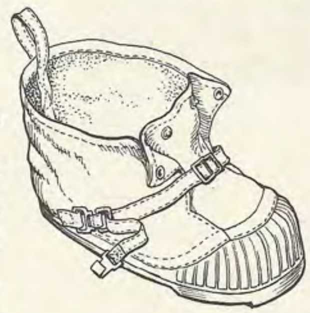
The dangers from meteoroids are less well known, due mainly to their random occurrence. Meteoroids are generally composed either of metal silicates, or iron and nickel, and vary in size from aggregates of atoms up to bodies several inches across. They travel around the Sun in random orbits and their velocities with respect to the Earth or Moon can vary up to about 64,000 m.p.h. Protecting astronauts (or even their spacecraft) from half-pound missiles travelling at this speed is, of course, hardly feasible. Fortunately the frequency of occurrence of such bodies falls off extremely sharply with increase in size and, as the results of various meteoroid-detection satellites have shown, only very small particles need be taken seriously. As a measure of their frequency, American investigators have shown that, near the Earth, one particle weighing 10^{-10}gm might be expected to occur in a detector area of 1sq cm each second.

With all these aspects in mind, therefore, it is obvious that the astronauts must be provided with some sort of protection which will provide, on a small scale, many of the standard systems in the spacecraft. Indeed, the suit and its equipment may be regarded as a close-fitting spacecraft. Respiration, mobility, temperature and humidity control, pressurisation, radiation-shielding from the direct glare of the Sun, elimination of body wastes, communication; all these have to be provided in a suit designed for extended operation outside the spacecraft in the lunar environment.

The Apollo astronauts are provided with two main items for wear on the surface: a suit suitable for exploration, and a portable life-support system, or back-pack. The normal wear for astronauts is a close-fitting water-cooled garment, worn next to the skin, and made of nylon weave supporting a network of cooling tubes. Water is alternately cycled through the garment and cooled in the back-pocket to maintain a comfortable body temperature. Fitting over this is the torso limb suit, which encloses the entire body except the face and hands. It is the pressure envelope, and is built in three layers—an inner pad-like cloth, or "comfort-lining," a pressure-bladder which maintains a pressure of 3.71lb/sq in, and a restraint layer which prevents deformation of the bladder. Fitting over this again, and laced to it (so that the two are put on together) is the astronauts' final covering, the thermal meteoroid garment. This suit has an outer shell of fire-resistant Beta cloth and seven layers of aluminium Kapton film, separated by six layers of neoprene-coated nylon. The knees, elbows and shoulders are reinforced against abrasion with a woven metal pad of Chromel-R. As its name implies, the function of the garment is to insulate the astronaut from direct solar heating, and to protect him from injury by small meteoroids. The pressure suit and outer garment together weigh 79lb on Earth.

A pressure helmet is worn at all times outside the spacecraft (and, at critical periods, inside). It consists of a transparent polycarbonate shell which locks into the thermal meteoroid garment by means of a bonded-metal collar. On the Moon it is supplemented by an extra-vehicular helmet consisting of another polycarbonate shell to which are attached two pivot-





These drawings by Flight artist Frank Munger show details of the Apollo astronauts' clothing. Above, the build-up of the spacesuit is described in the text. Left, the lunar overshoe, used only for EVA on the Moon; immediately below, basic flow diagram of the portable life-support system. Below, the three standard headgear units comprise the communication hat (worn at all times) the pressure helmet (worn during docking, undocking or EVA manœuvres) and the extra-vehicular helmet, worn over the other two

ing visors, for protection against, respectively micrometeoroids and solar radiation.

Pressure gloves are equally *de rigeur.* Each glove consists of an individually moulded, nylon-neoprene bladder surrounded by a fingerless glove, two covers and a restraint system. Over this fits a thermal-insulation cover, similar in construction to the thermal-meteoroid cover.

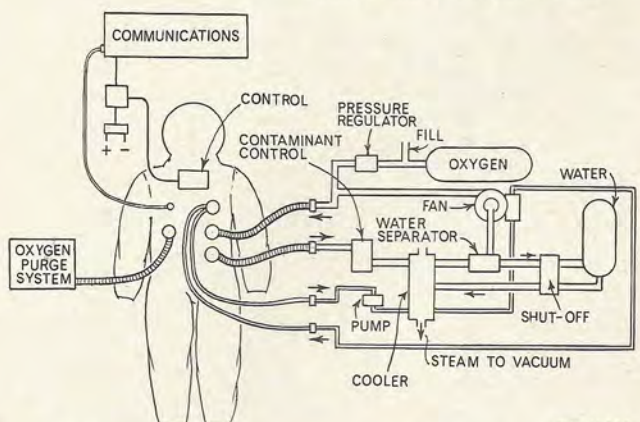
The surface temperature of the Moon varies between +100°C and −150°C (due to the poor heat-retaining qualities of the surface and the absence of "greenhouse effects" of atmosphere and clouds). Consequently some effective thermal insulation is necessary around the soles of feet. The first landings will be done very early in the lunar morning, when the ground, which is still in shadow, has a temperature of between −100°C and −150°C. Insulation and protection is provided by lunar overshoes, which fit over the integral boots of the thermal-meteoroid garment. Each shoe consists of an insulant and outer shell. The insulant is a 13-layer aluminised Kapton film separated by 12 layers of Beta cloth. The outer shell is a silicon-rubber sole sewn to a laminated Beta-cloth structure.

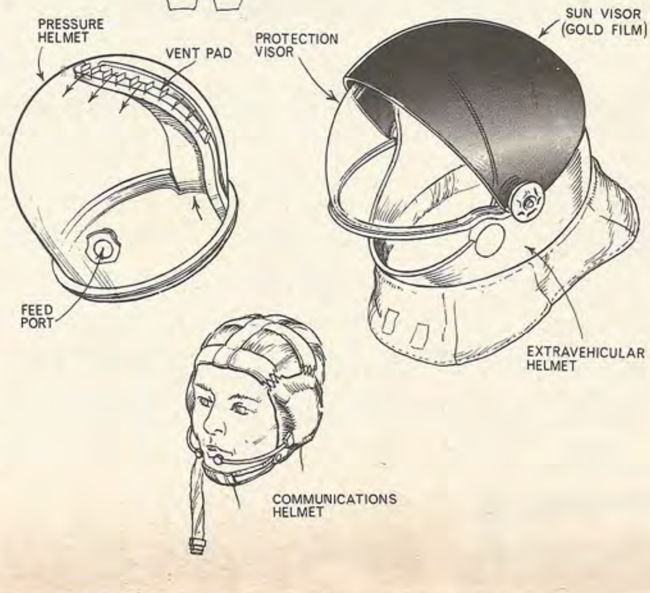
The portable life-support system is contained in a 26in × 17in × 11in glassfibre container contoured to fit the back, and weighing 84lb on Earth. The pack supplies oxygen for breathing, suit pressurisation and ventilation. It also supplies water and oxygen for body-cooling purposes and removes contaminants from oxygen circulating through the suit. The pack has its own control and monitoring equipment and a communications and telemetry set. It can operate at a normal level for 4hr before replacement batteries and lithium hydroxide capsules (for carbon dioxide removal) become necessary.

With all this equipment, and wearing a cumbrous space suit, the astronauts' freedom of movement is severely restricted, although adequate for the tasks of moving around and setting up equipment. The maximum reach height is only 6ft, while the range of comfortable working heights varies between 5ft 6in and 2ft 6in; it is not possible to reach below 22in without going down on one knee.

By the end of their short stay on the Moon, with its demanding tasks, the astronauts are glad to climb aboard the spacecraft and initiate the voyage back to Earth.

Later flights will take astronauts to more exciting places on the Moon—to Schroter's Valley, near Aristarchus, the brightest crater on the Moon and the scene of reported possible volcanic activity, and to the spectacular crater Copernicus, for example. But all these advanced flights will be based on the subjective and qualititive impressions on these first flights to the Moon.





At Paris was this replica of the Venus 4 probe. The capsule is attached to the lower part of the probe. The spacecraft in the cruise configuration measures about 16ft over the solar-cell array, and is about 14ft high **"Flight" photographs**

More results from the Venus probes

DATA RETURNED by the two Soviet Venus probes which entered the atmosphere of the planet on May 16 and 17 show that the concentration of carbon dioxide amounts to between 93 and 97 per cent, that of nitrogen (together with other inert gases) is between two and five per cent, while the oxygen content does not exceed 0.4 per cent.

According to the report of the USSR Academy of Sciences, the content of water vapour at an altitude corresponding to a pressure of 0.6 atmospheres lies between 4mg/litre and 11mg/litre, so that the higher layers of the atmosphere are not saturated. The height of the atmosphere was determined as 36km by Venus 5, and 38km by Venus 6. Corresponding radio-altimeter measurements, made by the two probes at the same temperatures and pressures, revealed altitude discrepancies of between 12km and 16km. These measurements, made only 186 miles apart, indicate that surface variations of this order exist.

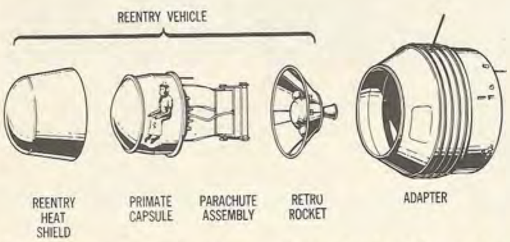
Measurements of atmospheric pressure were made between 0.5 and 27 atmospheres. These values were extrapolated, assuming an adiabatic temperature-altitude relationship, to derive the surface conditions which (says the report) are computed as 400°C and 60 atmospheres (Venus 5) and 530°C and 140°C (Venus 6), the difference being accounted for by the difference in ground levels.

The two capsules separated from their carrier spacecraft at distances of 37,000km and 25,000km respectively. While the two spacecraft continued on their way to burn up in the Venus atmosphere, the two instrument capsules approached the planet at speeds of 11.18km/sec. This was about 0.4km/sec faster than the Venus 4 capsule, and entailed strengthening of the 405kg capsule to withstand decelerations of 450g, some 50 per cent greater than those experienced by the earlier capsule, and the increased heating of the external surfaces. The design of the instrumentation has been modified over that of Venus 4, mainly to improve the accuracy of the atmospheric and radio-altimeter data, and to enable measurements to be made closer to the surface. Both capsules were capable of measuring external pressures of up to 25-27 atmospheres. In this context Russia now admits that the premature termination of the Venus 4 transmission was probably due to the collapse of the instrumentation bay due to the pressure rising above the design limit.

Aerodynamic braking of both vehicles continued until their speeds had reduced to 210m/sec, when their parachutes were deployed. Their surface temperatures "reached several thousand degrees Centigrade," but the capsules were protected, as with the Apollo command module, by ablative layers. Taking into account the much denser atmosphere revealed by Venus 4 compared with the previously accepted value, and the need to increase the speed through the atmosphere (presumably to reach and explore the lower levels before the temperature rise caused damage to the experiments), the area of the Venus 5 and 6 braking parachutes was reduced by two-thirds over that of their predecessor. The average speed of descent with parachutes deployed was 10m/sec. Descent through the atmosphere then took 53min for Venus 5 and 51min for Venus 6. Although the speed at impact on the surface would have been lower than this, due to the rapid increase of atmospheric density near the surface, it would not have been a soft lander. Probably the only effect of the touchdown impact was to spring the pennants with reliefs of Lenin; it has been stated that Venus 5 and 6, in common with Venus 4, were intended for deep sounding and not for exploration of its surface.

The instrumented capsule for the Venus 4 probe, which entered the atmosphere of the planet on October 18, 1967. The capsules for Venus 5 and 6 were basically similar but were strengthened internally and had modified equipment. The capsule measured about 4ft in diameter

SPACEFLIGHT



Left, the structural sub-assemblies of the Biosat 3 satellite. Right, surrounded by telemetry and scientific equipment, astromonk Bonny is checked out in his capsule. Below, the layout of equipment in the capsule is described with the aid of a key

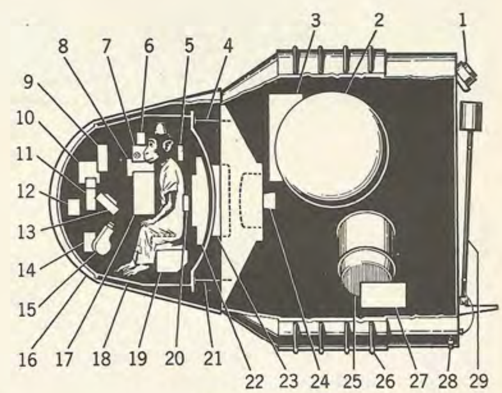
BIOSAT 3 LAUNCHED

Biosat 3, the third satellite in a series to investigate the biological effects of zero-gravity, was launched by long-tank Delta from Cape Kennedy into a 220-mile circular orbit on June 28. The subject is a 14lb male pigtail monkey, the physiological reactions of which will, in the course of a 30-day flight, be comprehensively monitored to provide a greater picture of the effect of weightlessness on mental, emotional and physiological activity than has been obtained so far in the entire American manned space programme.

The spacecraft weighs 1,536lb, is 7ft long, and consists of three sections: an adapter, which will remain in orbit, a re-entry vehicle (which carries a retro-rocket and heat shield) and the primate capsule. The re-entry vehicle will carry the capsule into the Earth's atmosphere over the Pacific. The capsule will then deploy a parachute, and will be recovered in mid-air by a USAF aircraft. If this is unsuccessful a beacon on the spacecraft will home rescue ships and aircraft to it in the water. A "shirtsleeves" environment, with 20/80 oxygen-nitrogen mixture (the first time such an atmosphere has been used aboard an American spacecraft) at 14.7lb/sq in and a temperature of 75°C, is provided to simulate Earth conditions.

The monkey is instrumented so that wave patterns from ten areas of the brain may be monitored. Measurements are also being made of heart action and respiration, the circulatory and urinary systems, and the trained behaviour of the animal to stimuli will be observed.

After the flight the monkey will be studied to assess changes in body weight and blood cells, fluid balance and the reproductive system. Data is telemetered to Earth at 22,400bits/sec from 18 to 26 times each day.



1 Horizon sensor
2 Cryogenic tankage
3 Power controller
4 Antenna—TM (re-entry)
5 Signal conditioner
6 Radiation dosimeter
7 Water dispenser
8 Capsule urine system
9 Tape recorder
10 Re-entry battery
11 Life-support controller
12 Programmer-timer
13 Behavioural panel
14 Recovery programmer
15 Camera
16 Re-entry vehicle
17 Food dispenser
18 Recovery capsule
19 Faeces collector
20 Blood pressure sensor
21 Antenna-recovery beacon
22 Gas-management assy
23 Recovery parachutes
24 Retro-rocket
25 Fuel cell
26 Radiator
27 Water accumulator
28 Attitude-control nozzle
29 Magnetometer boom (folded)

THIRD INTELSAT 3 COMPLETES WORLD SYSTEM

The third Intelsat 3 satellite was launched into geostationary orbit over the Pacific by Thor Delta from Cape Kennedy on May 22. Its subsequent successful orbital adjustments and commencement of operation signalled the inauguration of the first world-wide public communications system. In fact, the system of three satellites now in stationary orbit over the Indian, Atlantic and Pacific Oceans is able to reach about 90 per cent of the world's population; for the first time, instantaneous person-to-person communications over the globe are realisable by telephone, radio, television or any other conceivable form of communication; facsimile newspaper transmissions are possible, and widely separated computers are able to talk to one another.

Each launch operation has cost about $11.7 million, of which the launch vehicle and NASA services has taken $5 million and the satellite $6.7 million.

Since the first Intelsat 3 went into service on Christmas Eve last year, the new satellites have nearly doubled the transmission of international television. This emphasises the advantages accruing from the five-fold increase in capacity of each satellite over its predecessor, and the resulting decrease in tariffs which has been made possible. Comsat (the governing body of Intelsat, the 67-nation International Telecommunications Satellite Consortium) has reduced the rates charged for international television by 40 per cent, compared with those charged for similar traffic by Early Bird and the Intelsat 2s. This organisation predicts that, by the end of this year, the cost of a 3min transatlantic telephone call will be reduced to one-third of its present level, while direct-dial services between America and Europe by the general public are forecast for the next year.

By the end of 1969 there will be 43 Earth stations in 26 countries, which will increase to an estimated 70 stations in 47 countries by 1970.

A fourth Intelsat 3 will be flown into orbit alongside the existing Atlantic satellite to provide extra capacity and redundancy.

ELDO THIRD STAGE FAILS AGAIN

The ninth launch in the Europa 1 development programme, which took place from Woomera on July 3, ended in failure of the third (German-built) stage to ignite, with the consequent loss of this stage and the satellite test vehicle. This is the second occasion on which malfunction of the engine on this stage has occurred; during the F.7 flight last November ignition was achieved, but thrust terminated after a few seconds. The cause of the latest failure was not known at the time of writing.

F.8 was the second flight of Phase 3, in which completely representative live vehicles are launched to assess their behaviour under various conditions. The objectives of this flight were: the demonstration of 1st-stage perofrmance with increased propellant weight; demonstration of ignition and performance of 2nd-stage engines: demonstration of ignition and performance of 3rd-stage main and vernier engines; demonstration of the function of all launcher-separation systems, and the jettisoning of fairings; and demonstration of guidance-system performance. The Italian satellite test vehicle was to have been placed in a circular, 520km orbit.

In the event the launch was postponed by three days from nominal. The first day's delay was due to the accidental operation of an explosive separation bolt between the second and third stages, while low cloud which would have prevented tracking during the early stages of the flight resulted in a delay of two further days. The countdown itself is understood to have been the smoothest yet.

Once again the British Blue Streak first stage performed flawlessly; an extra bonus in velocity was achieved by cutting 1sec off the period between ignition and lift-off, and also by scheduling the first-stage cut-off signal about 1sec later, as a result of growing confidence and experience with the vehicle. The extra burn time would have resulted in a velocity increment of probably more than 100ft/sec at first-stage cut-off.

At the present time only one more launch is scheduled from Woomera: F.9, which will occur at the beginning of next year. F.10 was cancelled to save money, and the final two vehicles (Europa 2 development) will be fired from Guyana in the autumn of 1970 and summer of 1971.

EARLY BIRD RE-COMMISSIONED

Early Bird, the world's first commercial communication satellite, has been brought back into service following the failure of the Intelsat 3 satellite (notification of which was received after the final news item on the previous page went to press) which was launched on December 18 last to provide a relay over the Atlantic. These third-generation satellites are spin stabilised; in order to align the beam with a given Earth location the aerials have to be rotated at the same rate as the satellite, and the opposite direction; to achieve this they are mechanically de-spun, and it is this system which has failed.

While arrangements are being made to bring forward the next Intelsat 3 launch (already scheduled for the Atlantic service), the existing Intelsat 2 and Early Bird will be able to handle the majority of the present traffic, including full support of the forthcoming Apollo flight. TV from North America to Europe will be relayed from Jamesburg, USA, via the Pacific Intelsat 3 to Japan, and retransmitted from there to the Indian Ocean Intelsat 3 for relay to the new Goonhilly station in Cornwall.

APOLLO 11 FUELLING BEGINS

Steady but high-pressure progress continues with plans for the Apollo 11 flight, scheduled for launch on July 16. On June 18 the loading of fuel into the Saturn V launch vehicle began in preparation for a simulated countdown and launch, beginning on June 25. The rocket was due to remain fuelled after the test, in preparation for the launch. The three astronauts, Neil Armstrong (commander), Michael Collins (CM pilot) and Edwin Aldrin (LM pilot) are in excellent health, and are working a 10hr-day, six days per week during the final period.

The flight plan has been slightly changed (see *Flight*, June 12, page 987) by the addition of two extra orbits of the Moon in order to improve communications during critical manœuvres and to allow more time for decontamination of equipment deployed on the Moon. Adding one Moon-orbit prior to the undocking of the lunar module from the command and service module will allow acquisition by the 210ft Goldstone antenna of the LM during its descent to the surface. The other orbit will be added after the re-docking, and before the LM is abandoned, in order to allow extra time for the LM crew to remove and brush away Moon dust from the lunar-sample boxes before transferring them to the CSM for the return journey. The flight plan now calls for 30 revolutions (a total time of 59hr 30min) of the CSM around the Moon. The extra 4hr will be compensated by a faster flight home, so that the original splashdown time of 1249 BST on Thursday, July 24, is unchanged. It will, however, delay the touchdown on the Moon until 2123 BST on Sunday, July 20, and Neil Armstrong will venture on to the Moon at 0717 BST on the following day.

The decision to proceed with the flight was made by NASA on the basis of a review of the status of the Apollo 11 vehicle, crew and ground team, the state of progress and tests, and a final analysis of the anomalies discovered on Apollo 10.

In the latter mission the plane of the spacecraft did not rotate around the Moon as expected, and this caused the LM to make its low pass over Site 2 (the Apollo 11 landing area) four miles further south than had been expected. While these effects have still not been fully explained, they will be compensated by flying Apollo 11 at the same orbital inclination, so that the orbit can be biased to allow for the same variation as that of Apollo 10. This is expected to allow a powered descent well within the propellant-capacity margins allowed.

The problem with the docking tunnel was found to be the result of a wrong fitting on the tunnel-pressurisation dump line.

Glassfibre insulating material on the docking-tunnel hatch of the command module has been removed to eliminate the possibility of material escaping into the LM and CM as it did on Apollo 10.

The incident leading to the loss of attitude-control during the staging of the Apollo 10 lunar and command modules has not yet been satisfactorily explained. It is associated with switch circuitry in the abort-guidance system which provides a back-up for the lunar-module primary-guidance system. The use of the back-up system during Apollo 10 was a deliberate test to provide flight experience and data in this mode.

Finally, the vibration encountered in the S-1VB powered flight are stated to be well within safety limits; but instrumentation and provision for continuous telemetry are being installed on the Apollo 11 S-1VB.

The prospects for Apollo 11 look good. But, according to Gen Samuel C. Phillips: "We will not hesitate to postpone the flight if we feel that we are not ready in any way. Nor, once the voyage has begun, would we hesitate to bring the crew home immediately if we encounter any problems."

RUSSIAN MOON LANDING NEXT YEAR?

Alexei Leonov, the first man ever to walk in space (Voskhod 2, launched on March 18, 1965), is quoted by a group of Japanese science reporters on June 2 as saying: "If everything goes well, it will be possible for the Soviet Union to send a man to the Moon before the end of this year or next year." His statement was made through an interpreter, through whom Leonov is reported to have said that samples of lunar rock would be displayed by Russia at the Japanese International Exposition in Osaka in 1970.

The Soyuz vehicle can be linked with space stations containing up to four separate elements, and this could be used for a Moon flight. Alternatively, a "direct-ascent" flight could be made, according to the same report.

SPAIN TO OPERATE NASA STATION

The Cebreros tracking station, which has played an important part in Mariner and Pioneer flights, was operated for the first time under Spanish control on June 15. The $7.5 million station had been handed over by NASA to the National Institute of Aerospace Technology on the previous day. Cebreros, with its 85ft dish, forms part of the Robledo de Chavela space-tracking complex located 45 miles north-west of Madrid, and is associated with Fresnedillas and Robledo in a natural bowl in the landscape which provides some immunity from artificial electrical interference.