Cambridge News Extra

MOONQUEST

TUESDAY JULY 15 1969

A great goal in sight

"I BELIEVE that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to earth."

And so, in a sentence, the newly-elected President John Kennedy summed up the great American dream of the sixties.

The date was May, 1961. Three years later Kennedy was dead, but the dream lived on. Now, only a few months before the deadline, it is to be fulfilled. It is incredible, yet imminent.

Within a matter of hours, if all goes well, three American astronauts will be blasted off the earth on the first stage of a 500,000-mile adventure that will hold the world spellbound.

The composite picture (right) of the moon's craggy landscape with the crescent earth on the horizon is the sort of view the Apollo 11 astronauts will get as the little lunar module glides towards its landing site.

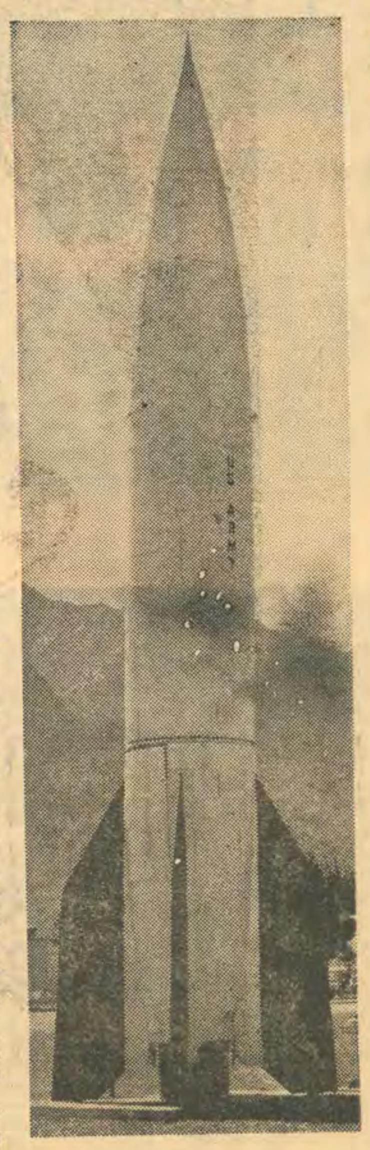
During the first half of their journey they will have faced many dangerous moments. But flights to the moon have been made before; those dangers are familiar and have been met by others.

The task that will lie ahead for the Apollo 11 crew after that has never been done before, and will be the most perilous ever undertaken by man — a moon landing. The great goal is in sight . . .

● This eight-page supplement looks at the steps that have taken man to the threshold of the moon, the amazing technical feat that will land him there, and the new dimensions in space travel which a successful Apollo 11 mission will open up.

EDWARD TOWNSEND tells the story of man's venture into space . . .

Slow off the mark—but America will win the moon race



THE ROCKET that began it all . . . the V2, which Hitler used to bomb London during the Second World War. It was designed by Werner von Braun, the brain behind America's space rocketry.

A WALK in space . . American astronaut Ed. White pictured from the Gemini 4 space capsule as it orbited the earth in June, 1965. White was killed two years later when an Apollo command module burst into flames.

ON THE EVENING of September 8, 1944, a row of eight houses at Chiswick in London were flattened. People were mystified. There had been no aircraft, no bombs and no noise. The V2 had arrived.

This Nazi rocket weapon, symbolising violence, also marked the birth of the first real hopes that man could leave this planet and one day travel in space.

The V2 had been built under the guidance of one of the most remarkable men of the 20th century—Werner von Braun, a brilliant German rocket scientist.

Von Braun's dedication to the development of rockets and space travel became, during the next 25 years, the inspiration behind the mammoth American Apollo programme to send a man to the moon.

When the war came to an end in 1945 both American and Russian military chiefs quickly appreciated the enormous part that future development of rockets would play in world strategy.

BY WING AND SAIL . . .

Von Braun, who had already been accused by the Germans of thinking more of space travel than war rockets, went to America with many fellow rocket experts. Others were snapped up by the Russians, and so began the great space race.

Man's first dreams of visiting other planets, however, go back into the dusty realms of history. We can find, dating from the Middle Ages, detailed diagrams of weird and wonderful contraptions with wings and sails designed to lift their occupants into the sky and land on the moon.

Over the centuries the great desire to conquer the unknown grew. Imaginative writers like H. G. Wells and Jules Verne put romance and mysticism into space travel and the 19th century rocket pioneers of Russia, France and the United States gave the world a glimpse into the distant future.

Then the 20th century dawned and soon two world wars were to provide the stimuli for rapid technological and scientific expansion. Rockets became reality and now the pressing problem was to make them powerful enough to escape the Earth's gravity.

Slowly but with increasing success the two contenders in the space race—Russia and America—began preparations and concentrated enormous effort in research and development.

The race started officially on October 4, 1957—much to the disappointment of the United States. The Soviet Union had got off to a flying start and an incredulous world learned that the tiny 184lb. Sputnick I was in orbit round the Earth.

No good would come of it all, said the sceptical and superstitious. Space shots would probably disrupt the world's weather.

But no pressure, either from the uninformed or those who felt that the money could be better spent on the world's immediate problems, could stop the race—and never will. The great adventure had begun and millions waited eagerly for the next instalment.

A DOG CALLED LAIKA

They did not have to wait long. A month later the Russians put Sputnik 2 into orbit and this time the spacecraft carried a dog called Laika.

The Americans were beginning to worry. Prestige was at stake. So on January 31, 1958, they shot their first satellite, Explorer 1 into orbit.

Perhaps more than the Soviets — and certainly with more money available — the Americans realised that in the very near future a massive, complex organisation would be needed to guide and direct the new exploration.

And by the time Explorer I was in orbit, N.A.S.A., the National Aeronautics and Space Administration, was being created.

Now the United States was in business. Huge numbers of satellites were planned, all designed to provide increasingly sophisticated information about inner space, and, most important of all, it was hoped that pride would be retrieved by Project Mercury, which would put a man in space.

Meanwhile the Russians moved quietly onwards. Experiments with animals in space had proved that man could follow and the next memorable date was April 12, 1961, when in 108 breathtaking minutes Yuri Gagarin became world famous. This first man in space was tragically killed in an air crash in March, last year.

NAME WILL LIVE ON

The firsts that America claimed after that initial Russian flight, and those they will claim in the future, will never match the aura of romance that surrounded the name of Yuri Gagarin. His is a name that nobody will ever forget, for he marked the beginning of it all.

A month later the Mercury programme got under way with a sub-orbital "hop" by Alan Shepard and in July another by Virgil Grissom.

Faced with what seemed at the time to be fierce competition from Russia, and with as yet no American in space, President John Kennedy then courageously committed his nation to landing a man on the moon before the end of the decade.

At N.A.S.A. headquarters arguments were raging. There were so many conflicting views as to how a man could be set down on the lunar surface.

RUSSIA'S FIRST . . . Yuri Gagarin, who in April, 1961, became the first man to travel in space. He died in an air crash last year.

One obscure engineer, John Houbolt, expounded his Lunar Orbit Rendezvous scheme, which involved ferrying three men to the moon and then, using a strange bug-like craft, send two of them down to the surface.

His scheme was thrown out, but Houbolt was not deterred and he decided to pursue his idea to the limit.

THE FIRST WOMAN

Meanwhile it was left to a burly U.S. Marine, John Glenn, to be the first American to orbit the Earth. In his spacecraft, Friendship 7, on top of a Redstone rocket, he was blasted from Cape Canaveral into the heavens for a three-orbit flight on February 20, 1962.

The previous year Herman Titov had been the second Russian in space and had completed 17 orbits in Vostok 2.

Six months after Glenn's flight the Russians sent up two men in separate craft that passed each other within three miles, and there were more long flights during the next 12 months. Among the cosmonauts was Valentina Terechkova, the first woman in space, who completed 48 orbits in June, 1963.

The Mercury programme plodded on, the longest flight being in May, 1963, when Gordon Cooper flew 22 orbits in Faith 7.

But now valuable experience had been gained and the Americans were ready for Gemini — 10 two-man space flights designed to find out how man could manoeuvre himself and his craft and generally increase knowledge of celestial mechanics and navigation.

In 1964 the Russian second generation spacecraft, the Voskhod, made its debut. The two Voskhod flights set the record for the first three-man space vehicle and Alexis Leonov became the first man to "walk" in space.

Gemini began on May 23, 1965, and by the end of 1966 many records had been set, including the longest duration flight — nearly 14 days — the first rendezvous by two manoeuvrable craft and the first docking. It also saw the first American space walk.

RUSSIANS DROP BEHIND

There had been delays and disappointments, but also many successes and at the end of the Gemini programme the path to the moon was a lot less cluttered with seemingly insurmountable problems than it had been a year before.

No longer was getting to the moon a true race. The Russians had made too many propaganda flights and had dropped behind. They were making fewer flights and to the rest of the world they seemed crude against the glorious, publicity-shrouded American efforts.

Perhaps it was at this time that the Soviets decided to abandon the idea of going to the moon and redirect their efforts towards the longer term aims of building space stations and trips to the planets.

At the Kennedy Space Centre in Florida, which had cost 875m. dollars, the enormous 525ft. high vehicle assembly building was ready for the Saturn rockets and the start of Apollo, described as the greatest scientific, engineering and exploratory challenge in the history of mankind.

Billions of dollars were due to be spent on the most sophisticated and complicated spacecraft ever built.

THE FIRST VICTIMS

Over the years both Russian and American moon probes and later moon landers revealed that the lunar surface could withstand the impact of a spacecraft and support the weight of a man.

A severe setback occurred on January 27, 1967, when astronauts Edward White, the first American to walk in space, Virgil Grissom, the veteran from the Mercury programme, and a newcomer, Roger Chaffee, became the first victims of the conquest of space.

Their Apollo command module burst into flames while they were inside completing a simulated countdown. They died almost immediately.

The same year, in the first flight of a new Russian spacecraft, Soyuz 1, Vladimir Komarow died when the parachutes tangled during the re-entry procedure.

Undeterred, the N.A.S.A. engineers and designers set about making widespread modifications to the Apollo command ship Ten months later they were ready for the first, historic flight of their moon craft, and the Saturn-Apollo 4 mission was near-perfect.

The world was beginning to have even greater admiration for the U.S. space shots, not only for their technical brilliance but also for the openness displayed by space officials in discussing publicly the whole of the space programme — something the Russions had never done.

During the first decade of the space age many of the highly valuable results from other launchings had been overshadowed by the urgency of getting to the moon. Hundreds of satellites were put into orbit, with many nations contributing, most of them with strict scientific aims.

Communications satellites were able to bounce television pictures across the world and now even this amazing achievement has become accepted as commonplace. International satellite corporations were formed and, more important, space treaties signed.

The moon programme went ahead spectacularly In November, 1968, the huge Saturn V rocket, with a payload of 130 tons —three times heavier than the combined weights of America's 20 manned craft so far launched — put astronauts Walter Shirra, Donn Eisele and Walter Cunningham into a 163 Earth orbit flight.

The years of preparation and the mobilisation of the top brains in the United States had paid off — the Americans were definitely on their way to the moon.

Just over a month later astronaut Frank Borman guided Apollo 8 out of earth orbit and headed for the moon. He and his companions, James Lovell and William Anders, went round the moon and came home — another great step forward had been taken.

THE FINAL REHEARSAL

While all attention was focused on Apollo II, Russian space ships were sent up, Soyuz 4 and 5. Taking their cue from the Americans, the Russians proudly showed the world television pictures of the inside of the craft.

But heads were turned eastwards for only a short time — everyone knew now that nothing short of disaster could stop Apollo.

Their successes were even amazing N.A.S.A. officials. On February 2 this year Apollo 9 and its crew of McDivitt, Scott and Schweickart, tested the lunar module in Earth orbit and proved its capabilities.

John Houbolt's scheme had been accepted years before and now he was being proved correct.

AMERICA'S FIRST . . . Commander Alan Shepard, who made a sub-orbital flight in May, 1961, becoming the first U.S. man in space.

The final rehearsal came in May when the wise-cracking, supremely confident Apollo 10 astronauts, Stafford, Young and Cernan, did everything except actually touch the lunar surface. They even managed to shave [illegible] space.

Now comes the final mammoth step, the culmination of so much effort. Everything possible has been done there is no point in further rehearsal — the race is almost won.

And as the stately Saturn V lifts slowly off its launch pad it will be interesting to reflect how man has progressed — even beyond his own imagination — since those eight houses in Chiswick were blown to pieces 25 years ago.

Our great voyage

By NEIL ARMSTRONG
Commander of Apollo 11

THERE is no earthly way—literally—to practice an entire moon mission. For all our calculations and planning, it will be a voyage into the unknown, and the flight itself will be the first full-dress rehearsal.

The best we can do is to break the mission down into its components—launch, rendezvous, lunar landing, lunar take-off and re-entry—and do our best to master each separate step with the help of an assortment of strange and sophisticated machines called simulators.

In the early days of the U.S. manned space flight programme, little was known about the rigours of space.

So the astronauts who were being trained for the first orbital flights were subjected to all manner of tortuous tumbling, whirling and centrifugal exercises, many of which, as it turned out, were quite needless. About the only device they had then for practising the techniques of space flght was the old Mercury Procedures Trainer.

The simulators we have now would satisfy the fondest dreams of any astronaut. Through an ingenious variety of electronic and mechanical tricks, these machines help create a world of serious make-believe.

As we train in that world we are surrounded by the sights, sounds, and even smells that we can expect to encounter on a lunar journey.

For example, at our headquarters in Houston, Texas, N.A.S.A. geologists have built a simulated lunarscape which, we believe, is so like the real thing that when we step out on to the moon for the first time, it will be almost as familiar as our own backyards.

Familiarising ourselves with the moon's gravitational pull—which is only about one-sixth that of the earth—was something else again.

An astronaut would find it easy to leap 20ft. off the lunar surface. But he would have to remember that his body mass remains the same, and bumping into a lunar rock at high speed would hurt just as much as bumping into a boulder on earth at the same speed.

Thus our training had to include learning how to walk on the moon, and the problem was to duplicate lunar gravity.

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. . . and foresees an era in which the dreams of science fiction may become fact

THREE WEEKS after Neil Armstrong is due to put that historic footprint in the lunar dust, N.A.S.A. officials will be waiting excitedly for the results of another mission, even more far reaching in its implications.

Last January two rockets were blasted into the heavens — forgotten by most of us, but watched intently by the men who know that their successful flight could solve many of the mysteries surrounding one of our nearest neighbours, Mars.

The two Mars probes are due to complete their 42 million mile journey on July 31 and August 2, and have been aimed to approach within 2,000 miles of its surface — the closest any spacecraft has been.

The N.A.S.A. men are excited because, if all goes well, the probes will send back live television pictures and photograph large areas of Mars, in some cases in close-up with resolutions up to ten times greater than provided by Mariner 4 in 1965.

Orbiting

From the data sent back to Earth, scientists will have a good idea of whether mysterious Mars is hospitable or not, and whether it will be worth trying to attempt a landing.

This year's probes are to be followed up in 1971 by two orbiting spacecraft, and in 1973 by two further Mars orbiters that will drop equipment on to the surface to perform soil analyses and other experiments.

The chart (right) shows the long journeys that must be undertaken in conventional rockets before astronauts arrive at the other planets. Venus has been discounted as not worth visiting as it has been proved to be a searing furnace, and that leaves only Mars as a possible goal for the reasonably near future.

In mater-of-fact terms the trip to Mars sounds credible; it can, in fact, take far less than the 1¼ years shown in the chart when Earth and Mars are in their closest relationship.

After the moon?

On galactic scale, moon trips are local excursions. Scale shows time/distance figures, for deep space missions using current rocket propulsion methods. Even future up-rated rockets giving 200,000 mph (see third column) will not suffice.

	Distance in millions of miles	Time conventional rocket	Time up-rated rocket
Moon	¼	65 hrs.	3 hrs
Venus	30	10½ months	2 weeks
Mars	42	1¼ yrs.	3 wks.
Mercury	63	2 yrs.	5 wks.
Sun	100	3 yrs.	7 wks.
Nearest star	26 billion mls.	720,000 yrs.	14,000 yrs.

Alternatives being developed by US and USSR

	PRINCIPLE	ADVANTAGES	EST. SPEED
NUCLEAR	Liquid hydrogen heated by uranium	Cheap	¼ million mph
ELECTRONIC	Propulsion by electron stream	Cheap, light, durable, powered by sunlight	Speed of light 186,000 miles per sec.

Reaching for the stars by photonic rocket

Man on Mars?

The supremely confident American attitude to space adventures often dulls our awareness of the awful difficulties — in almost every sphere of endeavour — that must be over come before man can leave this planet

But the Americans are looking forward beyond a possible manned landing on Mars in 1985 to even greater achievements. Not only does man want to visit the other planets that revolve with him around a weak little sun on the edge of a galaxy — he wants to travel into the heart of that galaxy and even beyond it.

The main stumbling block we all encounter when faced with imagining these voyages is distance. In fact the whole mystery of time is for many of us beyond comprehension.

New rockets

Journeys to the moon, a mere 250,000 miles away, and even the planets seem ludicrously short when viewed on a cosmic scale.

The chart shows that the nearest star is 26 oillion miles away, or about 4½ light years. To comprehend this distance, imagine that our own planet is represented by the full stop at the end of this sentence.

Assuming that the dot measures about a fiftieth of an inch, the Earth is therefore reduced to less than one 2,500-millionth of its size.

On this scale our moon is about five-eights of an inch away, the distance to Venus is 6ft., to the sun is 18ft., and the nearest star is over 1,000 miles away. Even on this scale the distance to another galaxy, that of Andromeda, is nearly 500 million miles.

To span these distances totally different types of rockets are needed, for, as the chart shows, it would take 14,000 years in even an up-rated "conventional" rocket to reach the nearest star.

Still dreams

The alternative propulsion methods being developed in both the United States and Russia are nuclear and electronic rockets.

Another type to which serious thought is being given is a photonic rocket. Basically it would replace the jet of physical particles that are ejected by a conventional rocket engine by a beam of photons — uncharged units of electromagnetic radiation.

Such a rocket would weigh thousands of tons, be incredibly powerful, and could approach a velocity nearing the speed of light.

Of course these rockets, while not in the realms of science fiction, are still dreams; years of research and a great deal more capability in space will be needed before they can be practically contemplated.

That capability will no doubt be increased enormously during the next decade or two, and we can expect to witness many more moon landings, moon stations, earth orbiting workshops, more complex satellites and probes to the planets

Astronauts Charles Conrad, Richard Gordon and Alan Bean have already been named as the crew of Apollo 12, the second manned mission to the moon.

Conrad and Bean have been chosen to ride the lunar "bug" to the moon's floor, and they will spend five hours exploring the immediate landing area. To learn more about lunar geography the Apollo 12 crew will take with them a larger load of scientific packages than on the Apollo 11 trip.

'Hardware'

There are, in fact, nine more moon landings proposed. The flights, to explore sites in the lowlands along the lunar equator and mountainous highlands beyond, will be carried out at the rate of two or three a year into 1972.

In 1971 it is hoped to begin the Apollo Applications Programme, designed to utilise the "hardware" and experience gained from the Apollo programme.

The ambitious and far-reaching programme will cover a huge number of projects. There are plans to convert the burned-out second stage of a Saturn V rocket into an orbiting space laboratory and to use the lunar module, equipped with solar telescopes, as an earth-orbiting sun observatory

The great barrier facing officials engaged on these projects is the gigantic cost of firing a rocket off the face of the earth.

Remember that a Saturn V — costing several millions of dollars — can only be used once. Its expensive stages are either lost in the sea or burned up in re-entry.

Near reality

The answer, being studied by U.S. designers, is a space shuttle, a wedge-shaped vehicle that could be fired vertically into orbit as a ferry, returning in the normal way but gliding in one piece on to a runway.

These developments are well on the way to becoming reality, although 20 years ago they would have been dismissed as pure fantasy.

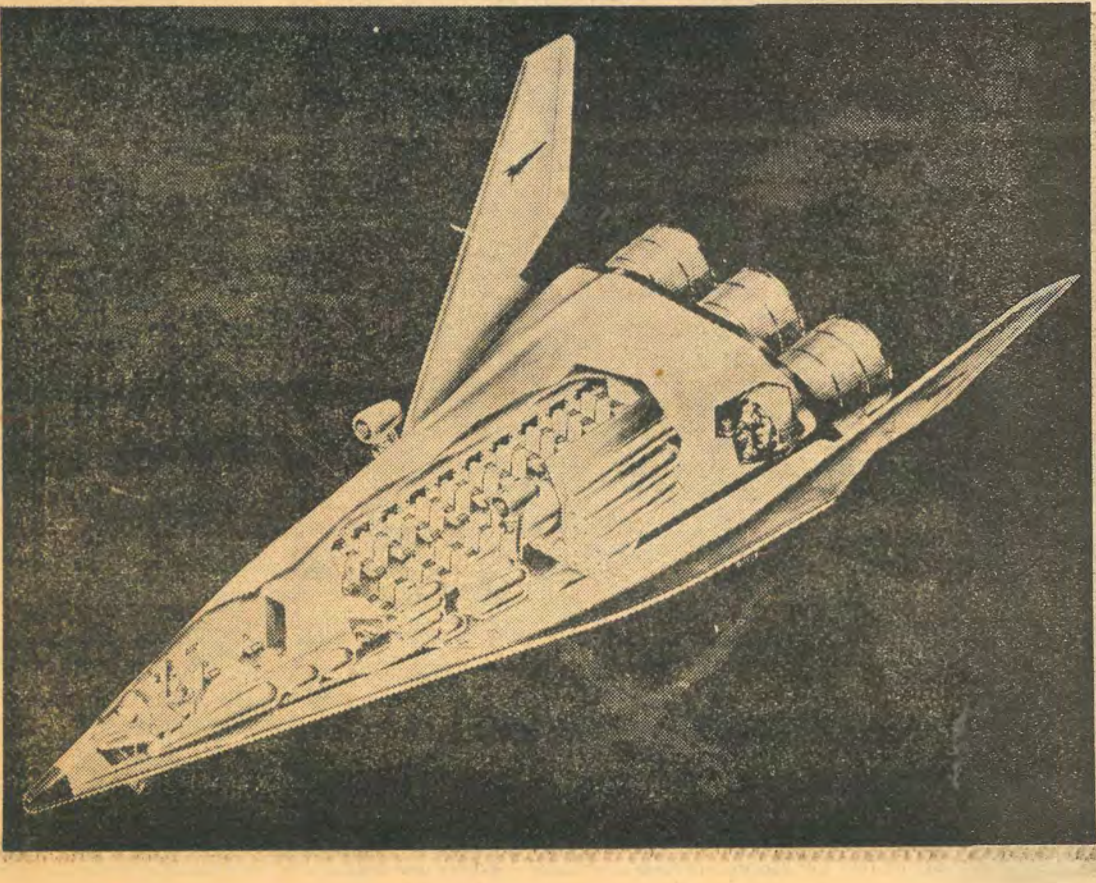
Yet in the middle of the 21st century, writers will no doubt look back on today's spacemen as romantic pioneers as they relate the landing on some distant planet of photonic rocket astronauts — or even, perhaps, interview the crew of a time machine!

SPACESHIP OF THE FUTURE?

This is a proposed re-usable spacecraft to follow Apollo, planned by Lockheed Missiles and Space. The cutaway drawing of Starclipper shows airliner-style seating for 46 passengers and two pilots.

The craft would be launched like a rocket, drop its auxiliary tanks and return to earth to land on a conventional undercarriage like an airliner.

Re-usable spacecraft would drastically reduce the costs of space travel, and Starclipper could be shuttled between earth and space stations carrying relief crews and supplies, and possibly used to intercept and inspect unmanned satellites in orbit.



into the unknown

From previous page

An aeroplane can provide a brief approximation for its passengers by flying up and over in a kind of parabola, like a car speeding over the crest of a hill. What we needed, however, was a machine that would enable us to practice moon-walking for hours on end.

Engineers solved the problem by designing some excellent devices. One of these is fitted with cables that suspend us so that we can walk with only one-sixth of our weight on an inclined board. Another variation, called the "Peter Pan Rig," carries us through the air on cables the same way that actors fly on stage.

Some of our training devices are so complex that they cost millions of dollars to build. They will have earned their keep, however, if they help us avoid a catastrophe later on. For example, one simulator uses an electronic computer allowing us to rehearse all of the manoeuvres we will be making on the flight to the moon.

Information comes to the pilot through instruments, and he also looks out of a window at a huge cinerama-like projection of the approaching moon. With this machine we practice a manoeuvre repeatedly until it becomes routine.

If we make a mistake, we simply push a "reset" button that starts the mission over again. We joke that if we get into trouble on the actual mission, we'll probably automatically start fumbling for the reset button!

Despite all our training, an actual flight will require some old-fashioned "seat-of-the-pants" flying.

Bringing two spacecraft together in a rendezvous in space, as we will have to do twice —once on our way to the moon, and again in moon orbit—will be like manoeuvring a boat into a moving dock in the middle of the night with only a half-pint of fuel left

But thanks to simulators, the guesswork will be cut to a minimum when we pilot "Columbia" and "Eagle" on the moon flight.

Several of the simulators are so authentic that they even smell like the real thing. One day astronauts Gordon Cooper and Tom Stafford were inside the cockpit testing a new device that simulated a Gemini mission

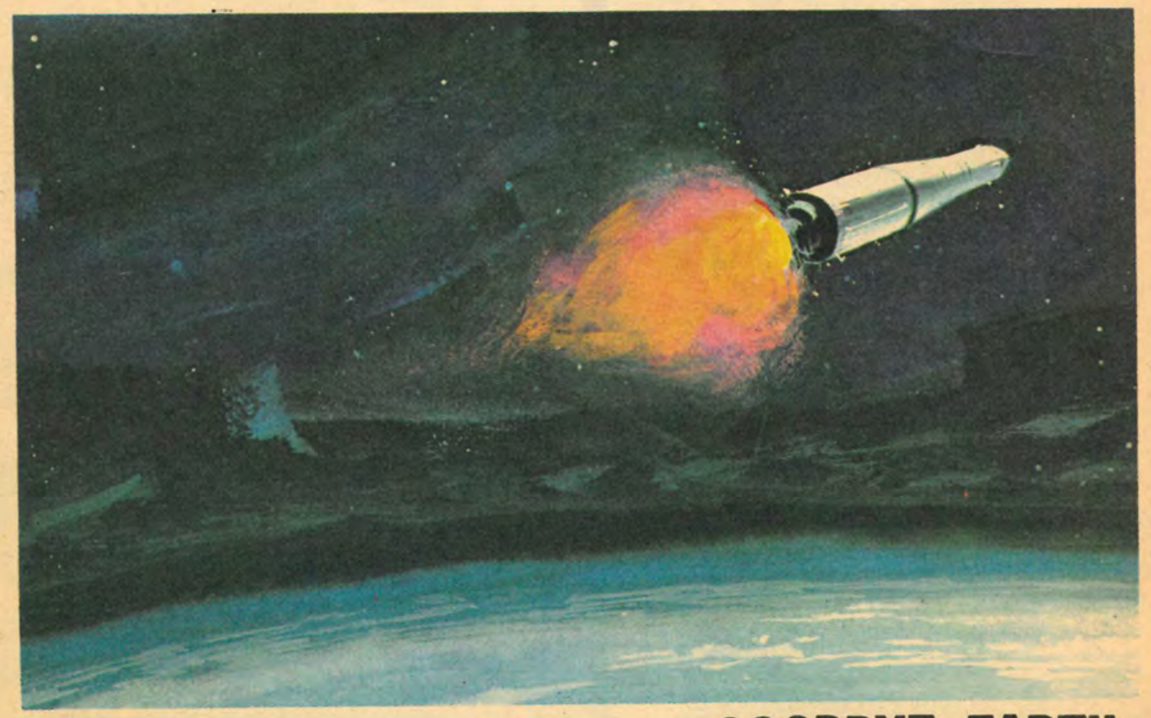
Suddenly the console operator who runs the flight pulled a switch and the cockpit filled with smoke and the acrid smell of an electrical fire.

Immediately Gordon and Tom reported: "Fire! Fire!" Then they found out the controller was only testing them. He had started a simulated fire—with a very real smoky smell.

MISSION TO THE MOON IN EIGHT TRICKY MOVES...

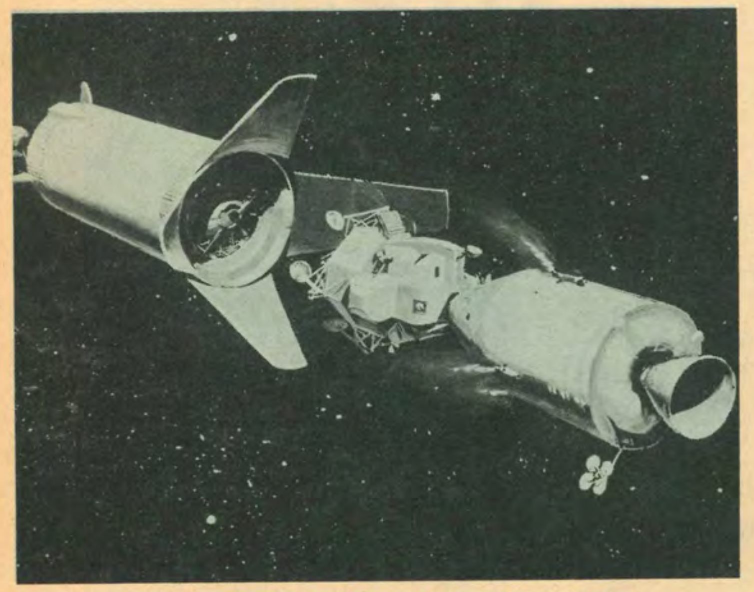
1. LIFT-OFF BY SATURN

The impressive, almost poetical, launch into a blue Cape Kennedy sky of man's most powerful rocket—the Saturn V. At the top, 360ft. up and under the launch escape rocket, lie the three astronauts in their command module. Within seconds this amazingly complex piece of "hardware" will be out of sight, travelling at 6,000 miles an hour and on the way to the moon. It takes four months to prepare the 8,000-ton rocket for lift-off, and every one of its 5,600,000 systems must be working perfectly.



2. GOODBYE EARTH

Twelve minutes and 115 miles later the spacecraft, now minus the first two Saturn V stages, is "parked" in earth orbit, waiting for that crucial moment when the third stage is fired. If all is well, at the exact decimal point of a second—decided by computer—the third stage is fired for about five minutes, sending the craft on its journey to the moon, 230,000 miles away, at a speed of nearly 25,000 miles an hour.

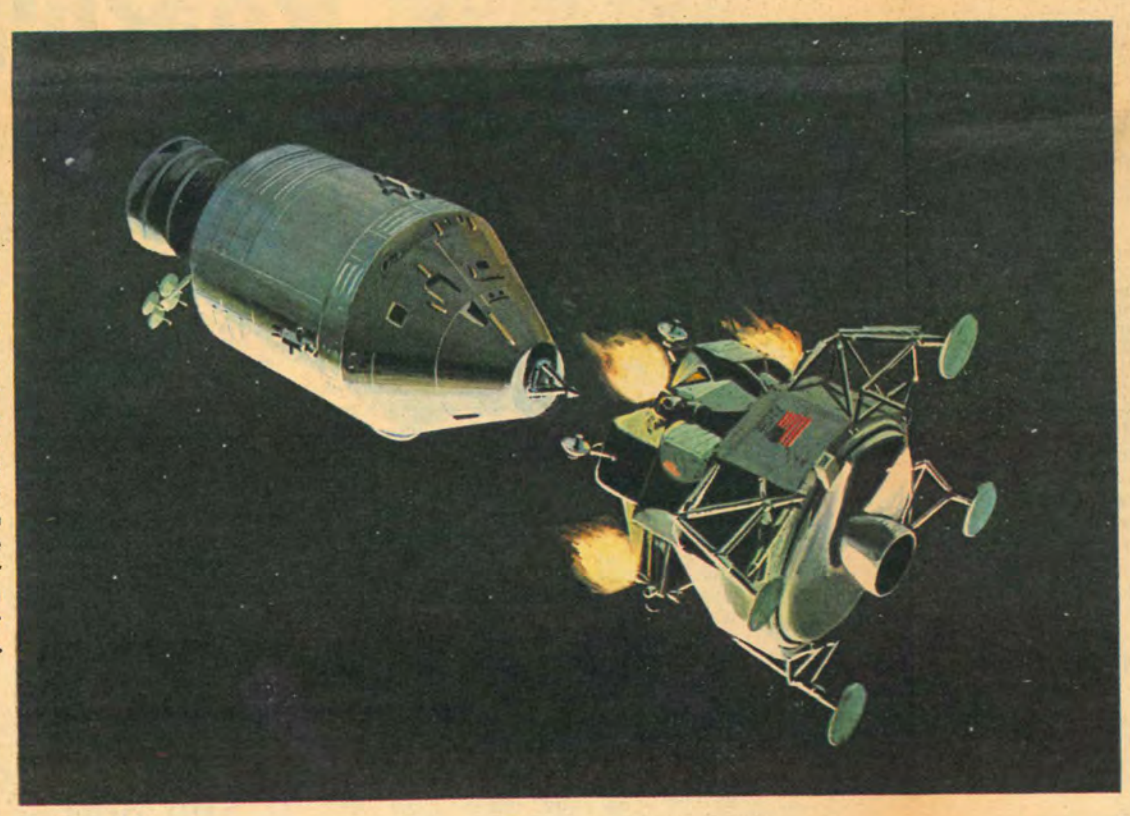


3. ASSEMBLY IN SPACE

Now comes one of the most delicate operations the astronauts have to perform. First, the combined command and service modules—on the right of the picture—will be detached from the burned-out third stage rocket, the pilot will turn to face the "jaws" of the conical adaptor, dock with the lunar module, and jettison the third stage. The modules could not be assembled this way initially as the astronauts had to be on top so they could escape in case of trouble at launching.

4. SEPARATION

After their three-day flight the astronauts, now rested and relaxed, fire the service module engine to reduce speed to 3,600 m.p.h. and enter lunar orbit. Later, when all systems have again been checked, the two "moon men" clamber through the narrow hatchway into the lunar module. The spindly landing legs are extended, and more thorough checks are completed before the 16-ton "moon bug" separates from the mother ship. Now, for a quarter of an orbit, the two fly in formation, watching each other cautiously until the descent begins.



5. GOING DOWN . . .

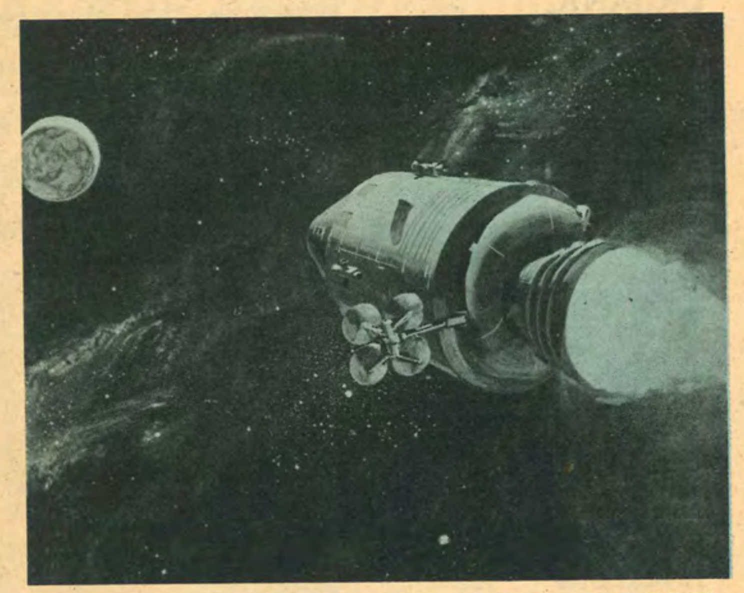
For what must seem one of the longest hours in their lives, the lunar module crew watch the moon's surface creep closer. The module descends the final 50,000ft. in a sweeping 230-mile arc, using the engine as a retrobrake. Fifty miles above the moon the command module continues to orbit, and its pilot can watch his companions making history. Automatic radar operates every second, measuring the module's aspect; only during the last few seconds does the pilot take over manually. Now the module can hover while the astronauts look for a suitable landing site. A decision has to be made quickly—there is enough fuel for only two minutes' hovering—and then the module will settle softly on to the dusty lunar surface.

6. MAN ON THE MOON

After that bump on to the surface, impatience must be curbed for at least ten hours. First, every system in the craft must go through the inevitable checking procedure. Then the astronauts stop for a meal and a four-hour rest. And there is another meal to be eaten before the cabin is depressurised, the hatch opened, and the first man sets foot on the moon. Wearing a protective garment over his space suit he will gingerly examine the lunar module and then return for a bag into which he will thrust a handful of dust. Later the second man will join him, scientific instruments will be erected and experiments carried out. Three hours later they will be back inside the module for the crucial blast-off.

7. L.M. BLASTS OFF

The next phase of the mission is lift-off from the moon. The astronauts will have been watching for some time for their command module to come over the horizon. The descent stage is disconnected to be used as a launching pad, and the engine, with its 3,600 lb. thrust, fired at precisely the right second to take the module into orbit just behind the command module. Gradually, at a rate of 10ft. per second, the two craft come together and dock.



8. HEADING FOR HOME

In the comparative safety of the command module, the astronauts jettison the new redundant lunar module, which goes into orbit round the moon. The on-board computer is fed with information ready for the ten-second firing of the service module engine. Now come the familier heart-stopping moments when the craft is hidden behind the moon. Then, if the engine fires properly, the explorers will be on their way home. Ahead lie the highly dangerous re-entry operation, and what must surely be the happiest moment in any astronaut's life—splashdown into the ocean.

Superlative – and rightly so

by EDWARD TOWNSEND

DID YOU KNOW that the 12ft.-high Apollo spacecraft contains about 15 miles of wire—enough to complete the wiring of 50 two-bedroom houses?

This is the sort of mind-boggling comparison that can be drawn from nearly every facet of this massive, awe-inspiring project.

The Americans have always been obsessed with superlatives—from the largest building to the largest tomato—and now the Apollo programme has provided the source for a huge mass of quite incredible data.

Most of us are aware by now that the cost of Apollo has run into several thousand million dollars, and that some 400,000 of the best and most highly skilled workers in the United States have been engaged on the project.

Huge fuel tanks

But few realise what a tremendously complex and powerful piece of equipment this enormous amount of effort has produced.

The interior of the fuel tanks on the mighty first stage of the Saturn V rocket, for example, are large enough to accommodate three furniture removal vans—side by side.

And the engines that have already blasted two crews of astronauts to the moon have the combined horse-power of about 550 jet fighters.

The fuel pumps of those engines push out fuel with the force of 30 diesel locomotives, and the rocket generates enough energy to drive a car for 18 million miles.

Each manned American space shot has become increasingly complex, and progressively more demands have been made on the sub-systems of the spacecraft.

Guidance system

Electrical power is a good example of increased system complexity. The power for the Mercury capsule in 1961 was supplied by six batteries; for Gemini in 1965 by seven batteries and two fuel cell power plants; for Apollo it is supplied by five batteries and three fuel cell power plants.

The Apollo craft is also the only American manned space ship to have its own guidance and navigation system.

When the astronauts climb into the command module, which is only a few cubic feet larger than the space in an average car, they are faced with a display panel that includes 24 instruments, 566 switches, 40 event indicators and 71 lights.

The spacecraft itself has 50 engines aboard—16 reaction control engines on both the service and lunar modules, 12 reaction control engines on the command module, the service propulsion engine, the lunar module ascent and descent engines, the launch escape motor, the tower jettison motor, and the pitch control motor.

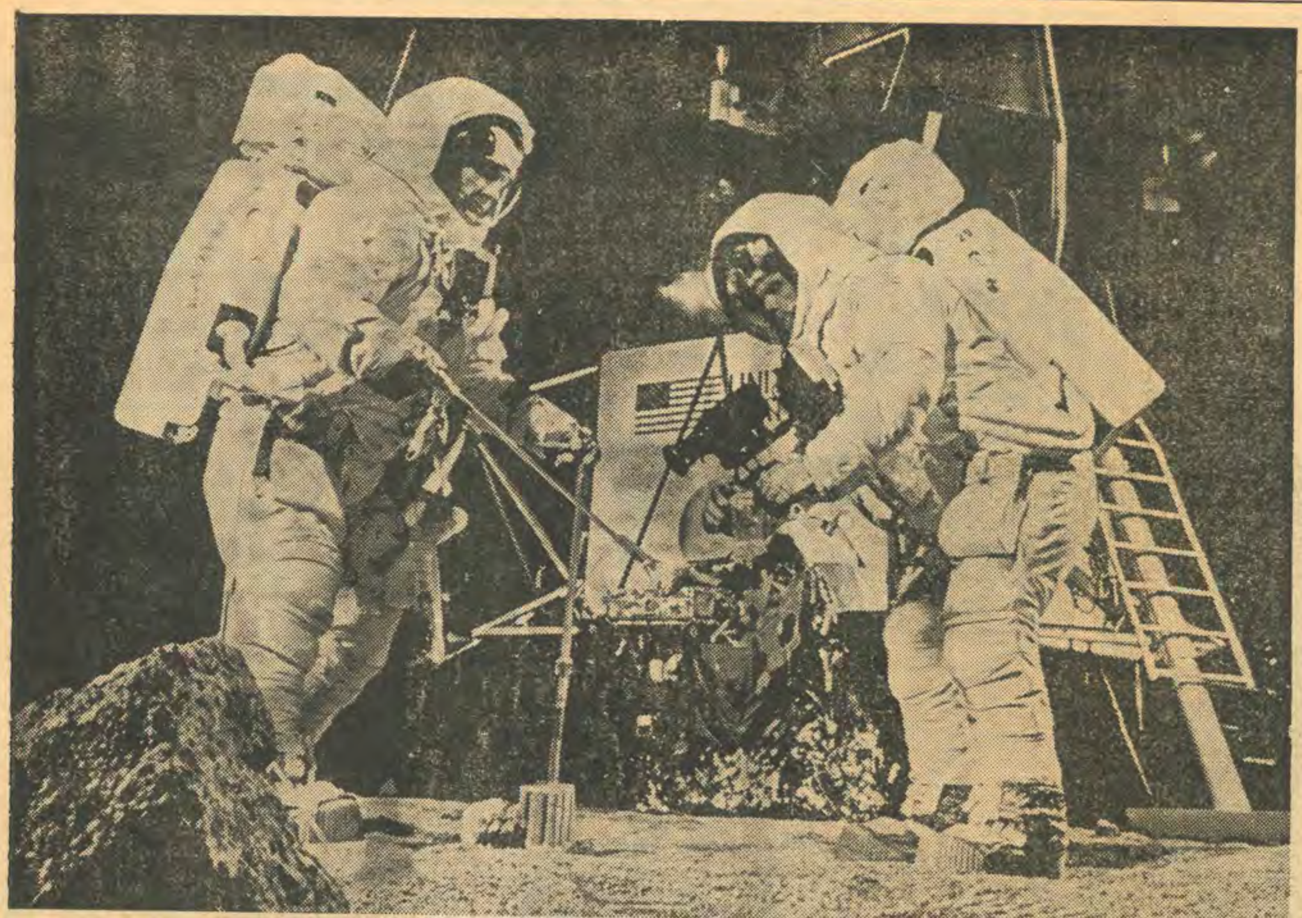
Functional parts

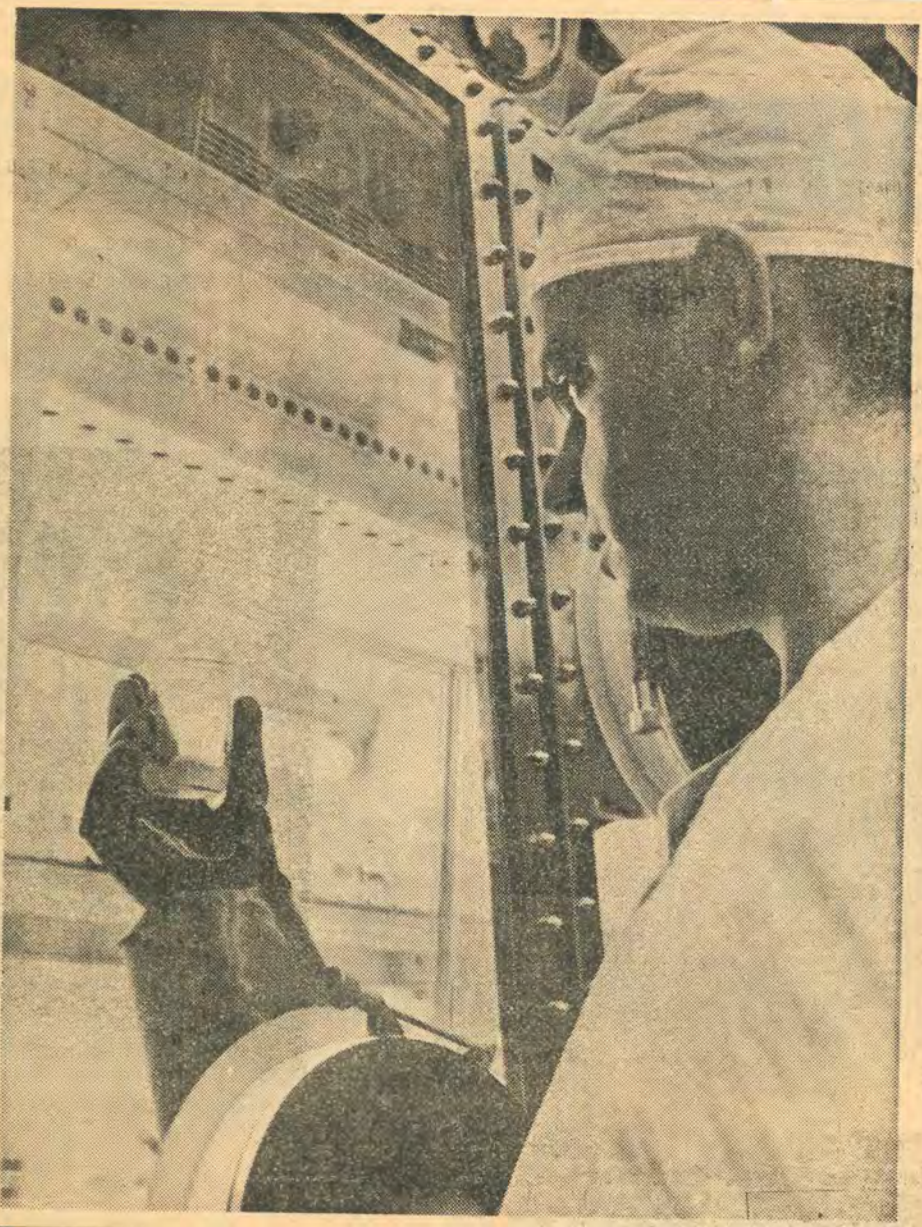
Ultra-cold liquid oxygen and liquid hydrogen on the Apollo craft are contained in tanks that are probably the only leak-free vessels ever built. If a car tyre leaked at the same rate as the tanks it would take 32,400,000 years to go flat.

The tanks in the service module are so well insulated that ice cubes if left inside would take nearly nine years to melt. It would take another four years before the water reached room temperature.

While a car has about 2,000 functional parts, the Apollo spacecraft has nearly two million, not counting wire and skeletal components; the main computer in the command module occupies only one cubic foot.

Finally, the astronauts are probably pleased to know that the chance of their craft being hit by a micrometeoroid during the eight-day flight has been computed as one in 1,230.





ABOVE: Lunar module pilot Edwin Aldrin (on left), uses a scoop to take surface samples, while mission commander Neil Armstrong takes pictures during a practice session at the Manned Spacecraft Centre, Houston. RIGHT: A laboratory technician holds a jar containing plant life which will be used in the comprehensive physical, chemical and biological testing of lunar samples.

What secrets does the moon dust hold?

By Rodney Tibbs

EACH new space exploit has the effect of bringing the moon closer to us, revealing progressively more of its secrets.

Only a few years ago man had never seen the lunar surface with greater clarity than that provided by an astronomical telescope. However good the instrument, the information it can provide is poor alongside a moon-based television camera.

But moon probes have now become highly accomplished instruments which have scraped up bits of lunar material, crushed it, tasted it, dropped weights on it, and even photographed it in colour.

Even so, scientists the world over are simply waiting for the day when man sets foot on the moon, gathers samples of its surface and brings them back to earth.

ANALYSIS

The American programme for putting men on the moon is obviously dedicated to getting them back alive, but assuming that all goes well, the next objective will be filling the 'unar shopping basket.

The spacemen will collect about 112lb. of moon material, and among the 150 or so agenices who have been asked by the Americans to receive pieces of moon for analysis is the Department of Mineralogy and Petrology at Cambridge University.

And Dr. J. D. C. McConnell, head of the electron microscope department, is quite prepared to receive something which might be vastly different from any material on earth.

"It has been subjected to all forms of radiation and bombardment, and this will have brought about changes which we are most anxious to study" he says.

ORGANIC

A variety of techniques will be employed at Cambridge to study the chemistry, mineralogy and microstructure of the lunar material, which will weigh only a few milligrammes.

The scientists will be looking for traces of organic origin which may help to solve the question of whether life has existed on the moon.

This does not necessarily mean observing bits of fossilised life. Modern techniques can now determine molecular structures which could only have come about through the processes of living organism.

It is not the quantity of lunar material which concerns scientists awaiting its arrival, but its freedom from contamination on arrival at the laboratory.

At the Goddard Space Flight Centre in America, a special laboratory is being set up to handle samples for a variety of purposes.

VACUUM

The major difficulty in gathering moon samples lies in the fact that they are being picked up in would be regarded as a complete vacuum.

This means the container in which the samples are carried must not only be able to withstand full atmospheric pressure when it re-enters the earth's asmosphere; it must be opened in as near a perfect vacuum as man is able to create.

Unpacking, measuring out, and sending the lunar material to different laboratories without any form of contamination presents difficult problems. But the Americans hope to have them solved by the time the samples reach earth.

What is the material likely to be when it finally arrives at the Cambridge Department of Mineralogy and Petrology for detailed study?

MOUNTAINOUS

Composition of the moon's surface was specifically studied by the Surveyor 5, 6 and 7 landings, and the results analysed by the United States Geological Survey at Menlo Park, California.

Surveyors 5 and 6 landed in the "seas," Mare Tranquillitatis and Sinus Medii, while Surveyor 7 landed in the foothills of the mountainous region known as the Southern Highlands, close to the crater Tycho.

All these sites were considered for the manned landing, which is why Surveyors were sent there. (Apollo 11 will, in fact, land on a site in Mare Tranquillitatis).

According to Surveyor analysis, not as precise as chemical techniques but nevertheless accurate to within a few per cent. in determining ratios of different elements, it looks as though moon dust is very similar to basalt.

Surveyors 5 and 6 found material closely resembling flood basalts, one of the earth's most common forms of basalt. Surveyor 7 found a similar kind of basalt, but one which contained more aluminium oxides relative to iron oxides.

Thus it seems likely that the lunar seas were covered with volcanic flow materials, and that the surface close to the crater Tycho has been covered by molten rock flung out by meteor impact.

What you expect to find on the moon varies according to your interests.

Some scientists are hoping for water, perhaps buried some feet beneath the surface. Others are expecting to find diamonds, not as a way to riches but simply to support theories about pressures and the origins of material.

Only one thing seems reasonably certain at the moment. The story books were wrong when they said the moon was made of cheese.

A BRITISH INVENTION GIVES APOLLO ITS POWER

IT WAS on August 25, 1959, that I watched a demonstration in Cambridge of the world's first practical fuel cell. It operated a fork-lift truck, a circular saw and electric welding equipment.

Among the spectators was Mr. Francis Bacon, of Little Shelford, Cambridge, the inventor of this revolutionary source of power.

After the demonstration I wrote: "Applications of the fuel cell when it is developed to a higher degree could be numerous. It would have possibilities in rail traction, submarines, aircraft, public service vehicles and, in time, cars.

"The Americans make no secret of the fact that they are interested in the fuel cell as a source of electrical supply for manned space stations. It could also supply auxiliary power for space rockets."

Entire needs

As events turned out, it was the American space programme which exploited the fuel cell, and British industry which showed little interest.

Now fuel cells supply the entire electrical requirements of all American manned space craft, and it would be difficult to visualise an alternative source of power for their computers, television and communications systems, and telemetry systems.

Mr. Bacon's cell was demonstrated in Cambridge as part of a National Research and Development Corporation attempt to get industry interested; there was no such thing as a space programme, and the Russians had yet to put their first, small but electrifying Sputnik in space.

But the Americans acknowledge the importance of the fuel cell idea in space technology, and this year Mr. Bacon was presented with a small gold-plated model fuel cell of the type used in Apollo at a dinner given by American scientists in his honour.

Full time

The principle of the fuel cell was known as far back as 1840. Ludwig Mond and Charles Langer did further work on the principle in 1889, but the practical problems had to wait for Francis Bacon, a direct descendant of the Francis Bacon, to turn his attention to them.

He worked on the cell while at the searchlight reflector department of C. A. Parsons and Co., at Newcastle in 1932. The job with Parsons took him up to 1940, when he then worked on the fuel cell full-time at King's College, London University.

Money was continually short, and time and again various backers pulled out, leaving him with merely his enthusiasm for company. The war then meant that he left the fuel cell to work on submarine problems, but he was able to resume experiments in 1946.

Mr. Bacon, a graduate of Trinity College, returned to Cambridge to continue his work. The National Research and Development Corporation backed him, and a team of people worked on the fuel cell at Marshalls of Cambridge for four years.

Development

The demonstration I saw was designed to interest industry, but it did not really succeed, and for a while it looked as though the fuel cell had proved an abortive invention.

Then along came the American space programme, and Pratt and Whitney developed the cell to a high degree.

But what is now one of the most important features of space power owes its existence directly to the efforts, in the face of indifference and lack of support, of one determined Englishman.

In principle the fuel cell is relatively simple, and is well suited to operation in limited space and in unusual environments.

Briefly it converts chemical energy directly into electrical energy without the intervention of any moving parts.

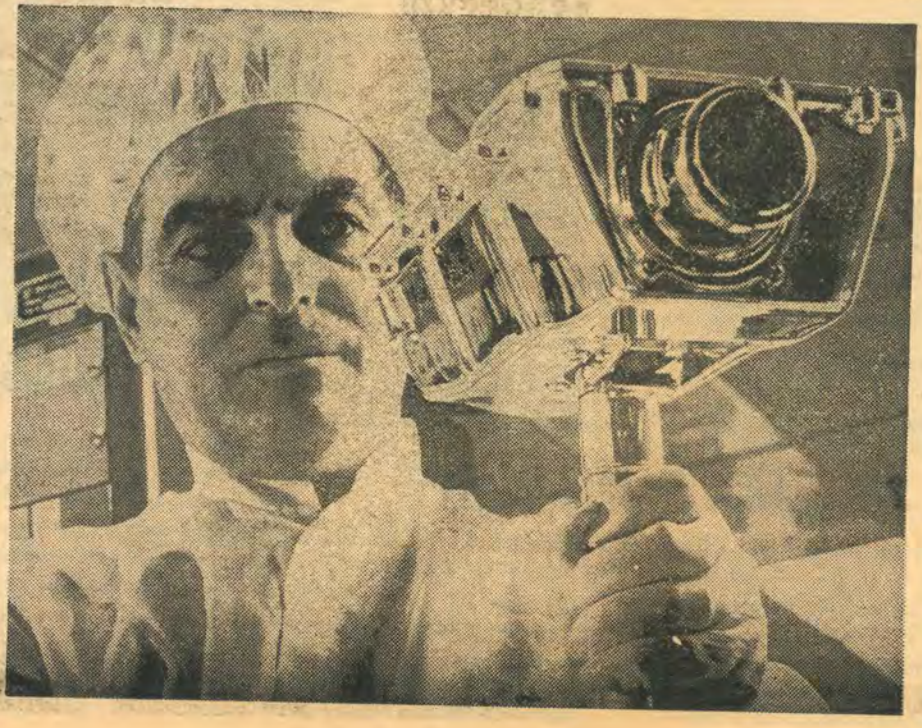
Form of fuel

Each unit of the cell consists of two electrodes immersed in a solution of caustic soda or potash.

Hydrogen and oxygen are introduced into the porous electrodes of the cell as a form of fuel, and as they combine they produce heat and electricity, which appears as a voltage between the electrodes.

What one does with the voltage in space is anybody's guess. When Apollo 7 made its flight, Walter Schirra commented in the high quality of the coffee he had prepared for himself. It was heated by fuel cell power.

Rodney Tibbs



Camera behind the Apollo Show

WHEN men first set foot on the moon, a small, low-power but very sensitive television camera will accompany the astronauts to send live television pictures back to earth.

The camera, developed by the Westinghouse Aerospace Division for NASA's Manned Spacecraft Centre, is itself a miracle of technology.

Hand-held by the astronaut or mounted in the spacecraft, the camera will provide television viewers with coverage of the Apollo 11 mission.

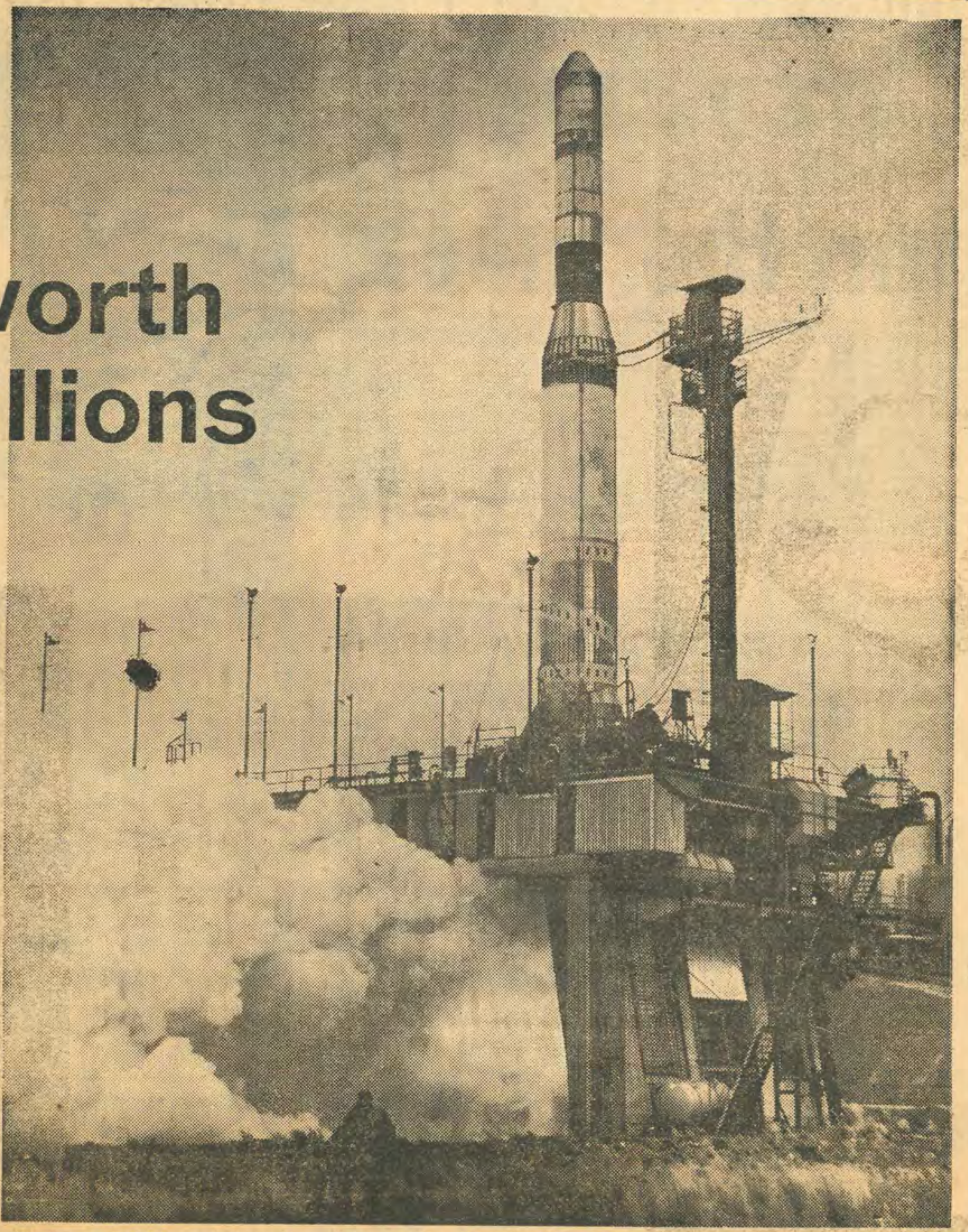
In several respects, the camera is unique among Apollo's electronic equipment; it is one of the few items that must operate under all phases of mission environment—from launch pad to the moon, on the moon's surface, and back to earth.

The main mission of the camera is to provide live television pictures of all phases of the Apollo mission. A secondary mode of camera operation will provide high-resolution, slow-scan pictures for detailed scientific viewing.

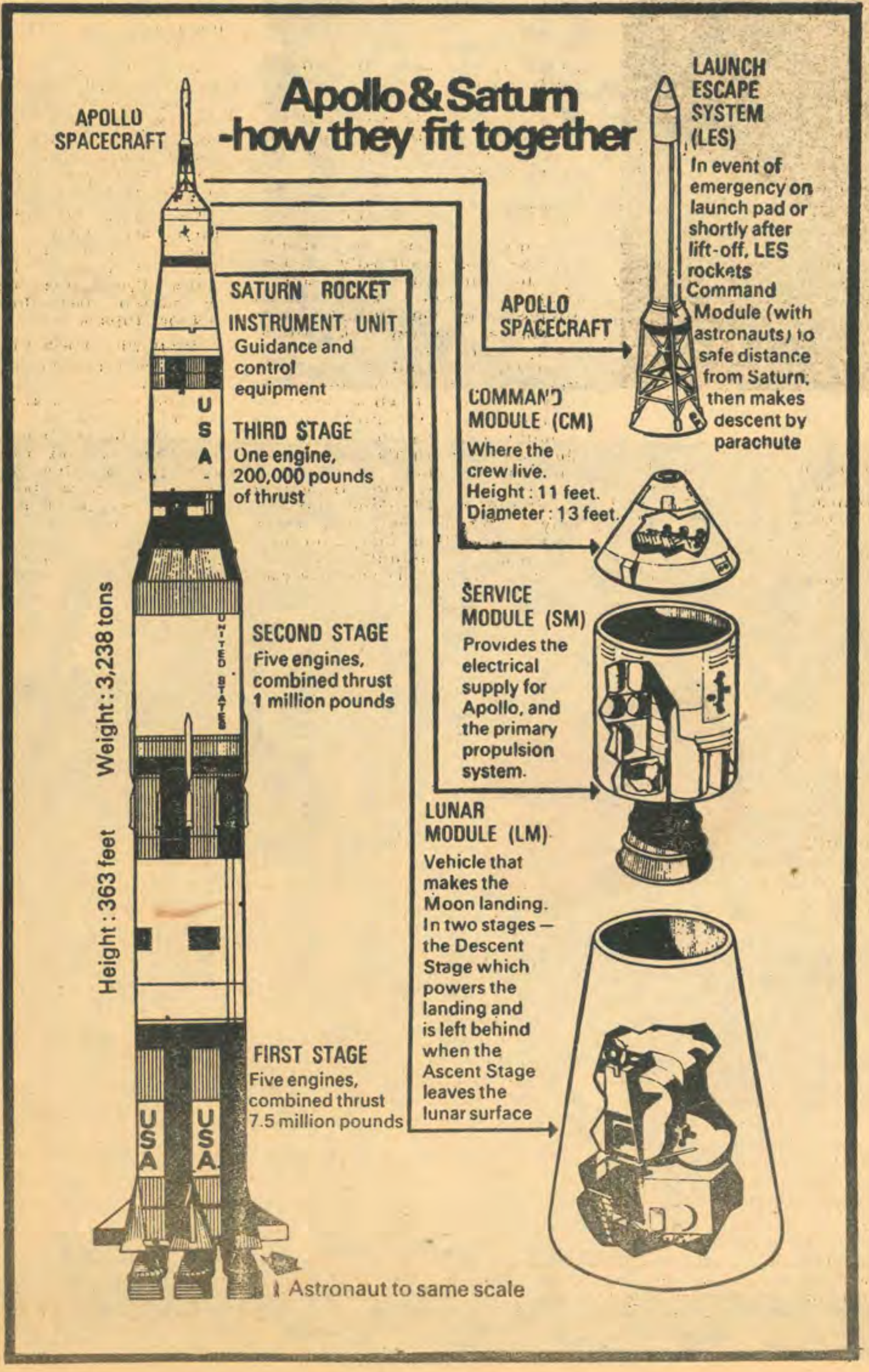
'There is no doubt in my mind that the tremendous challenge of space produces long-term benefits to society as a whole.'

'If man has the means to explore the solar system, is it not right that he should do so, as he has already explored his own planet?'

Why it is worth spending millions on space



Rockets—British and American. Above: Blue Streak the British contribution to the ELDO rocket, powered by Rolls-Royce engines. This month it performed perfectly for the ninth successive time . . . an impressive feat even by the standards of international rocketry. Below: A diagram showing how the world's most powerful rocket, Saturn V and the Apollo spacecraft are integrated



By
A. V. CLEAVER
Director and general manager of the Rocket Department at Rolls-Royce Industrial and Marine Division, Ansty, Coventry.

THE ORIGINS of space flight (or astronautics) lie many centuries in the past. Man has dreamed of travel to other worlds ever since he realised that some of the pin-points of light in the night sky were planets like his native Earth.

At about the turn of the century, it became clear that the dream might be made to come true. Pioneer scientists had seen that rocket propulsion would be even more effective in the vacuum of outer space than it is within the atmosphere, so that there actually existed a practical means of driving vehicles from the Earth to the moon, or even further afield.

Now, within days, this tremendous achievement seems likely to be realised.

The amazing success of the Apollo 7, 8, 9 and 10 missions promises well for the chances of Apollo 11 — though it must never be forgotten that Armstrong, Aldrin and Collins will still be facing large and unknown risks, and that things can still go wrong.

However, even if they fail in the attempt, it would be their wish that their colleagues should try again, and we can be sure that ultimate success would not be long delayed.

V2 rocket

When the first wartime V2 rocket was flown from Peenemunde — developed by Dr. Wernher von Braun who is responsible for Apollo's Saturn V launching rocket — it is recorded that the German General Dornberger exclaimed: "Today the spaceship is born!"

In 1957, there followed the first Russian artificial satellite, maintaining itself in orbit around the Earth by reason of the circular velocity of 18,000 m.p.h. imparted to it by its launching rocket. Only four years later Gagarin made the first manned orbital flight, with the American Colonel Glenn soon following.

It is a sobering thought that now, only 12 years after the first Sputnik, the Americans seem likely to win the next round of the space race by actually landing men on the moon.

Let no one imagine, however, that the Russians have retired from the race; in the intervening years their unmanned space probes, like the Americans', have flown to the moon, Mars and Venus, and it is very likely that we shall shortly be witnessing some further spectacular performances by cosmonauts as well as astronauts.

'Stations'

The rest of this century will, in all probability, see the establishment of large manned space stations around the Earth, the small-scale colonisation (with scientific settlements) of the moon, and the first manned expeditions to Mars.

Re-usable launching vehicles will be developed, in place of the huge expendable monsters now employed. Burning chemical propellants (such as kerosene or liquid hydrogen with liquid oxygen) they need to be as large as the 3,000 tons of Saturn V in order to achieve the 25,000 m.p.h. escape velocity from the Earth, send less than a ton of true payload to the moon and bring it back safely

Future space vehicles will employ nuclear power, with reactors heating their rocket jets of pure hydrogen, or else (in deep space) electrical rocket propulsion systems of low thrust but high efficiency.

Costly

How much of this comes to pass, and how soon, depends more on the continued willingness of mankind to expend the necessary effort, and hard cash, than it does on the technical problems involved. These are extremely difficult, but we can already be sure that they can be overcome

However, space flight is a very costly business. The Americans are spending a total of more than £2,000m. annually on all its aspects: the whole Apollo programme has cost about £10,000m. and at its peak the annual total expenditure on space in the U.S.A. was nearer £3,000m.

It is believed that the Russian effort is at least as great as the American, and even Europe now spends about £150m. every year—of which the British share is some 15 per cent.

The French and German space programmes are already significantly greater than ours, and soon this will also be true of the Japanese.

Perspective

These figures are so huge that to most of us they become almost meaningless. Perhaps they can be reduced to a correct perspective by pointing out that they are much smaller than those spent by the same countries on armaments.

The Apollo programme has cost vastly more than the Vietnam war, has benefitted more people and harmed far fewer.

It has also, incidentally, cost very much less than the expenditure over the same period by American women on cosmetics and beauty culture, or by Americans of both sexes on alcoholic drinks or on smoking. So it is unlikely to bankrupt the U.S.A.!

Even so, many people would argue that it is not justifiable to spend these great sums on space science and technology One hears the suggestion that the money ought, instead, to be spent on social welfare, on aid to under-developed countries, or on medical research, and so on.

The first answer to these objections is perhaps cynical, but is none the less true. It would not be!

Secondly, however, it is true that it could not be.

The same amount of money, the same skills of the same people, could not be directly and easily transferred to these other activities. And it is doubtful whether, for example, American social welfare could in practice be aided in any better way than by the large-scale employment which is afforded by the space programme.

Benefits

There are, of course, other answers to those who object to the space programmes. There is no doubt in my mind, or in those of most of my technological colleagues, that the tremendous challenge of space (like that of aviation in the past) produces long-term benefits to society as a whole.

It stimulates general progress in materials, invention and techniques. These improvements, eventually and gradually, find applications throughout industry. So also will the new discoveries made in pure space research.

Worthwhile

A further reason — and perhaps the most cogent of all — is concerned with a more direct example of such technological "fall-out" or "spin-off." It might be said that the spaceship is itself a child of the military ballistic rocket, as Dornberger observed.

I believe, as a philosophical conviction, that it is worthwhile in itself; if man now has the means to begin to explore the Solar System, is it not right that he should do so as he has already explored his own planet?

However, whatever one believes about this, there can surely be no doubt about the value of another aspect of space flight.

The ballistic rocket, and the spaceship, have had other children which are already hard at work earning their keep for the immediate and practical benefit of mankind.

When you watch the Apollo 11 mission on your TV screens, it will be by courtesy of telecommunication satellites, which also carry a high proportion of the world's long-distance telephone traffic.

Less glamorous

Other satellites are beginning to help with weather-forecasting and with the survey of the Earth's resources, for mineral-prospecting, surveillance of crop and forest health, movements of shoals of fish, silting of river estuaries, and so on.

Yet others are providing navigational aids for ships and soon will perform a similar function for air traffic control.

Their military counterparts give invaluable reconnaissance data which, on any realistic view, is an aid to maintaining the precarious balance of peace in the world.

These close-Earth orbit applications of space technology are the other, perhaps less glamorous but more practical and commercial, aspect of space. Within a decade or so they will begin to be greatly augmentd by the first large manned space stations.

The relatively modest European space effort (including the British) is almost entirely devoted to these shorter-term aspects of space and not to the more spectacular one of putting men in the moon, which immediately springs to mind for most people when "space" is mentioned.

Contribution

Following the merger of Rolls-Royce and Bristol Siddeley in 1967, a significant contribution to the British programmes has been made in the Coventry area. Since that time the headquarters of all Rolls-Royce rocket engine activities has been based at Ansty.

Even before then the reliable engines of Black Knight were developed on this site, as now are those for both the first and second stages of Black Arrow.

Black Arrow is the small British national satellite launch vehicle, but Rolls-Royce RZ2 rocket engines are also used in the Blue Streak first stage of the larger European (ELDO) vehicle Europa.

Much learned

The prototype Black Arrow was launched for the first time from Woomera on June 28. It unfortunately went out of control during the first minute of its flight and had to be destroyed, but much will be learned from the trial.

Trials are indeed conducted for this very purpose, and all other countries engaged in rocketry have known similar early disappointments and failures.

On July 3 the ninth ELDO vehicle was also launched from Woomera and much the same observation applies, since on this trial there was a failure of the German third stage.

However, Blue Streak and its Rolls-Royce engines again performed perfectly, for the ninth successive time.

Three men for the moon

THREE highly-skilled fighter pilots — men who have faced extreme danger in war and peace — have been selected for Apollo 11, the climax and the most hazardous part of the ten-year race to the moon.

All three were born within a few months of each other 38 years ago; they all married, with several children. For the last six years they have been undergoing intensive astronaut training for the nine-day mission.

★ ★

NEIL ARMSTRONG (left) mission commander will be the first man to set foot on the moon. He is the only civilian of the three, but was a pilot in the U.S. Navy during the Korean War and flew 78 combat missions.

Armstrong joined N.A.S.A. in 1955 as a research pilot, and flight-tested the X15 rocket plane. This was launched from a bomber's wing, and took him to a height of 40 miles and a speed of 4,000 m.p.h.

He has experience of space flight as commander of the Gemini 8 mission in March, 1966, when the first space-docking with a target vehicle was performed.

★ ★

MICHAEL COLLINS (centre) is command module pilot, and will remain in the orbiting C.M. while his fellow astronauts descend to the moon. It will be his task to go down and help the lunar module if things go wrong.

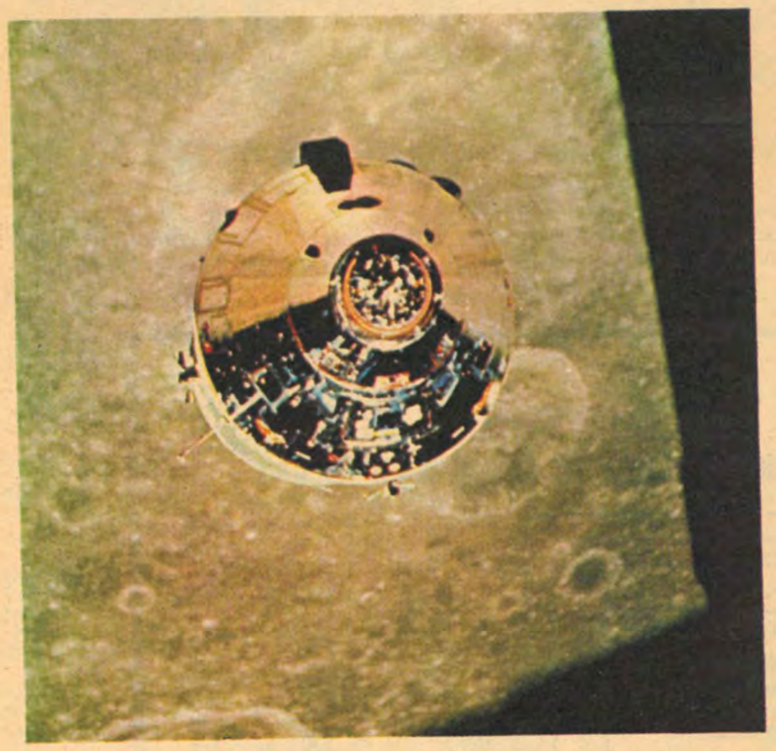
Collins is an Air Force lieutenant-colonel, and was a test pilot in jet fighters. His one previous space flight was in the Gemini 10 craft in July, 1966, when he became the first man in space to cross to another vehicle, and Agena rocket.

★ ★

EDWIN ALDRIN (right) is the lunar module pilot, who must perform the tricky job of guiding the strange craft to the moon's surface and back. Twenty-five minutes after Armstrong has stepped out on to the moon, Aldrin will follow.

A thesis on orbital rendezvous techniques won him a doctorate at the Massachusetts Institute of Technology. As well as being a scientist he is an Air Force colonel, with 66 Korean War combat missions.

Aldrin has spent more hours in space than the other two put together. He flew with James Lovell on the four-day Gemini 12 flight in November, 1966, and on his trips outside the space craft he "walked" round the world three times!



Heading for a lunar landing...

AFTER several moon orbits and painstaking preparations, the command and lunar modules will say "au revoir" to each other 50 miles above the lunar surface.

Armstrong and Aldrin will then carefully coax their ungainly, fragile and noisy moon taxi into a new chapter of space exploration.

Before the descent they will take their last look for 24 hours at the mother ship (left) as it remains patiently in orbit, the sun glinting off its highly polished nose.

Snug in his soft command module couch, Collins will also be watching — no doubt with a prayer on his lips — as his comrades call in on the moon.

He will see reflections (right) as sunlight glints on the L.M.'s spidery legs — thin pieces of metal that would buckle if the craft was landed on earth.

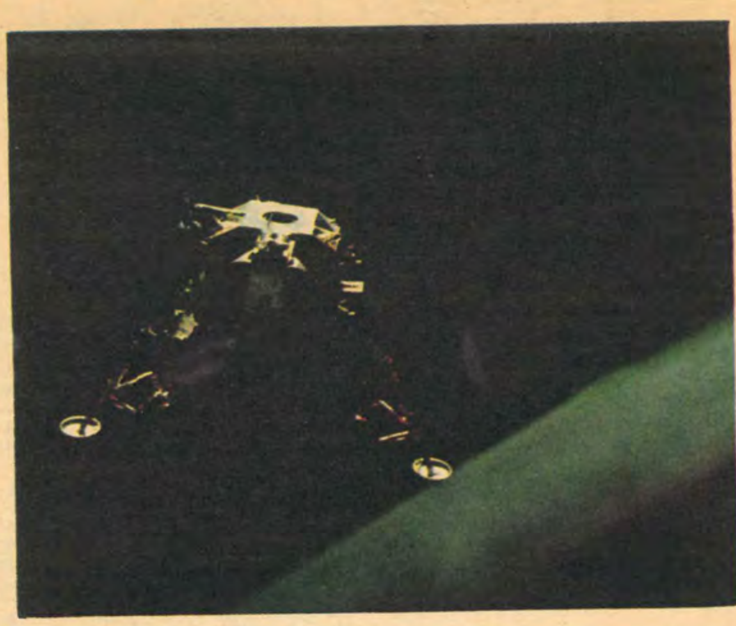
This unique craft, is, in fact, the first to be built for use exclusively in space.

Since it was first dreamed of —and ridiculed — eight years ago, designers have cut down everything to produce the lightest possible lunar landing ship. In its final version it weighs 16 tons.

★ ★

A quarter of a million miles away the world will be waiting breathlessly as the L.M. descends. The aspirations of centuries will be close to being fulfilled, yet there is another nerve-wracking hour before what everyone hopes will be a successful touchdown.

These pictures were taken by the crew of the near-perfect Apollo 10 mission during the lunar landing rehearsal. The success of that operation cleared the way for the final assault on the moon.



...and for splashdown

NOW nearing the end of the return journey, only the small command module remains. Reaction control engines have been fired to turn it round so that the blunt end and heat shield are facing earth's atmosphere.

At 25,000 m.p.h. the little cone-shaped nerve-centre of the Apollo flights re-enters. At 24,000ft., after two "rolls" through the sky and a reduction in speed to 300 m.p.h., a drogue parachute deploys. At 10,000ft. the three main parachutes blossom from the craft, steadying it and dropping it into the Pacific at a speed of 24ft. per second.

Apollo 11 splashdown is due at 5.51 p.m. B.S.T. on Thursday, July 24, and what lies in store for the astronauts after that is unique in space travel.

Frogmen, dropped from helicopters to attach the inflatable collar round the craft, will provide the astronauts with biological isolation garments which they will wear until they are encased in a quarantine trailer on the recovery ship.

The Americans are taking no chances on the earth being contaminated with unknown bacteria brought back from the moon. For 21 days the moon explorers will stay in isolation, watched closely by doctors and scientists until they are satisfied there have been no ill effects.

★ ★

Splashdown itself is a marvel the world has shared on successive Apollo flights. Those of us who saw on television the Apollo 10 craft drifting out of a pre-dawn Pacific sky were amazed at the accuracy with which the recovery ship pinpointed the spot.

Across the few thousand yards of water, the astronauts joked that they were on target—it was the ship that was off-course.

We will be waiting again on the evening of July 24 for the home-coming of Armstrong, Aldrin and Collins. They will be at the end of a journey that marks a beginning of new adventure, new achievements and new dreams.

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