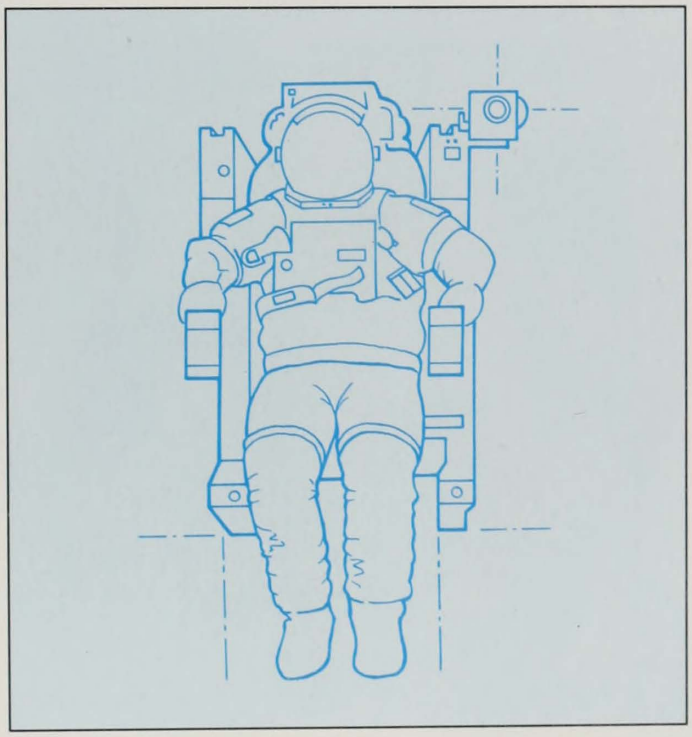
A DORLING KINDERSLEY BOOK

LOOK INSIDE CROSS-SECTIONS SPACE

SEE INSIDE 12 FASCINATING SPACECRAFT

Sean Corbett

LOOK INSIDE CROSS-SECTIONS SPACE



LOOK INSIDE CROSS-SECTIONS

SPACE

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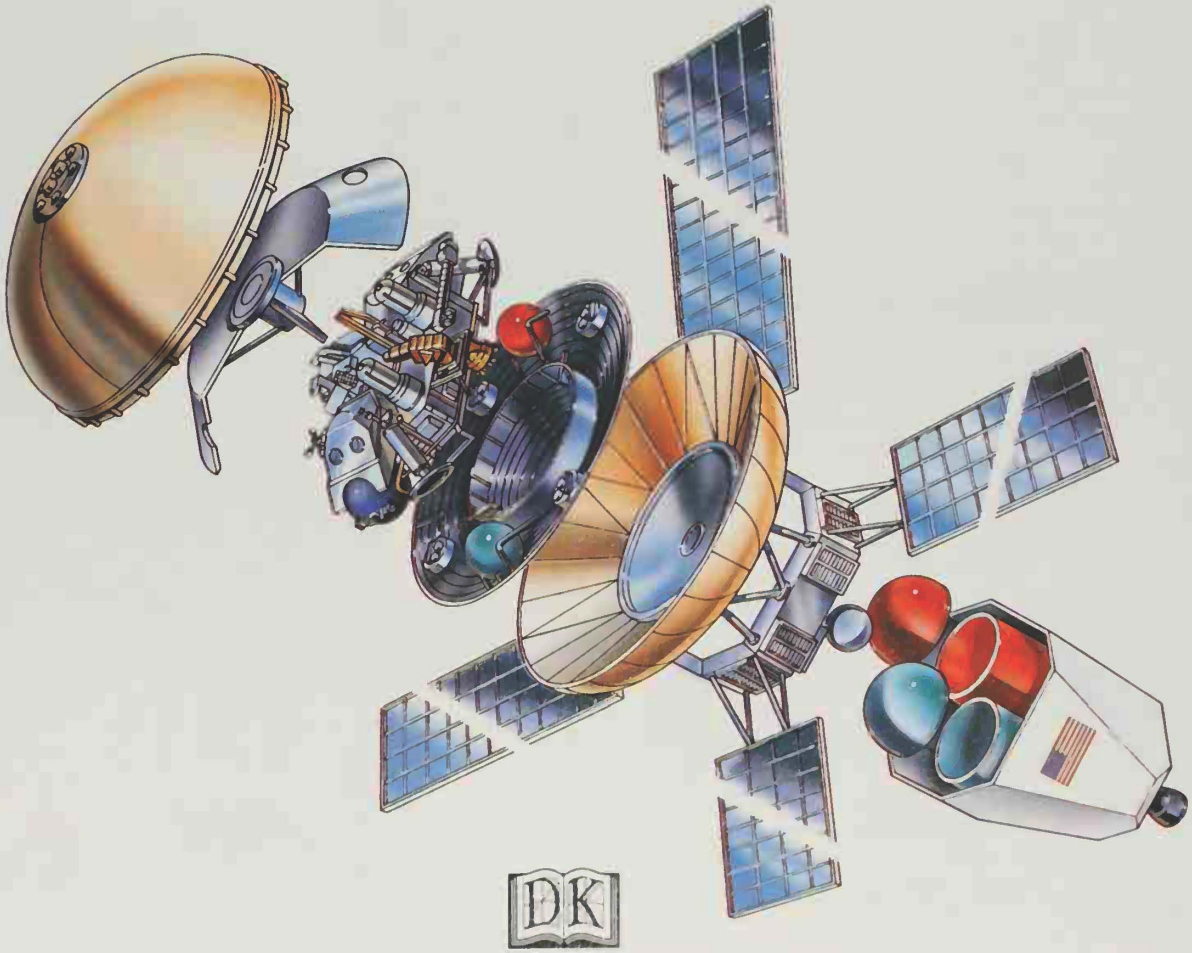

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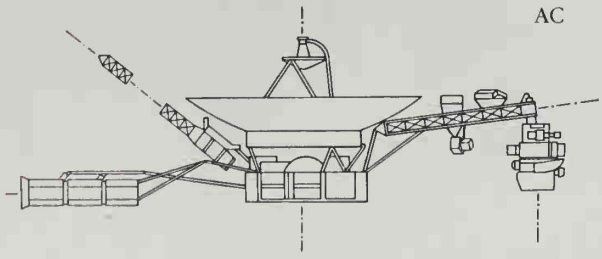

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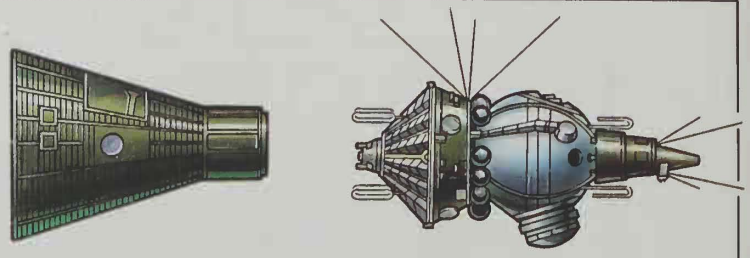
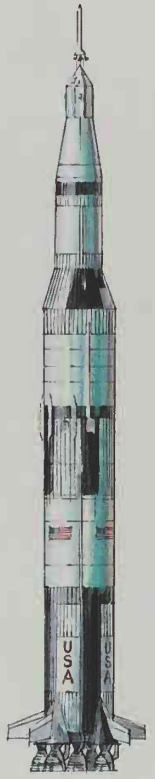
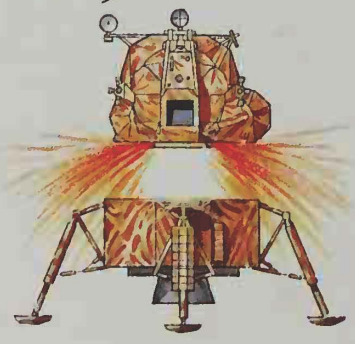
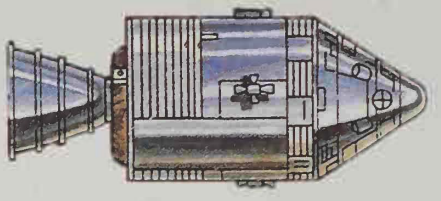
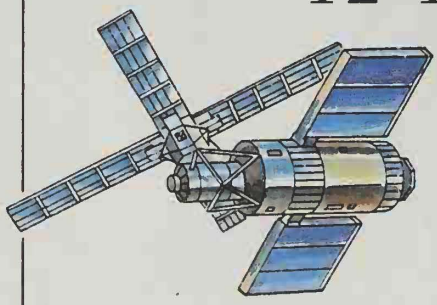
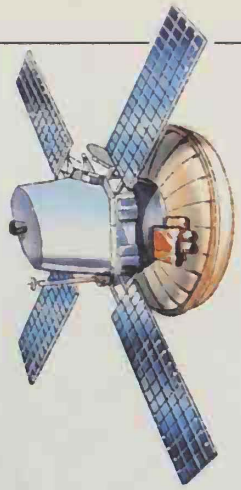


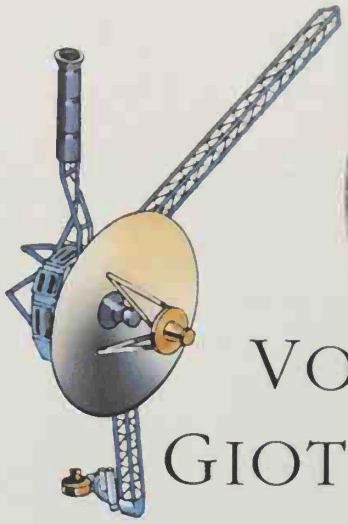


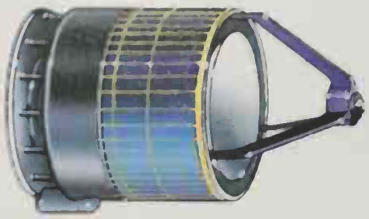


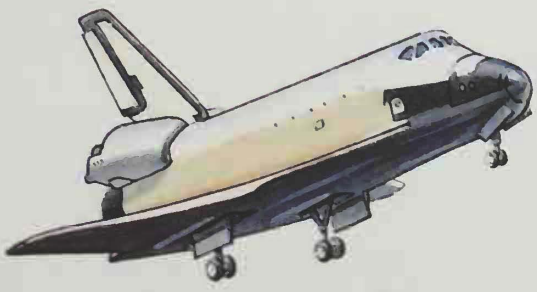


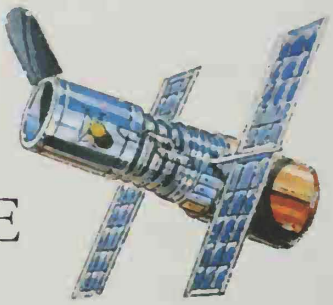


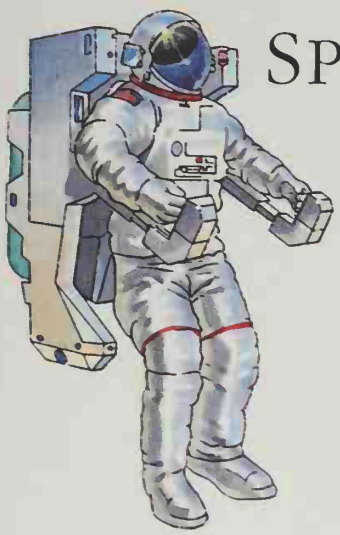


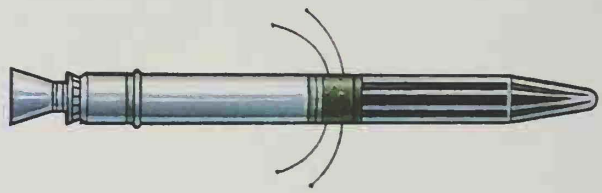


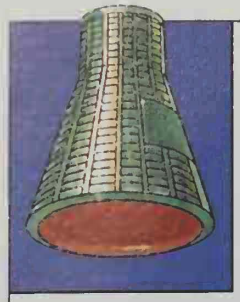












MERCURY

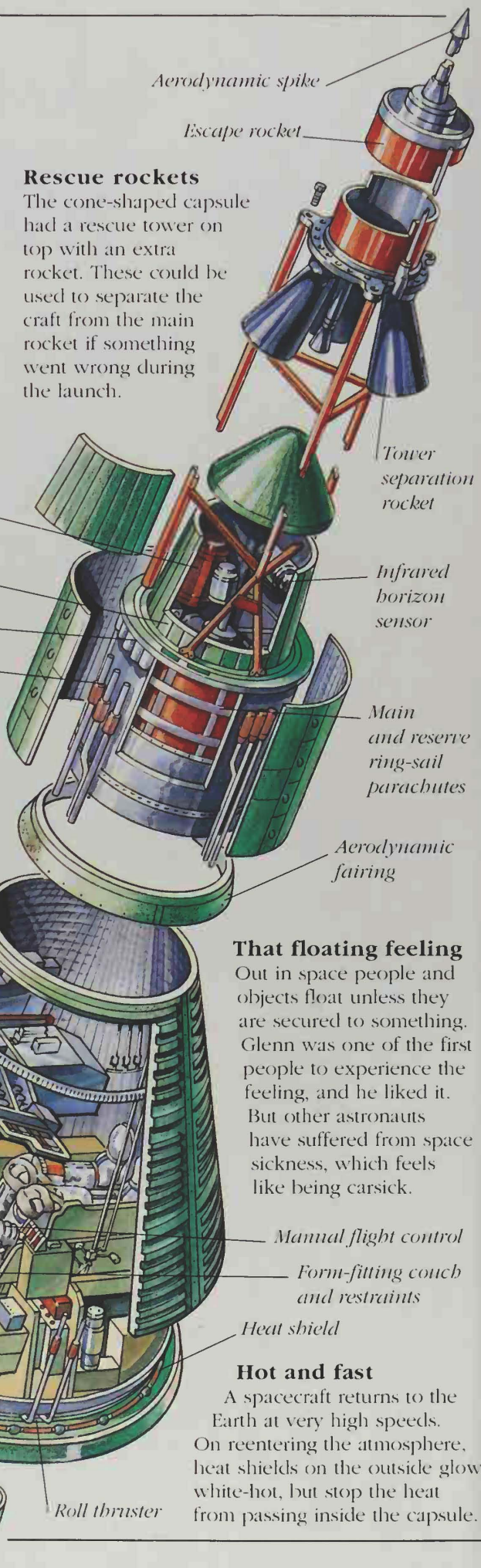
ON OCTOBER 4, 1957, THE USSR launched the world's first satellite, called *Sputnik 1*. As this small aluminum sphere hurtled through space, it set off what was to be known as the "Space Race," with scientists in the USSR and the US competing to achieve supremacy in space. On February 20, 1962, the Americans put their first astronaut ("star sailor") into orbit in the Mercury spacecraft *Friendship 7*. His name was John Glenn and he became a national hero after he orbited the Earth three times in a trip lasting five hours.

Liftoff

A spacecraft must blast off at high speed or it will be pulled back to the Earth by gravity. *Friendship* was launched on top of a big rocket. Once the rocket had boosted it up, the manned capsule separated away and the rocket fell back toward the Earth.

Rescue rockets

The cone-shaped capsule had a rescue tower on top with an extra rocket. These could be used to separate the craft from the main rocket if something went wrong during the launch.



Under pressure

Around the Earth there is a layer of air called the atmosphere that pushes down on us. We need this pressure; without it, our lungs wouldn't work. Out in space, pressure has to be provided artificially. John Glenn's capsule was pressurized using pure oxygen.

That floating feeling

Out in space people and objects float unless they are secured to something. Glenn was one of the first people to experience the feeling, and he liked it. But other astronauts have suffered from space sickness, which feels like being carsick.

Hot and fast

A spacecraft returns to the Earth at very high speeds. On reentering the atmosphere, heat shields on the outside glow white-hot, but stop the heat from passing inside the capsule.

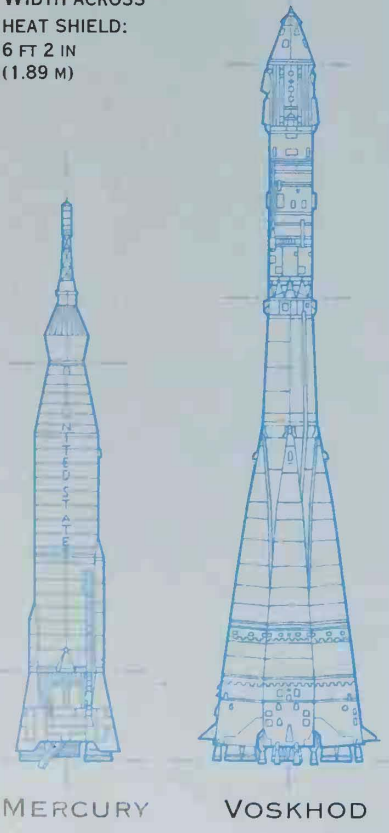
TECHNICAL DATA

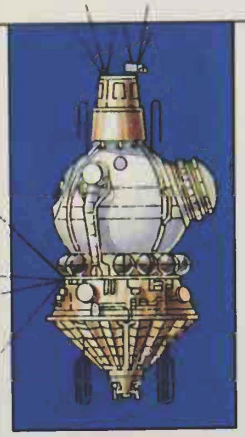
HEIGHT (INCLUDING TOWER): 26 FT (7.9 M)

HEIGHT (INCLUDING SPACECRAFT): 125 FT 10 IN (38.4 M)

DIAMETER: 90 FT 6 IN (23 M)

WIDTH ACROSS HEAT SHIELD: 6 FT 2 IN (1.89 M)





VOSKHOD 2

THE USSR WON THE RACE to put a human into orbit on April 12, 1961, when they sent cosmonaut ("sailor of the cosmos") Yuri Gagarin into space in a Vostok spacecraft. Later versions of that craft were called Voskhods. This picture shows *Voskhod 2*, launched in 1965. One of its crew, Alexei Leonov, made the first-ever walk in space on March 18, 1965.

Top and bottom
Voskhods were built in two parts. The cosmonauts sat in the top module. This was attached by metal straps to an equipment module. On the return trip, the equipment module was jettisoned and only the manned module landed.

Are you there?
There were two cosmonauts inside *Voskhod 2*. They kept in touch with their base on Earth via communications antennae on the outside of their craft. All spacecraft have antennae that receive and send radio signals.

A walk above the world
Leonov put on a pressurized space suit inside the craft. He then went into a foldout air lock, a tunnel with an inner and outer door. He shut the inner door to keep air from escaping, then opened the outer door and stepped out. He tumbled around for 12 minutes, attached to his spacecraft by a tether. When he came back, he found it difficult to squeeze into the air lock because his suit had expanded.

Television camera
Communications antenna
Reserve retropack
Heat shield
Inflatable air lock
Portable motion picture camera
Porthole
Fixed seat
Air lock inflated
Tether 17 ft (5 m) long
Oxygen tank
Nitrogen/ oxygen tank to supply life-support systems
Pressurized space suit
Tension strap (holds two parts of craft together)
Communications antenna
Equipment module
Communications antenna
Retro-rocket

SATURN V

"FIVE, FOUR, THREE, TWO, ONE — We have liftoff!" At the end of a launchpad countdown like this, the roar of giant engines fills the sky and huge engine nozzles spit columns of white-hot flames and gas, pushing an entire rocket upward. Between 1968 and 1972, giant *Saturn V* rockets carried the American Apollo manned missions toward the Moon. The noise of a Saturn launch sounded like a volcano erupting. A *Saturn V* took *Apollo 11* into space on July 16, 1969. Four days later, two of the crew members made history when they became the first humans to walk on the Moon.

Inside the engines
Inside a rocket there are separate tanks of liquid fuel and liquid oxygen, powerful propellants. They are pumped into a combustion chamber inside each engine. There they are mixed and set on fire, producing the hot gases needed to propel the rocket.

STAGE 1 (S-IC)
F-1 ENGINE

Main engine nozzle

F-1 engine assembly

Stage 2 (S-II) (5 X J-2) engines

Many missions
Saturn V rockets were the biggest and most powerful launchers ever built. They were used 13 times altogether, including 10 manned missions.

Stage 1 (S-IC) liquid oxygen tank

Stage 1 (S-IC) (5 X F-1) main engines

Engine nozzle fairing

Rocket casing

Stage 2 (S-II) liquid fuel tank containing liquid hydrogen

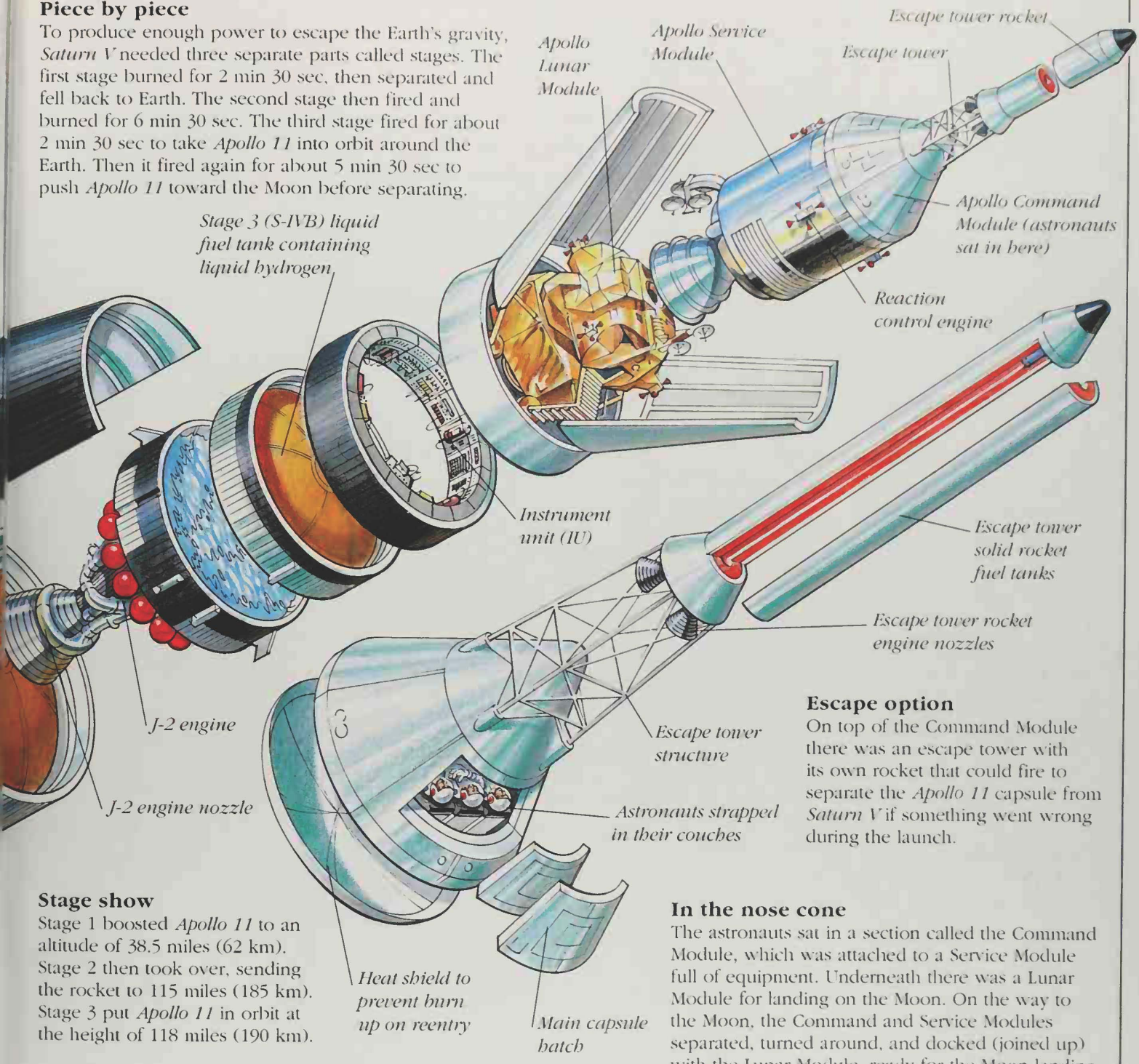
Stage 1 (S-IC) liquid fuel tank containing kerosene (paraffin)

Aerodynamic fin

Rocket basics
If you blow up a balloon and then let it go, the air rushes backward out of the neck and pushes the balloon forward. Rockets work in just the same way. Inside the rocket engines, gases are made by burning fuel. The gases rush backward out of the engine nozzles, pushing the rocket forward.

Piece by piece

To produce enough power to escape the Earth's gravity, *Saturn V* needed three separate parts called stages. The first stage burned for 2 min 30 sec, then separated and fell back to Earth. The second stage then fired and burned for 6 min 30 sec. The third stage fired for about 2 min 30 sec to take *Apollo 11* into orbit around the Earth. Then it fired again for about 5 min 30 sec to push *Apollo 11* toward the Moon before separating.



Escape option

On top of the Command Module there was an escape tower with its own rocket that could fire to separate the *Apollo 11* capsule from *Saturn V* if something went wrong during the launch.

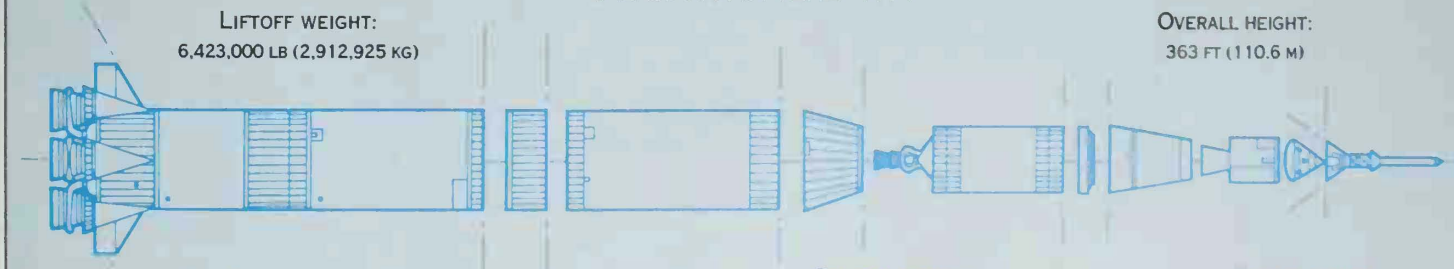
Stage show

Stage 1 boosted *Apollo 11* to an altitude of 38.5 miles (62 km). Stage 2 then took over, sending the rocket to 115 miles (185 km). Stage 3 put *Apollo 11* in orbit at the height of 118 miles (190 km).

In the nose cone

The astronauts sat in a section called the Command Module, which was attached to a Service Module full of equipment. Underneath there was a Lunar Module for landing on the Moon. On the way to the Moon, the Command and Service Modules separated, turned around, and docked (joined up) with the Lunar Module, ready for the Moon landing.

TECHNICAL DATA



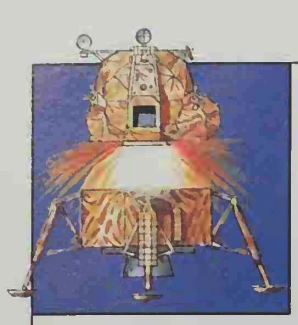
LIFTOFF WEIGHT:
6,423,000 LB (2,912,925 KG)

OVERALL HEIGHT:
363 FT (110.6 M)

F-1 ENGINE NOZZLE:
19 FT (5.79 M) TALL, 12 FT 6 IN (3.81 M) WIDE

STAGE 1 LENGTH:
137 FT 8 IN (42 M)

ESCAPE TOWER:
33 FT 5 IN (10.2 M) LONG



APOLLO LM

NASA HAD LAUNCHED A SERIES OF manned Apollo test flights, gradually taking astronauts closer to the Moon. Finally, on *Apollo 11*, astronauts were ready to land on the Moon's surface! As *Apollo 11* went into lunar orbit, two members of the crew, Edwin "Buzz" Aldrin and Neil Armstrong, crawled into the Lunar Module (LM for short). The module, code-named "Eagle," separated from the Command and Service Module and dropped down to the Moon, using rockets and radar to guide it. The astronauts depressurized the cabin and checked their equipment. Then, on July 20, 1969, Armstrong opened a hatch, left the module, and took the first step on the Moon's surface.

Space bug
The Lunar Module had a strange insectlike shape. But because it operated only in space, where there is no air, its designers didn't need to worry about giving it a streamlined shape.

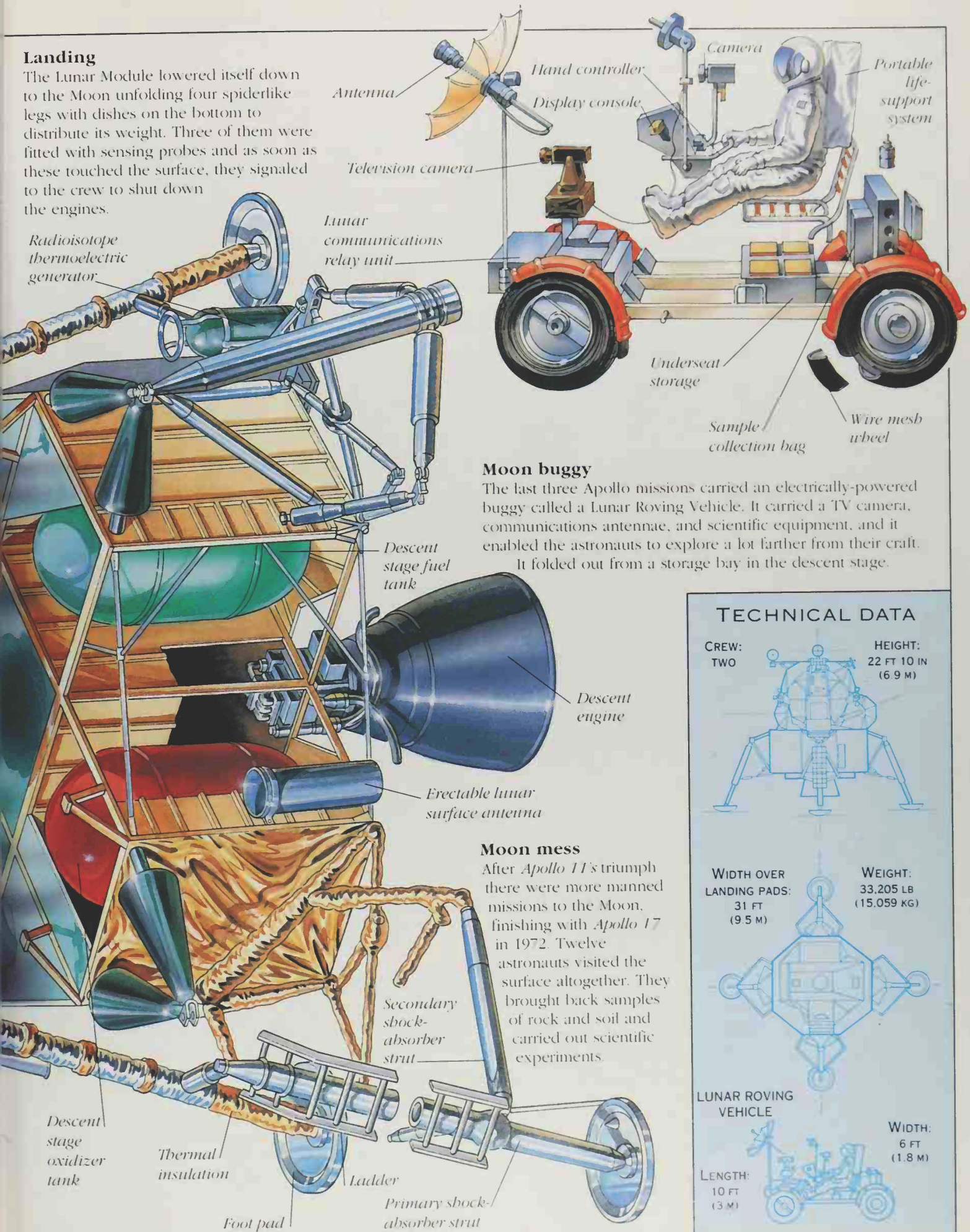
Reaction control system fuel
Reaction control system oxidizer
Docking hatch
VHF antenna
Relay box
Ascent fuel tank
Reaction control system pressurant
Ascent engine
Portable life-support system
Entry/Exit platform and rails
Entry hatch
Rendezvous radar
Steerable antenna
Pilot's console
Reaction control system thruster

Room inside
Inside the pressurized cabin there were computer consoles, viewing windows, and supplies. When the crew went out, they had to carefully monitor the controls of their bulky space suits. If they ran out of oxygen, water, or any other supply, they would see warning lights and return to the cabin. The *Apollo 11* astronauts spent 2 1/2 hours on the surface of the Moon before returning to the LM cabin.

Taking off again
The "descent stage," the bottom section with the legs, served as a launchpad for the "ascent stage" when it was time to leave the Moon. It was left on the surface as the ascent stage flew up to dock with the Command and Service Modules. Once the crew were safely back in the Command Module, the ascent stage was also jettisoned.

Landing

The Lunar Module lowered itself down to the Moon unfolding four spiderlike legs with dishes on the bottom to distribute its weight. Three of them were fitted with sensing probes and as soon as these touched the surface, they signaled to the crew to shut down the engines.



Moon buggy

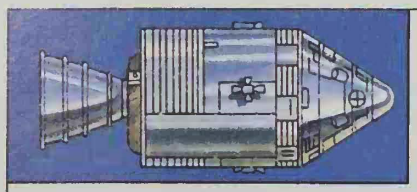
The last three Apollo missions carried an electrically-powered buggy called a Lunar Roving Vehicle. It carried a TV camera, communications antennae, and scientific equipment, and it enabled the astronauts to explore a lot farther from their craft.

It folded out from a storage bay in the descent stage.

Moon mess

After *Apollo 11's* triumph there were more manned missions to the Moon, finishing with *Apollo 17* in 1972. Twelve astronauts visited the surface altogether. They brought back samples of rock and soil and carried out scientific experiments.

TECHNICAL DATA



APOLLO CSM

WHILE TWO *APOLLO 11* CREWMEN were busy on the lunar surface, another, Michael Collins, stayed in the Command and Service Modules (CSM for short), orbiting around the Moon. When their work was finished, the Moon-walking pair blasted off in the ascent stage of the Lunar Module. They docked with the CSM and crawled through a hatch into the cabin. The Lunar Module was jettisoned and then it was time to head for home.

Keeping in touch
NASA personnel at the Mission Control Center in Houston, Texas, kept in contact with the astronauts and monitored the workings of *Apollo 11*.

S-band antenna

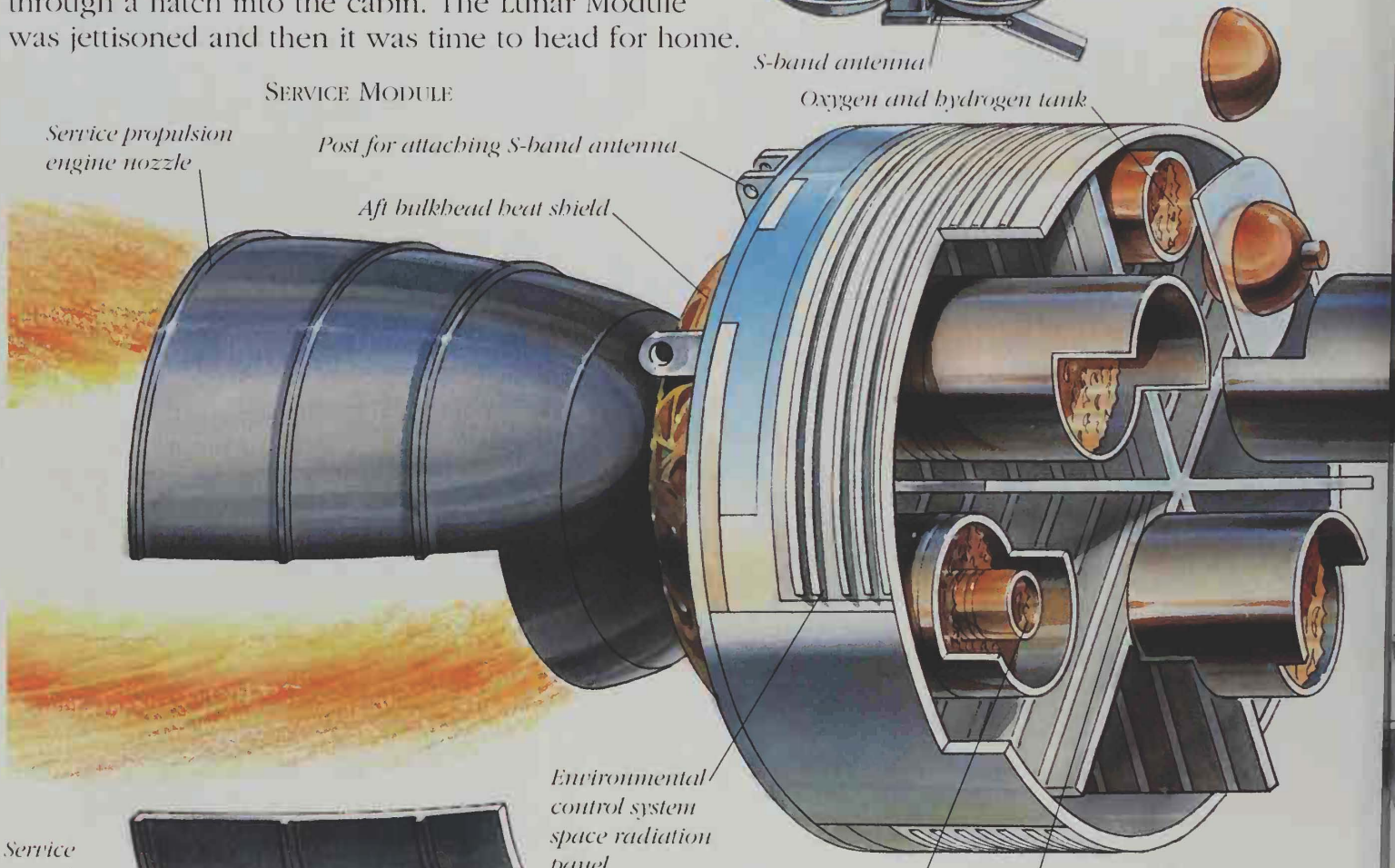
SERVICE MODULE

Service propulsion engine nozzle

Post for attaching S-band antenna

Aft bulkhead heat shield

Oxygen and hydrogen tank



Environmental control system space radiation panel

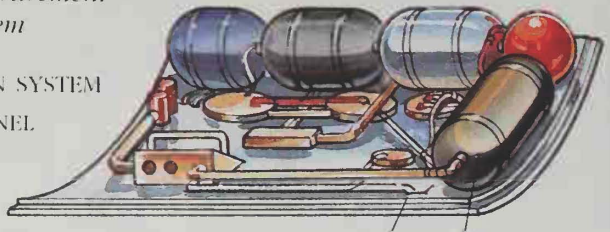
Service propulsion engine nozzle cover

Tank quantity measurement system

Supporting frames

APOLLO 11
MISSION BADGE

REACTION SYSTEM
QUAD PANEL



Outer skin of SM

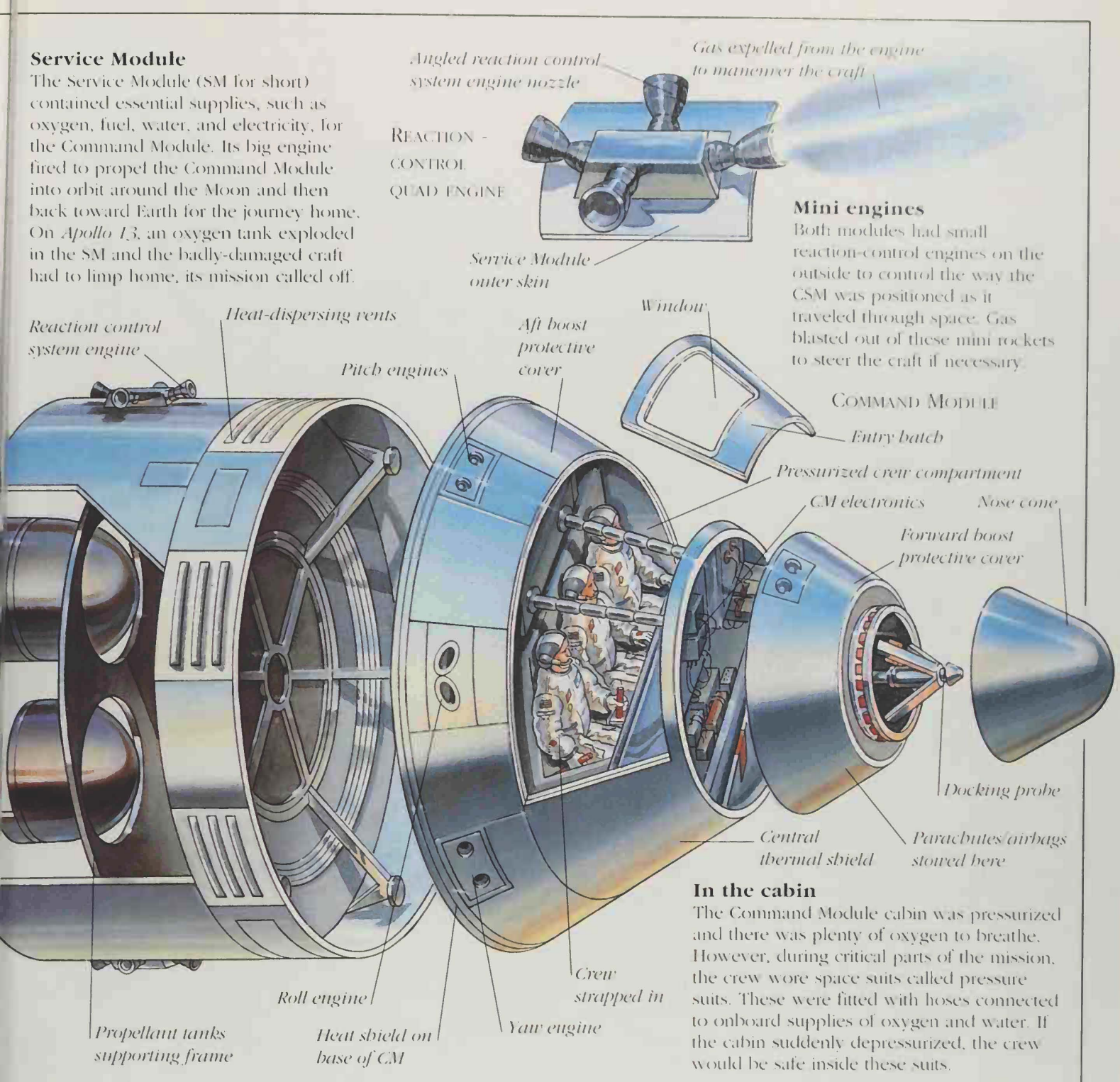
Propellant tank

Splashdown
The Command Module reentered the Earth's atmosphere at 24,243 mph (39,010 km/h). As it neared journey's end, parachutes opened to slow its speed, and it hit the water at only 17 mph (27 km/h). Three airbags inflated like giant balloons to keep it upright until US Navy helicopters could winch the crew to safety.

Hello again!
The crew had radar to help them dock the CSM and the Lunar Module. The Command Module had a long probe that fitted into a dish-shape on the Lunar Module. The probe was guided into a hole in the center of the dish and the two craft locked together. Then hatches were opened so that two of the crew could crawl through.

Service Module

The Service Module (SM for short) contained essential supplies, such as oxygen, fuel, water, and electricity, for the Command Module. Its big engine fired to propel the Command Module into orbit around the Moon and then back toward Earth for the journey home. On *Apollo 13*, an oxygen tank exploded in the SM and the badly-damaged craft had to limp home, its mission called off.



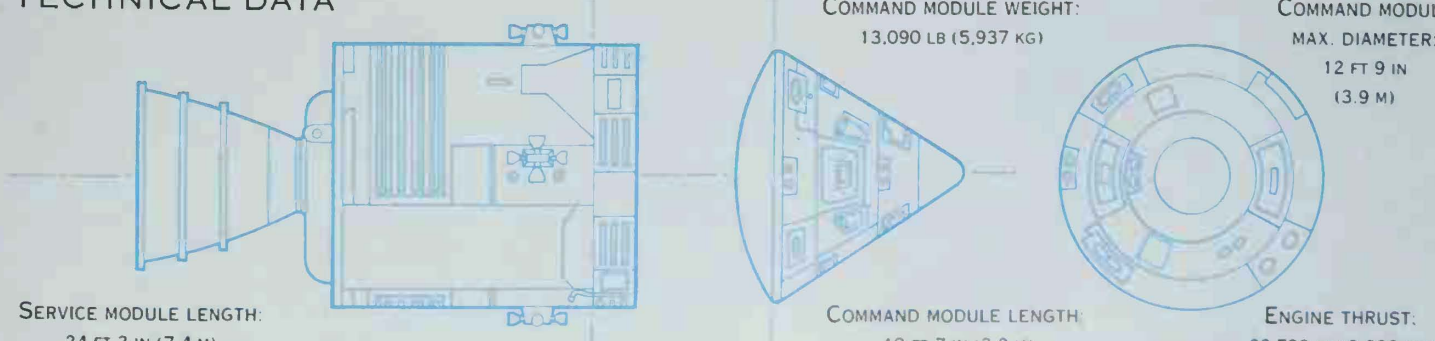
Mini engines

Both modules had small reaction-control engines on the outside to control the way the CSM was positioned as it traveled through space. Gas blasted out of these mini rockets to steer the craft if necessary.

In the cabin

The Command Module cabin was pressurized and there was plenty of oxygen to breathe. However, during critical parts of the mission, the crew wore space suits called pressure suits. These were fitted with hoses connected to onboard supplies of oxygen and water. If the cabin suddenly depressurized, the crew would be safe inside these suits.

TECHNICAL DATA



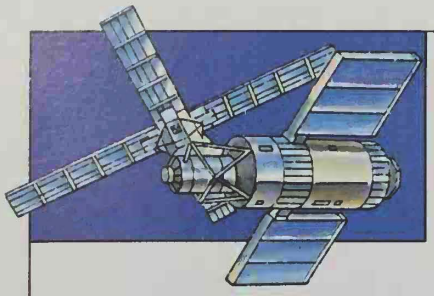
SERVICE MODULE LENGTH:
24 FT 3 IN (7.4 M)

COMMAND MODULE WEIGHT:
13,090 LB (5,937 KG)

COMMAND MODULE LENGTH:
10 FT 7 IN (3.2 M)

COMMAND MODULE MAX. DIAMETER:
12 FT 9 IN (3.9 M)

ENGINE THRUST:
20,500 LB (9,300 KG)



SKYLAB

ONCE THE US HAD LANDED HUMANS on the Moon, the next step was to build a space station where people could live and work. The Russians launched a space station called *Salyut 1* in 1971. The Americans launched *Skylab*, shown below, in 1973. During 1973 and 1974, it was home to three different astronaut crews, who traveled to it in Apollo spacecraft. Their bodies were constantly monitored to see how well they coped with long-term life in space. They spent their time doing experiments and taking photographs. They also had to repair their station. It was so badly damaged during its launch that, without repair, it would have been uninhabitable.

APOLLO TELESCOPE

Solar panel

Solar shield

Extension linkage

Oxygen tank

Nitrogen tank

Orbital workshop hatch

AIR LOCK MODULE

Battery and regulator module

Coming and going

When a crew arrived, their Apollo spacecraft docked with the Multiple Docking Adapter part of the space station. Latches held the two spacecraft together so that the crew could move through an air lock module. When their mission was over, they left in the Apollo spacecraft.

COMMAND MODULE

Propulsion engine nozzle

Axial docking hatch

Radial docking port

MULTIPLE DOCKING ADAPTER

Infrared spectrometer

Multiple Docking Adapter workshop

Apollo Telescope Mount support struts

Vernier control motor

SERVICE MODULE

Nowhere to hide

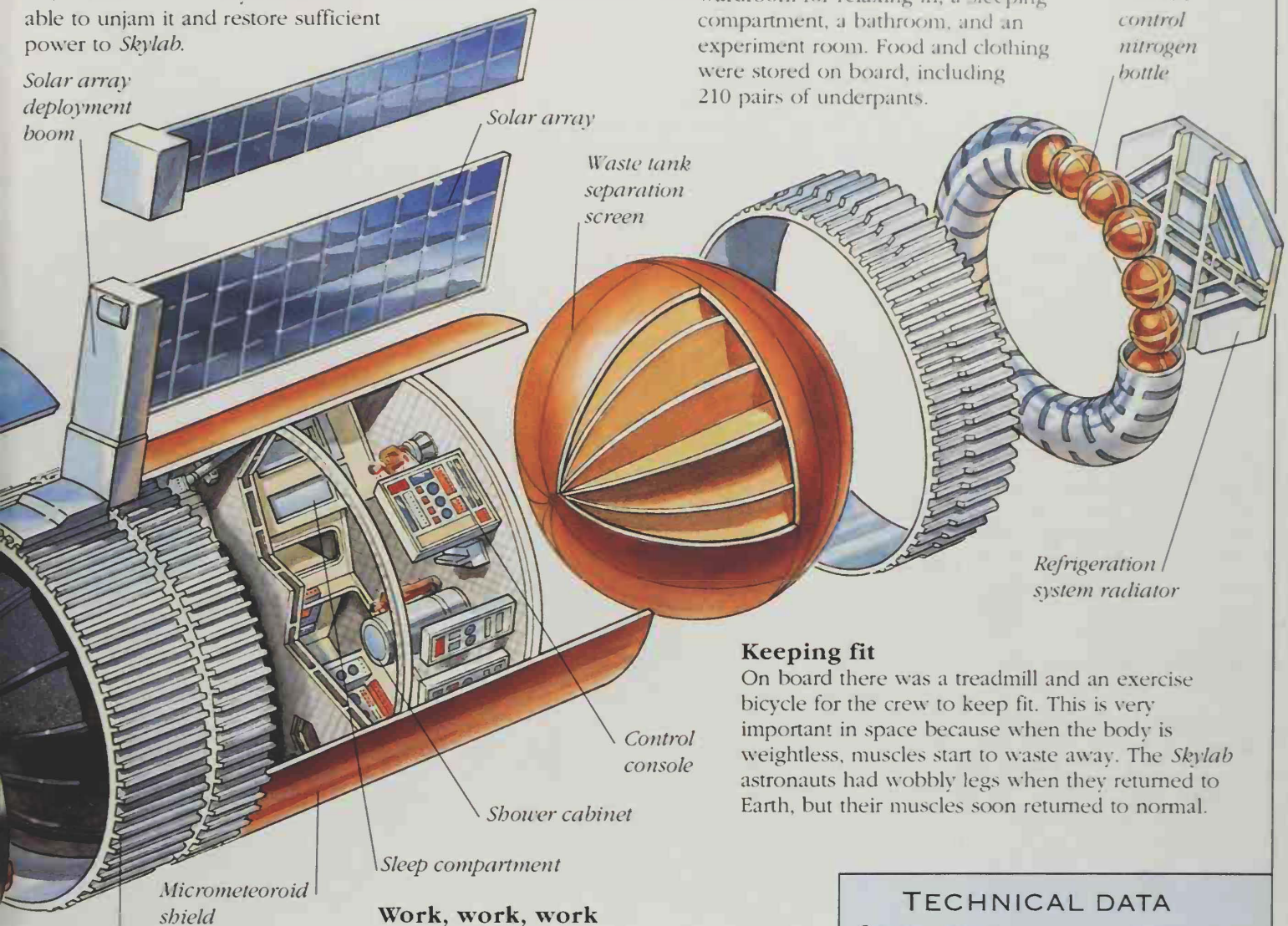
Every minute of the day, the crew's conversations were recorded and relayed down to Mission Control, Houston, the main Earth base. Life was not easy and they occasionally complained that they were overworked. But they had to be careful what they said because someone was listening all the time!

Energy savers

Skylab was fitted with huge solar arrays that converted the Sun's rays into electricity. During the launch one was torn off. Another jammed, leaving *Skylab* underpowered and overheated. Fortunately the first crew was able to unjam it and restore sufficient power to *Skylab*.

Living in a space home

Skylab was built using the third stage of a *Saturn V* rocket. One of its fuel tanks was converted into a workshop with a wardroom for relaxing in, a sleeping compartment, a bathroom, and an experiment room. Food and clothing were stored on board, including 210 pairs of underpants.



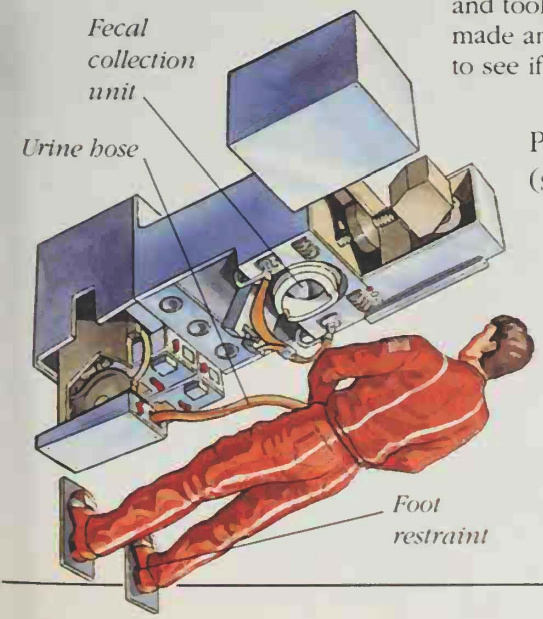
ORBITAL WORKSHOP

Keeping fit

On board there was a treadmill and an exercise bicycle for the crew to keep fit. This is very important in space because when the body is weightless, muscles start to waste away. The *Skylab* astronauts had wobbly legs when they returned to Earth, but their muscles soon returned to normal.

Work, work, work

Above the station there was a platform called the Apollo Telescope Mount, which studied the Sun. The astronauts monitored its work and took photographs of the Earth. They made and tested metal, glass, and crystals to see if any developed differently in space.

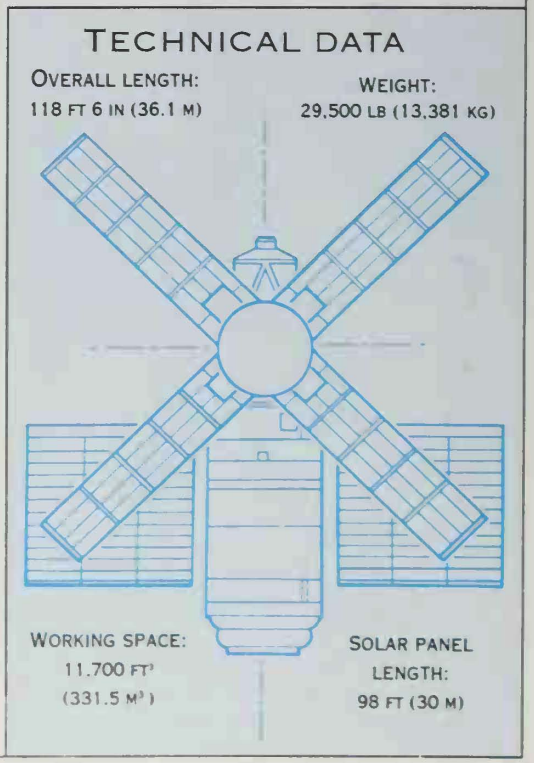


PERSONAL HYGIENE STATION (SPACE TOILET)

Space washing

In the bathroom there was a toilet that worked by vacuum suction. The waste was sucked away and stored so that the crew could take it back to Earth for study. An astronaut wanting a shower climbed into a collapsible tube device with a lid on the top to stop water globules from floating away.

TECHNICAL DATA



VIKING PROBE

UNMANNED SPACE PROBES are complex robot explorers that journey far away to other planets. They send back fascinating new information and pictures. This is one of two Viking probes, both launched in 1975 toward the planet Mars. People have always wondered about outer space. Are there really Martians living on Mars? The Viking probes investigated puzzles like this by surveying the planets and searching for life-forms.

Landers at work

The landers carried computer-controlled instruments that analyzed the landscape, wind, and temperature. Each lander had a remote-controlled arm with a shovel on the end for collecting soil.

Top of biologically protected capsule

Cable to release biologically protected cover

High-gain directional antenna

Radiator

Biological analyzer

Television camera

Seismometer

VHF relay antenna

Aerodynamic casing and parachute to slow down lander capsule

Meteorological instruments

Viking lander in folded position

Legs in fully extended position

Heat sensor

Retro-rockets for lander capsule

Fuel tank

Landing foot

Retro-rockets for landing

Roll control

Radar altimeter antenna

Telescopic remote control arm

Device for collecting samples

Magnet and hoe

SOIL COLLECTING DEVICE

Motor to rotate arm

Motor for sieve and crushing system

Sieve with 2 mm brush

Hoe

Teeth for crushing sample

Brush

Lid

Magnet

Shovel

Landing the lander

Once separated from its orbiter, each lander traveled down toward Mars. Near the surface, its protective shell was ejected and a parachute opened to slow the craft down. Its legs unfolded and its rockets ignited to give it a slow, soft landing.

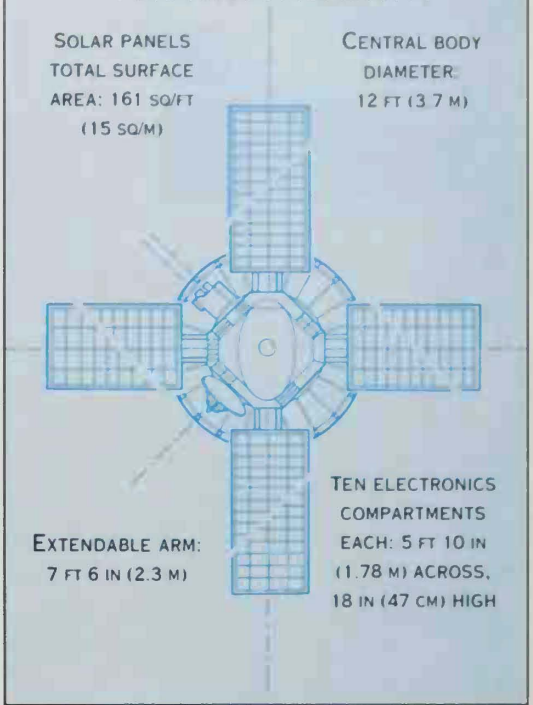
Viking parts

Each Viking probe was made up of two parts – the orbiter and the lander. The lander separated from the orbiter above Mars and landed on the surface. Meanwhile, the orbiter continued to circle the planet, recording pictures of the surface and relaying the information collected by the lander.

Rock or roll?

Before the Viking missions scientists weren't sure whether the surface of Mars had a hard crust or a thick layer of soft dust that a Lander would sink down into. They found that it was hard and covered with chunks of rusty-red rock.

TECHNICAL DATA



Attitude control micronozzles (gas jet)
Solar panel
Infrared thermal mapper
Visual Imaging System
Fuel tank
Heat shield
Mars atmospheric water detector
Solar panel
STEERABLE SCIENTIFIC PLATFORM
Fuel tank
Heat control louvers
Outer casing
Oxidant tank
Base of biologically protected capsule
Helium tank
Oxidant tank
Main rocket engine nozzle

All about Mars

Data collected by the Viking probes showed that Mars was very cold and barren. Strong winds whipped up huge dust storms that turned the sky pink. There were mountains, canyons, dormant volcanoes, and craters, but no signs of life. However, scientists still cannot rule out life definitely. In the future another probe may find something different at a new landing site.

SPACE SHUTTLE

THE FIRST US SPACE SHUTTLE was launched on April 12, 1981. The Shuttle is reusable, and since that first journey, many more missions have been flown, teaching astronauts a lot more about living and working in space. The Shuttle Orbiter is a cross between a space station and a space plane. People can live inside it as it orbits the Earth. It can land its crew safely back home and then, after being checked and refitted, it can fly on another mission. It is mainly used to launch satellites and to recover them for repair.

Keeping cool
Heat-absorbing liquid is pumped through pipes around the Orbiter, collecting heat. Eventually the pipes pass through radiators inside the payload bay doors, which are left open in orbit to lose the extra heat into space.

Rudder and speed brake

Reinforced carbon carbon (RCC) tiles on leading edge

Payload bay

Getting up there
The plane part of the Shuttle, shown here, is called the Orbiter. When it is launched, it is attached to a fuel tank and two rocket boosters, which help lift it into orbit. After the launch, the boosters are jettisoned. They parachute back to Earth to be used again for another launch.

Maneuvering engine

Aft control thrusters

Main engine

Getting to work
All the Orbiter's systems are controlled by computers. The crew checks these systems by looking at consoles on the flight deck, high up in the nose. The computers are constantly monitored by Mission Control back on Earth.

Body flap

Elevon

Living on board
Astronauts have a miniature kitchen called a galley, where they heat up their food in pre-packed containers. Four people can rest in the "sleep station," strapping themselves into sleeping bags. One sleeps upside down and one sleeps standing up. Because they are weightless, it feels no different than normal.

Space radiator inside door

Hydrazine and nitrogen tetroxide tank

Payload bay door

Landing-gear well

The crew
The Orbiter can take up to seven crew members, led by a commander. On board they float around weightlessly. However, they can anchor themselves, using straps into which they can fit their boots.

RMS
A 50-ft (15-m) long robot arm is installed in the payload bay behind the nose. It is called the RMS (Remote Manipulator System) or Canadarm, because it was made in Canada. A gripping mechanism on the end can be used to grab satellites.

Getting down again
Returning home, the Orbiter reenters the atmosphere at 17,000 mph (28,000 km/h). Its nose and wingtips glow white-hot, but the Orbiter is protected by heat-proof silica tiles. It glides the whole way down to Earth.

TECHNICAL DATA

ORBITER LENGTH: 122 FT 2 IN (37.24 M)

ORBITER HEIGHT: 56 FT 8 IN (17.27 M)

WINGSPAN: 78 FT 1 IN (23.79 M)

PAYLOAD BAY: 60 FT X 15 FT (18.3 M X 4.6 M)

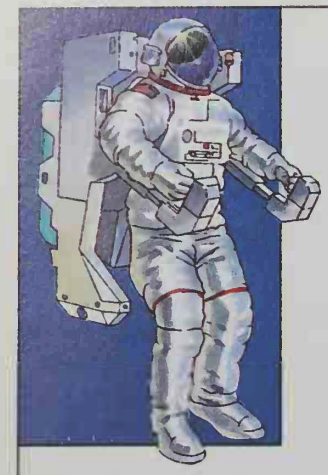
SHUTTLE ORBIT SPEED: 17,500 MPH (28,160 KM/H)

MISSION DURATION: BETWEEN 5 AND 30 DAYS

ALTITUDE IN ORBIT: BETWEEN 115 AND 690 MILES (185 AND 1,110 KM)

ORBITER WITHSTANDS TEMPERATURES UP TO 2,300°F (1,260°C)

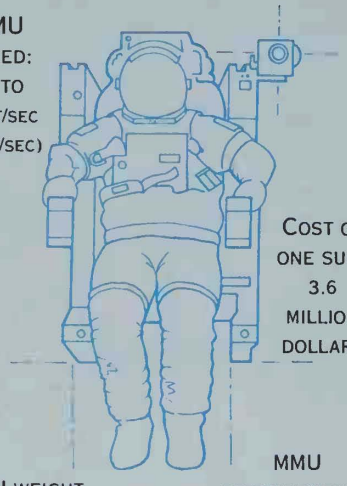
EVA (Space) suit
Air lock door
Remote Manipulator System (Canadarm)
Astronaut stands on platform fitted to RMS to repair satellite
Satellite
Camera
Payload handling controls
Rearview window
Low temperature thermal insulation
Commander
Pilot
Mission operations displays and controls
Flight deck controls and display
Forward control thruster
Main wheel
Black tile coating
Rendezvous and docking controls
Air lock
Sleep station
High temperature thermal insulation tile
Oxidizer tank
Nose-wheel
Reinforced carbon carbon (RCC) sheath



SPACE WALK

SOMETIMES ASTRONAUTS HAVE TO VENTURE outside of a Shuttle to capture and repair satellites or to test new equipment. But they would die a quick, painful death if they were not properly equipped. Going outside is called "extra-vehicular activity," or EVA. An astronaut on EVA must wear a complicated space suit for protection, to maintain pressure, and to provide air for breathing. Until recently, astronauts on EVA had to be tethered to their spacecraft with a cable. Otherwise they would float away, and it would be very hard to rescue them. Now they can use a "Manned Maneuvering Unit," or MMU. Shaped like the top part of an armchair, with arms and a back support, it jets the astronauts wherever they want to go.

TECHNICAL DATA

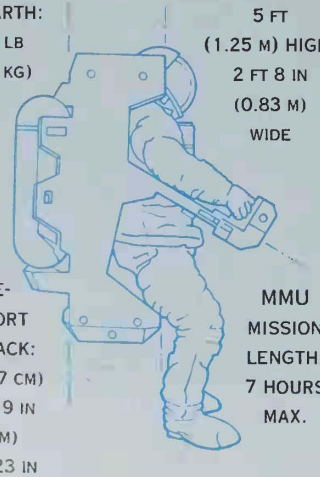


MMU SPEED: UP TO 66 FT/SEC (20 M/SEC)

COST OF ONE SUIT: 3.6 MILLION DOLLARS

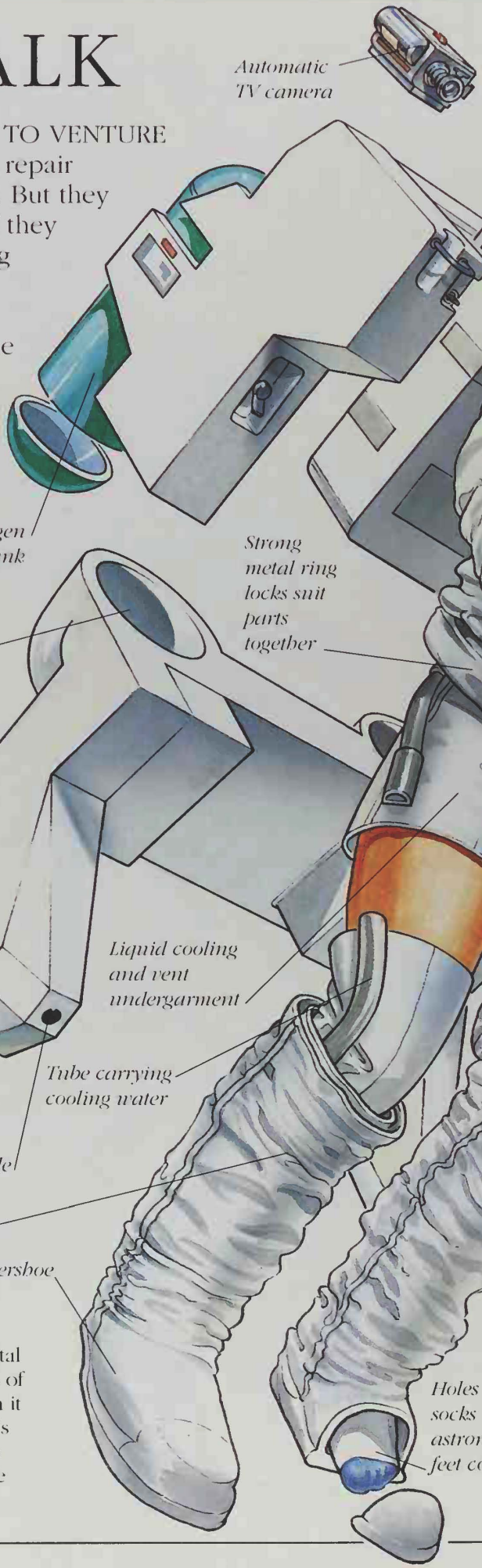
MMU WEIGHT ON EARTH: 240 LB (109 KG)

MMU MEASUREMENTS: 5 FT (1.25 M) HIGH, 2 FT 8 IN (0.83 M) WIDE



LIFE-SUPPORT BACKPACK: 30 IN (77 CM) HIGH, 19 IN (50 CM) DEEP, 23 IN (58 CM) WIDE

MMU MISSION LENGTH: 7 HOURS MAX.



Astronaut underwear
Because astronauts can spend many hours inside their space suits, the first thing they put on is a urine collection device. Next they pull on a cooling suit with a network of water-filled tubes. The water absorbs body heat, which the tubes circulate to the space suit's backpack, where it radiates out into space.

Astronaut outerwear
The outer suit has parts that lock together with airtight metal rings. Made from many layers of nylon material, it has pleats in it that stretch to fit an astronaut's body. The inside of the suit is pumped full of air to keep the astronaut's body pressurized.

Life-support backpack with oxygen supply and water for cooling system

Helmet

Headphones

Microphone

Sunglasses

Clear plastic helmet rubbed with anti-fogging compound to keep it from misting up

Visor shields face from the Sun

Heart rate and breathing monitor

Chest pack with computer controls and LED display

Adjustable arm

Gloves

Left-hand joystick unit for making the MMU go backward or forward

Oxygen from life-support system enters suit here

Face mask

Oxygen respirator

Outside made of space suit material

Carrying handle

Back and front

Suits are called "extra-vehicular mobility units," or EMU's. A life-support pack on the back carries enough oxygen for a seven-hour trip. A computer in the chest pack monitors the way the suit is working.

EMU SUIT IN STORAGE POSITION

Moving the MMU

The MMU has 24 small nozzles called thrusters. The hand controls on the arms are used to make nitrogen gas jet out of the thrusters, pushing the MMU.

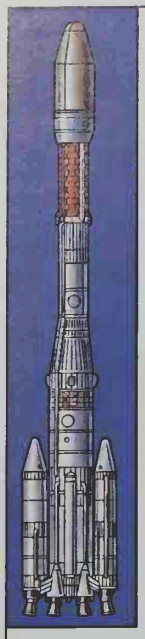
A bad idea

If you went on a space walk without a pressurized space suit, your blood and body fluids would quickly begin to boil. You would inflate like a balloon, suffocate, and nitrogen bubbles would cut off the blood supply to your brain.

RESCUE BALL

Space rescue!

Shuttle orbiters have only three full EMU suits on board, but carry a crew of 7. In case something goes wrong and a Shuttle crew has to abandon ship, the space rescue ball has been designed to help the rest of the crew escape. It is made from space suit material, and holds an oxygen supply so that an astronaut can be safely evacuated to another waiting Shuttle.



ARIANE 4

IN FRENCH GUIANA, SOUTH AMERICA, a massive launch site has been cut out of the surrounding jungle. This is the base for the European Ariane rockets, the workhorses of space. They regularly launch satellites into orbit around the Earth. They are "commercial space carriers," which means that any country can hire them to have satellites carried up and released. This picture shows the rocket most often used – the *Ariane 4*. It has three stages that separate from each other during flight, on the same principle as the *Saturn V* rocket on page 8/9. But unlike the *Saturn V*, it is an "off-the-peg" rocket – it comes in six different sizes.

Command by computer
Ariane rockets rely completely on onboard computers. They command the rocket stages to separate by triggering small explosive charges around the top of each stage, and they command all the different engines to fire at the right times.

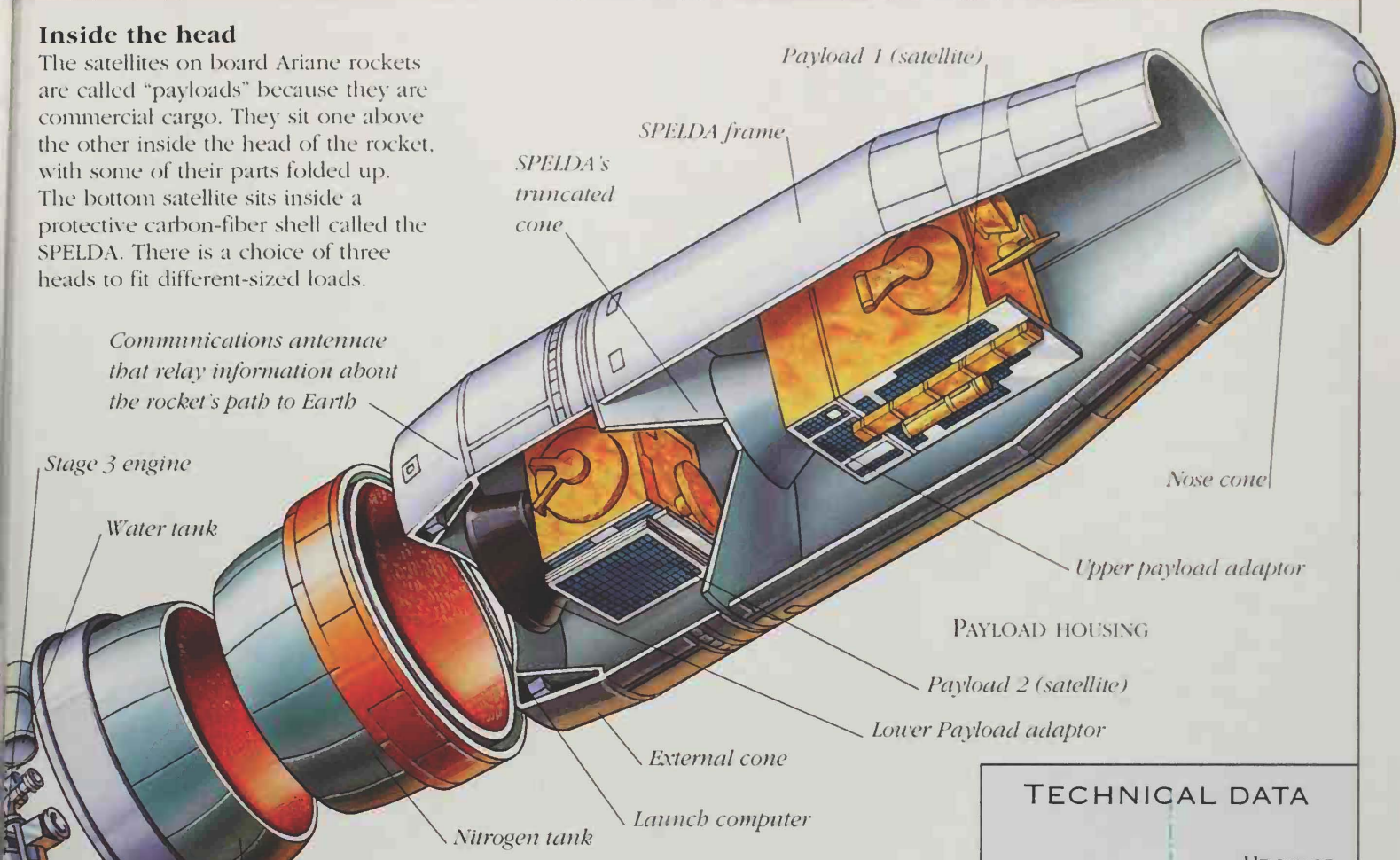
Booster rockets
The biggest versions of *Ariane 4* have extra booster rockets attached to stage 1, so they have extra pushing power to launch heavy satellites. Some have two boosters; some have four.

Nose cone
Rocket head
Booster rocket casing
Solid fuel (burns down center)
Eight separation rockets move the first stage away from the second
Nozzle
SOLID FUEL BOOSTER
Nitrogen peroxide tank
Water tank
Steel frame
Interstage skirt
Separation mechanism
Water supply pipes for engines
STAGE 2
Exhaust nozzles
Stage 2 separates at altitude of 83.8 miles (135 km)
TOP OF STAGE 1
Liquid fuel supply pipes for engines
Liquid fuel tank
BOTTOM OF STAGE 1
Engine shield
Arms to fix booster rocket

Stages 1 and 2
Stage 1 and the booster rockets burn first. The boosters are jettisoned and then stage 1 separates. While the stage 2 engines are burning, the head is jettisoned, revealing the top satellite. Then stage 2 separates as it reaches its altitude goal.

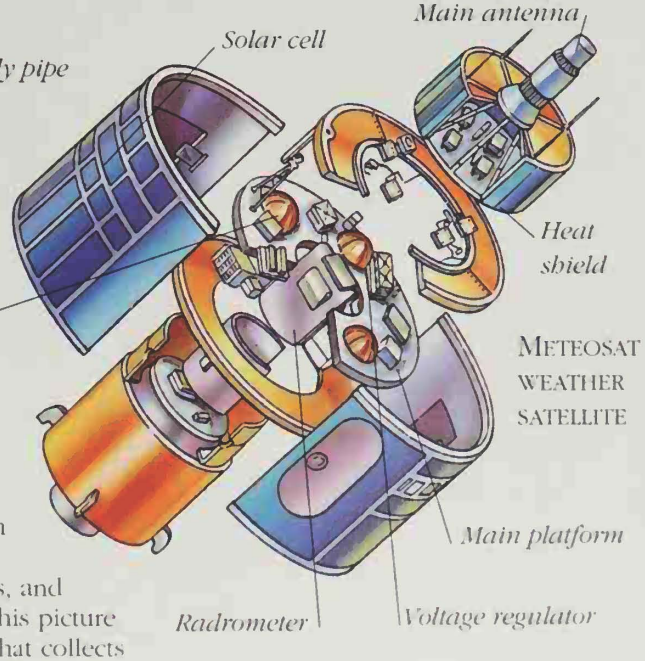
Inside the head

The satellites on board Ariane rockets are called "payloads" because they are commercial cargo. They sit one above the other inside the head of the rocket, with some of their parts folded up. The bottom satellite sits inside a protective carbon-fiber shell called the SPELDA. There is a choice of three heads to fit different-sized loads.



Stage 3

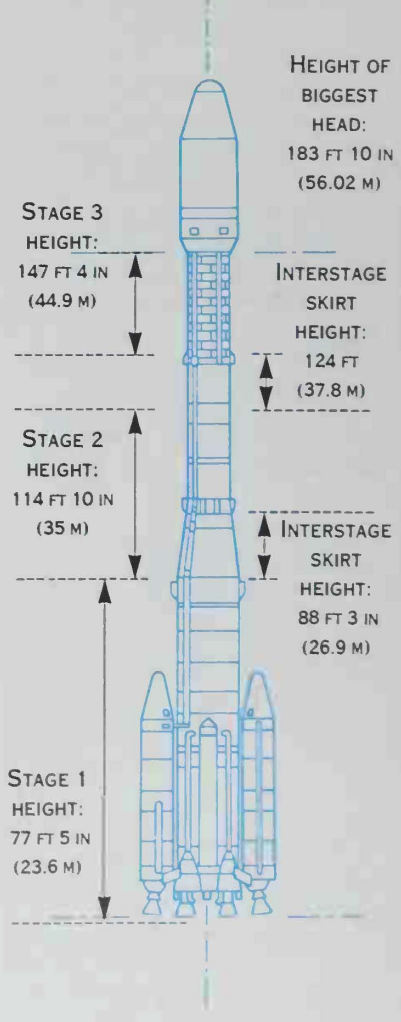
When stage 3 reaches the right height, its engines switch off. It points the top satellite the right way and starts it spinning if necessary (some satellites spin in orbit). Small explosive charges release the payload and then the process begins again for the second launch. Once stage 3 finishes its job, it is sent on a safe path well away from the payloads it has launched.



All about satellites

Ariane 4 rockets have launched many different kinds of satellites. They all orbit around the Earth. Some take automatic measurements that help with such jobs as land surveying. Some are used to relay TV and radio signals, and some are even used for spying. This picture shows a satellite called *Meteosat* that collects and transmits data about the world's weather.

TECHNICAL DATA



VOYAGER

TWO VOYAGERS, 1 AND 2, were launched in 1977, beginning an exciting long-distance journey into deep space. They were sent to the outer reaches of the Solar System where they found strange frozen moons and giant planets enveloped in poisonous gases. They are still traveling onward through outer space, carrying a message from Earth to any intelligent beings.

Radioisotope thermoelectric generators

On board the Voyagers
The Voyagers are controlled by computers. Their scientific instruments measure such things as magnetic fields, and their cameras send back spectacular images of the planets.

Magnetometer

Extendable arm

Dish antenna

Magnetometers

Fuel tank

Electronics packs

Reflecting dish base

Aluminum framework

Antenna inside dish

Reflecting dish

The journey so far
Both Voyagers were launched in 1977. They flew past Jupiter in 1979 and went on to Saturn, which they reached in 1980/81. By this time they were so far away their radio signals took 1.5 hours to reach Earth. *Voyager 2* flew past Uranus in 1986 and Neptune in 1989.

TV cameras to photograph moons and planets

Cosmic ray detector

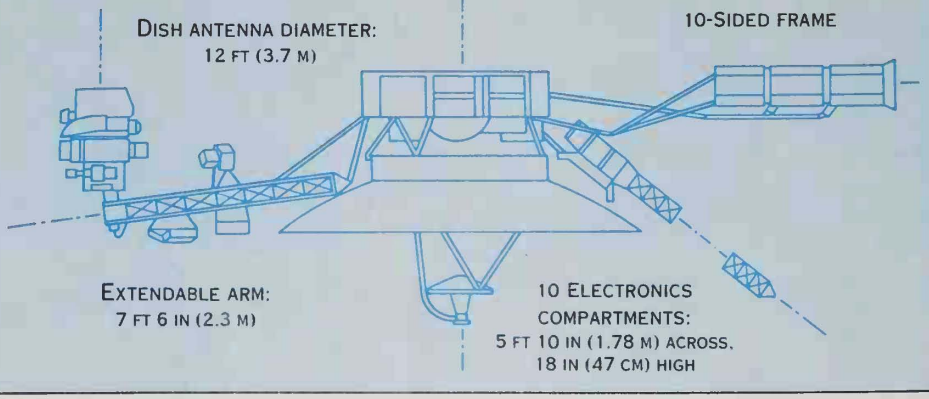
Plasma detector

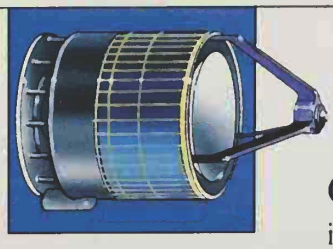
Steerable platform

Scientific instruments to collect various data, including gases, rays, and particles around planets

Amazing space
The Voyager probes have made many amazing discoveries on their journey past the outer planets. The spectacular pictures they have sent show new moons and planet rings. The "Great Red Spot" that astronomers had noticed on Jupiter turned out to be a gigantic swirling storm of deadly gas clouds.

TECHNICAL DATA





GIOTTO PROBE

GIOTTO WAS LAUNCHED IN 1985 AND, IN 1986, it passed close to Halley's Comet, taking measurements and pictures as it went. Halley's Comet is an object that orbits the Sun, passing the Earth every 76 years. For many centuries people thought it was a magical sign that heralded some great change. Scientists in modern times just wanted to find out what it was made of.

Main body made to spin 15 times a minute to stabilize Giotto *in space*

Tripod

Magnetometer experiment for measuring the comet's magnetic field

Antenna for receiving command signals from Earth

Dish antenna for sending data to Earth

Mechanism to stop the dish antenna from spinning with the main body

Solar cells

Hydrazine tank

Fuel tank for rocket engine

Attitude control thrusters

Rocket engine to get Giotto *into orbit after its launch*

Lower platform

Shield to protect from buffeting

Shell to close off engine nozzle after use (to stop comet particles from getting in)

Camera

Giotto's job

Giotto was sent to examine the comet's nucleus (its center). The probe passed within 375 miles (605 km) of the nucleus, transmitting information back to Earth as it traveled by. When it got in close, it was hit by a giant jet of dust that knocked it off course and damaged its instruments. But by that time it had already sent back lots of valuable data.

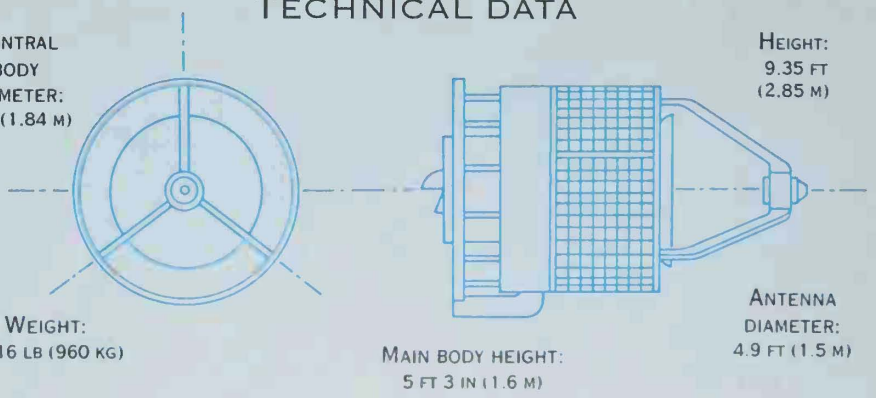
Giotto's experiments

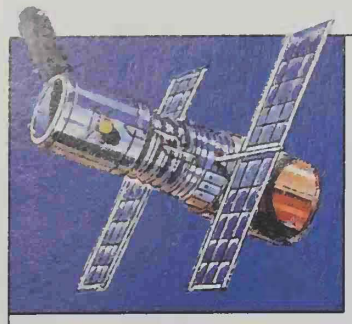
On its lower platform *Giotto* carried instruments for monitoring the comet. These included a camera and impact detectors to measure the buffeting that *Giotto* got from the dust and ice particles around the comet. All the information was transmitted back to Earth.

Comet profile

Giotto found that Halley's Comet is really a kind of giant dirty snowball. Its solid peanut-shaped spinning nucleus is made of water and dust. Jets of dust, gas, and ice particles spew out of cracks in its crust as it gets heated up by the Sun. These jets reflect the Sun's light, so they look like a glowing tail streaming out behind it.

TECHNICAL DATA





HUBBLE TELESCOPE

IN 1990 A NASA SPACE SHUTTLE launched a satellite called *Hubble*. It was a space telescope designed to peer into the far reaches of space and relay back information. Telescopes on Earth must look through the cloudy, dusty atmosphere, which blurs their vision. *Hubble* orbits above the atmosphere and so can see much farther. When *Hubble* was first launched, the images it sent back were very fuzzy. As well, its solar arrays (panels on either side) often shook badly. So NASA sent another Shuttle to make the most expensive repairs yet in space history.

Communications antenna

Primary mirror

Light shield

Radial SI module (1)

Aperture door mounting

Secondary mirror

Secondary baffle

Optical telescope assembly

Central deflector

Aluminum shield

Epoxy resin frame

What does it do?

Hubble detects and measures the light given out by galaxies and stars. Some forms of light can be seen. Others, such as infrared rays and ultraviolet rays, can't be seen but can still be measured. When *Hubble's* mirror is pointed at an object sending out light, the light is focused onto various instruments inside the satellite, where it is measured.

Getting information

Hubble converts the data it collects into radio signals. It sends these to a communications satellite, which sends them on to Earth. Computers on Earth convert them into electronically made images that astronomers can study.

Aperture door

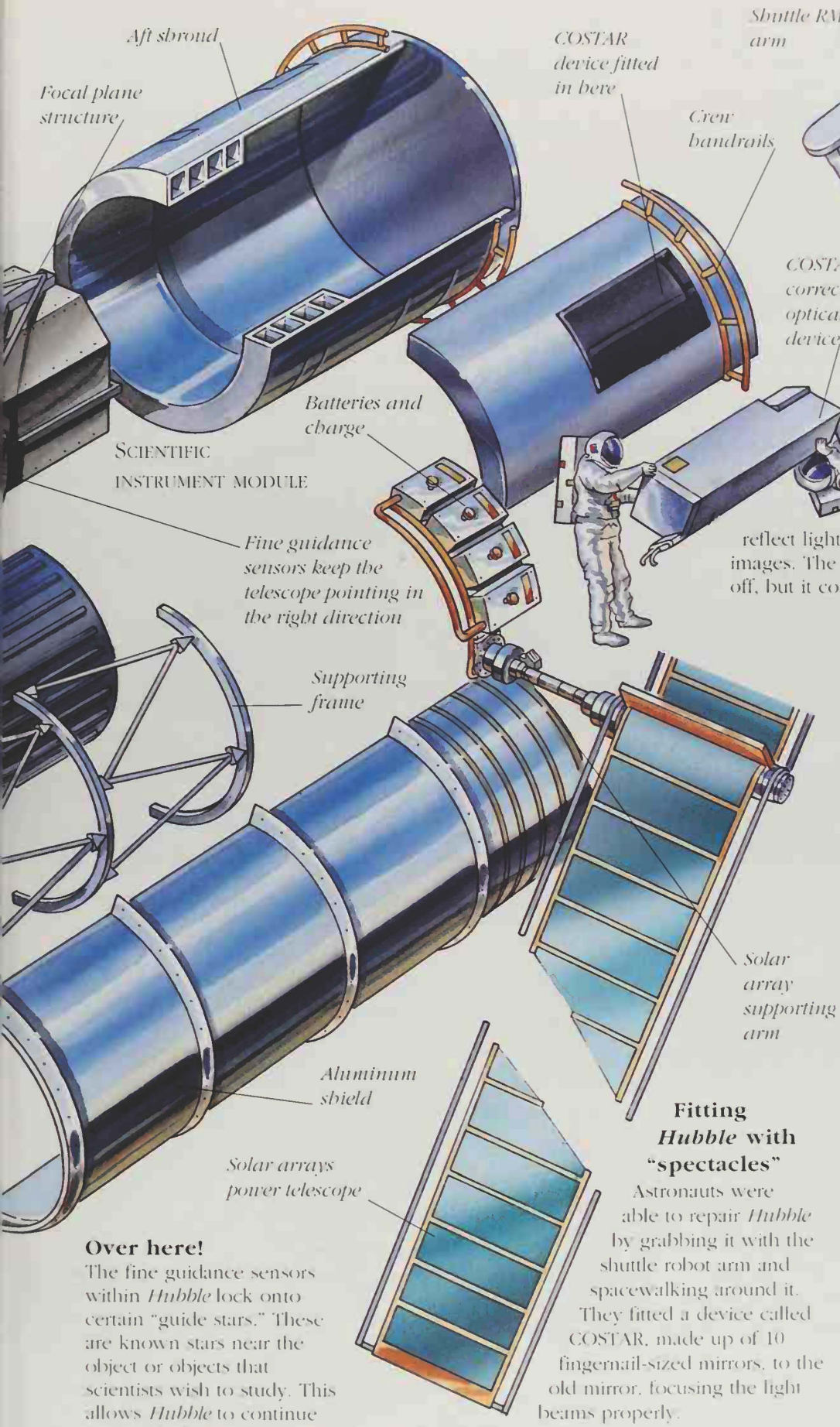
Aperture

SUPPORT SYSTEM MODULE

Crew handrails

Picking up the past

Some of the objects that *Hubble* sees are so far away that their light takes millions of years to arrive. The pictures that *Hubble* produces from this ancient light show a time when the universe was much younger than it is today. Scientists may be able to use them to figure out when the universe began and how big it is.



See you soon

Hubble parts are designed so that they can easily be taken off and replaced with new ones. A shuttle will visit it regularly to keep it serviced during its 20-year life.

Mirror mistake

Unfortunately, *Hubble*'s main, or primary, mirror was the wrong shape. It was too flat near its edges, so it did not reflect light beams correctly, resulting in fuzzy images. The shape was only 0.006 ft (0.002 m) off, but it cost NASA $630 million to repair.

Over here!

The fine guidance sensors within *Hubble* lock onto certain "guide stars." These are known stars near the object or objects that scientists wish to study. This allows *Hubble* to continue pointing in the right direction.

Fitting *Hubble* with "spectacles"

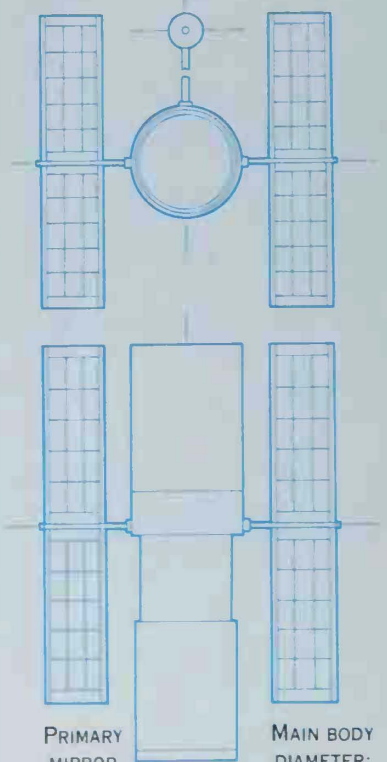
Astronauts were able to repair *Hubble* by grabbing it with the shuttle robot arm and spacewalking around it. They fitted a device called COSTAR, made up of 10 fingernail-sized mirrors, to the old mirror, focusing the light beams properly.

TECHNICAL DATA

LENGTH: 43 FT 6 IN (13.25 M)

PRIMARY MIRROR DIAMETER: 7 FT 1 1 IN (2.4 M)

SECONDARY MIRROR DIAMETER: 12 IN (30 CM)



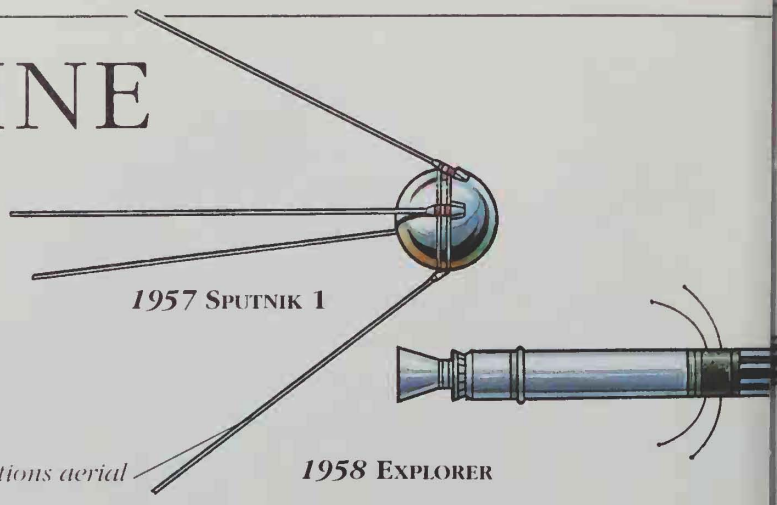
PRIMARY MIRROR THICKNESS: 12 IN (30 CM) MAX

MAIN BODY DIAMETER: 14 FT (4.27 M)

ORBIT ABOVE EARTH: 373 MILES (600 KM)

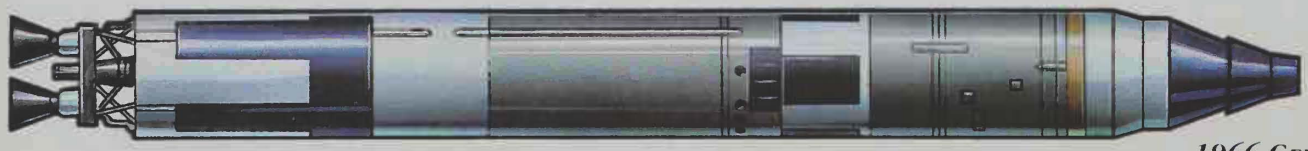
SPACE TIMELINE

HUMANS DID NOT BEGIN to explore space until the twentieth century. In the beginning, small unmanned rockets and satellites were used. Since then, spacecraft have developed into the most complex and expensive machines ever built. Here are some milestones in the development of modern spacecraft.

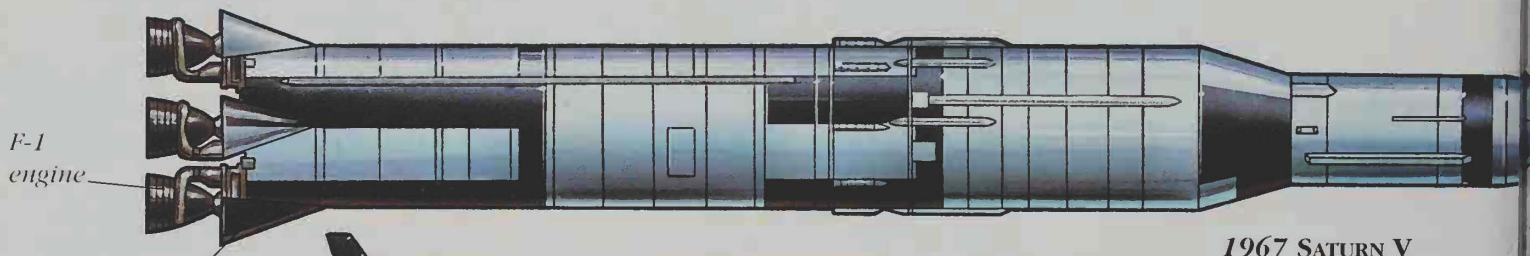


1957 SPUTNIK 1

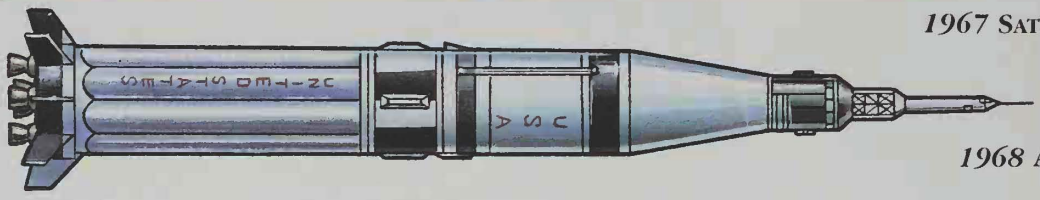
1958 EXPLORER



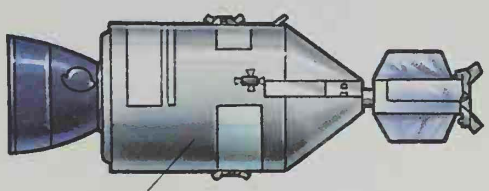
1966 GEMINI 8

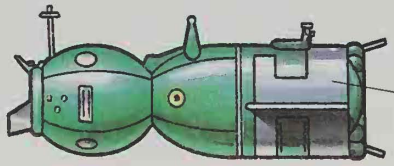


1967 SATURN V



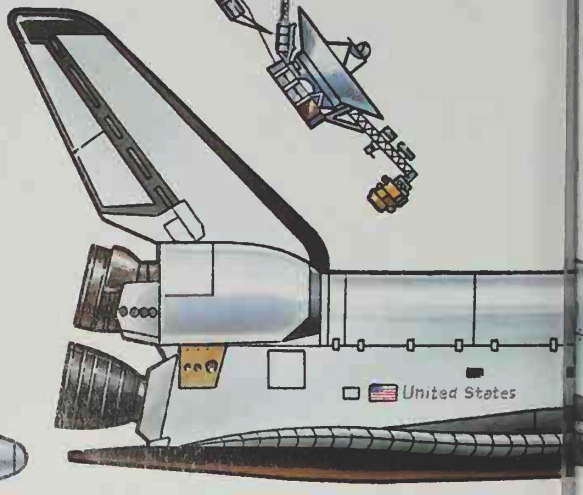
1968 APOLLO 7

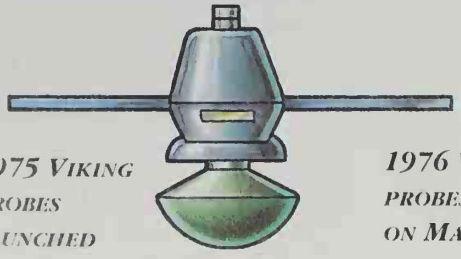




1975 APOLLO/SOYUZ *PROJECT*

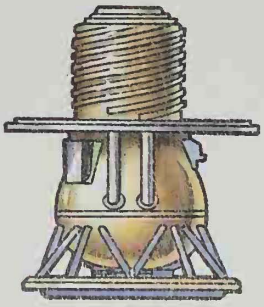
1977 VOYAGER SPACE PROBES LAUNCHED



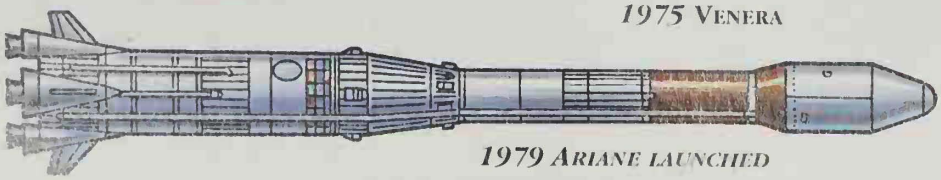


1975 VIKING PROBES LAUNCHED

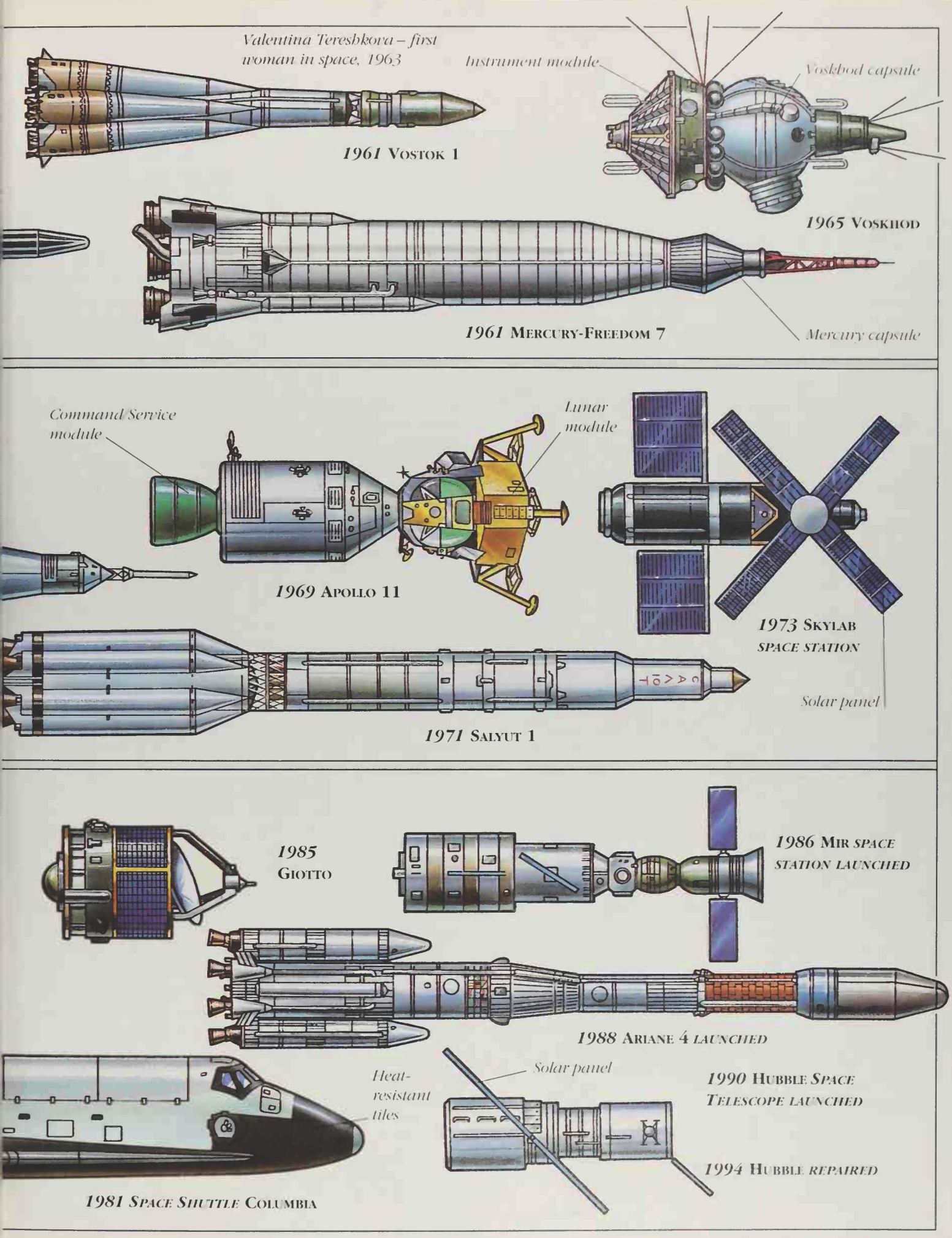
1976 VIKING PROBES LAND ON MARS



1975 VENERA

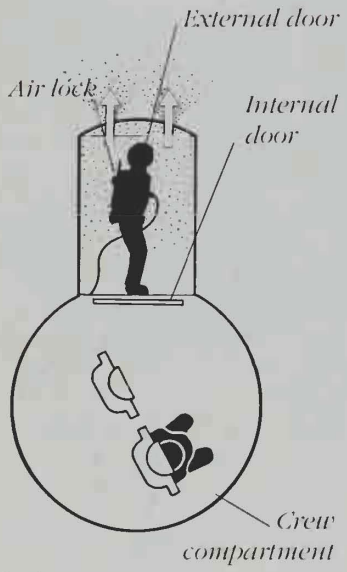


1979 ARIANE LAUNCHED


Valentina Tereshkova – first woman in space, 1963
Instrument module
Voskhod capsule
1961 VOSTOK 1
1965 VOSKHOD
1961 MERCURY-FREEDOM 7
Mercury capsule
Command/Service module
Lunar module
1969 APOLLO 11
1973 SKYLAB SPACE STATION
Solar panel
1971 SALYUT 1
1985 GIOTTO
1986 MIR SPACE STATION LAUNCHED
1988 ARIANE 4 LAUNCHED
Heat-resistant tiles
Solar panel
1990 HUBBLE SPACE TELESCOPE LAUNCHED
1994 HUBBLE REPAIRED
1981 SPACE SHUTTLE COLUMBIA

GLOSSARY

Air lock
A space between an inner and outer door on a manned spacecraft. Crew members usually put on space suits here. Then they close the inner door tightly and let out all the air from the air lock. Only then can they open the outer door. If they didn't use an air lock, all the air in the craft would be sucked out into space when they went outside.



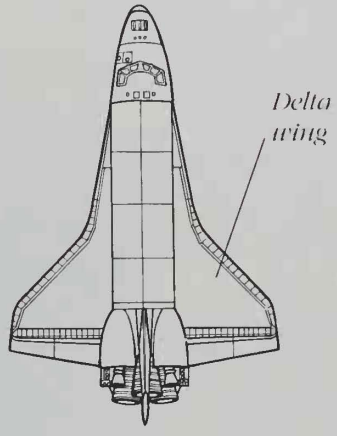
Antenna
A dish or rod aerial for receiving and sending radio signals to and from Earth.

Booster rockets
Extra rockets fitted onto a bigger launch rocket to help it gain extra speed as it travels up into space.

Command and Service Module
CSM for short. Part of an Apollo spacecraft. It orbited around the Moon with one crew member on board while the other crew members landed on the Moon's surface in the Lunar Module.

Console
A dashboard display with controls and switches for a space crew to use.

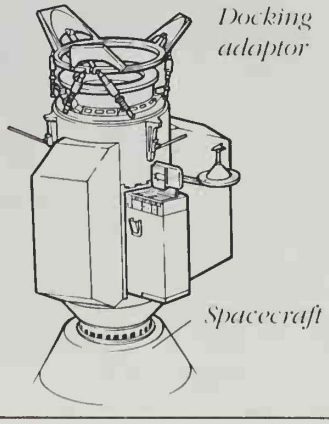
Delta wing
A swept-back wing shaped like a giant V, used on the space shuttle.



Depressurized
A place is depressurized when all the air is removed from it. For instance, air locks are depressurized when astronauts are ready to go outside on a space walk.

Docking
One spacecraft joining up with another in space.

Docking adaptor
The part of a spacecraft designed to lock onto another spacecraft when they dock together.



Docking hatch
A hatch that can be opened between two docked spacecraft, so that crew members can move through from one to the other.

Extra-vehicular mobility unit
EMU for short. Space jargon for a space suit.

Extra-vehicular activity
EVA for short. Space jargon for a space walk.

Fuel
The substance needed to make rocket engines work. Some fuel is liquid, some is solid and rubbery. It is burned together with a substance called an "oxidizer" to make gases that rush out of engine nozzles, pushing a launch rocket or spacecraft forward.

Heat shield
A protective layer of heat-resistant material built around a spacecraft. This is particularly important if a manned spacecraft returns to Earth, because as it plunges down, the outside surfaces get very hot and the crew needs to be protected inside the cabin.

Life-support system
Equipment that provides crew members with the air, water, and warmth they need to survive in space.

Lunar Module
LM for short. The part of an Apollo spacecraft that landed on the Moon.

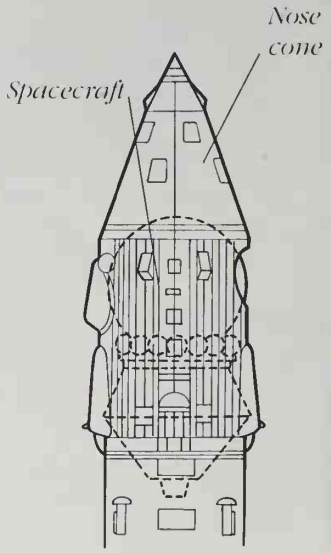
Lunar Roving Vehicle
LRV for short. A battery-powered buggy used for driving over the surface of the Moon.

Mission Control
The main space center on Earth where scientists monitor a spacecraft and keep in contact with the crew members on board.

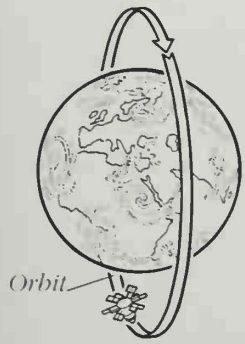
Manned Maneuvering Unit
MMU for short. A rocket-powered backpack used by astronauts to fly around outside their spacecraft.

NASA
The National Aeronautics and Space Administration. The organization in charge of space exploration on behalf of the United States, founded in 1958 by President Eisenhower.

Nose cone
The top part of a launch rocket. Manned spacecraft or satellites sit inside the nose cone while they are being taken up into space.



Orbit
A circular path followed by a small object revolving around a larger object, such as a satellite revolving around the Earth or an Apollo spacecraft revolving around the Moon.



Oxidizer
A substance (usually a gas) that is burned together with fuel to drive a rocket engine.

Payload
A commercial cargo, such as a satellite, carried on board a spacecraft. Customers pay to send it into space.

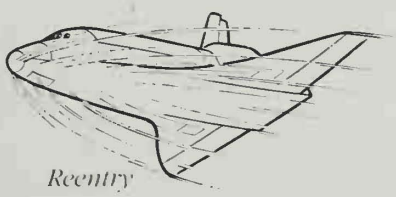
Personal hygiene station
The bathroom/toilet on board a spacecraft.

Pressure suit
A simple form of space suit sometimes worn inside the cabin of a spacecraft. It protects crew members in case the cabin loses its air supply during a critical part of the mission, such as launching or landing.

Pressurized
A place is pressurized when it is filled with air. Spacecraft cabins and space suits are pressurized to imitate the pressure existing in the atmosphere around the Earth.

Reaction-control system
Controls, usually mini rocket nozzles, which are used to change a spacecraft's position in space.

Reentry
The point when a spacecraft reenters the Earth's atmosphere on the way home. At this stage, air molecules start to rub against the craft as it falls, making its outer surface very hot.

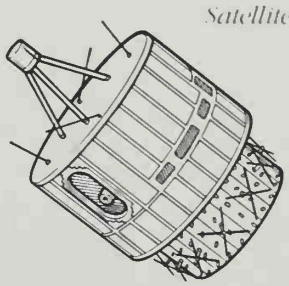


Remote Manipulator System
(RMS for short, also called Canadarm.) The robot arm attached to a space shuttle. It is used for jobs such as launching and repairing satellites. It was made in Canada.

Rocket
An engine that carries its own fuel and oxygen so that it can work in space as well as in the atmosphere. It is pushed upward by gases streaming out of its exhaust nozzles. Launch vehicles are made up of several rocket stages linked together.

Remote sensing instruments
Equipment that measures different kinds of radiation. These instruments are fitted to spacecraft to do various jobs.

Satellite
A satellite is something that circles (orbits) around a much larger object. Artificial space satellites are unmanned. They orbit the Earth doing different jobs, such as relaying telephone calls or surveying and measuring the landscape.



Sleep station
The crew sleeping quarters on board a manned spacecraft.

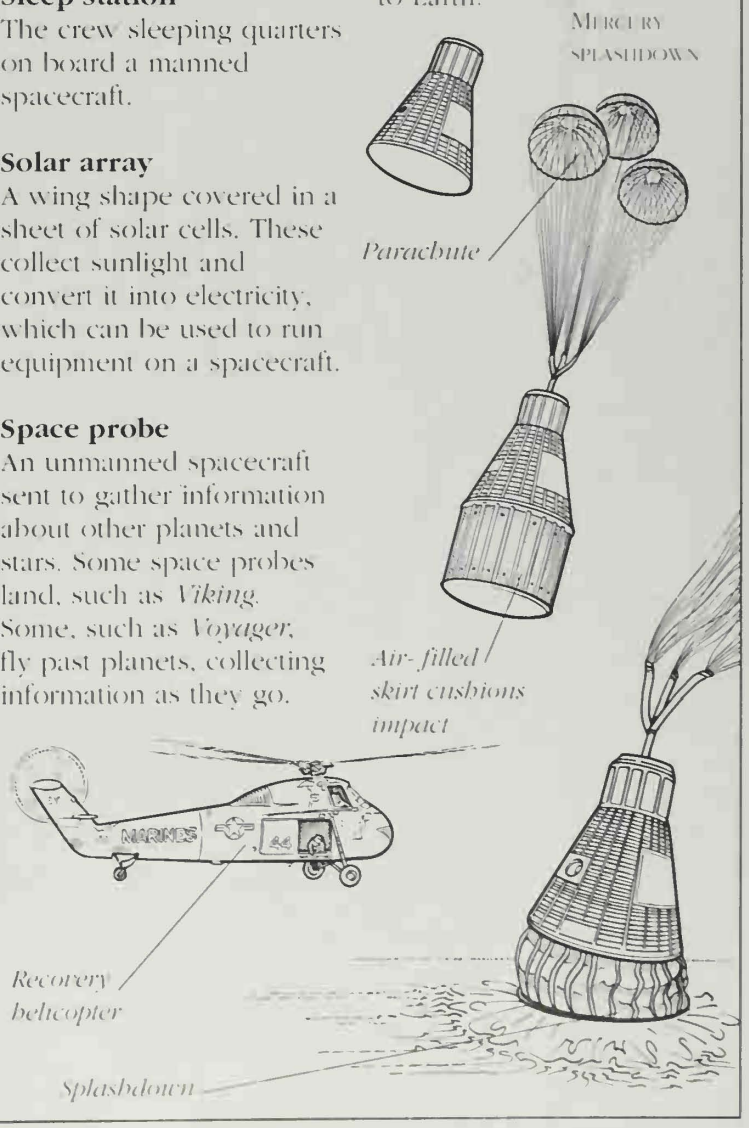
Solar array
A wing shape covered in a sheet of solar cells. These collect sunlight and convert it into electricity, which can be used to run equipment on a spacecraft.

Space probe
An unmanned spacecraft sent to gather information about other planets and stars. Some space probes land, such as *Viking*. Some, such as *Voyager*, fly past planets, collecting information as they go.

Space station
A manned spacecraft that orbits the Earth. Crew members can live and work on board for long periods of time.

Space lab
A laboratory workshop situated in the shuttle cargo bay. Scientific experiments are carried out in this lab by astronauts up in space.

Splashdown
The moment when a manned spacecraft hits the water, if it splashes down in the ocean on its return to Earth.



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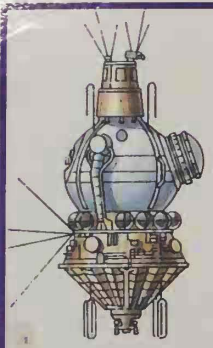

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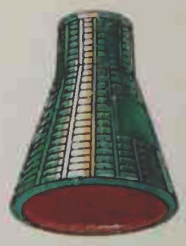
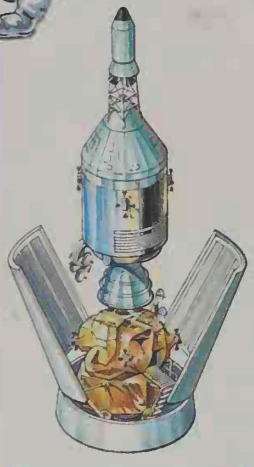
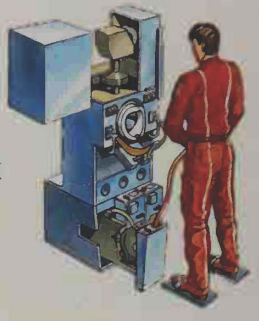


SEE INSIDE 12 FASCINATING SPACECRAFT



WHICH

faulty piece of space equipment was repaired in December 1993? • space probe landed on Mars? • US space station burned up on reentry in 1979?

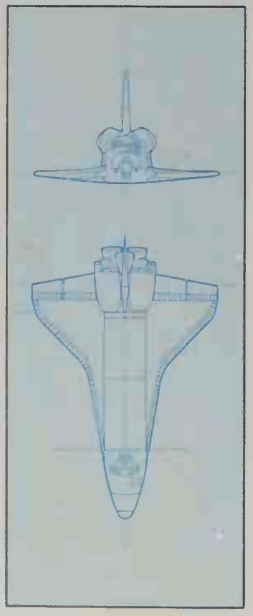


WHO

was the first human to walk on the Moon? • was the first woman in space? • performed the first space walk?

WHAT

does "astronaut" mean? • was the first reusable space vehicle? • is a splashdown?



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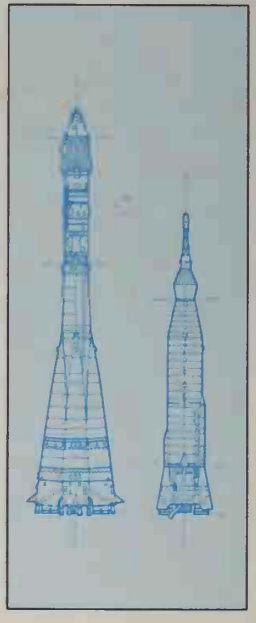

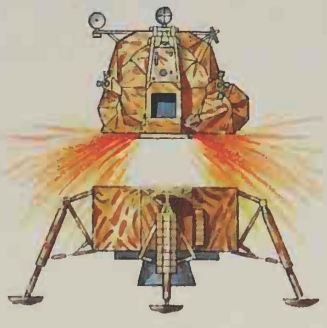

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