pictured, but vertical landings are also possible.

An additional part of the capsule is a laboratory for earth-orbiting trips. However, of all the Apollo modules, only the command center can re-enter the earth's atmosphere and be recovered.

The actual landing on the moon will be made at a site surveyed earlier by an unmanned spacecraft. This is necessary in order to learn if there are any obstacles in the landing area and to get information about the landing surface. A moon-landing gear cannot be designed before the composition and hardness of the lunar landing surface is known.

The take-off from the moon after landing will be a difficult operation done by only three men, in contrast to the hundreds of experts on the launching pad on earth. All the equipment for take-off must be prepared, erected and checked out.

The propulsion system for the lunar take-off must be the most reliable part of the Apollo capsule. The time of take-off must be precisely planned and the guidance equipment must work perfectly for starting the capsule on the right path for its return to earth.

On trips to the moon the most serious radiation problem that threatens man will be from solar flares. Some giant solar flares send out particles of such energy and intensity that shielding against them would weigh too much to be practical.

Fortunately, flares may possibly be predicted several days in advance and flights avoided when they occur. In the past ten years, only seven giant flares were observed. Many answers about the radiation problems are still lacking, but much of this information is anticipated from scientific satellites and space probes.

During the flight to the moon, the space pilot will help maneuver the capsule.

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PHYSICS

Atom Blasts for Research

➤ IF THE NUCLEAR test ban talks now stalled at Geneva fail completely, United States scientists are brimful of ideas for purely scientific research using nuclear explosions.

They see the nuclear blasts as "uniquely necessary" for many experiments in basic research. The decision concerning whether their proposals will be accepted depends on a "difficult mixture" of scientific, economic and political arguments.

One of the suggested experiments for nuclear blasts would be the creation of elements heavier than 103, the heaviest man-made element now known. Element 106, for instance, might last for many years, compared to the fleeting part of a second that element 103 exists.

The "Scientific Applications of Nuclear Explosions," or SANE, is more limited than Project Plowshare, the Atomic Energy Commission's project concerning all peaceful uses of nuclear explosions, particularly those of economic importance such as excavating harbors or moving mountains.

Nuclear explosions are of interest to the research scientist chiefly as uniquely intense sources of neutrons (electrically neutral particles of matter, one of the building blocks of the universe), neutrinos (elusive atomic "ghost" particles that interact very rarely with matter), plasmas (gas clouds), high temperatures, gamma rays, X-rays, light, shock and radioactive isotopes. The explosions also have the capacity to transform large quantities of elements through neutron reactions.

Radioactive contamination could be kept at a very low level by conducting the nuclear blasts underground, Dr. George A. Cowan of the Los Alamos Scientific Laboratory, N. M., reports in Science, 133:1739, 1961. He suggests that some of the nuclear explosions now in the planning stage for purposes of improving seismic detection or in connection with Plowshare programs can also be used for purely scientific measurements.

Dr. Cowan states it should be possible to avoid charges of evading test ban agreements when conducting such explosions by making the tests open to all. This would increase "opportunities for cooperative research on an international scale."

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MILITARY SCIENCE

Gas-Germ Warfare Defense

➤ DESPITE growing public awareness and expanded military research, the United States has a long way to go before defenses against chemical and biological warfare are adequate.

Army officials made this clear in testimony before a House appropriations subcommittee considering Department of Defense budget proposals for the next fiscal year.

Maj. Gen. Marshall Stubbs, chief chemical officer, said a detection and warning system is essential for such attacks, "just as radar gives advance warning of oncoming missiles and planes."

The Army has a chemical agent detector kit, effective at short ranges, and is adding to its knowledge of toxic agents as new ones become known. But an actual chemical attack probably would be with "odorless, colorless and tasteless clouds," which must be detected at a distance before troops are reached and overpowered, Gen. Stubbs said.

Biological attack offers problems even more difficult. A single aircraft could release enough material to cover "several hundred to several thousand square miles." The organisms are odorless, tasteless and invisible to human eyes.

Fast, accurate identification of biological attacks is considered "technically impossible" by many scientists, Gen. Stubbs said. But recent laboratory devices show "considerable promise" for automatically detecting biological aerosols—suspensions of fine biological particles in air or gas. A contract for industrial development has been awarded.

Masks and protective clothing have been developed to protect the respiratory system and the skin against biological and chemical agents. Col. Dan Crozier, chief medical consultant for the Surgeon General's office, said the Army has "effective vaccines against many of the diseases which are potential biological weapons," and is making rapid progress on others.

Disease casualties, he said, may have two to ten days between exposure and illness. But lethal gas casualties in chemical warfare may have only "a matter of seconds and minutes" for treatment. He believes a vast educational program is needed to make the public aware of treatment methods.

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MILITARY SCIENCE

Long-Range System For Spotting Submarines

➤ A SONAR SYSTEM for detecting and tracking enemy submarines long before they reach United States shores is being developed by the U. S. Navy.

The system uses a roving sound transmitter, packed on a ship, earphones on the ocean floor, and relay stations spotted along the ocean waters. The sonar system is part of the Office of Naval Research's Project Artemis.

The submarines are detected when sound waves sent through the water by the transmitter bounce off the submarine. By measuring the time the waves take to travel back, the distance to the submarine can be determined. The exact range of the anti-submarine system is still undisclosed by the U. S. Navy.

The sound transmitter, or transducer, which is five stories high and weighs hundreds of tons, will be carried on a former Navy tanker, the USNS Mission Capistrano. The ship is equipped to raise and lower the transmitter into the water and also provide power for its operation.

The U. S. Navy has already built a relay tower, called Argus Island, on top of an extinct underwater volcano off the Bermuda coast. The man-made island, sticking nearly 100 feet above the ocean surface, will relay sound waves picked up by hydrophones scattered along the ocean floor.

Columbia University's Hudson Laboratories, the prime contractor of Project Artemis, is working with nearly 30 university, Governmental and industrial scientific groups in carrying out the program.

The ship is scheduled to operate in waters stretching from Cape Hatteras to Bermuda.

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