

## SPACE

**After Apollo 11**

WHEN the Americans have landed on the Moon on July 20—and so far nothing has turned up in the debriefing of the Apollo 10 crew to prevent astronauts Armstrong, Collins and Aldrin from keeping to their timetable—what is the United States to do with the two Saturn V launchers which will be ready to fly and the seven in various stages of construction? Some of the answers were given last week by Dr George E. Mueller, associate administrator for Manned Space Flight, who was in London to receive an award, on behalf of NASA, from the British Interplanetary Society commemorating December's circumlunar flight of Apollo 8. But first Dr Mueller warned of possible disappointments with Apollo 11—NASA is not taking any risks, and the mission will be cut short at any stage if it seems necessary. The pressing question, which Apollo 10 photographs should resolve, is whether the proposed landing site in Mare Tranquillitatis is smooth enough; the steepest slope on which the lunar module can land without toppling over is 20°. If the landing goes as successfully as everyone hopes, NASA will use the first of the remaining nine launchers for a landing in a mare region in the Moon's western hemisphere, which may contain different material from the first landing site in the eastern hemisphere.

With this experience behind them, NASA intends to embark on an exploration of the visible face of the Moon with eight landings in regions representative of the lunar highlands (Fra Mauro and Censorinus), impact craters (Tycho and Copernicus), vulcanism (Littrow and the Marius Hills) and tectonism (Schröter's Valley and the Hyginus Rille). The radio communication problem precludes landings on the hidden side. Apart from its intrinsic interest, Tycho is to be explored because of the clues it will give to the rocks within the Moon. After a tricky landing as near as possible to the rim of the crater, the astronauts will collect rocks ejected by the impact, which it is conjectured will come from well below the surface. Samples believed to be from even deeper levels will be picked up by the expedition to Copernicus, which will land inside the crater, which is 12,600 feet deep and 56 miles wide, near a central peak thought to be material forced up from deep levels. Additional equipment developed in time for the later expeditions of the series will permit a 3-day stay on the Moon, instead of the 22 hours planned for Apollo 11, and a new spacesuit will allow the astronauts to walk up to five miles compared with the 200 yards which Armstrong and Aldrin will cover.

After lunar exploration, Dr Mueller sees space stations in Earth orbit as the next priority. One plan being considered is to use exhausted Saturn IVB stages, converted in orbit into workshops and laboratories. But by the time space stations are a reality, the Saturn V launcher will be going distinctly grey around the edges. Dr Mueller is clearly looking forward to reusable launchers, and spoke about two designs for placing men and materials into Earth orbit. One is the ultimate extension of the drop-tank principle, applied for years by the world's air forces. It involves the traditional delta lifting body, fitting snugly into a massive V-shaped drop-tank, enveloping the sides of the delta and containing rocket engines. The combina-

tion is launched vertically, and when the delta has been boosted towards orbit, the drop-tanks fall away. Returning from the space station, the delta makes an aerodynamic landing on an airstrip. The second design is also for vertical launch, and is made up of three reusable lifting bodies strapped side by side. Two of the "trimese" elements, as they are in danger of being called, peel off and return to base after dispatching the third into orbit. Each of the elements is roughly the size of a Boeing 727 airliner, and has a narrow wing. But by the end of the 1970s rocketry is in any case likely to be changing with the adoption of nuclear engines based on Nerva for the upper stages of Saturn vehicles.

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**Where to go Next**

THE decision to go ahead with the Apollo 11 launching on July 16 followed by a Moon landing on July 20 is likely to be taken after this weekend, and will depend on whether NASA engineers are satisfied that the faults which turned up on Apollo 10, such as the misorientation of an antenna and overheating of a fuel cell, can easily be remedied. Despite a mishap with the cameras during the Apollo 10 mission, the vital close up photographs of the landing site are "adequate", according to NASA's reluctant administrator, Dr Thomas O. Paine. Dr Paine was in London this week en route for the Paris airshow. He denied that his arrival, hard on the heels of NASA officials, Dr G. Mueller and Dr R. Jastrow, means that NASA is negotiating with the British Government. And he had no comment to make on rumours that Russia is planning a lunar expedition for the June 25/July 7 launch window—possibly a manned circumlunar flight or an unmanned landing with the return of lunar samples. With its goal of ten years within its grasp, NASA is not going to be hurried over the final step. "We go when we are ready", Dr Paine said, and there will be no hesitation in bringing Apollo 11 back without achieving a landing if there is any sign of trouble. In any case, Apollo 12 will be ready to fly two months later. There is some room for slippage in the launch date of Apollo 11 if any last minute faults occur, but if July 16 is missed by more than a few days then NASA will re-schedule the flight for the next launch window which occurs in mid August. Among other factors, the landing will only take place if the lighting conditions of the site fulfil certain conditions, and launch windows are roughly twenty-eight days apart. Before July 16, the lunar module pilot, Neil Armstrong, is expected to get in some practice at piloting the notorious Lunar Landing Research Vehicle, two of which have already been lost in crashes, and which simulates the flight dynamics of a lunar landing. The LLRV has been grounded for a period, but Dr Paine was confident of the safety of Armstrong, said to be one of the most experienced pilots in the United States, having flown an extraordinarily diverse cross-section of aircraft, including the X-15 rocket plane.

Assuming Apollo 11 is a success, what next? Nine further Saturn V/Apollo combinations for lunar exploration are funded, and a preliminary programme of landings has been drawn up, although a number of alternative plans are still being considered. One

attractive possibility is an extended circumlunar flight in a polar orbit lasting 28 days so that all the Moon is covered by the astronauts. NASA is also committed to the Apollo application programme, which Dr Paine sees as the prototype of a space station which could be started in, say, 1975, and be gradually built up over a period of a decade to hold fifty astronauts.

The ten flights to the Moon will decide whether further trips would be useful and whether a lunar station would be worthwhile. By then the United States may be deciding on a manned expedition to Mars, which Dr Paine thought could take place in about 1985. But it looks as if the United States is not going to be stamped into a trip to Mars in the same way as the Moon expedition came about. NASA is sending a series of probes to Mars to see whether a manned mission would be valuable. Two Mariners are to make a close approach to the planet, with television pictures, on July 31 and August 6.

#### ROYAL SOCIETY

### Cook Bicentenary

THE Royal Society on Tuesday this week celebrated the observations of the transit of Venus across the Sun by Captain Cook from Tahiti on June 3, 1769. Plainly the society is proud of the sea captain with a passion for navigation and measurement who literally and in every other sense put a large part of Australasia on the map. The celebrations this week seemed accurately to convey the sense that it is entirely proper for the Royal Society to mark this old feat of navigation even though academies elsewhere are more deeply involved in celebrating navigation to the Moon and other places now as obscure as what are known as the Antipodes used to be.

Lord Blackett, president of the society, and himself once a naval officer, made it clear that Captain Cook would not be forgotten. Sir Richard Woolley, Astronomer Royal, provided a splendid ten minute sketch of the importance of the observation of the transit of Venus from Tahiti two hundred years ago, with accurate navigation only just possible because of the development of an accurate chronometer—Kendall's first copy of the watch with which Harrison won the prize for a chronometer was proudly shown on Tuesday. The object of the observation of the time taken for Venus to cross the distance of the Sun was to derive an accurate value for the solar parallax. The point is that observations from two latitudes can be combined together to produce a value of some sort, as Halley pointed out in 1716. Sir Richard Woolley explained why the transit of Venus in 1761 had yielded nothing useful—there had been incomplete measurements from a southern latitude, partly at least because of the fecklessness of Messrs Mason and Dixon, the freelance surveyors, now commemorated by the Mason-Dixon line in the United States, but then, in February 1761, scolded by the Royal Society for lack of persistence.

Cook was a different fellow and found his way efficiently to Tahiti. Sir Richard Woolley was at pains on Tuesday to rehabilitate the reputation of this expedition, for many years in disrepute on the grounds that the value of the solar parallax eventually obtained was too far from the truth. He pointed out that Simon Newcombe, in the nineteenth century, had used Cook's

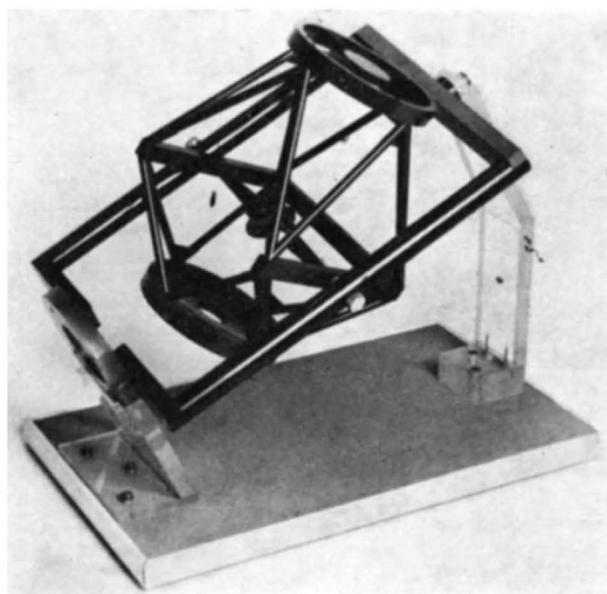
observations to obtain values not very different from 8.794 seconds of arc, afterwards accepted. To be sure, it is no longer necessary to wait for the transit of Venus to make this measurement, but even so, there will no doubt be more than sentimental interest in the next transit of Venus in AD 2004.

#### INFRARED ASTRONOMY

### Further Infrared

from our Astronomy Correspondent

WITH the design complete of the 60-inch infrared telescope to be built at Imperial College, London, Professor J. Ring, who leads the infrared team is looking forward to the 120-inch telescope which is the logical next step. Experience gained with the 60-inch, which will be one of the largest telescopes purely for infrared work, will be used in the design study for the 120-inch. So far, however, the team at Imperial College has money only for the smaller telescope, £27,000 awarded earlier this year by the Science Research Council (*Nature*, 221, 214; 1969). A start has nevertheless been made on testing suitable sites for an observatory, and the island of Tenerife in the Canaries



Model of the 60-inch telescope.

still seems to be hot favourite. The intention is to have the 60-inch telescope built and fully installed by late 1970.

Although an equatorial mounting has been chosen for the 60-inch, the 120-inch may have a different system. One possibility is the increasingly fashionable altazimuth mounting, with one axis of rotation horizontal and the other vertical, which has the advantage that for a given altitude direction, the stress on the telescope (especially the mirror) is the same for all azimuths. The problem of keeping altazimuth instruments trained on a particular star has now been overcome by computer—a suitable small computer would cost less than £10,000. Several other more or less bizarre new mounting systems are being considered, and Professor Ring hopes that by the end of the year the choice will be narrowed down to one or two. The