spaceflight would like to believe. This is not to say that the landing of men on the Moon, who will pick and choose interesting pieces of rock to be brought back for examination on the Earth, will not have a considerable scientific payoff. And it is hard to believe that men scrambling about on the surface will not make valuable deductions about the forces which have moulded the Moon's pock-marked landscape. The Christmas flight of Apollo 8 was a daring trail-blazer for this kind of activity to which the scientific community will look forward no less than anyone else. But the photographs of the illuminated part of a narrow strip of the Moon along the lunar equator which are now released will add next to nothing to what was already available in 1966 and 1967. The reason for this is that the Orbiter series of lunar satellites launched by the Americans has already mapped almost 99 per cent of the Moon, with a resolution as good as the Apollo

Looking south at the crater Goclenius, 40 miles in diameter. Goclenius is at latitude 10° south, longitude 45° east.

photographs. Operating at altitudes as little as 40 km above the surface, the Orbiters were equipped with medium and high resolution cameras to take pictures more detailed than those now published. The astronauts' photographs were, it seems, taken with a conventional camera from 110 km.

Following what has been the Russian practice, the Orbiter cameras use film as an intermediate stage rather than direct television transmission. The 200 foot roll of 70 mm film in Orbiter I was processed on board and the result radioed back to the Earth. Roughly 90 per cent of the 211 frames which could be accommodated on the roll of film in Orbiter I were used to map possible landing sites, each frame consisting of one high resolution and one medium resolution picture. The two lenses had a focal ratio of $f/5{\cdot}6$, the high resolution lens was a 600 mm "Paxoramic" and the medium resolution lens an 80 mm "Xenotar". A measure of the success of Orbiter I and its successors launched during 1966–67 is that photographic coverage of the Moon is now better than that of the Earth. The first three Orbiters concentrated on possible landing sites, with resolutions down to one metre in selected areas; subsequent Orbiters are more concerned with mapping the remainder of the surface.

Detail down to 50–100 m seems to be visible on the Apollo pictures so far available, roughly ten times better than ground based observations but not an improvement on the Orbiter results. Any advantage which the Apollo views have is in the availability of the original negatives, rather than at second-hand as was the case with the Orbiter series. This means that the Apollo pictures are likely to show finer gradations of shade. The colour photographs which have now been brought back may not add a great deal either. As a whole, the Moon seems as good an approximation to a grey body as can be found in the solar system. So much has been clear since the attempts at colour photography in the Surveyor programme by automatically inserting a sequence of colour filters in front of the lens of the television camera. An essentially colourless Moon was revealed by the reconstituted colour photograph.

ROCKETRY

Rocket for Apollo 8

Dr D. G. King-Hele writes:

As the sky darkened after sunset on the evening of December 21, 1968, hundreds of people in Britain saw a new object in the western sky, a very bright glow about 1° in diameter near the star Altair. It was a glowing cloud of ionized gas produced by the ejection of rocket propellants from the Saturn IVB rocket that had boosted Apollo 8 into its trajectory towards the Moon less than an hour before. The glow lasted from about 16 h 50 m UT, when the western sky was still light in southern England, until about 17 h 20 m, and at one time was reported to be nearly as bright as Venus. The approximate celestial coordinates were right ascension 19 h 40 m, declination +3°.

After an interval when no glow was visible, further propellants were vented from the rocket, and a new fan-shaped cloud was seen telescopically at 17 h 48 m: this glow was afterwards visible to the naked eye for an hour, about magnitude zero at its brightest. For much of this time the glow remained in the shape of a fan, or the stem of a wine-glass, with the apex, or stem, towards the right. Less than ½° to the right of the apex a small circular glow was visible, about magnitude four at brightest. As seen from southern England the objects moved nearly in a straight line, from right ascension 20 h 16 m, declination +1·2°, at time 18 h 00 m, to right ascension 20 h 43 m, declination −0·9°, at time 19 h 00 m. During this interval the distance of Apollo 8 increased from about 50,000 to about 60,000 km.

A number of satellite observers took this opportunity to make their first observations of objects in deep space. At Cowbeech, Sussex, G. E. Taylor, using his 500 mm reflecting telescope, was able to observe the Saturn IVB rocket flashing to magnitude 9 every 6 s and the Apollo 8 very close to it (within one minute of arc) at magnitude 11 to 12. Although the main glow was caused by propellants ejected from the rocket, the small circular glow may have been created by ionized gas from control jets or waste material released from Apollo 8 itself.

Optical observations of space probes have been made before, and clouds of ionized gas were used as "marker-beacons" by Russian Luna space vehicles. But the

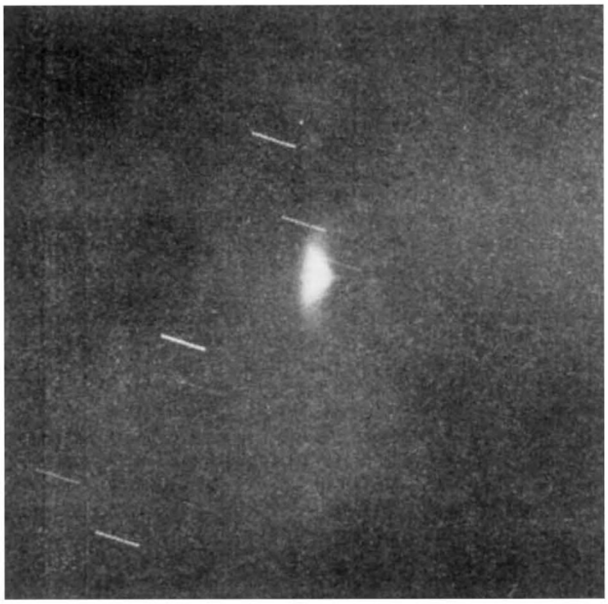

Fig. 1.

unintentional display of luminosity by Apollo 8 and its rocket shows that unburnt propellants in the rocket booster of a space vehicle might provide a glowing gas cloud throughout a journey to the Moon. Analysis of photographs of such a cloud might yield useful information on the structure of the outer reaches of the Earth's magnetosphere, just as analyses of clouds of glowing vapour from sounding rockets have been valuable in studying the upper atmosphere at heights between 100 and 200 km.

Fig. 1 is a photograph of the glowing clouds taken by Commander H. Hatfield at Sevenoaks, Kent, using a 12 inch telescope for guidance (1820 UT).

ASTRONOMY

Ammonia Line Detected

from our Astronomy Correspondent

THE spectrum of the radiation which radio astronomers collect is usually continuous, but a few spectral lines have been found and have turned out to be exceedingly useful. The most important are the well known neutral hydrogen line at 21 cm, which has made possible the charting of interstellar gas, and the line at 18 cm due to the hydroxyl radical. The detection of weak microwave emission from ammonia molecules in interstellar space by a team at the University of California, Berkeley, has now added another line to the list (*Phys. Rev. Lett.*, **21**, 1701; 1968). Although the result is not entirely unexpected, the measurement is nevertheless a considerable achievement by the five scientists responsible—A. C. Cheung, D. M. Rank and C. H. Townes of the Department of Physics and D. D. Thornton and W. J. Welch of the Radio Astronomy Laboratory. To pick up the ammonia signal, a new 20 foot diameter antenna, tuned to 1·25 cm, was set up at the Hat Creek Observatory of the University of California. The team directed its telescope at a number of objects, including Cassiopeia *A*, *W*51 and *NML* Cygnus, without finding ammonia emission or absorption. But observations of a dense cloud of gas and dust in the direction of the galactic centre yielded a profile of the predicted ammonia line after several hours of recording. During the observations the movement of the telescope to track the source was controlled by a computer, which also superintended an observing sequence designed to rule out the possibility of the signals coming from the Earth's atmosphere. Two lines corresponding to inversion transitions of rotational levels in the vibrational ground state of the ammonia molecule were picked up, but the detection of the weaker of the two lines is not definite.

A dense dust cloud in Sagittarius *A*, just south of the direction of the galactic centre, is probably the source of the emission. The region is also one in which there is strong absorption by the OH radical, which is presumably why the cloud was singled out for observation. According to the report, the frequency of the line is Doppler-shifted, corresponding to a velocity with respect to the local frame of rest of $+23$ km s^{-1}.

In its report, the California team speculates on conditions in the cloud, based on these preliminary measurements of the ammonia emission. Assuming that the cloud of ammonia is not optically thick, the number of ammonia molecules in all states in the line of sight comes out as 2×10^{16} cm^{-2}. Taking into account the size of the cloud, the volume density of ammonia molecules is roughly 10^{-3} cm^{-3}. This means that perhaps one per cent of the nitrogen in the cloud is combined with hydrogen as molecules of ammonia. Adsorption of hydrogen and nitrogen on grains of interstellar dust is the most likely source of the ammonia molecules, followed by sublimation, photodetachment or particle bombardment.

The detection of the ammonia line is important because of its relevance to the processes of star formation, which are believed to take place in the relatively cool regions of gas and dust clouds, where the hydroxyl radical is present. The cloud in Sagittarius is a typical example. Observations of the ammonia emission should help, among other things, in discovering the part played by nitrogen, and to this end radio astronomers will be scanning cool dust clouds for further signs of ammonia molecules.

RAW MATERIALS

Sweet Sense

ANYONE who was shrewd enough to invest his money in cocoa futures last January would now be sitting pretty with a very handsome profit. This January, the Cassandras of the commodity markets are tipping sugar as a sound gamble even though, at the United Nations this week, it looked very much as if as many as thirty-three of the major sugar exporting and importing countries, but not including the United States, which is not a member of the International Sugar Commission, had signed a new International Sugar Agreement in an attempt first to increase and then to stabilize the price of sugar on the world market. Since the expiry of the last international price agreement covering the five years 1959–63, the price of sugar has fluctuated between £100 and £10 a ton. In the past four years, however, it has been depressed at about £20 a ton. The sugar