distribution and angle of arrival of solar wind protons. The Centre d'Etudes Nucleaires de Saclay is to measure electrons, protons and alpha particles of solar and galactic origin; and together with the University of Milan will look at the spectrum of cosmic ray electrons in the range 50–600 MeV.

HEOS-A also contains an experiment devised by the Max Planck Institute for Extraterrestrial Physics. This consists of a 2·5 kg capsule of barium to be ejected when the satellite is some 20,000 km from the Earth, crossing the boundary of the magnetosphere. The plan is to release the capsule at some suitable time, when the resulting cloud of barium ions can be photographed from Kitt Peak, Arizona, and from the site of the proposed European southern hemisphere observatory in Chile. The motion of the cloud yields information on the magnetic field at the ignition point.

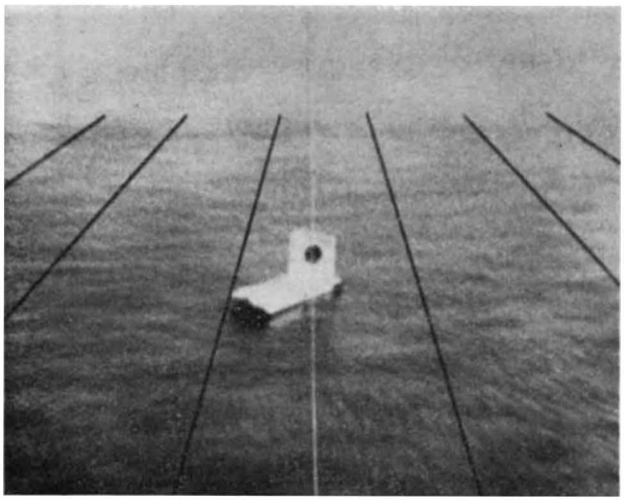
The experiments were tested on Monday this week when HEOS was just outside the magnetosphere. This first test seems to have caused some consternation at the ESRO control centre in Darmstadt, until it was realized that large readings in the Imperial College and the joint Italian–Belgian solar proton detectors did not represent a disastrously high noise level, but arose because the experiments had been fortuitously switched on in the midst of a solar event. Indications are that all the equipment is working well. The total cost of the project is $16 million, which includes the experiments and $3·6 million paid to the Americans for the launching operation.

DEFENCE

Missile by Television

THE completion of a successful series of firing trials of the Anglo-French Martel missile system has sparked off a substantial order for this novel weapon from the Ministry of Technology. The special feature of the British version of this air-to-ground strike missile is the television camera mounted in the nose cone, which sends back to the controlling aircraft a continuous transmission of the missile's forward view.

The missile part of the system has been designed and developed by Hawker Siddeley Dynamics in Britain and Engins Matra in France. Two versions of the weapon have been produced. The television version—for which Britain has the prime responsibility—is controlled from the launcher aircraft by a weapons controller who receives live transmission from the missile's camera. He is then in a position to steer the missile visually on to its target. The job is apparently sufficiently full-time as to eliminate using the pilot as the weapons operator. The picture below shows the view of a target as seen on the operator's television monitor, this particular target being moored at sea. The television guidance system has been developed by the Marconi Company, which claims that the technological barriers overcome in producing the compact electronics necessary to make the weapon operational have given the Anglo-French team a world lead in this field.



The picture shows the target as seen by the weapon operator on his television monitor screen.

The French version of the missile is designed to destroy enemy radar installations. It can operate against multiple targets, and achieves its end by homing directly on to the radar transmitters. Both the French and British versions are equipped with elaborate electronic counter-measure devices, essential to a system so susceptible to jamming.

Although the manufacturers are reluctant to give details of the missile's performance, it seems that the television version has destroyed targets ten feet in diameter from a distance quoted as "some tens of miles". The anti-radar model has had similar successes. The contracts already placed by the British Government seem to cost more than £10 million; Hawker Siddeley alone claims that it is benefiting to the tune of about £10 million, and Marconi claims that the orders are worth several million pounds to it. Both companies are confident of sizable export orders, particularly to NATO and Commonwealth countries.

NUCLEAR POWER

What Price Plutonium?

PLUTONIUM is not one of the metals the price of which is determined by the London Metal Exchange. Even that venerable institution, skilled as it is in determining the balance of supply and demand, might find it hard to keep up with the arguments which go to determine the price of plutonium. But four American utilities, Yankee Atomic, Consolidated Edison, Consumers Power and Commonwealth Edison, are sufficiently confident to have set up a joint association to fix export prices. Other utilities are likely to be invited to join the association, which will be safe from anti-trust action as long as the pricing agreements are intended only for export markets.

It would be fair to guess that the four utilities and any others that join the association will find it hard to agree on prices. Much will depend on the attitude taken towards the fast breeder reactor, for which plutonium provides the ideal fuel. It can also be used to fuel thermal reactors, and at the moment this seems to be the course that American utilities are adopting. But in Britain this attitude is seen as very much the second best, because of plutonium's characteristics. In any reactor, fissile plutonium has the advantage of emitting more neutrons per fission than does fissile uranium. Unfortunately, at the energies used in thermal reactors, plutonium also absorbs more, so it offers little, if any, advantage. In fast reactors, the absorption is hardly affected, and the advantage conferred by the greater number of neutrons per fission can be exploited.

Arguments like these have convinced the UKAEA that it is more sensible to retain plutonium within the system, although small amounts are exported if the price is right. This year an agreement was signed for the export of plutonium to Belgium at an undisclosed price, but the amount involved was small in comparison with Britain's annual production. The much maligned Magnox reactors are prolific producers of plutonium, and the annual production of plutonium in Britain will soon be approaching 2·5 tons a year, just about enough to start a 1,000 MWe fast reactor. Dr Hans Kronberger, chief scientist at the Risley establishment of the AEA, told a conference in Washington recently that Britain would have enough plutonium to construct 15,000 MWe of fast reactors between 1975 and 1985, and that only a severe setback in the fast reactor programme would convince him of the need to re-cycle plutonium through thermal reactors. The chances are that if fast reactor development continues to go well, even the need to construct thermal reactors as plutonium producers will decline. It may even be cheaper in the long run to build a fast reactor, and run it on enriched uranium for the first few years of its life until it had generated sufficient plutonium for that to be used as fuel. Fast reactors operated in this way are excellent producers of plutonium, although their energy cost is increased by about 0·15 pence per unit. Looking at the system as a whole, it might still be cheaper to do this than to build thermal reactors like AGRs and HTRs, which are poor plutonium producers. (The SGHWR is slightly better, and the Canadian CANDU better still.)

The price of plutonium is such a doubtful quantity that Mr C. E. Iliffe and Mr P. J. Searby of the AEA have devised a model of the nuclear section of the British fuel economy which assumes that the system consumes only the plutonium which is generated within it. Under these conditions, the effect of the generating cost of the entire system of any price assigned to plutonium cancels out in transactions between reactors within the system fed on uranium or plutonium. The model also allows a price for plutonium to be calculated, however, by substitution in the model of reactors of the same capacity, but fuelled by uranium. The difference in total cost of the system would then put a value on the plutonium which had thus been made available for sale. This method is used for calculating prices for the small amounts of plutonium which have been exported.

None of these arguments seems to have carried much weight in the United States, however, where the utilities still seem set on re-cycling plutonium through thermal reactors. To them, the fast reactor still seems a remote possibility, and scarcely worth waiting for in the hope of earning more for the plutonium they hold. But Dr Kronberger did make an intriguing suggestion to those determined to re-cycle plutonium. Magnox plutonium contains little of the undesirable isotope Pu240, and it is therefore ideal for thermal reactors, in which Pu240 acts as an absorbent. The plutonium produced in American reactors is much less suitable for re-cycling, but it is fine for fast reactors. Dr Kronberger therefore suggested the idea of a plutonium exchange between countries; he said that 0·734 kg of Magnox plutonium would give the same value as 1 kg of PWR plutonium when re-cycled. The PWR plutonium, on the other hand, would have to have only 0·176 kg of Magnox plutonium added to it to make it as good as 100 per cent Magnox plutonium in a fast reactor. By exchanging the two, he suggested there would be a net gain of about 5 per cent.

EDUCATION

Student Wastage

THE wastage rates among undergraduates at British universities show no sign of decreasing. According to the University Grants Committee's *Enquiry into Student Progress 1968*, published in August (*Nature*, **219**, 549; 1968), 13·3 per cent of the 35,386 undergraduates who might have been expected to graduate at the end of the academic year 1965–66 did in fact leave the universities without obtaining a degree. The other striking fact which emerged from the UGC's survey was that the failure rate was remarkably constant. In 1955, 14 per cent of university students did not get a degree and in 1966 the figure was virtually the same. The figures in the Department of Education and Science's latest volume of *Statistics of Education 1967, volume 5* (HMSO, 13*s* 6*d*), published on December 10, indicate that the rate has not declined and may even be increasing. Seventeen per cent of the 20,180 men and 13 per cent of the 8,498 women students in universities in England and Wales who held full value grants in 1967, either from the Government or from local education authorities, failed to complete their degree courses. Assuming that the failure rate in Scottish universities is comparable with that in the rest of Britain and that full grant holders are not more prone to failure than undergraduates who hold lesser awards or are without awards, the average 1967 failure rate among students of both sexes reached about 15 per cent. The failure rate among students at all establishments of further education other than the universities is even more alarming. In England and Wales in 1967, no fewer than 34 per cent of the men and 28 per cent of the women failed to complete their courses.

The total public spending on education and related services—which includes such things as school meals, transport of pupils and maintenance grants—reached £1,571 million in 1966–67, an increase of 10 per cent over the previous year and 69 per cent more than five years earlier. For the first time the amount spent on education proper has been distinguished from all the associated spending. The universities received £198·6 million, the schools £852·4 million and maintenance grants cost £73·2 million. £33 million went to university students. The number of students holding grants has increased faster than the total spending on education, and in December 1967 there were 230,500 students with grants of one sort or another.

The distribution of the number of grant holders per thousand in the 18–19 age group within the UK is illuminating. In England, 61·3 per thousand of this age group held full or lesser awards at the universities and 49·5 per thousand held grants at colleges of education; in Greater London, new awards taken up at the universities amounted to 73 per thousand of the age group whereas only 40 per thousand took up grants