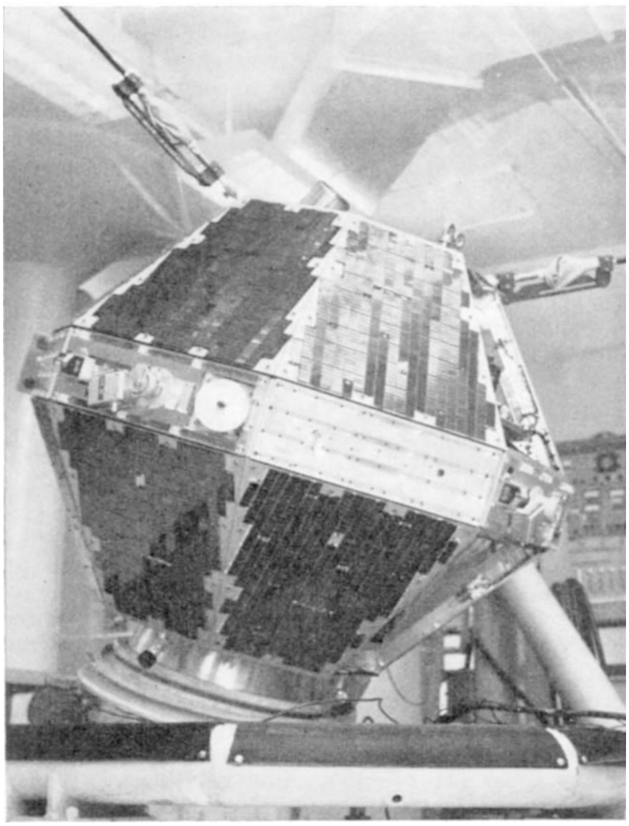
perigee 574 kilometres. The satellite itself is roughly a sphere in shape, with a diameter of 50 inches and a height of 41 inches; it weighs 525 pounds. It was put together by RCA Victor of Montreal, one of the companies bidding for the contract to build Canada's own domestic communications satellite.

The experiments carried by ISIS-A resemble in many ways those carried by Alouette II. But the increase in sophistication and power of the experiments has made it a much more elaborate satellite. One new feature is a spin and attitude system designed both to control the spin of the satellite in space and its attitude relative to the Sun and the Earth. ISIS-A is also provided with a data storage system on board, and 11,000 solar cells which should provide five hours a day of full operation under mimimum Sun conditions after a year in orbit. The most notable feature of the satellite is the antennae which will be extended to their full length—240 ft from tip to tip—on command in orbit. On Alouette II, the bending of the antennae caused the spin of the satellite to decline too rapidly, but on ISIS-A this will be prevented by the provision of a magnetic torquing device which is capable of controlling spin rate to between 1 and 3 r.p.m.

The four experiments carried for the Defence Research Telecommunications Establishment include two ionospheric probes, a radio noise experiment, and a special radio receiver for measuring the very low frequency signals generated by lightning flashes and other natural phenomena. The artificial generation of these phenomena will also be attempted by a generator carried in the satellite. NASA has provided one experiment—an electrostatic probe to measure the temperature and number of electrons near the satellite—and the NRC has fitted in a detector for very energetic particles. The USAF Cambridge laboratories experiments set out to detect and identify the types of charged particles near to the satellite, and to measure their temperature and density. The University of Western Ontario has simply installed a radio beacon whose signals to the Earth will give information about the irregularities in the ionosphere, and the US Southwest Center for Advanced Studies has a detector for low energy particles.



The ISIS-A satellite.

From this catalogue, it is clear that the information gathered by the satellite is likely to be a further aid in understanding the ionosphere, though it would be a surprise if it turned up anything very new. Ionosphere probes have become something of a glut on the market, and very often the information they provide is scarcely worth the expense involved—in this case, $13 million for the Canadian side of the project. It is, however, fair to add that the Alouette satellites have been useful, and that the three satellites built in Canada (and particularly ISIS-A) have put Canadian industry into the right frame of mind for the serious business of launching the communications satellite.

RESEARCH FINANCING

Boom and No Boom

"This is a year of watershed", says Dr Caryl Haskins in his presidential report for 1967–68 on the Carnegie Institution of Washington. The watershed is, of course, the sharp levelling off of United States Government support for science which, as the past 3 years have proved, is no transitory phenomenon. Between 1953 and 1964, federal spending on research and development rose from $3,500 million to $14,600 million and the scientific community generally assumed that the boom would continue indefinitely. But the bubble burst in 1965, since when the modest increases in federal allocations for research and development have been cancelled by inflation. In effect, federal support for research and development has barely increased since 1965.

Dr Haskins argues that the only way to avoid the inevitable disruption that follows violent swings from over-financing to under-financing is to fix a basic floor for federal support. This floor should be exceeded where possible, but only cut under the gravest of circumstances. He says that, during the coming years, "we should concentrate less on trying to determine realistic ceilings for our research expenditures and give more thought to how we might provide assured floors to our support of research". This would remove one of the most traumatic features of the current cutback, which is not so much the magnitude but the suddenness and unexpectedness of events. As one example, Dr Haskins cites a survey of 119 university physics departments, made recently by the American Institute of Physics, which revealed that 16 per cent of the senior staff had lost all federal support for their research in 1967–68 and that, this year, the proportion may be as high as 21 per cent. According to Dr Haskins, "such indicators, it is evident, are but icebergs' tips, visible hints of possibly greater problems ahead".

His answer is to suggest that the Federal Government should, for the future, set 0·7 per cent of the gross national product as a minimum level of support for research. This is the proportion of its funds which the government currently spends on research and it also happens to be very close to the average proportion of the gross national product spent on research in most industrialized countries. As Dr Haskins points out, it is a myth to suggest that the United States spends an exceptionally large proportion of its wealth on research. What it does do is spend a greater proportion than other countries on development, particularly space and defence work, which accounts for one of every two dollars in the federal research and development budget.

The role of private foundations, never more important than at times when government funds are being reduced, is to maintain centres of excellence. Citing Sir Hans Krebs's arguments for centres of excellence (*Nature*, **215**, 1441; 1967), Dr Haskins says, "We should give the most critical thought, in this year of the watershed, to protecting and cultivating the vitality, and above all the verve, of the scientific way". The Carnegie Institution does this through its six research departments, which include the Mount Wilson and Palomar Observatories, the Genetics Research Unit at Cold Spring Harbor, and the Geophysical Laboratory and Department of Terrestrial Magnetism in Washington.

The catalogue of the year's achievements at the six departments is the primal evidence of their pre-eminence in their fields of research. The observatories, for example, following their successful optical identification of quasars in 1962, made a survey of quasars in the entire sky and concluded that there must be at least 10 million, implying that quasars are not local objects, that is, confined to our galaxy. The observatories also collected new evidence which favours the oscillating model of the origin of the universe, which suggests the universe began with a series of big bangs spaced about 80,000 million years apart. They had less success with pulsars, however, and have failed to detect them optically.

Perhaps the outstanding find at the Geophysical Laboratory was the discovery of a new allotropic form of carbon, Chaoite, detected in shocked graphite from a meteoritic crater. And among much other important work the institution's biologists were involved in the conclusive proof that the chromosomes of viruses are integrated into those of host cells during transformation. While at the Biophysics Section of the Department of Terrestrial Magnetism, which for several years has housed a group outstanding for its exploitation of DNA and RNA hybridization techniques, the ribosomal RNA genes in *E. coli* have been isolated.

There is, of course, scarcely a better example of the flexibility of private institutions than the Carnegie Institution's Biophysics Section, which was set up early in the molecular biology boom, and yet is now happily housed in a laboratory originally established to work on magnetism. Nevertheless, the institution clearly intends to stay in the mainstream of biology. The final section of the report quotes from Stent's obituary of molecular biology, "there now seems to remain only one major frontier of biological inquiry for which reasonable molecular mechanisms cannot even be imagined; the higher nervous system". The report goes on to describe the successes of its admittedly modest fellowship scheme to promote work on the central nervous system. No doubt the biology of the brain will increasingly occupy more space in the institution's annual reports.

PIPELINES

Cheaper by Pipe

THE University of Alberta at Calgary is to set up a centre for the study of pipeline technology, supported by government and industry. Pipeline technology is particularly important to the Province of Alberta, which possesses large resources of oil and natural gas which are not always conveniently situated near roads or railways. For some years the province has also been supporting work on the transport of solids by pipeline, and this could turn out to be even more important for the development of Alberta and the Canadian North. This work is now being transferred from the Research Council of Alberta at Edmonton to the new Institute for Pipeline Research at Calgary.

Very long fluid pipelines have been operating in North America for almost a hundred years—the first was built by the Tidewater Pipe Line Company in 1879, after John D. Rockefeller had gained control of the railway. Solids have also been carried in pipelines in the form of a slurry, but that method has two drawbacks; it can only be used for materials which do not need to be kept dry and uncontaminated, and it requires greater pumping power, because the flow in the pipeline must be maintained in the turbulent region to keep the particles suspended. The concept of capsule pipelining developed at the Research Council of Alberta avoids both difficulties by encapsulating the material in containers made from plastic or aluminium. When carried along in a fluid of similar density, the capsules need scarcely more energy than would be required for the fluid alone. Even if the densities are different, the capsules ride along the pipe with very little friction, insulated from the wall of the pipe by an annulus of liquid. The best results are obtained when the diameter of the capsule is about 90 to 95 per cent of the diameter of the pipe. At the ideal speeds, 3–6 ft per s, the capsules plane along in a slightly nose-up attitude with a wedge of liquid between them and the pipe.

According to the enthusiastic director of the research work, Mr Erik Jensen, capsule pipelining has been very thoroughly proved. In one test, a 16 inch steel capsule was carried for 109 miles along a conventional 20 inch pipeline, and extensive testing was carried out in a 4 inch pipeline set up at the research council in Edmonton. So far, however, nobody has had the courage to invest money in a fully operational system, though Mr Jensen is convinced that if this were done the doubters would soon be convinced. The cost of laying the pipeline would be very much less than either a railway or a road, and the system seems particularly applicable to the problems of developing the resources of the North. The research council estimates that the costs of such a system would lie somewhere between that of a conventional railway and an oil pipeline (see figure), which suggests that it would probably be worthwhile for distances of up to 1,000 miles or so. Mr Jensen believes that such systems will come into use in situations where a railway branch would be uneconomical, or where ground transportation does not exist and personnel transport can be handled by air.