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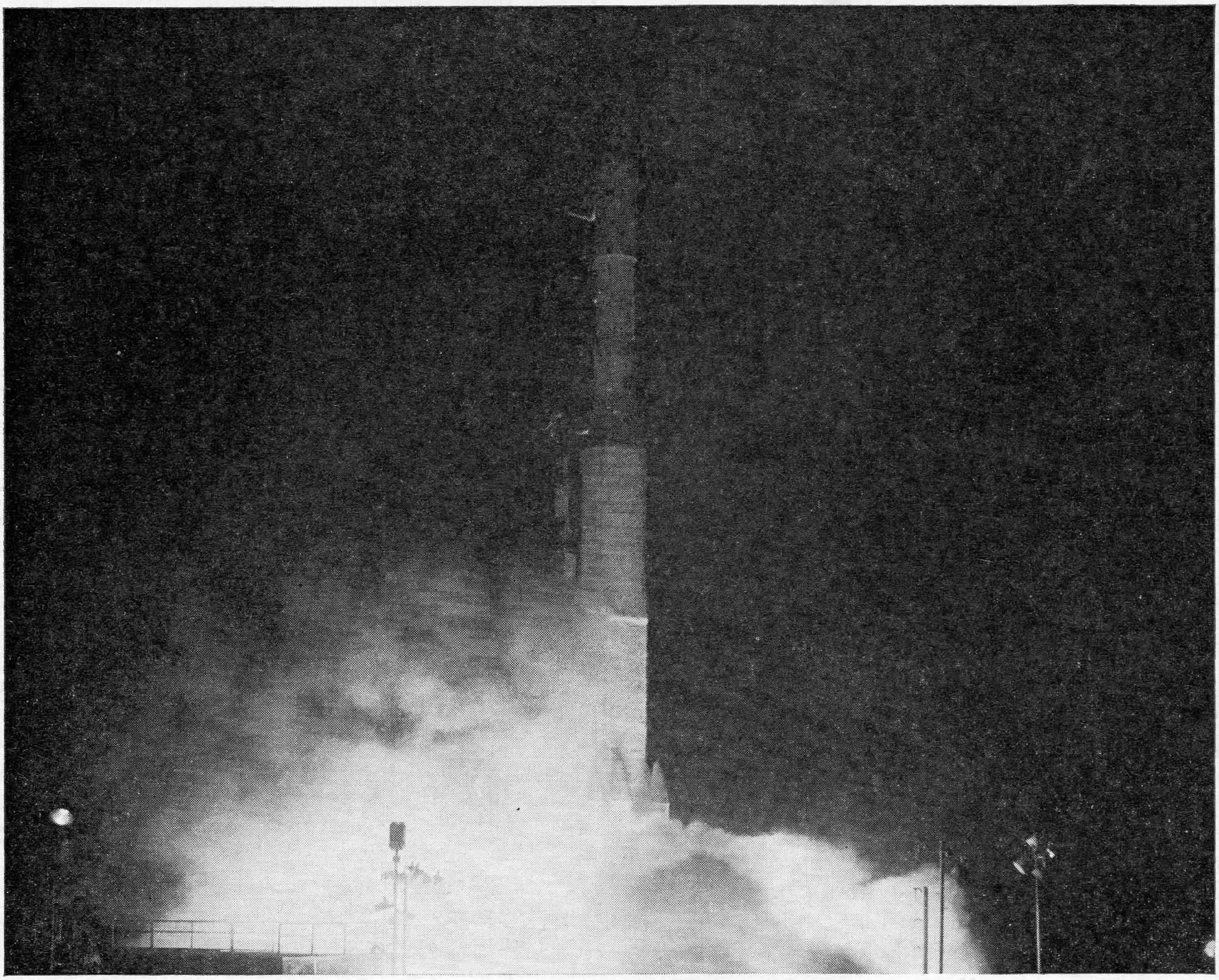
Student Satellite in Orbit



Thor-delta 76 blasts off Photograph, *NASA*

On 23 January 1970 the seventy-sixth Thor-Delta rocket was fired from the Vandenburg launch pad in California. The primary spacecraft was a NASA weather satellite, TIROS-M. However, to a group of students at Melbourne University the secondary satellite was of much more interest. This was AUSTRALIS OSCAR-V, a satellite designed and built by members of the University Astronautical Society. As AUSTRALIS OSCAR-V separated from the Delta second stage, two radio transmitters were turned on, and their antennae unfolded. About one thousand miles beneath the satellite, an amateur radio station in Malagasy, reported that the very high frequency (VHF) transmitter was operating. A few minutes later a weak signal from the high frequency (HF) transmitter was heard in Darwin, six thousand miles away. This was the first of many reports of anomalous radio propagation received from all parts of the world.

The idea of building the satellite originated with the Melbourne University Astronautical Society, a student group active in satellite tracking. Some of its achievements had been the reception of radio signals from United States and Soviet moon probes, and the first reception in Australia of weather satellite photographs.

During 1965 Astronautical Society members tracked the OSCAR III and OSCAR IV amateur radio satellites, built in the United States by the Project Oscar group (OSCAR is an acronym for Orbital Satellite Carrying Amateur Radio). While discussing the results of these spacecraft, it was realized that it was technically feasible to build a similar sort of satellite in Australia. Accordingly a proposal for an Australian satellite was sent to Project Oscar. To the surprise of many members of the Society the proposal was accepted and Project Oscar agreed to try to obtain a launch for an Australian satellite. As this was Australia's first satellite, there were hardly any people in the country with experience of space technology. Because of this it was decided that the proposed satellite should be a relatively simple system consisting of two radio beacons, one operating in the high frequency radio spectrum and another in the very high frequency spectrum. To keep the spacecraft antennae orientated in such a direction as to provide a strong signal for receiving stations on the earth, some sort of orientation system was required. So that the performance of the spacecraft could be assessed it was necessary to provide a telemetry subsystem. Whilst it would have been useful to keep the satellite operational for a year or more, the necessary solar cells were beyond the finances of the society. Hence the satellite was powered by a bank of chemical batteries, which would give an operational life of about six weeks, long enough to obtain all the desired information from the spacecraft telemetry system. This simple system represented some significant advances on previous amateur satellites. It was the first amateur satellite to carry a HF beacon, which could be used for ionospheric studies. In addition no other amateur satellite possessed a stabilization system or had a complex telemetry system. Due to the relatively high power output (for spacecraft at least) of the high frequency transmitter a command system was included in the satellite, with the object of turning the transmitter on and off.

On separation from the launch vehicle a small spacecraft is usually tumbling in space. Due to the vacuum and the lack of gravity there is nothing to stop this tumbling. The stabilization system used reduces tumbling by converting the kinetic energy of motion (in this case the tumbling) into heat. This is accomplished by special iron alloy rods which interact with the Earth's magnetic field and thus generate a damping force on the satellite. As the satellite stops tumbling a bar magnet built into it aligns itself, and hence the spacecraft, with the Earth's magnetic field.

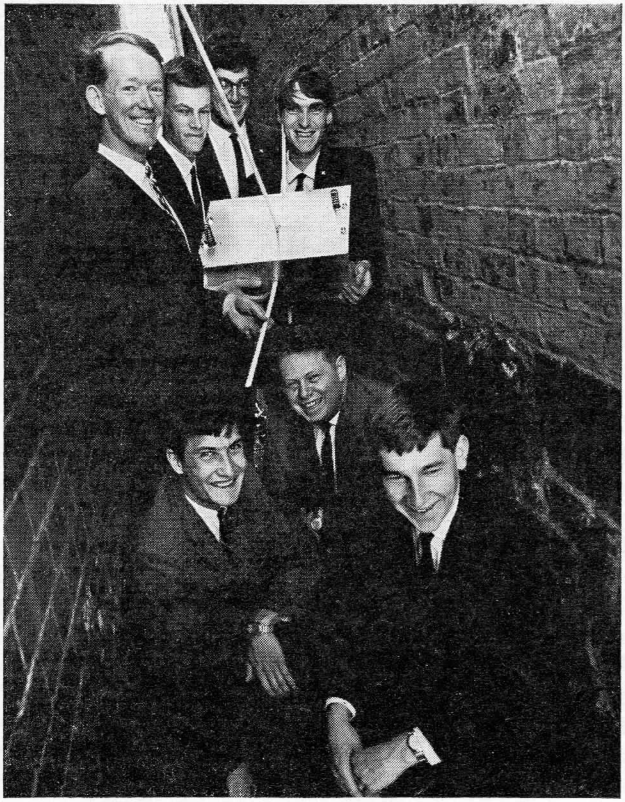
In order that as many amateurs around the world could decode the telemetry information transmitted back to Earth, a simple system was required. The approach used was to encode each of the seven channels sampled as an audio tone, whose frequency was related to the measured parameter. These tones were then transmitted sequentially back to earth, each tone being transmitted for seven and a half seconds. The start of a telemetry sequence was indicated by transmitting the letters HI (the international amateur greeting) in morse code. The seven parameters measured were the battery voltage and current, temperatures at two points in the satellite and three horizon sensors (from which the spin of the satellite could be determined).

Construction of the satellite took about eighteen months and in June 1967 three society members delivered AUSTRALIS OSCAR-V to Project Oscar in California. Nearly two years of frustration followed and by 1969 the Society had given up hope of having the satellite launched. It was during this period that the Weapons Research Establishment launched from Woomera, Australia's first satellite, WRESAT. In early 1969 the Radio Amateur Satellite Corporation (AMSAT) was founded in Washington. This new group offered to try to obtain a launch for AUSTRALIS OSCAR-V from NASA. In November 1969, NASA agreed to fly AUSTRALIS OSCAR-V as a secondary payload with the TIROS-M weather satellite. A condition of the launch was that the satellite must have a 'scientific or technological justification'. This was satisfied by the HF transmitter. By studying the signals received from satellites after they have passed through the ionosphere, it is possible to deduce some properties of the ionosphere.

After many delays caused by problems with the launch vehicle, AUSTRALIS OSCAR-V was successfully launched on 23 January 1970, becoming catalogue number 1970-008 B. Once in orbit, reports of reception of the two beacons were received from Australia, Germany, the United Kingdom, North America and many other countries. In Melbourne, Astronautical Society members tracked the satellite on its first orbit of the earth and on all subsequent orbits which came in range of the tracking station on the roof of the Physics building at the University.

In order to know when and where to point antennas, orbital predictions had to be provided. A special technique was devised to permit any station in the world, given several pages of computer-generated data, and brief predictions at regular intervals, to track AUSTRALIS OSCAR-V. The Project Australis headquarters at Melbourne University provided the data for any station in the world, except those in the United States which were served by AMSAT.

The spacecraft performance was almost flawless. The stabilization system removed the satellite spin almost completely by a week after launch. The only failure in the satellite was that shortly after launch the telemetry



Photograph, *Fairchild Australia*

John Monro, Paul Dunn, Richard Tonkin, Geoffrey Thomson (back row), Owen Mace, Peter Hammer, Stephen Howard

on the high frequency transmitter slowly faded even though the transmitter itself continued to operate. While this was a disappointment to amateurs wishing to extract the telemetry data from this beacon, it was not a serious problem as the same telemetry information was easily recovered from the VHF beacon. The propagation experiments made no use of the HF beacon so they also were unaffected by the loss of the telemetry.

By late February the batteries supplying the VHF beacon became so flat that the transmitter became inaudible and by the middle of March the HF beacon battery pack also became flat, thus rendering the satellite just one more of the hundreds of pieces of space junk destined to remain in orbit for thousands of years. Several thousand reports of reception of the satellite's transmitters and decoded telemetry information have been received from around the world. These are presently being analysed.

Following the successful flight of AUSTRALIS OSCAR-V, construction of a prototype for a second satellite has commenced. This satellite is planned as a communications repeater, capable of relaying messages between amateurs thousands of miles apart.

Normal long distance radio communication utilizes short wave frequencies. Here the radio signals are reflected by the Earth's ionosphere and can thus follow the curvature of the Earth's surface. Because the ionosphere varies with time, and from day to night, it can only be used at certain times of the day (or night) and at certain frequencies to provide long distance communications. A satellite allows the use of frequencies which are too high to be reflected by the ionosphere, and hence pass right through it. The satellite receives these signals, and after amplification and changing their frequencies, retransmits them back to the Earth. As long as the two ground based stations wishing to communicate can both see the satellite then they can communicate through it. Thus they are not limited to communication with each other by the variability of the ionosphere.

This second satellite is a joint project between Australia, America and Germany. Project Australis will construct the telemetry and command systems as well as the primary repeater, the German group will provide a second repeater while AMSAT will design the package to house the electronic modules and will also provide the power supply to run the satellite. By using solar cells and a rechargeable battery, it is hoped to obtain an operational life in excess of one year.

The budget for the Australian systems is about five thousand dollars. Depending on how readily this finance can be raised, it is hoped to have the satellite completed by the end of 1970.

P. HAMMER & O. MACE