RAL

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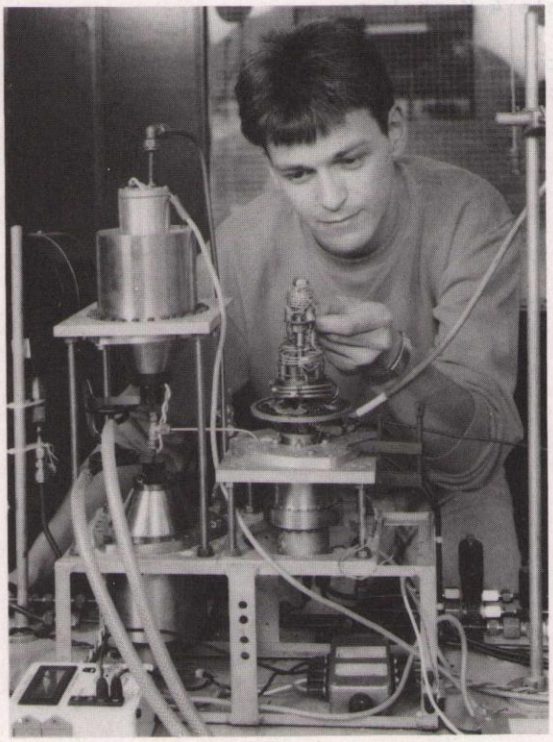
RUTHERFORD APPLETON LABORATORY

SCIENCE AND ENGINEERING RESEARCH COUNCIL

Closed Cycle Coolers for Long life Space Applications

Remote sensing of the Earth from satellites is playing an increasing part in our understanding of climate and the chemistry of the upper atmosphere. Many of these observations are made in the infra-red region of the spectrum and large improvements in sensitivity and signal to noise can be made by cooling the detectors to very low temperatures. In the past this cooling has been accomplished by the use of solid or liquid cryogens but such systems have limited lifetimes and large mass. Closed cycle coolers with high reliability are required to increase the life of these space instruments.



The first prototype Joule-Thomson stage mounted on a development two-stage cooler

The development at Rutherford Appleton Laboratory of Stirling cycle coolers for space use evolved from work with Oxford University on a single stage cooler required for the ISAMS (Improved Stratospheric and Mesospheric Sounder) instrument due to be launched on the NASA Upper Atmosphere Research Satellite (UARS) satellite in 1991. The outcome of this development programme was a cooler that exceeded the required performance specification by a wide margin; 875 mwatts of cooling power at 80 K for 30 watts electrical input power. The cooler also passed the vibration and environmental tests leading to space qualification. Long lifetimes have been achieved by the use of accurately maintained clearance seals to eliminate rubbing parts; an early prototype ran for approximately two and a half years on test. This technology was transferred to industry and British Aerospace Space and Communications division

at Bristol now manufacture the single stage coolers for space applications.

A similar refrigerator has been developed at RAL for ATSR (Along Track Scanning Radiometer); an instrument designed to measure sea surface temperatures which will be launched on the European Space Agency's Earth Resources Satellite, ERS-1, later this year (1990).

Work on multi-stage coolers at RAL has convincingly demonstrated that the same technology can be used at lower temperatures. The increase in complexity introduced by multi-staging the single-stage design is small; indeed, the the first "breadboard" multi-stage 20 K cooler at RAL was a modified single-stage design. This small prototype multi-stage cooler had a base temperature of around 18 K. A larger two stage cooler has been built as part of a further programme concerned with the development of a long life 4 K cooler for the European Space Agency. This cooler has reached 16.4 K and produces 300 mW of cooling at 30 K from approximately 85 watts of input power. Refrigeration at this temperature can be useful both for cooling detectors directly, and for cooling the radiation shields of liquid helium cryostats to increase the lifetime of the stored cryogen.

Many detectors require still lower temperatures to function effectively. To provide cooling at around 4 K a Joule-Thomson expansion stage is precooled by the two stage Stirling cycle cooler. The high pressure gas required for the expansion is provided by two valved compressors in series. The low pressure gas after expansion feeds back to these compressors making this a closed cycle 4 K cooler.

The compressors run 'back-to-back' to minimise vibration, but work has begun on a dedicated momentum compensation device to further reduce vibration for sensitive instruments.

For further information, contact;

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