DEPARTMENT OF PARTICLE PHYSICS

Staff

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Homopolar Generator Section

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Plasma Physics Section

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Physical Chemistry Section

Senior Fellow:	R. Mills, M.Sc., Ph.D.
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The Homopolar Generator

During the first half of the year the generator was assembled sufficiently for exhaustive tests to be made of the basic performance of the machine. These tests were very successful and established the validity of the general approach. The servo-controlled bearing system functioned well and no instabilities in the rotor position were detected. The electrical energy from the rotors was absorbed in an electrolytic load with resistance programmed to give current pulses of varying shape and duration, approximating in form the current pulses which would be delivered to an inductive load. The machine was pulsed repeatedly for long periods with complete reproducibility of output, at currents up to 1.5 million amperes. On one occasion, due to a fault in the electrolytic

load, a peak current of 1.8 million amperes was recorded. The energy extracted from the rotors in a pulse was over 100 million joules. The jets of sodium-potassium alloy used to collect the current from the rotors showed no signs of being overloaded, even at 1.8 million amperes, although the flows through the inner jet were less than half the design figure.

These experiments were interrupted following an unfortunate accident on 3rd July, during the process of supplying extra sodium-potassium alloy to the system from the drums in which it is supplied. Material damage done by the unexpected explosion was slight, but one technician was badly burned and both his eyes had to be removed. Very full precautions were observed, these resulting from experience overseas and in these laboratories. As a result of this accident, and subsequent enquiry by a Committee appointed by Council, tests were not resumed for about two months, and were continued until an oil leak made it necessary to shut down. It was found during tests that the insulation between rotors broke down spasmodically due to an unexpected passage of the NaK alloy along the outer surfaces of the rotors, past insulating baffles. Accordingly, the generator was dismantled at the end of the year to allow the oil leakage to be eliminated and the insulation improved.

The dismantling operation was carried through successfully and expeditiously, despite massive contamination of all parts by the NaK alloy, and the occurrence of wet weather which caused rapid attack of exposed alloy. There is little doubt that this, which had appeared to be the most hazardous of all operations involving the handling of NaK, can be carried out with complete safety of persons and of the equipment.

Thought is now being given to the modifications required to remove all remaining dangers in the use of the reactive NaK alloy, and to make the generator a reliable tool for physical investigations. The great success of the tests has enhanced the belief that the homopolar

generator is the most economic source of very large pulsed electrical power: the regrettable accident has delayed progress, but has encouraged a review of the whole task which will result in safer and more reliable operation.

Plasma Physics

Observations on the motion of a glow discharge in a transverse magnetic field have been extended over a larger range of parameters with the completion of a glass covered chamber with dismountable electrodes of various sizes and types. A bakeable glass vacuum system has been completed and is ready for experiment with high purity gas.

The larger air cored magnet and power supply, permitting the operation of arcs up to 80 amps. in fields up to 16,000 gauss, has been in operation over most of the year. Observations of arc characteristics for a range of gases and pressures have been made, with particular attention to transitions in mode of operation of the arc and cathode and anode phenomena.

A device for the study of pulsed heavy current discharges between long parallel cylinders, with dipolar orthagonal structure and magnetic fields, has been set up and preliminary experiments performed.

A 100,000 joule capacitor bank has been ordered for general use in experiments requiring large pulse currents and voltages. It is also intended that these capacitors be used in conjunction with the homopolar generator. Design studies of large magnetic field coils and devices which can be powered by the homopolar generator, are being made.

Physical Chemistry Unit

In fuel cell research an apparatus for studying diffusion in molten salts has been constructed and is under test. A high temperature fuel cell was built and operated on hydrogen and propane fuels. Useful currents and voltages were obtained but corrosion of the electrodes

limited its working life. A new cell with silver electrodes is now being made.

In liquid diffusion, studies were made of the tracer-diffusion in non-electrolyte system and at very low concentration levels of electrolytes. A diaphragm cell with a teflon sinter is being developed to open up new concentration areas.

Study Leave

Sir Mark visited laboratories in England and the U.S.A. in August and September, to discuss the handling of NaK, distillation of sea water, and developments in accelerators and fast neutron reactors. While overseas he attended the Ninth Pugwash Conference at Cambridge, England, and the Tenth Pugwash Conference in London.

Dr. W.I.B. Smith was granted leave to remain for a second year at Harvard University to continue work on the Cambridge Electron Accelerator. Dr. Smith is due to return from leave in February, 1963.

Mr. B.F. Wadsworth remained on leave at the Massachusetts Institute of Technology in Cambridge, U.S.A., and is due to return in August, 1963.

Dr. A.H. Morton left Canberra in April on leave for two years at the Culham Laboratory of the U.K. Atomic Energy Authority, Abingdon, England.

Mr. P.O. Carden left in October to spend his study leave working at the National Magnet Laboratory of the Massachusetts Institute of Technology at Boston, U.S.A.

Publications

Blamey, J.W., Carden, P.O., Hibbard, L.U., Inall, E.K., Marshall, R.A., Oliphant, M.L. - "The Large Homopolar Generator at Canberra - Initial Tests". Nature, 195, 113 (1962).

Blamey, J.W., Smith, W.I.B. - "The Canberra Homopolar Generator". Chapter 20 of "High Magnetic Fields". M.I.T. Press and John Wiley & Sons, Inc. N.Y. (1962).

Hibbard, L.U. - "The Canberra Homopolar Generator". Atomic Energy 5, 3, (1962).

Inall, E.K. - "The Liquid Metal Jet System - Canberra Homopolar Generator". Atomic Energy, 5, 3, (1962).

Mills, R. - "The effect of ionization of water on diffusional behaviour in dilute aqueous electrolytes". J. Phys. Chem, 66, 2716, (1962).