Temperature Measurement in the Herald Reactor

A SPECIAL PLATINUM THERMOCOUPLE

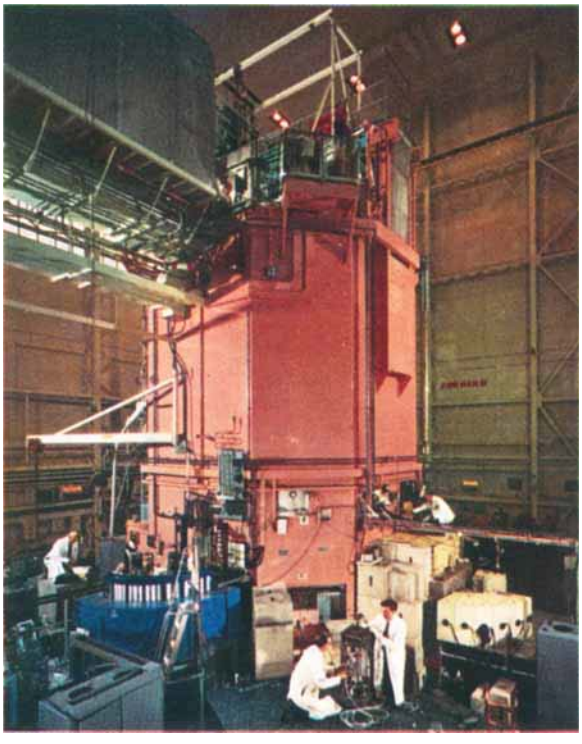
By A. J. L. Bignell and C. R. N. Clark

Johnson Matthey Metals Limited

A mineral insulated platinum: 13 per cent rhodium-platinum thermocouple, clad with 10 per cent rhodium-platinum and stainless steel, has been manufactured for experimental work in the Herald Reactor at Aldermaston. The clad thermocouple unit was 30 feet long and passed through 23 feet of cooling water to a reaction chamber at 1200°C.

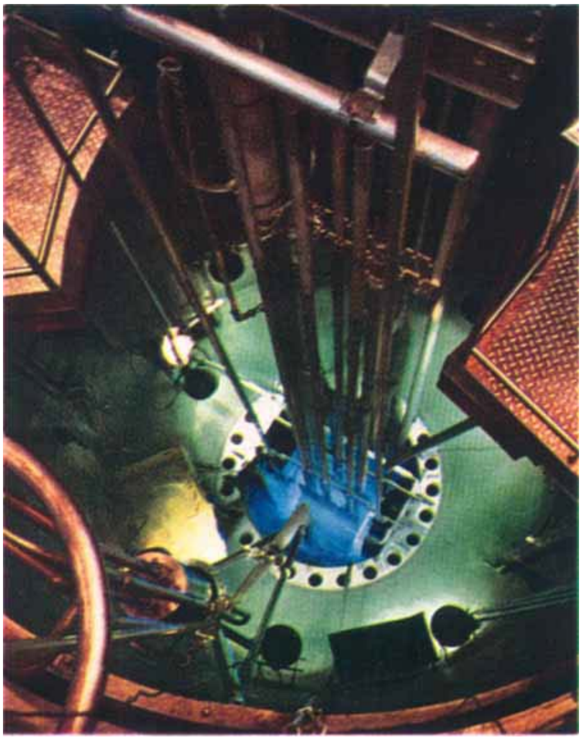
The Central Electricity Generating Board are carrying out investigations into the effect of radiation on nuclear fuels at different temperatures. When uranium dioxide, for example, is bombarded with neutrons, the resulting exothermic reaction results in the formation of impurity atoms, many of which precipitate into secondary defects whose concentration and size is a function of the irradiation temperature. The irradiation temperature can be varied from one experiment to another by altering the number of molybdenum heat shields which surround the samples of uranium dioxide. In these experiments this temperature was accurately measured by a platinum : rhodium-platinum thermocouple.

These experiments are at present being carried out at Aldermaston on the Herald Reactor. This 5 megawatt research reactor is one of the largest of the open tank types. The central reactor core is surrounded by circulating cooling water to a depth of 23 feet. The interior is seen by looking down on the reactor core from above. The blue glow to be seen around the core is known as the



Exterior view of the Herald reactor showing the accumulation of equipment around the base for various experiments

Interior view of the reactor core, seen from thirty feet above the core. The blue glow is caused by the Cherenkov effect



Cherenkov effect, the result of the electrons in the water becoming accelerated to speeds which are greater than the speed of light in water. On collision with other water atoms energy is released as light in the blue area of the spectrum.

The core itself is made up of a series of fuel elements, each one consisting of a number of trimetal plates of uranium-aluminium alloy clad on either side with pure aluminium. By adjusting the arrangement of these fuel elements in the core it is possible to achieve high or low neutron flux conditions at points around the core.

The reactor is available for research by all groups of the U.K.A.E.A. as well as by the C.E.G.B., the Universities and Industry. Samples of moon rock have recently been irradiated, for example, on behalf of Sheffield University.

The Thermocouple

The thermocouple used in these experiments must pass through 23 feet of cooling water before entering the reaction chamber. The mineral-insulated type of thermocouple is well suited to this sort of application as it is leak tight without being cumbersome. A platinum: 13 per cent rhodium-platinum thermocouple was chosen as the temperatures to be measured were in the range 900 to 1500°C. A rhodium-platinum sheath over that portion of the unit in the hot zone was also necessary to withstand the high temperatures. The remainder of the sheath, in the interests of economy, was of stainless steel.

The general design of metal-clad mineral-insulated thermocouples has been described before in this journal (1, 2). The total length of this thermocouple was 30 feet, of which one foot was sheathed in 10 per cent rhodium-platinum and the remainder in stainless steel. The outside diameter of the sheath was 0.065 inch and the platinum and 13 per cent rhodium-platinum thermocouple wires ran through all 30 feet of the unit.

The leak tightness of the stainless steel portion of the sheath was tested by using a helium mass spectrometer leak detector at a vacuum level of 10^{-5} Torr. A leak rate of less than 4.6×10^{-11} cm^3/sec was achieved, demonstrating that the stainless steel sheath was essentially leak free.

After the thermocouple had been completely assembled the entire unit was checked for absence of porosity, particular attention being paid to the brazed joint between the stainless steel and the rhodium-platinum parts of the sheath. This check was effected by immersing the unit in water for 24 hours and then measuring the resistance of the magnesia insulation that separates the thermocouple wires from the sheath and from each other. Such a measurement was also taken after the noble metal part of the sheath had been immersed in liquid nitrogen for a few hours.

In both cases the megohmeter recorded values in excess of 10^4 megohms for the insulation resistance. Had any imperfections been present in the sheath, the magnesia would have absorbed water and the insulation resistance would have dropped to a few hundred ohms. These test results demonstrated that the thermocouple unit was entirely leak tight.

The Use of the Thermocouple

The hot end of the thermocouple was coiled around the uranium dioxide specimens in the reaction chamber. This 3-inch long coil was $\frac{3}{4}$ inch in diameter and consisted of 4 or 5 turns, showing the flexibility of the thermocouple unit.

In the first experiment the temperature recorded initially was 1235°C. Rearrangement of the fuel elements caused the temperature to drop to 1180°C, stabilising at this value after two hours. This reading was maintained for 13 of the 16 days of irradiation. During the final three days the temperature reading increased to 1205°C; this change was due mainly to a further adjustment of the fuel elements. It is possible, however, that transmutation of the thermocouple elements also contributed slightly to the change in reading. However, no drift in reading due to this phenomenon was observed over the first 13 days of the experiment.

That temperature most relevant to the experiment was the equilibrium temperature achieved a few hours after the start of radiation. The subsequent changes in temperature were of secondary interest only; hence the thermocouple has been completely successful. The radiation level in the first experiment was 5×10^{19} neutrons/cm^2/sec and further experiments are in progress at the moment. Each single experiment will consume a new thermocouple as the reaction chamber is not re-usable.

Thanks are due to U.K.A.E.A., Aldermaston and to the C.E.G.B. for assistance in the preparation of this article and the permission to publish.

References

1 *Platinum Metals Rev.*, 1960, **4**, 127
2 *Platinum Metals Rev.*, 1969, **13**, 93

Platinum Contacts in Automatic Landing Systems

All BEA Trident aircraft are equipped with the Smiths' Series 5 flight control system. This "blind landing" system has steadily increased in application since its first use in June 1965. At the present time 100 or more automatic landings using this system are made by Trident aircraft every month. This demonstrates the very real lead in fully automatic operations which has been achieved by wholly British technology.

The circuitry of this flight control system incorporates some 2,000 micro relays of the single-pole changeover type which are hermetically sealed. The 10 per cent rhodium-platinum contacts in each relay are gold-plated and are suitable for switching either very low signal energies or higher powers up to 15 VA. The relay is designed with a strong accent on reliability which is clearly of prime importance in this application.

The 10 per cent rhodium-platinum is used in order to guarantee a contact resistance of less than 0.1 ohm. The alloy is in the form of 0.017 inch diameter wire which is gold-plated to a depth of 150 micro-inches. Some three inches of this wire is used in each relay.

The relay is sealed by passing the rhodium-platinum wires through a glass pellet and fusing the glass on to the rhodium-platinum at 1000°C. This glass-to-metal sealing work is carried out on Smiths' behalf by Wesley Coe Ltd, of Cambridge.