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ZAPPER - A DEVICE FOR REPAIRING OPEN-CIRCUITED THERMOCOUPLES

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STATEMENT OF PROBLEM			
Document the construction and use of the thermocouple "ZAPPER."			
ABSTRACT:			
A device to weld remote breaks in thermocouples has been developed. It is an adjustable capacitive discharge welding machine capable of repairing thermocouples attached to in-pile irradiation experiments where accessibility is not possible.

ZAPPER* - A DEVICE FOR REPAIRING OPEN-CIRCUITED THERMOCOUPLES

A device to weld remote breaks in wire or cable has been developed at AI. It has been used successfully to fix thermocouples attached to in-pile irradiation experiments where accessibility was impossible. In many cases, thermocouple repair allowed continuation of expensive nuclear fuel tests that had open-circuited instrumentation and thus resulted in substantial cost savings. One instance of such a repair was the U-305 experiment which was operated in the U-3 loop of the NRU reactor at Chalk River in Canada.**

The original ZAPPER was conceived and built by W. J. James in order to attempt to salvage some of the failed thermocouples then located on irradiation experiments. It is basically an adjustable, capacitive discharge welding machine, capable of storing 135 watt-seconds of energy at potentials of up to 1000 volts. It features adjustable charge voltage, switchable capacitance banks to accommodate various wire sizes, and has a measuring circuit to determine voltage breakdown across the wire gap before discharge and repair is attempted.

It has been found that thermocouple wires open most frequently during periods of thermal cycle.*** In-pile thermocouples most notably fail during reactor shutdown, startup or scram. A common thermocouple combination is Chromel-Alumel wire with MgO insulation swaged into a stainless-steel tubular sheath. A significant difference in thermal expansion exists between wire and sheath and upon temperature rise, the stainless steel sheath, which has the higher coefficient of expansion, tends to pull the wires apart. This most commonly occurs in the Alumel leg, and appears at times as a thermal switch, i.e., it is open at elevated temperature and closed when cool. The ZAPPER has been used frequently to mend this type of failed T/C with the small associated wire gap. It is admittedly a "last ditch" method of repair, useful only for open circuits, and then only when other repair methods are not possible. The

*ZAPPER - Zone Applied Power Providing Electrical Repair

**"Cost Reduction Abstracts," published by U.S.A.E.C., September 1966

***NAA-SR-10511, "Increasing Thermocouple Reliability for In-pile Experiments,"
E. L. Babbe

"fixes" are not permanent at all times. Some in-pile T/Cs have been repaired as many as ten times. However, the probability of making a repair is good, averaging about 90%, depending on operator skill and judgment. Occasionally a thermocouple will not be repairable because of excessive gap or because the electrical discharge arcs through the insulation and shorts the wire to the sheath. The discharge may also, on occasion, tend to "burn" the wire back and make the break wider than it was originally. This has actually been observed, while occurring, on a dynamic image enlarging X-ray system. The cause of this "burn back" seems to be excessive capacity in the energy storage circuit. In most cases, this can be avoided by adherence to the operating procedure in which the switchable capacitor banks built into the ZAPPER are used in successively increasing steps.

In a small number of cases a new measuring junction is formed by the arc shorting the thermoelements at a location different from the original. This may or may not be detectable by resistance and/or temperature readings and should be considered when using the experimental data after repairs are made.

The current model presently in use is pictorially shown in Figure 1, and schematically in Figure 2. The normal operating technique is to first find the voltage necessary to break down and bridge the wire gap. This is indicated by the voltmeter on the left side of the instrument. One capacitor bank is then charged to a voltage about 10% higher than the break-down voltage previously measured, and a discharge is made. If the wire fails to weld, a second capacitor bank is switched into the circuit and the procedure is repeated. More capacitance is added until either a repair is made, the wire shorts to ground, or the capacity of the machine is reached.

Failed thermocouples in experiments being irradiated at Chalk River, were routinely "ZAPPED" on a weekly schedule. Wire breaks in this instance, were repaired at distances of 150 to 175 feet from the instrument. The ZAPPER has also been used for thermocouple repairs on SNAP fuel experiments being irradiated in the Hanford production reactors. These experiments also contain ADIT pressure sensors for in-pile dynamic measurement of pressures within the fuel elements. These pressure sensors depend on a make-break electrical contact for balance indication and, occasionally, contact resistance

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builds up to a point where balance cannot be determined. The ZAPPER has been used to burn through this high resistance contact coating and again enable use of the pressure measuring device.

The ZAPPER has been in use at various reactor sites for the past five years and has proven to be an extremely useful operational tool.

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FIGURE 1. ZAPPER - A Device for Repairing Thermocouples

ZAPPER
FIGURE 2