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Remote Balance Weighs Accurately Amid High Radiation

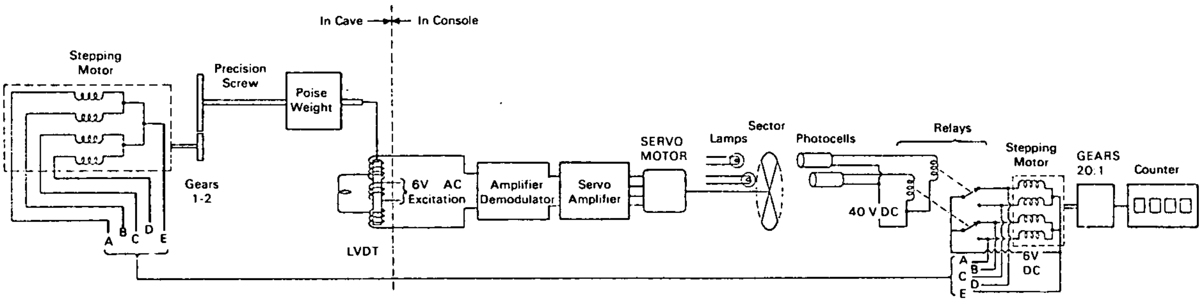

Fig 1 Schematic of the Balance

The problem:

Accurate weighing of breeder-reactor fuel pieces when they are radioactively hot. All handling and weighing must be done in a shielded cave by remote control. The balance must be reliable and rugged because remote-handling and decontamination procedures would cause repairs to be time-consuming and costly.

The solution:

A commercial beam-type balance, modified and outfitted with electronic controls and digital readout, can be remotely controlled for use in high-radiation environments (*1*). The balance has a poise weight positioned by a precision screw that is driven by a stepping motor. The remote readout is coupled to a mechanical counter driven by another stepping motor that operates synchronously with the balance motor. The balance is accurate within 2 g between 100 and 18,000 g; it has operated for more than 1 year at gamma-radiation levels as high as 10^6 r/hour.

How it's done:

The radiation precludes use of most organic materials and glasses; the balance is almost entirely of metal, except for ceramic and formvar wire coatings, asbestos sheathing of wires, and radiation-resistant lubricant. The low-humidity atmosphere precludes use of graphite as a lubricant.

The weight measured by the balance is determined by the number of turns of the precision screw from its zero-weight position (Fig. 1); the number is found by counting of the steps taken by the stepping motor. The count is an algebraic sum, backward steps being subtracted from the count. A second stepping motor, in the readout console, is wired in parallel with the balance motor, and the two make precisely the same steps. By appropriate gearing, a bidirectional mechanical counter, driven by the second stepping motor, then indicates the net number of forward steps taken by the balance motor.

The position of the balance beam is sensed by a linear variable-differential transformer (LVDT) whose output is nominally zero at balance. The amplitude of the LVDT a-c signal varies nearly linearly with the amount of beam deflection either way from its balance position, but the signal phase on one side of balance is 180° from that on the other. The signal is amplified and then demodulated to give a positive output potential on one side of balance and a negative potential on the other.

(continued overleaf)

The demodulated potential is led into a servo amplifier driving a bidirectional servo motor, whose direction of rotation then depends upon which side of balance the beam is located. Its speed is approximately proportional to the amount of beam deflection and therefore it stops at balance. The servo motor turns a two-bladed sector disk that interrupts the light to two photocells. The photocells operate two mercury relays that switch currents to the stepping motors.

This system has several advantages for reliability. The speed of the stepping motor decreases as the weight beam approaches balance; thus overshoot and time for balancing are reduced. Also there is no ambiguity in direction of turning of the stepping motors, since there is no drift that would cause the LVDT crossover and the motor-directional signal to become displaced and make the motors turn in the wrong direction over a range of weigh-beam deflection. Moreover, the system is self-checking for possible missed counts in case the two stepping motors should not move in synchrony.

Reference:

1. D. N. Eggenberger and A. B. Shuck, *Nuclear Instr. Methods* **57**, 89 (1967).

Note:

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Patent status:

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