March 1971 Brief 71-10043

AEC-NASA TECH BRIEF

Space Nuclear Systems Office

Inexpensive System Protects Megawatt Resistance-Heating Furnace Against High-Voltage Surges

The problem:

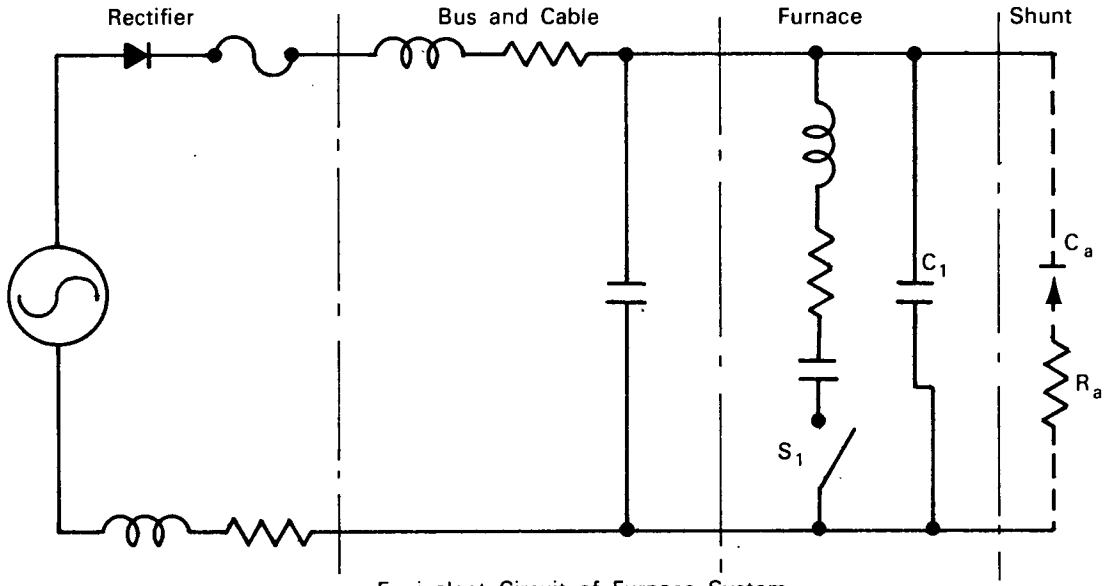
Serious damage can be caused in a resistance-heating furnace if the resistance elements break and suddenly open the inductive circuit. The problem is more acute when the heater resistance is actually a test specimen being evaluated for high-temperature characteristics. When a test specimen breaks, it is essential to stop arcing across the resulting gap to prevent obliteration of significant specimen details.

The solution:

Use a coolant gas to extinguish arcing across the break in the heater element, and an air-gap shunt to bypass the high-voltage impressed across the circuit as a consequence of the energy stored in the magnetic field associated with the circuit inductance.

How it's done:

The diagram shows a simplified equivalent circuit of the furnace system. The circuit represents the power supply and buses, the heater element (S_1), and the protective air-gap shunt (C_a, R_a) across S_1. The latter is represented as an open switch, indicating that the heater element has been broken. Not shown is the fact that the heater element is a hollowed graphite rod through which an inert cooling gas is made to flow. C_1 is the capacitance of the insulator separating one end of S_1 from the furnace ground frame.



Equivalent Circuit of Furnace System

(continued overleaf)

At the moment that S_1 breaks in a test, the inductance of the bus and interphase winding of the rectifier transformer acts to maintain the current, and arcing begins at the break. The coolant gas flowing across this break rapidly extinguishes the dc arc. The energy stored in the inductive field is released across the protective air-gap shunt which has been adjusted to break down at a voltage well below the safe operating voltage of the heater element (S_1). The voltage developed across R_a (the resistance of the protective shunt) energizes a trip-relay circuit (not shown) which cuts off the furnace power supply.

Notes:

1. This system has provided complete protection for a furnace operating at 240 V, 400 A dc. Cutoff was achieved within 0.030 sec after start of the induced voltage rise in the resistive heater element.
2. A key feature was the design of the air gap electrode system, which must maintain an arc until shutdown occurs. A combination of a paper dielectric and a 0.0064 cm (0.0025 in.) gap provides a range of 700-900 volts for establishing an arc.
3. Requests for further information may be directed to:

   Technology Utilization Officer
   AEC-NASA Space Nuclear Systems Office
   U.S. Atomic Energy Commission
   Washington, D.C. 20545
   Reference: B71-10043

Patent status:

No patent action is contemplated by the AEC or NASA.

Source: E.J. Stearns of
The Westinghouse Astronuclear Laboratory
under contract to
AEC-NASA Space Nuclear Systems Office
(NUC-10239)