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NASA TECH BRIEF

Ames Research Center

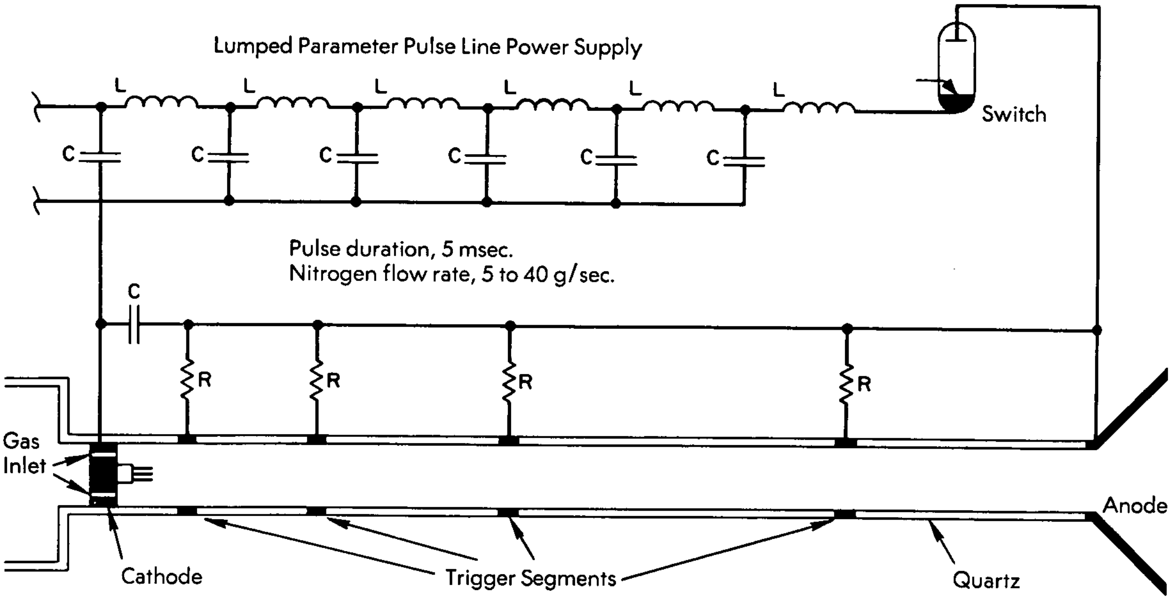
Pulsed High-Power Arc Heater with Improved Cathode and Triggering Mechanism

The problem:

The simulation of hypervelocity reentry conditions for the performance of critical tests requires constricted arc heaters of the order of 30-MW power level. Continuous operation of high-power constricted arc heaters requires a large investment for the acquisition and maintenance of power supplies and water-cooling systems for arc sections. For certain applications, however, in which test runs of millisecond durations are permissible, low-cost lumped-parameter-line pulse-power supplies may be substituted for continuously operated water-cooled power supplies. In either case, the arc is often initiated by an exploding thin wire, but this leads to contamination of the plasma stream and the inconvenience of reloading the trigger wire. Moreover, single-attachment cathodes can cause corrosive plasma jets in the vicinity of the cathode.

The solution:

A system employing a pulsed, constricted arc heater capable of multi-MW power which permits quasi-stationary flow conditions during the latter half of a pulse of about 5 msec. Since the power output is not continuous, only a modest investment in storage-capacitor power supplies is required, a cooling system is not necessary, and the tube containing the arc can be made of quartz so that photographic observations can be made. A cascading trigger circuit eliminates the problems connecting with exploding



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wires, and a multi-attachment electrode eliminates cathode jets of hot plasma.

How it's done:

The constricted arc heater consists of a long tube made of fused quartz through which a gas flows. The flow of gas (nitrogen, for example) is pulsed on for about 0.2 second by electrical actuation of a shutoff valve to fill a small plenum chamber, and then is metered from the plenum chamber into the arc constrictor through four sonic orifices. These orifices issue gas jets in a tangential direction; they can be aligned so that they all blow in the same direction, creating a strong vortex, or can be aligned to create a turbulent gas flow without swirl.

The cathode consists of four parallel 0.3-cm diameter thoriated (2%) tungsten rods pressed into an 1.27-cm diameter copper slug. The rods are about 2 cm long and are spaced about 1 mm apart. High-speed films of the cathode attachment area have shown that the arc attaches to the tungsten rods simultaneously, which lowers the currents at each attachment area and results in a lower cathode erosion rate. If a single cathode is used, *Maecker* cathode jets of hot plasma develop which cause destruction near the cathode.

The arc is initiated by a cascading triggering circuit as shown in the diagram; the space between the first copper segment in the constrictor wall and the cathode is broken down electrically when the *Ignitron* switch closes. The arc current drawn by this segment is limited to about 40 amperes by a resistor. The axial gas stream sweeps hot arc gases down the contrictor which leads to electric breakdown of the following segments in succession until the full arc current of some kA starts to flow when the hot gases reach the anode.

A nearly rectangular arc current pulse is obtained from the discharge of a lumped parameter transmission line. Such a line consists of *n* capacitors, C, and inductors, L, connected as shown in the diagram. Arc current ranges from 1.8 to 3.6 kA with a flow rate of nitrogen from 5 to 40 g/sec.

Notes:

1. The cascading trigger circuit works very well except at high gas flow rates and low charging voltage; it is adaptable to varied conditions.
2. Other investigators have tried multiple cathodes which were balanced with ballast resistors; in the present configuration, no ballast resistors were required – perhaps due to the length and close spacing of the thoriated-tungsten rods.
3. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA CR-1246 (N69-17212), Experiments on a High Power, Pulsed, Constricted Arc Heater
4. No additional documentation is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B72-10048

Patent status:

No patent action is contemplated by NASA.

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