A Dual-Ignitron Crowbar

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A high-voltage protective device (crowbar) is described that is capable of operating at 100,000 V. This device has two ignitrons in series, with the appropriate electronics to trigger the tubes to a conducting state when desired. The crowbar is needed to increase the reliability of the transmitter, as the present tubes have difficulty operating at over 60,000 V. A new photon generator was designed and tested using light-emitting diodes and infrared-detecting pin diodes in conjunction with fiber optics for transmitting a pulse to the high-voltage deck and triggering the ignitron crowbar.

The 400-kW transmitter located at DSS 14, Goldstone, California, operates as part of the DSN, generating radio signals to control and gather data from spacecraft. The transmitter uses a klystron to generate these high-power signals. The klystron tubes operate at high voltages (70 kV) and are, therefore, subject to arcing. Arcing can easily destroy a tube, and it is mandatory to protect the tube with a crowbar. A crowbar is a protective device that senses catastrophic failure in the klystron and, in a few microseconds, short-circuits the destructive high currents until the high voltage is removed.

A prototype dual-ignitron crowbar was fabricated and tested (Ref. 1) using two small G.E. ignitron tubes. These tubes have a small capacity (10 kA) and need a holding anode power supply and interlocking circuits to disconnect the holding anode after it is energized. The prototype proved the feasibility of using two series ignitrons, and if higher voltages are needed in the future, this technique may be expanded by using the desired number of tubes in series in order to meet the voltage requirements.

Phase II is now under way, consisting of a more rugged version of the prototype that uses two National NL1040 ignitrons. This tube is slightly larger than the prototype unit, will take higher currents (65 kA), and does not require the extra holding anode power supply. This circuit (Fig. 1) arrangement will hold off 100,000 V. The circuit works in the following manner: The klystron arc causes a surge in the high-voltage line which is sensed, and the protective circuitry develops a pulse through an infrared (IR) light-emitting diode. This IR light pulse is transmitted through fiber optics to the high-voltage deck. The fiber optics supply the necessary isolation (70 kV) from the high-voltage deck. On the high-voltage deck, the IR pulse is detected and converted to a voltage pulse to trigger the ignitrons to the conducting state. V1 then conducts, discharging C1 through R4 (Fig. 2) and ignit-

ing V2, causing both ignitrons to conduct. This short-circuits the power supply, thus protecting the klystron.

An improved method of detecting the IR pulse has been developed (Fig. 3). An IR pulse is generated on the ground level by the photon generator (an IR laser diode) and transmitted to the high-voltage deck (70 kV) through fiber optics. This light pulse then triggers a photo diode, which converts it to a voltage pulse, excites a Schmitt trigger, and gates the triggered spark gap to place the ignitron in the conducting state. The elapsed time is less than 1 μs.

This dual-ignitron system is the fastest tested to date by JPL and is in the configuration that will be used on the new high-powered transmitters at DSSs 63 and 43.

Table 1 shows the devices that have been tested, along with their delay times. Delay times are measured from the photon generator to the pulse at the ignitor.

Reference

1. Finnegan, E. J., "A New High-Voltage Crowbar," in *The Deep Space Network Progress Report*, Vol. III, pp. 146–148, Technical Report 32-1526, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1971.

Table 1. Dual-ignitron delay times

Photon generator	Elapsed time, μs	Detector
EG&G zenon lamp	3.5	EG&G photo diode
NE2H neon lamp	3.5	EG&G photo diode
AR9 argon lamp	2.0	EG&G photo diode
Laser diode or LED	1.0	United Detector Tech. (UJT600)
Laser diode or LED	7.0	United Detector Tech. (UJT500)
Laser diode or LED	<1.0	EG&G photo diode

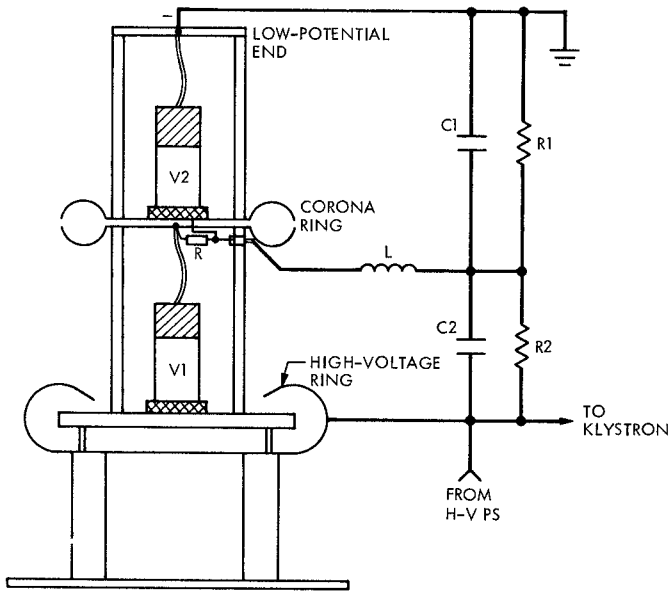

Fig. 1. Dual-ignitron crowbar

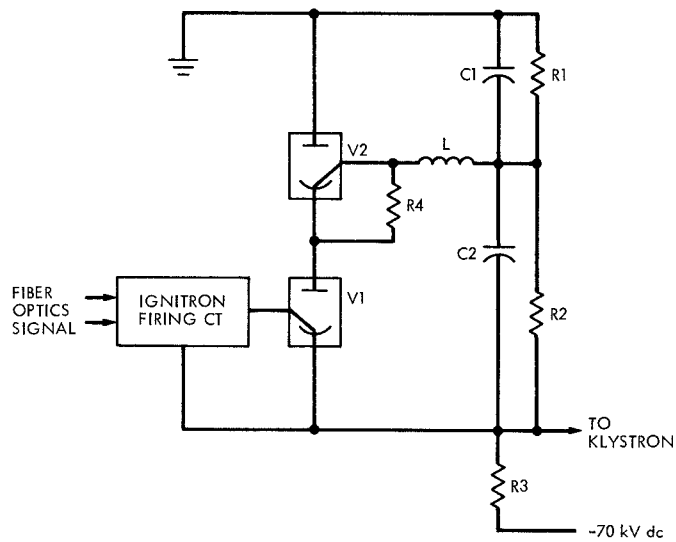

Fig. 2. Dual-ignitron schematic

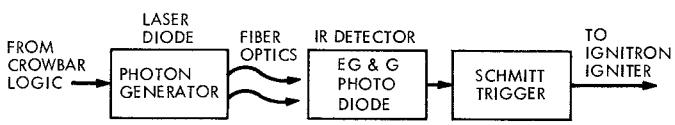

Fig. 3. Trigger and detector block diagram