# A New Dual Ignitron High-Voltage Crowbar

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*A crowbar is described which is capable of holding off 100,000 V dc using two mercury pool ignitrons connected in series. This crowbar assembly will replace the single high-voltage ignitron in the 400-kW transmitter at DSS 14 and will be part of the DSN 100-kW transmitters being constructed overseas. It was necessary to develop a higher voltage device in order to improve the reliability of the crowbar used to protect the high-powered RF klystron from self-destruction. The single ignitron has trouble operating over 60,000 V. An engineering model was built and has been operating satisfactorily at DSS 13.*

## I. Introduction

DSS 14 utilizes a 400-kW transmitter to generate radio signals that are used to command and monitor spacecraft. The klystron tubes which amplify the RF signals operate at high voltage and are therefore subject to damage due to high-voltage arcing. Since the cost of these tubes is very high, a great deal of effort is applied to their protection. One of the protective devices used is a crowbar that senses high-voltage arcs and short-circuits the destructive high currents from the klystron until the high voltage is completely removed. Ignitron tubes are used to perform the short-circuit functions. Open circuited, they are capable of holding off high voltages without significant leakage; when fired the dc drop is only several volts even at kiloampere currents.

## II. Crowbar Background

A prototype dual ignitron crowbar was designed and tested to check feasibility, and from this prototype a more rugged engineering model was fabricated using NL 1040 ignitrons (Ref. 1). These ignitrons are capable of withstanding 50,000 V; two in series will operate reliably at 100,000 V (Fig. 1). The engineering model has been operating at DSS 13 for two months. An infrared gallium arsenide laser and light pipe is being used in conjunction with it to trigger the crowbar.

## III. Description

The circuit functions in the following manner. When the klystron arcs, the high current is sensed and triggers a light-emitting diode (LED) which generates photons. The photons propagate through fiber optics to the high-voltage deck; the fiber optics isolate the high-voltage deck. The photon pulse is then detected by a photo diode and amplified in order to turn on the ignitron assembly. The system time delay is less than 4 $\mu$s. The energy available from the capacitor is 1/2 $CV^2$ (Fig. 1) or 1800 J. The energy reaching the tube without a crowbar would be 1/2 $CV^2 (R_t/R_3)$ or 45 J ($R_t$ is typically 0.1 ohm when the klystron arcs) and this would be destructive to the tube. The energy reaching the tube with a crowbar and $R_4$ would be

$$1/2\, CV^2 \left(\frac{R_t}{R_3 + R_4}\right)\left(\frac{2T}{CR_3 + R_5} + \frac{L}{CR_3R_5}\right) = 8\text{ J}$$

where

$T = 4\ \mu$s, response time of the new ignitron assembly

$L = 100$ nH, ignitron inductance

$R_t =$ typically 0.1 ohm when the klystron arcs as determined by tube laboratories experimentally

$C = 1\ \mu f$

$V = 60{,}000$ V

This should be safe for most tubes. The exact amount of energy that will destroy a klystron is unknown and therefore intuitive.

## IV. Conclusion

The engineering model will continue to be tested at DSS 13; another ignitron assembly will be fabricated and installed at DSS 14, thus giving faster crowbar protection and more reliability for the 400-kW klystron.

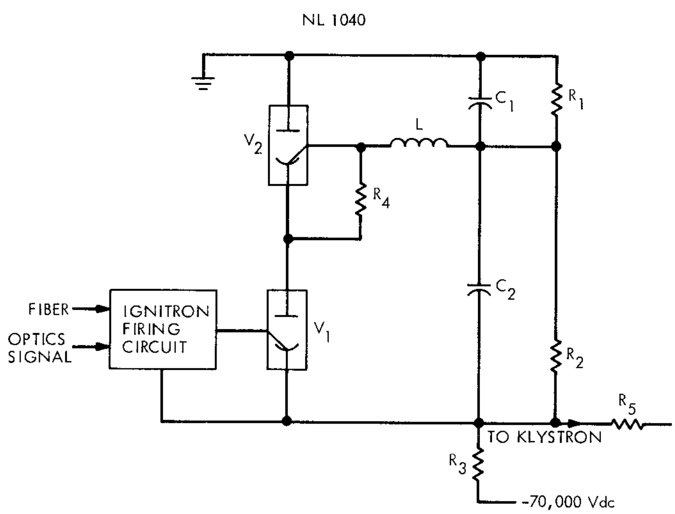


**Fig. 1. Dual ignitron schematic diagram**