SLAC-TN-69-19
C. R. Carman
J.-L. Pellegrin
November 1969

SPARK CHAMBER TRIGGER AMPLIFIER

ABSTRACT

The design, operation, and performance of a spark gap driver are described. The instrument accepts a NIM* logic input pulse and delivers in parallel, six high voltage pulses capable of firing spark chambers. Emphasis was put on reliability, ease of operation and ruggedness, yet without giving up sophisticated circuits.

I. Introduction

The operation of a spark chamber system requires that a high voltage trigger pulse be applied simultaneously to several spark gaps. A fast rising pulse of large amplitude is always desirable, since it minimizes the delay and jitter of the firing gaps. The spark gap trigger amplifier we describe is a fan-out circuit producing such high voltage pulses from a low level logic signal.

Although no particularly new technique has been used in the design of this pulse amplifier, an effort was made to build a reliable unit, compact, easy to operate and to maintain, and having electrical characteristics comparable to existing circuits.

II. Circuit Description

When triggering spark chambers it is customary to apply to the trigger electrodes as large a pulse as possible, perhaps as large as the gap voltage itself, that is, well above the trigger breakdown threshold. Thus, only another spark gap discharge can deliver such a pulse and produce the required peak power. The driving of this gap (Fig. 1) necessitates also a large and fast rising

*AEC Nuclear instrument modules standard #TID-20893.

pulse, less powerful however, and we use an rf power triode (ML8533) which has been found satisfactory for this purpose and has a long life. The input impedance of this tube is of the order of 150 ohms during conduction, and its cut-off bias voltage around -150 volts. Full conduction can therefore be obtained by providing a minimum grid pulse of 150 volts to overcome this bias. The solution adopted was to drive the triode from an avalance transistor Marx generator. We proceed now to the description of this circuit.

III. Series Avalanche Transistors

The series connection of three avalanche transistors is pictured on Fig. 1. Such circuits, (omitting the Zener diodes) have been studied by a number of authors [1] [2], and exhibit a fast risetime, short pulse propagation delay and high power capability. The capacitors C_1, C_2 and C_3 are charged in parallel to the transistor holding voltage BV_{CBS} (collector to base breakdown voltage, with base and emitter shorted, typically 100 V). As the base-emitter junctions are simultaneously forward biased, the transistors go into avalanche and their collector-emitter voltage suddenly drops to a lower value, typically 60 to 70 volts below BV_{CBS}. The three capacitors become connected in series and discharge into the load, namely the vacuum tube input impedance. The phenomenon is interrupted when the avalanche current supplied by the capacitors becomes small enough, so that the bases regain control of the normal transistor action, and reduce the current to zero.

Even if the Marx generator appears to be well suited to drive the rf triode, the proximity of the avalanche transistors in their usual configuration, and the firing gap, was found to be disastrous. Indeed, when the base-emitter hold-off voltage is simply zero, small disturbances on the power supply line or on the ground, are sufficient to trigger into avalanche. Then the whole amplifier goes through a burst of relaxation oscillation whereby the gap triggers the front end and vice versa, until all storage capacitors are emptied. An excellent remedy to this oversensitivity consists in returning the avalanche transistor base of each stage to a negative voltage source. A Zener diode and a current limiting resistor are inserted in series with all emitters, thus providing a base-to-emitter reverse bias of 7.5 V. This arrangement does not interfere with the operation of the series avalanche, since all base-emitter junctions are still allowed to assume a high potential during the discharge. Furthermore, the base circuit can also retain a low series resistance, the dynamic impedance of the diode being few ohms only.

Yet the obvious drawback of building a higher input threshold into the Marx generator is that a larger input trigger becomes necessary, and a stage of amplification is needed. Hence, the pulse propagation delay is increased by 4 nsec, bringing to 13 nsec the total delay of the trigger amplifier front end. (Figure 2.)

IV. Triode and Spark Gap

The vacuum tube is loaded by the gap trigger electrode capacitance. Thus the voltage developed across this electrode depends on the tube current capability It appears that a trigger electrode breakdown is obtained 2 to 4 nsec after the turn-on of the triode. As some ions are liberated in the main gap by the arcing of the trigger electrode, the process of ionization takes place and full conduction is obtained after 10 to 30 nsec, depending on the gap voltage and the gap pressure.

Every effort was made to reduce the circuit inductance, particularly at the location of high currents. One will note the connection of the triode plate to the gap trigger electrode (Fig. 3), as well as the ground path provided between the gap and the output connectors. (Figure 4.)

A view of the disassembled spark gap is shown in Fig. 5, and Fig. 6 presents the instrument front panel with its monitoring equipment and gap adjustment.

V. Spark Gap Trigger Amplifier Specifications

(a) Input requirements: Trigger: -700 mvolts into 50 Ω typically
Pulse width: greater than 10 nsec
Clock: an internal trigger is available at 1 cps or 5 cps

(b) Ouput: Measurements were performed with the discharge of a 5400 pF capacitor into a 50 Ω load. Figure 7 displays the output pulse delay and jitter as a function of the gap voltage, with the gap pressure as a parameter. The output risetime is also shown on Fig. 8, as a function of the gap pressure.

For all these measurements the gap spacing was set such that the operating voltage was 200 to 400 volts below Corona.

(c) Miscellaneous: Six type HN output connectors are available in the back of the unit. A monitoring output signal appears on the front panel.

A maximum pressure of 16 lbs can be sustained by the gap assembly and gaskets; two pipe fittings are provided for a circulation of gas when necessary.

REFERENCES

1. T. H. O'Dell, "Series operation of avalanche transistors," Electronics Letters 5, 94 (1969).
2. W. B. Mitchell, "Avalanche transistors give fast pulses," Electronic Design 6, 202 (March 14, 1969).

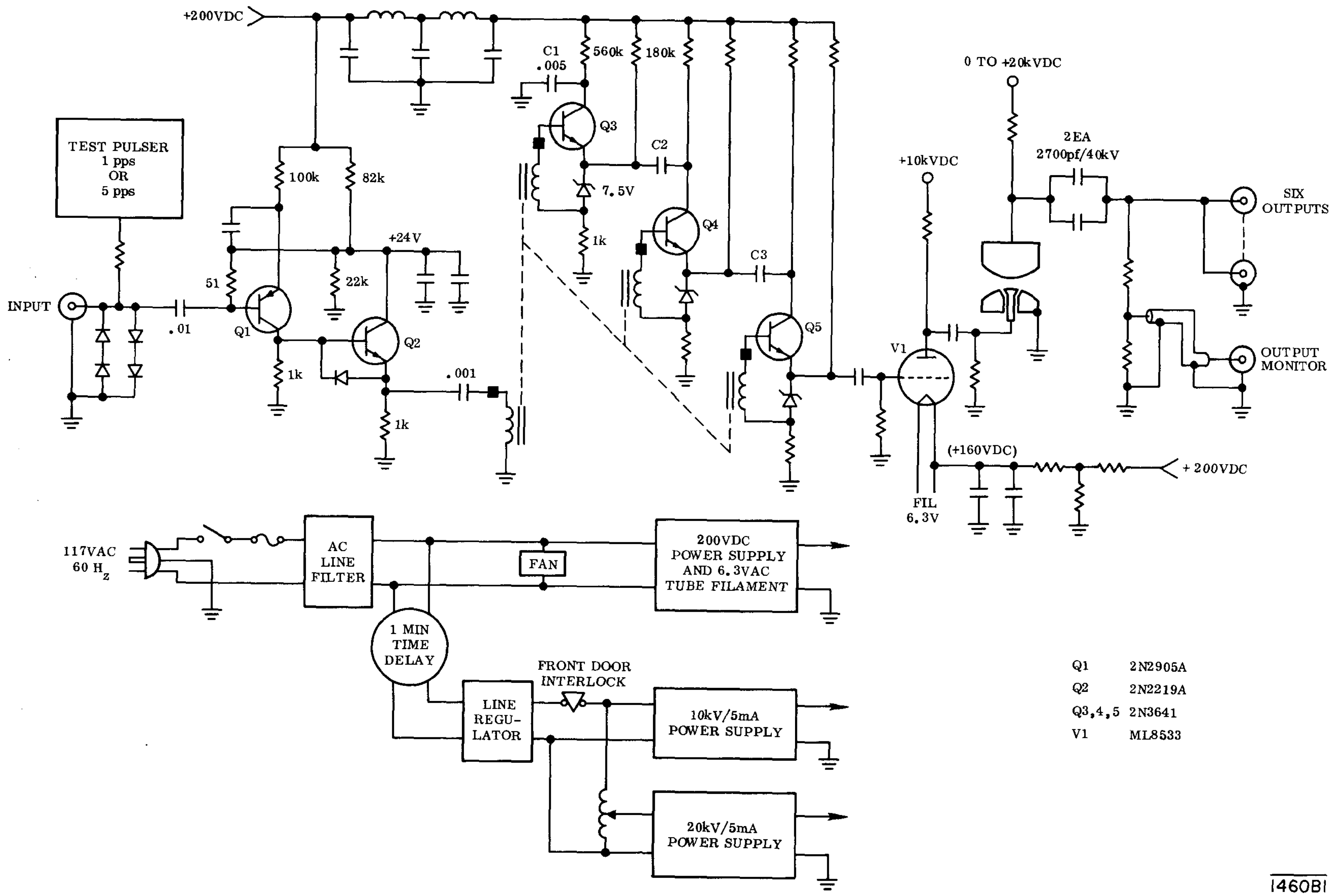


FIG. 1--Circuit diagram of trigger amplifier.

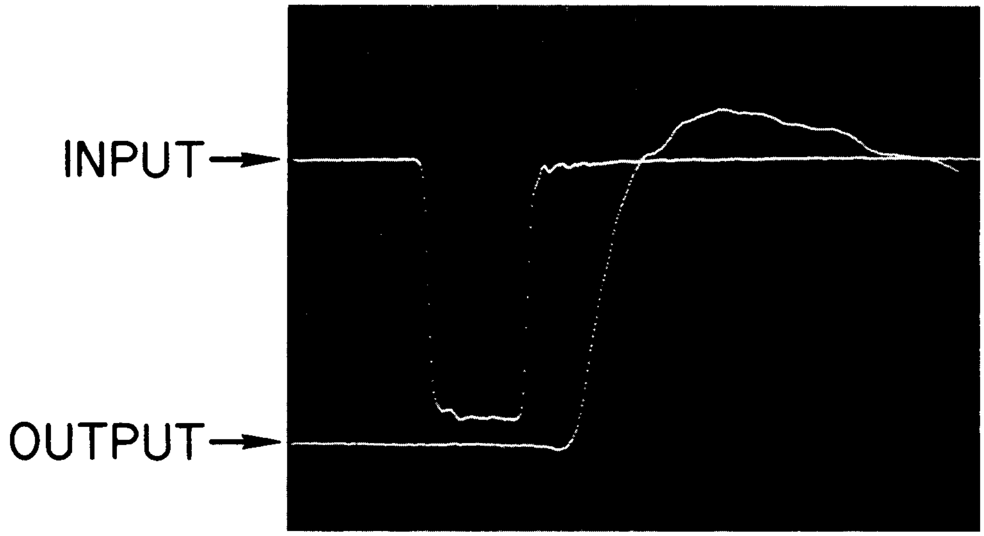


FIG. 2--Input output waveforms of Marx generator.

Input scale: 200 mV/cm

Output scale: 40 V/cm

Time scale: 5 nsec/cm

1460A2

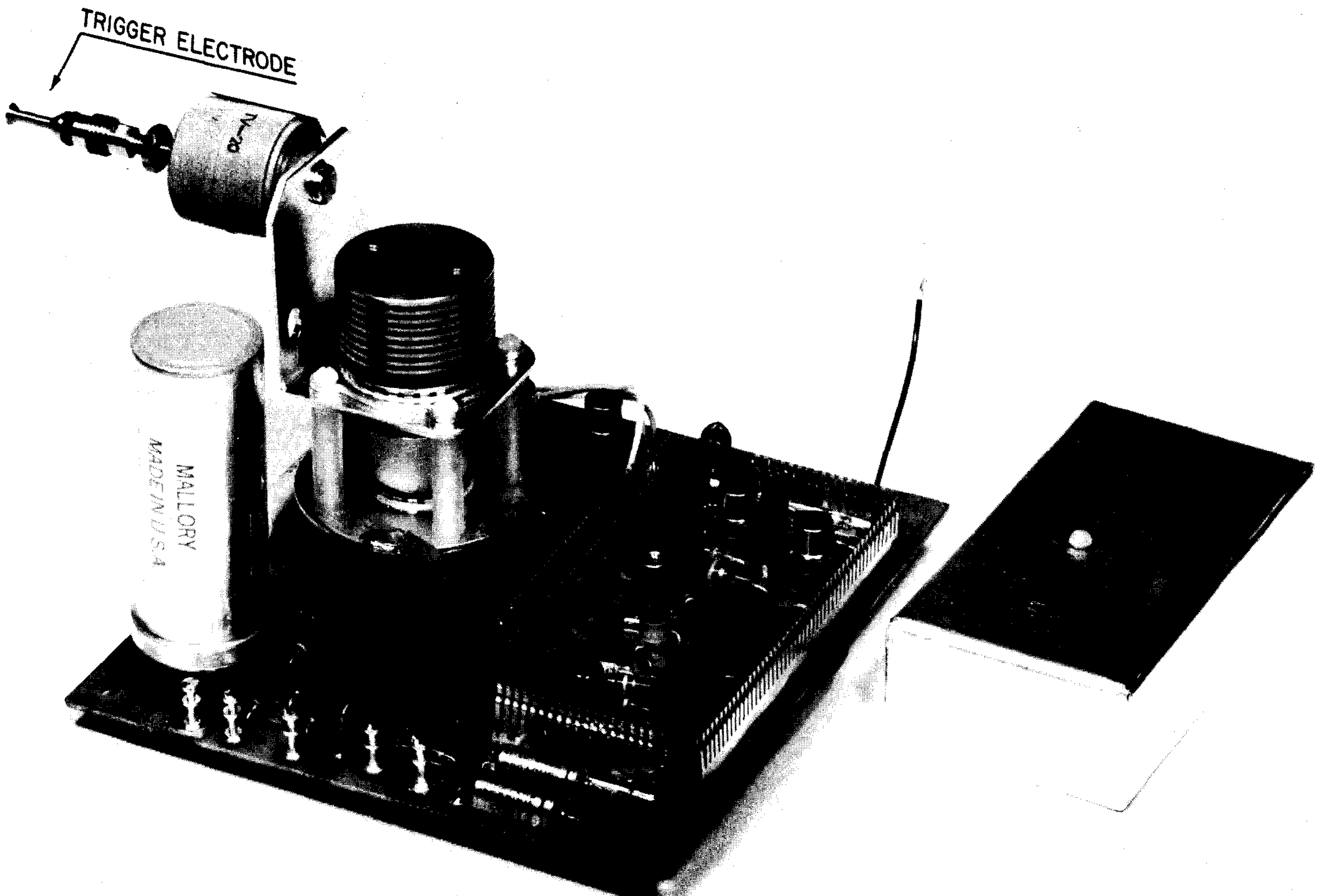
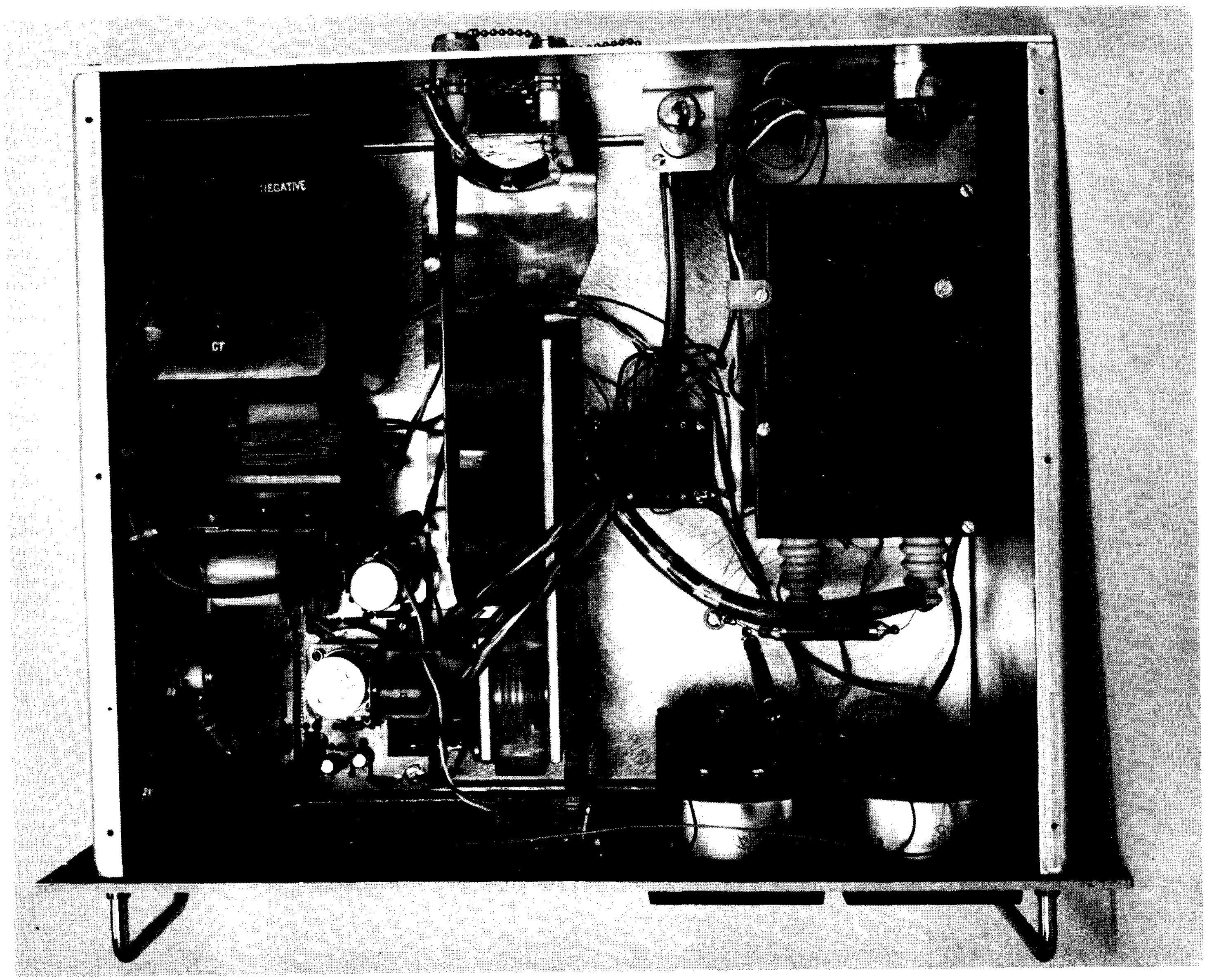


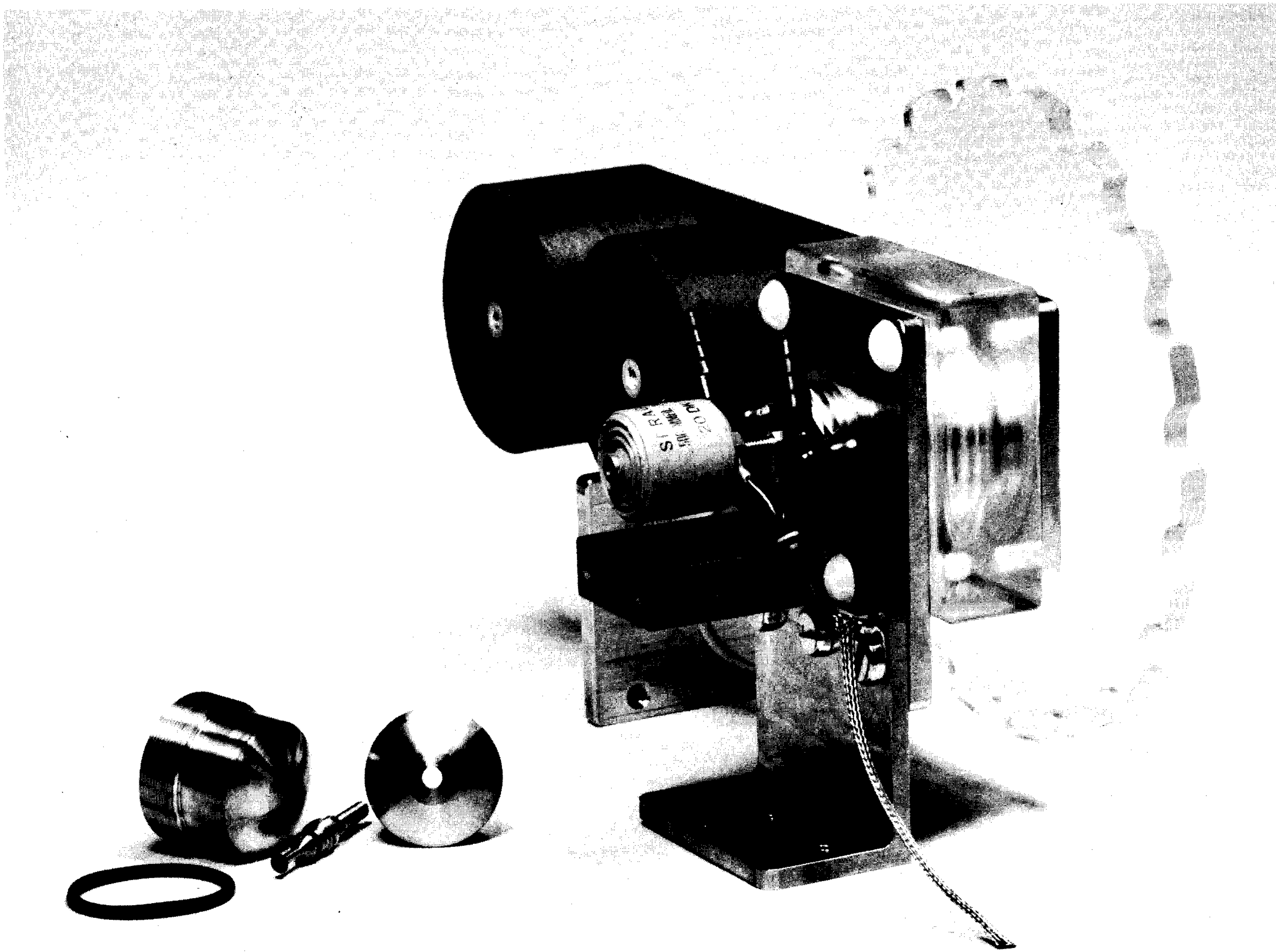
FIG. 3--Transistorized front-end and triode assembly.

1460A7



1460A5

FIG. 4--Top view of spark gap trigger amplifier.



1460A8

FIG. 5--View of disassembled spark gap.

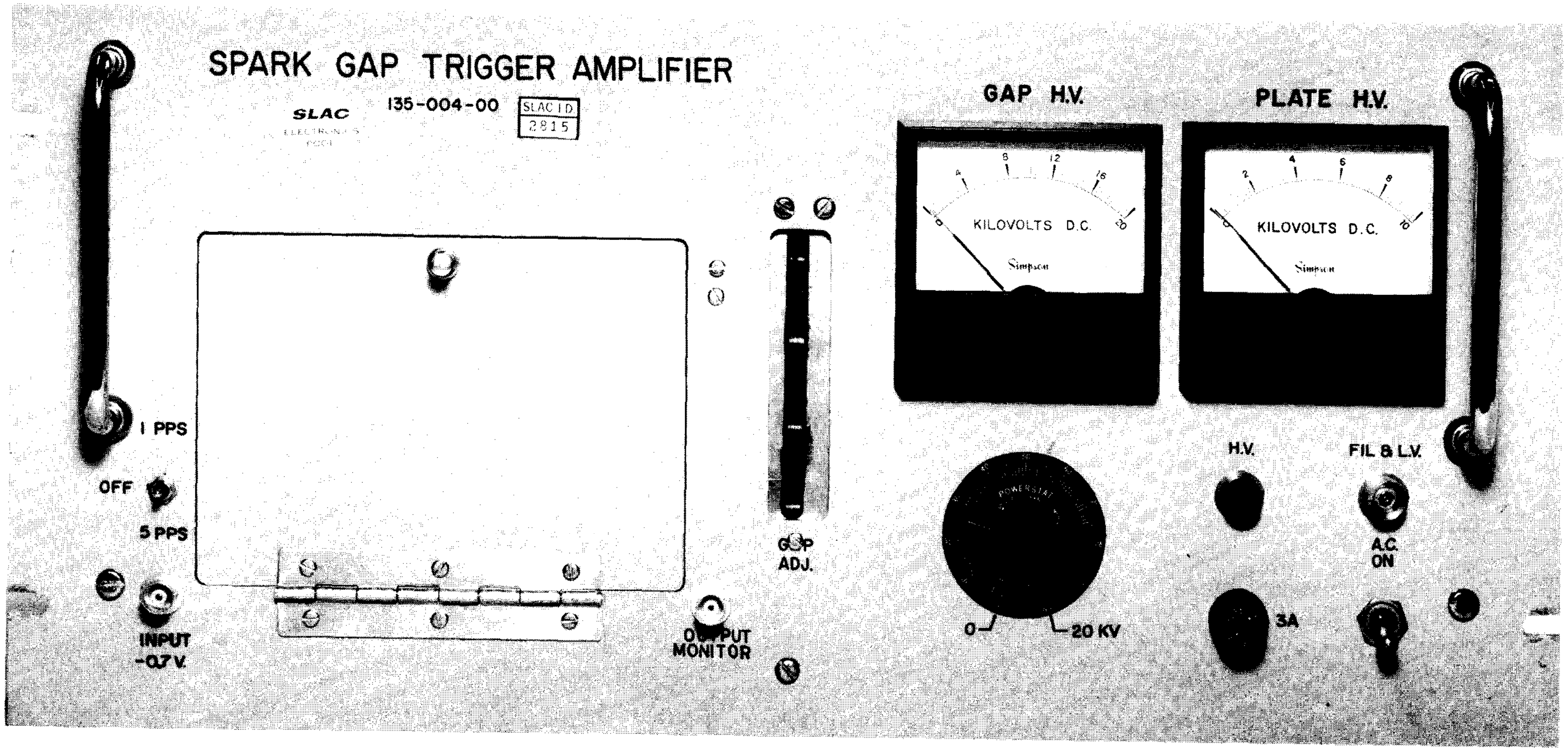


FIG. 6--Spark gap trigger amplifier front panel.

1460A9

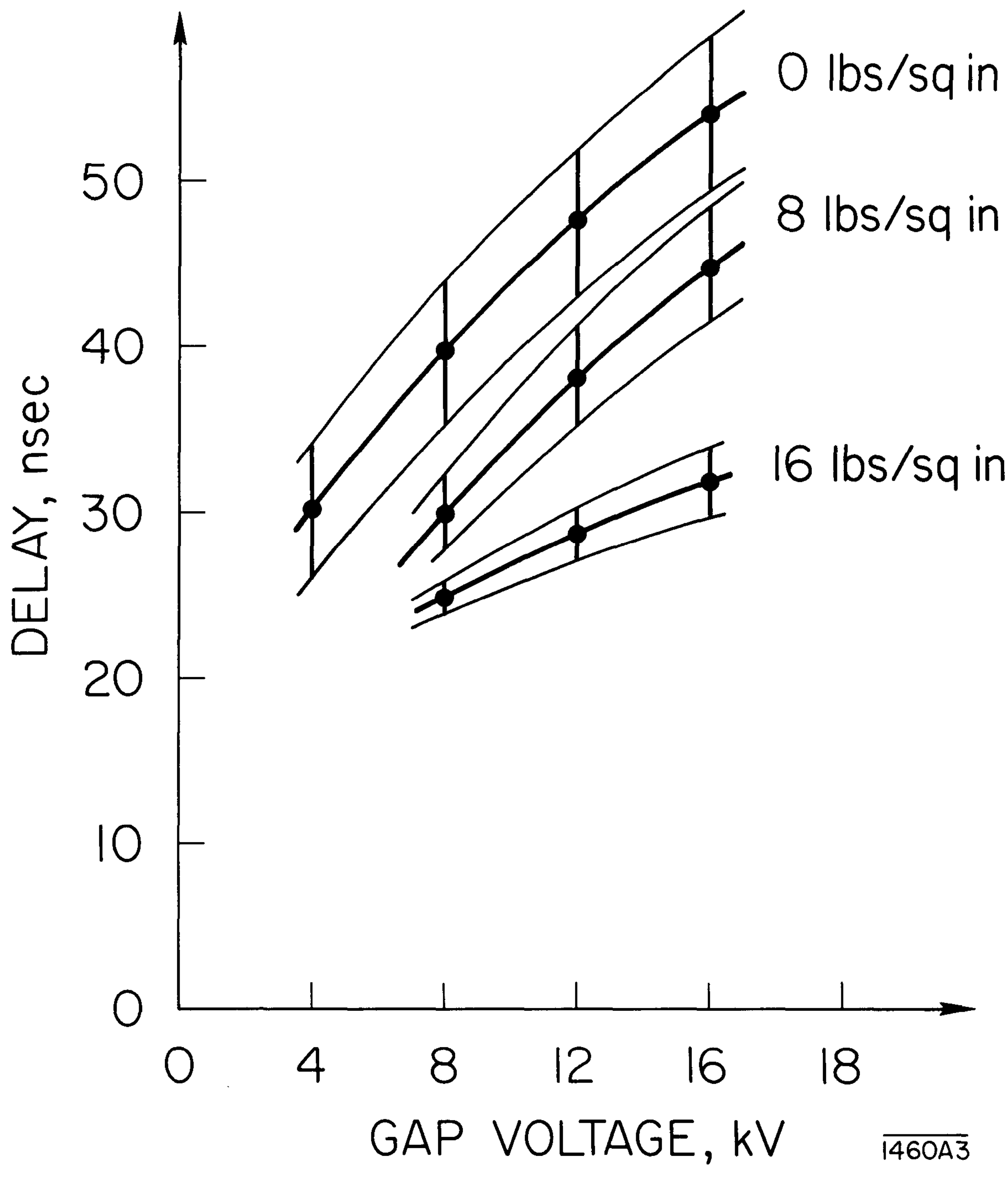


FIG. 7--Delay and jitter of spark gap trigger amplifier; parameter: gap relative pressure.

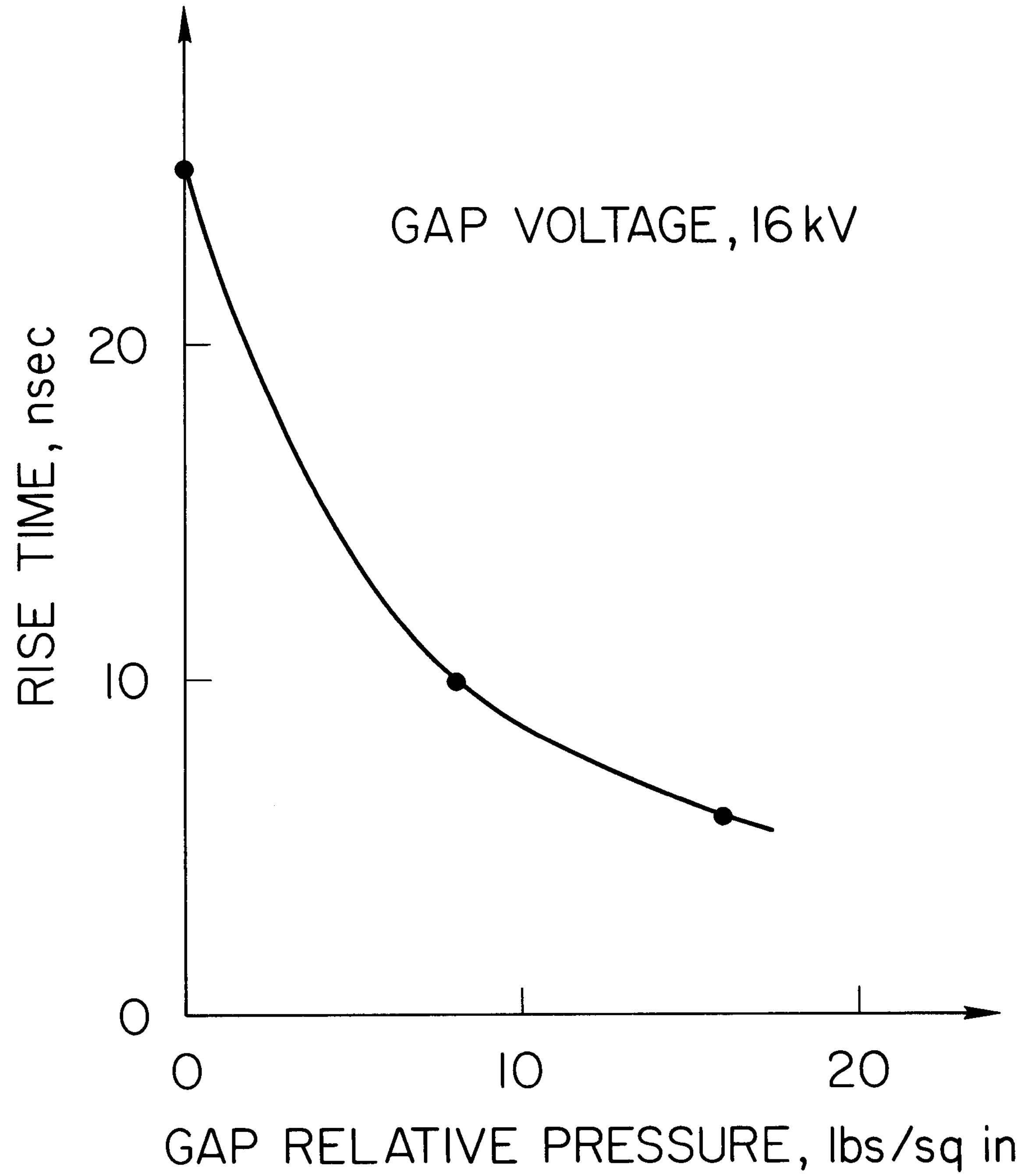


FIG. 8--Risetime of spark gap trigger amplifier.