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ELECTRONIC CIRCUITRY FOR A HIGH INTENSITY FLASHLAMP

By
Harry E. Cleaver

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ABSTRACT: (U) A Garton-Charatis flashlamp was used with the NOL Ballistic Piston Compressor for absorption spectroscopy measurements in the ultraviolet region. This report details the power circuits needed to produce the high pulse currents required in the operation of the flashlamp.

Technical Management
NASA Lewis
R. W. Patch

Approved by: A. B. DIETEMANN, Chief
Chemical Engineering Division
Chemistry Research Department
U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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Electronic Circuitry for a High Intensity Flashlamp (U)

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ROBERT ENNIS
Captain, USN
Commander

Albert Lightbody
ALBERT LIGHTBODY
By direction

CONTENTS

ILLUSTRATIONS

REFERENCES

(1) Samson, J. A., "Techniques of Vacuum Ultraviolet Spectroscopy", Wiley and Sons, New York, 1967, Unclassified.
(2) Charatis, G., and Hershey, T., University of Maryland Institute for Fluid Dynamics and Applied Mathematics Technical Note BN-361, 1964, Unclassified.
(3) Lalos, G., and Hammond, G., NOLTR 70-15, "Gas Opacity Measurements with a Ballistic Piston Compressor", 21 Nov 1969, Unclassified.

INTRODUCTION

Absorption spectroscopy experiments with the NOL ballistic piston compressor require the use of a background light source of high brightness temperature. For experiments in the ultraviolet part of the spectrum, the brightness temperature must be extremely high to overcome the rapid decrease in transmission of optical components and air with decreasing wavelength. Conventional ultraviolet sources, such as high pressure hydrogen or deuterium lamps, are not bright enough for wavelengths less than 2000 Å, and high energy, transient discharges must be used for these vacuum-ultraviolet wavelengths.

A device that satisfies all the requirements of high brightness temperature, line-free continuum spectra, reproducibility, ease of operation and compactness is the Garton-Charatis flashlamp (references 1 and 2). An improved prototype version of the lamp was obtained by NOL from the Naval Research Laboratory Plasma Physics Section for evaluation with the NOL compressor. Spectroscopic observations with the aid of this lamp are described in reference 3. Electronic circuitry has been developed to synchronize the lamp firing with the peak of the compression cycle of the compressor.

PHYSICAL CHARACTERISTICS

The lamp consists of a 6.3 cm long capillary of 5mm bore in a phenolic cylinder. The tungsten electrodes at each end of the capillary also have 5mm diameter holes through which the light generated by the sliding spark discharge in the capillary passes to the ultraviolet transmitting Suprasil II windows at each end of the lamp. Further details of lamp construction are shown in Figure 1.

The lamp is filled with air at approximately 5mm Hg pressure. The application of 5000 volts across the electrodes is sufficient to cause electrical breakdown in the capillary and the resulting discharge is characterized by a peak current density of approximately 1.4×10^3 amp/cm^2, and a brightness temperature of 30,000K in the visible portion of the spectrum. The plasma generated in the capillary consists of a mixture of air and high density ionized organic material ablated from the capillary walls.

When used with the NOL compressor, the lamp is mounted with the capillary axis horizontal and aligned with the axis of the viewing ports in the compressor test section. Vertical alignment is achieved by rotating the large nuts on the threaded rods at each side of the lamp mounting brackets. In Figures 2 and 3 the lamp and mounting brackets are shown attached to the energy storage pack housing.

The peak brightness temperature of the lamp is maximized when the electrical characteristics of the lamp minimize the self-inductance

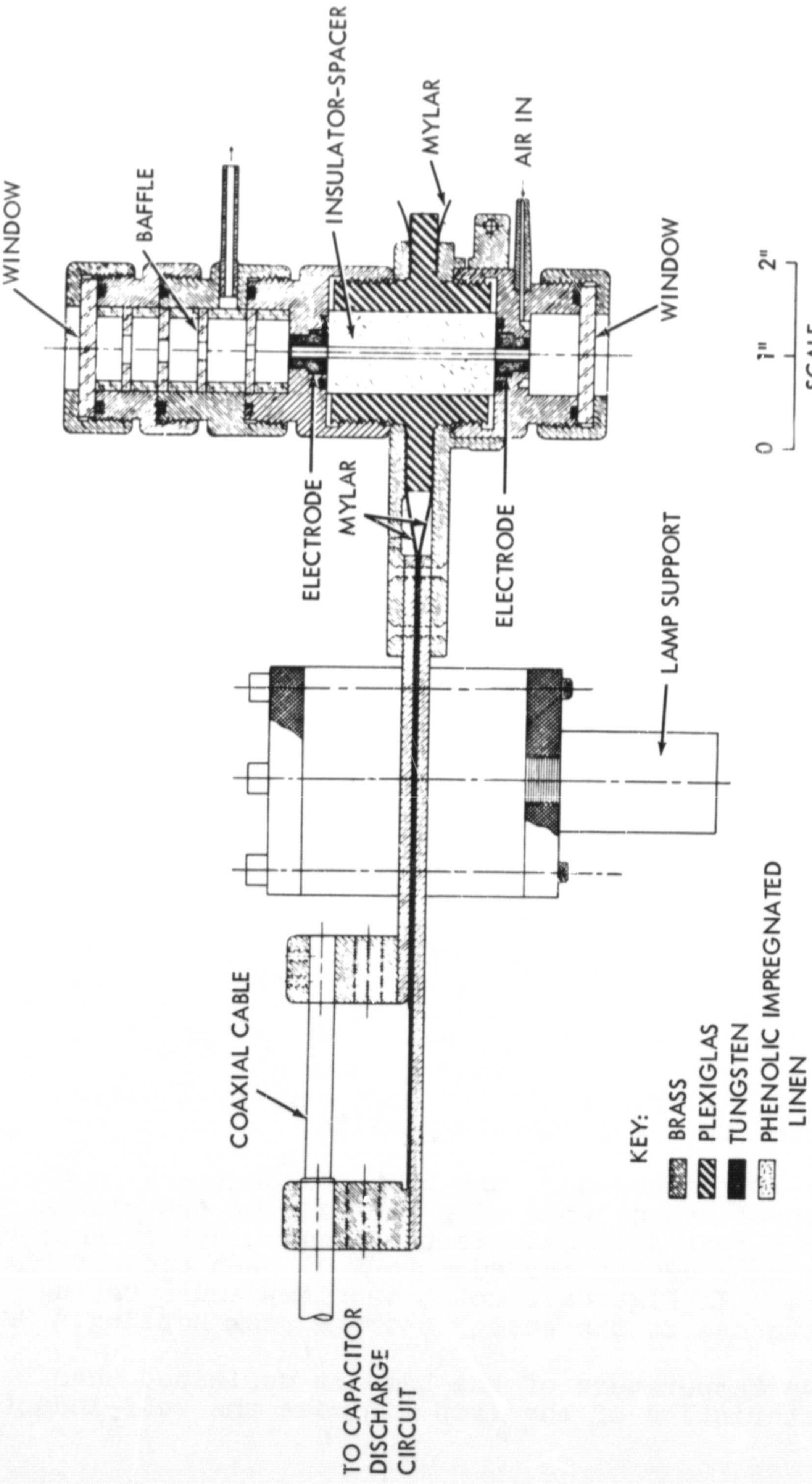

FIG. 1 HALF-SECTION OF FLASH LAMP ASSEMBLY

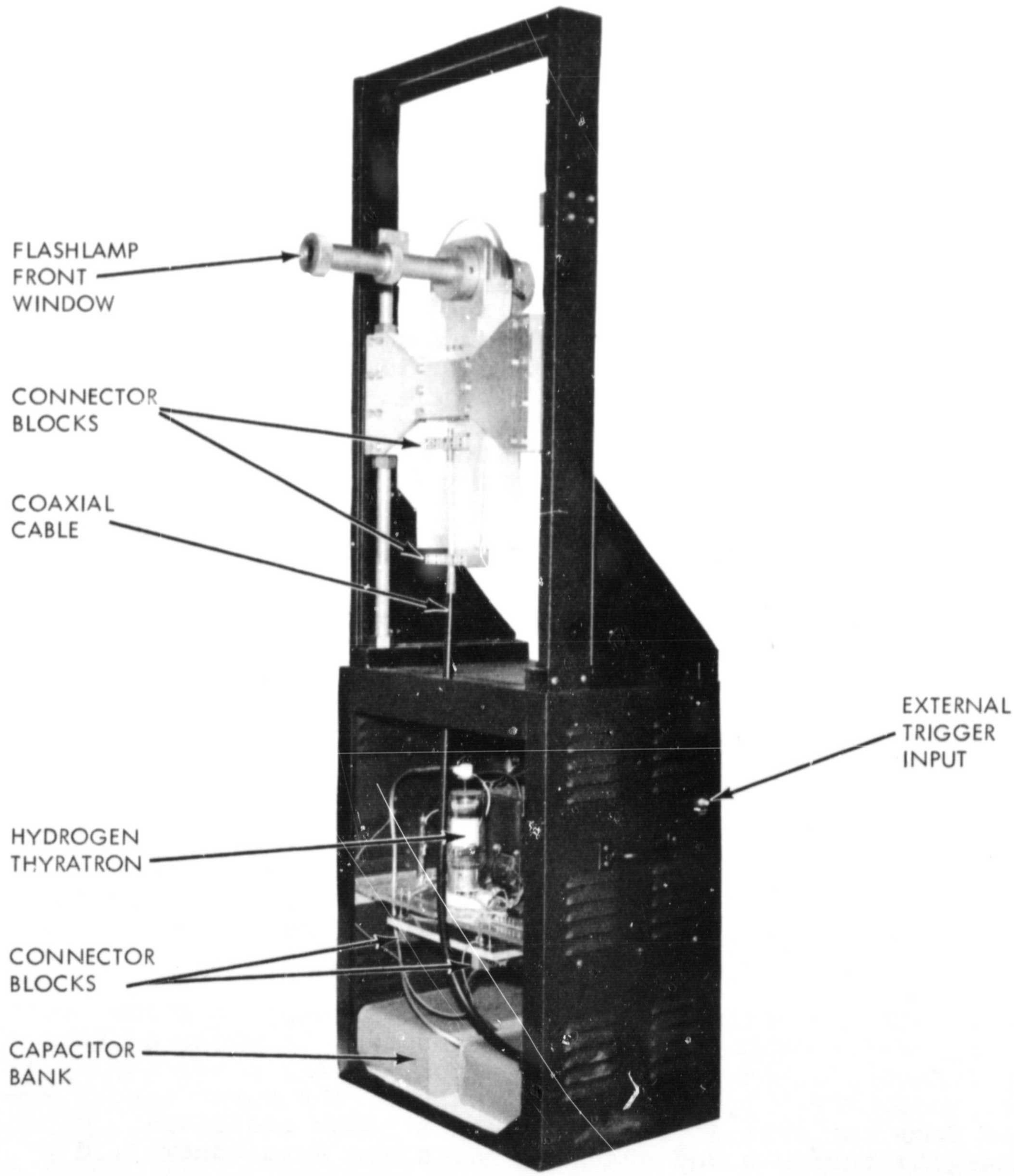

FIG. 2 FLASH LAMP AND POWER PACK HOUSING, FRONT VIEW

of the discharge circuit. To achieve this, the lamp can be connected to the energy storage capacitors by multiple parallel coaxial cables.

CIRCUIT DESCRIPTION

The energy storage capacitor bank shown in Figure 4 consists of two six microfarad, 7500 volt capacitors connected in parallel. The voltage level impressed on the capacitors is monitored using a resistance voltage divider and a Fairchild Model 7050 digital voltmeter. Resistor values in the voltage divider were chosen to allow the most accurate readings possible from the digital voltmeter by operating in the up-scale portion of the range selected. With the voltmeter operating on its 15 volt range, the LOW monitor terminal is used when measuring capacitor voltages up to 5000 volts. Above 5KV the HIGH monitor terminal should be used with the voltmeter still on the 15 volt range. An exact voltage measurement was not as important in the experiments described in reference 3 as was the ability to reproduce a given voltage level.

Energy stored in the capacitor bank is delivered to the flashlamp by using a 5C22 hydrogen thyratron as the switching device. 5C22 thyratrons are high plate voltage, high peak current tubes designed for pulsing service. The grid drive circuit may be operated at zero bias, as it is in this design, and requires a 200 volt minimum pulse to fire the tube.

Lead wires carrying the high discharge currents are shown as darkened lines in Figure 4. A heavy braided-wire conductor is used to connect those parts of the circuit to a coaxial cable connector block. Lead lengths were kept as short as possible.

A one megohm, high voltage resistor is connected across the flashlamp terminals. It serves as a bleeder resistor to prevent static voltage buildup on the flashlamp electrodes caused by leakage currents.

A commercially available 10,000 volt power supply is used to charge the capacitor bank. The output voltage is adjusted from 0 to 10KV by controlling the a.c. voltage input to the power supply with an autotransformer. The output terminals of the power supply are isolated from the capacitor bank by eight 100KΩ resistors. Capacitor bank charging currents and charging rates are also controlled by these resistors.

5C22 thyratron tubes require a cathode heating time of at least five minutes before high voltage is applied to the plate. To allow for this warmup time, two thermal relays connected in series provide a five minute delay before power can be applied to the autotransformer and high voltage power supply.

Pulses used to fire the thyratron are generated in the triggering section and coupled to the grid of the 5C22 by a 1:10 step-up

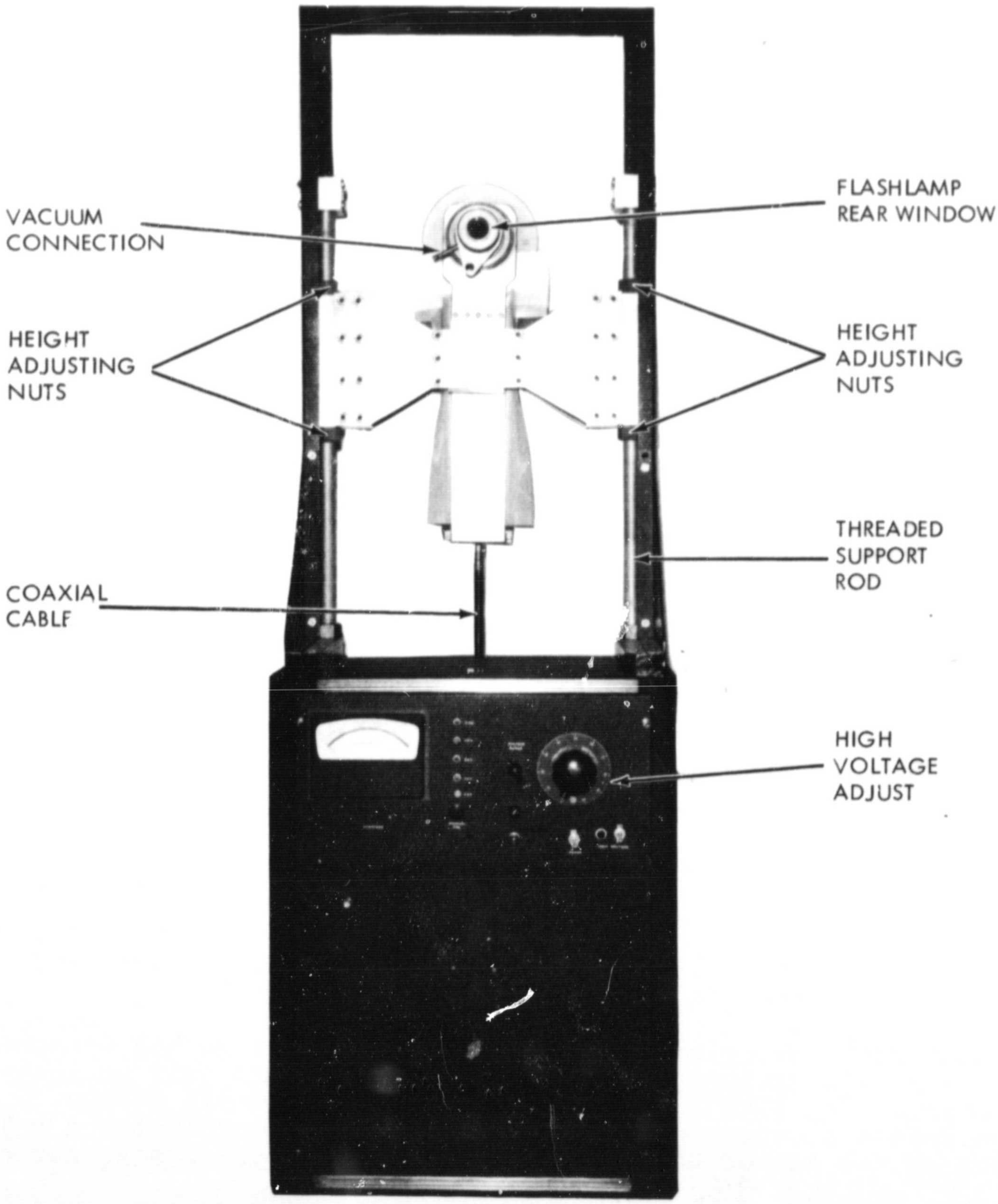

FIG. 3 FLASHLAMP AND POWER PACK HOUSING, REAR VIEW

transformer. The triggering section is powered by a voltage doubler circuit that provides 78 volts DC maximum to charge a 0.01 μf capacitor. Although the voltage level on the capacitor is variable, it must be above the level required to produce the 200 volt minimum grid drive pulse. Grid drive pulses above the 200 volt minimum will shorten the turn-on time of the tube. When the 2N1885 silicon controlled rectifier (SCR) is triggered on, the 0.01 μf capacitor discharges through the primary of the pulse transformer and the necessary grid drive pulse is developed. The 1N538 diode across the primary of the pulse transformer suppresses the negative transient voltage swing generated by the transformer.

The 1.1 megohm resistor controls the charging rate for the 0.01 μf capacitor. It also isolates the SCR from the power source and causes current flow through the SCR to drop below the level required to maintain conduction once the capacitor has discharged. When the current falls below the holding level, the SCR will automatically turn off and may then be recycled.

The triggering section may be operated manually by a switch on the front panel or remotely by the circuits designed to synchronize lamp firing with the peak of the compression cycle of the compressor.

PERFORMANCE AND CONCLUSIONS

Oscilloscope displays of the flashlamp light pulse were made with an RCA 7200 photomultiplier tube (S19 response) in a vacuum monochromator set at 1900 Å. Measurements were made with the capacitor bank charged to 5KV. There was a time delay from thyratron triggering to peak light intensity of $14 \pm 1\mu$ seconds. The light pulse exhibited a rise time of about 5μ seconds followed by a slower exponential decay yielding a pulse half-width of about 10μ seconds.

When the autotransformer was left untouched between shots and the lamp fired at a constant value of the digital voltmeter display, the peak intensity of the light pulse was reproducible to ±1%. Most of this variation is attributable to changes in window transmission and capillary properties from shot to shot, so we conclude that variations in the discharge circuit performance are negligible.

No detectable deterioration in thyratron operation has occurred in more than 300 firings, and no other circuit component has required replacement. The flashlamp circuitry has exceeded all design requirements and, coupled with the lamp itself, constitutes a valuable addition to the set of NOL Ballistic Piston Compressor accessories.

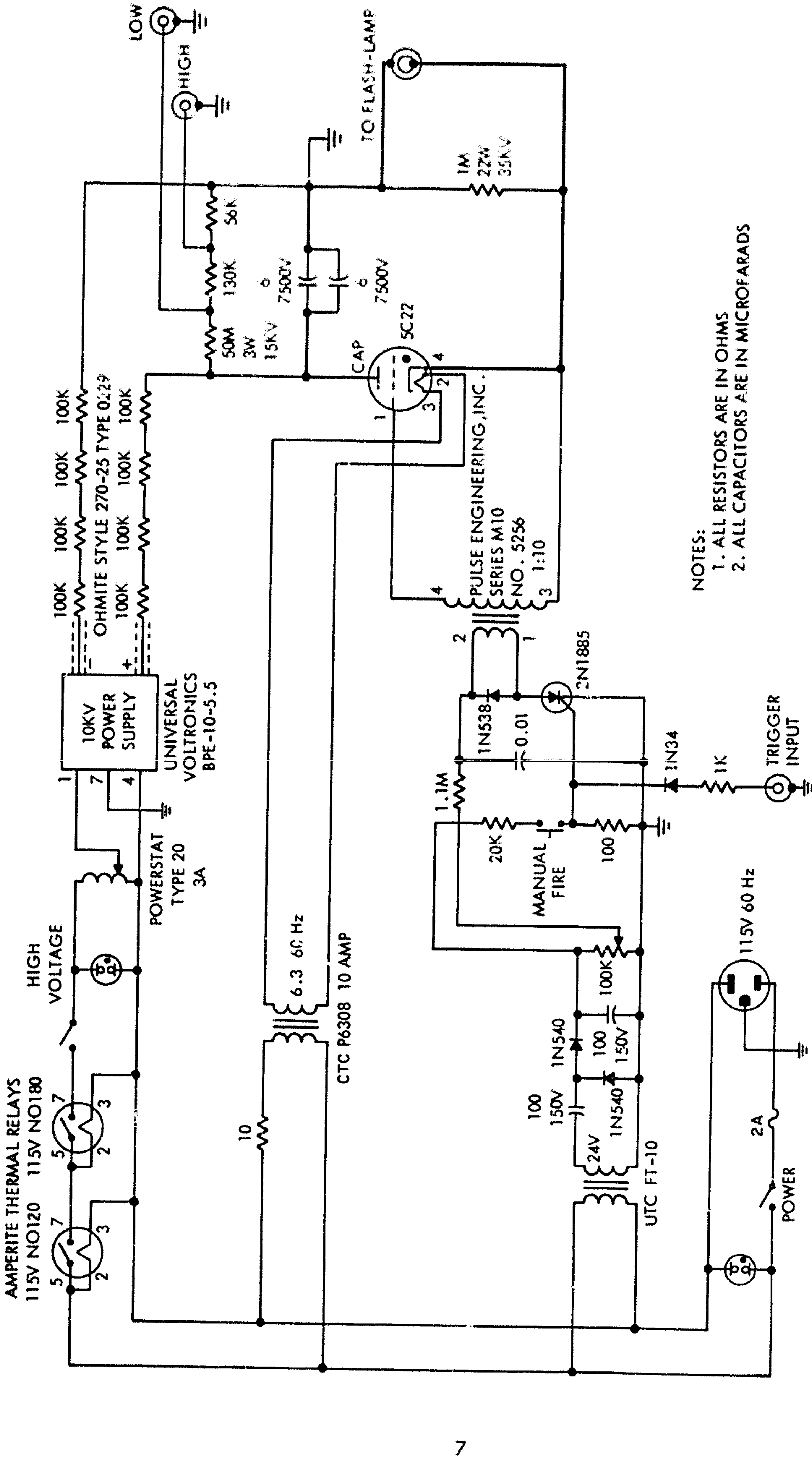

FIG. 4 FLASHLAMP CAPACITOR DISCHARGE CIRCUIT

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