RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY ENGINEERING NOTE	JOB NUMBER 4508-41	FILE NO. CVL-3	PAGE 1 of 3
SUBJECT TOY TOP PLASMA INJECTOR	NAME F. Coensgen W. Cummins, A. Sherman		
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Introduction

It is the purpose of this note to describe the construction and operation of the plasma injectors used in the magnetic high compression experiments in progress at the Lawrence Radiation Laboratory at Livermore. As the investigations of these injections is still in progress, remarks concerning their operation or the characteristics of the injected plasma are of a tentative nature.

Construction and Power Supplies

The plasma injector is essentially an enlarged version of the plasma generator used in an energetic ion source developed by Ehlers, et. al.[1] and is described by us in a paper[2] to be published in "The Physics of Fluids". The essential part of the injector consists of a stack of deuterated titanium washers 3/4" outside diameter and 1/2" inside diameter. Although thinner washers have been used we use washers fabricated from .060" stock because they are mechanically rugged. Each washer is separated from the adjacent washer by mica or ceramic spacers. The hole in the rear washer is only 1/4" in diameter. An insulated electrode (trigger electrode) is brought into this hole. The other end of the stack is open. The details of the construction are shown in Fig. 1. The coaxial arrangement of the conductors was found convenient for mounting, for reduction of the mechanical forces on the conductors and for reduction of inductance. However, such construction is not essential.

In operation an electric discharge between the trigger electrode and the 1/4" washer generates enough plasma within the hole to insure passage of the main discharge through the center of the stack rather than along the outside. A wide variety of power supplies have been used both for the trigger pulse and for the main discharge. For the data described below, the supply for the main discharge was a 7.5 µf capacitor charged to -10 KV and connected to the end washers thru a 5550 mercury ignitron. The discharge current is of the order of 15,000 ampere and the period is approximately 20 µs. The trigger supply is a 1 µf capacitor charged to 5 KV and discharged through the primary of a 5:1 step up pulse transformer.

Operation and Plasma Characteristics

Considerable information concerning the injectors has been obtained as they were used in the magnetic compression work. Recently a more detailed investigation was started using a vacuum chamber 20 ft long and 18" diameter which is provided with a uniform magnetic field. The injectors are fixed at one end of the chamber and an analyzer is provided at the other end. The analyzer consists of a magnetic spectrometer followed by an electrostatic system. Thus, both the momentum and energy are measured which determines the ez/m ratio as well as the ion energy. The energy measurement is cross checked by a "time-of-flight" determination from the source to analyzer. Typical energy distribution for the deuterium ions are shown in Fig. 2. The energy distribution is not strongly dependent upon the stack length (L) from 1" to 4" upon the capacitor potential from 5 KV to 15 KV, upon the size of the capacitor, or upon the magnitude of the magnetic field. However, the number of particles ejected varies with the voltage and capacitance of the main discharge circuit. In normal operation the output is of the order of 10^{17} ions per pulse.

If deuterium loaded washers are used the repetition rate must be of the order of once every 10 seconds with the ringing discharge from the 7 1/2 μf capacitor. For a pulse rate as low as 1 every 30 seconds the hydrogen contamination is about as great as the deuterium output which decreases by an amount about equal to the hydrogen contamination. For very infrequent operation (1 pulse in 3 min) and a 1 μf capacitor only hydrogen is obtained after the first few pulses. For any operation the output is about 50% heavy ions, principly multiply ionized titanium, however, carbon is a persistent impurity. By comparison of the energy distributions of the multiply charged titanium ions all ions appear to be accelerated by the same potential.

By replacing the loaded titanium washers with tantalum washers the energetic deuterium component was found to originate from the washer at the open end. Currently injections are operated with only this washer loaded and all other washers fabricated of tantalum.

It is important to note that all the above observations were made with the initial applied potential to the stack positive at the open end. Operation with thic potential reversed is very erratic and the high energy component is not obtained. Similarly series resistance appears to destroy the high energy component.

The life time of the injectors is of the order of 3000 pulses. They usually fail due to faults at the trigger electrode or broken glass insulation. Although no temperature measurements have been made it is noted that upon removing an injector from the vacuum chamber it is still hot enough to burn the operators hands.

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References

1. Ehlers, Gow, Ruby and Wilcox, Rev. Sci. Instr., 29, 614 (1958).

2. Coensgen, Cummins and Sherman, "Multistage Magnetic Compression of Highly Ionized Plasma", to be published in July issue Physics of Fluids.

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PLASMA SOURCE —— MULTI - STAGE COMPRESSION AND TRANSFER DEVICE

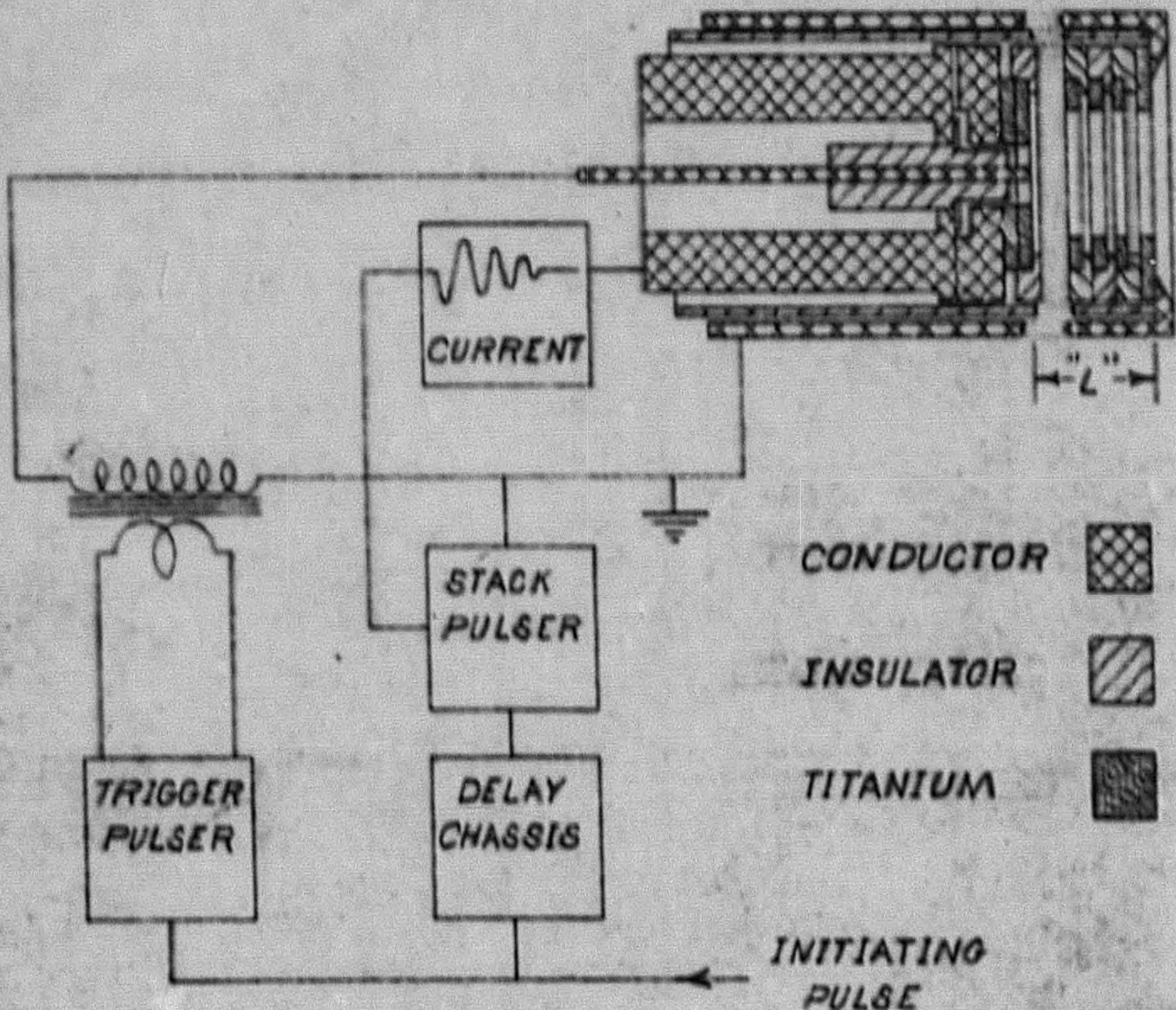

Figure 1

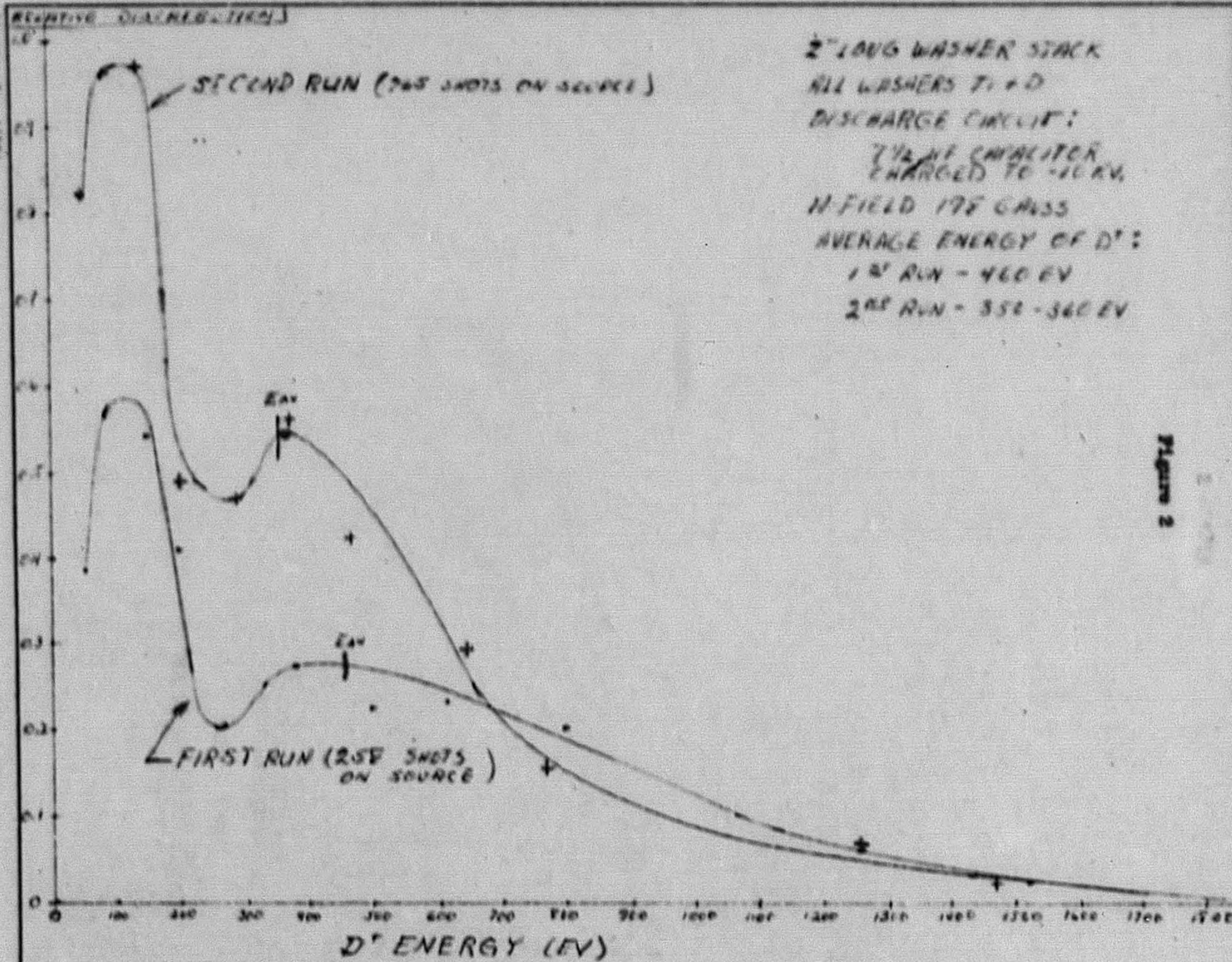

Figure 2

ENGINEERING NOTE

D^+ ENERGY DISTRIBUTION FOR TOP PLASMA INJECTION

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