Device for loading thin wires in a vacuum

D. R. Kania[a)]

Department of Nuclear Engineering, The University of Michigan, Ann Arbor, Michigan 48109

(Received 31 May 1983; accepted for publication 26 September 1983)

A simple device has been developed to load thin (25 μm in diameter) wires in vacuum for an exploding wire plasma system. Wires may be loaded with high reliability, straight, and accurately positioned. An improvement in the reproducibility of the wire explosion results and is attributed to the ability to repeatedly form the electrical contacts between wire and electrodes.

PACS numbers: 52.50.Lp, 84.70. + p

INTRODUCTION

Exploding thin, 25-μm-diam wires in vacuum have been used as a plasma source for several decades. Unfortunately, there are several drawbacks attributable to this source. The wire material is typically difficult to handle. Data acquisition is slowed by the tedious process of loading individual wires and evacuating the experimental chamber. Finally, the inability of manual loading techniques to form reproducible electrical contacts contributes to the strong variations seen in wire explosions. The motivation for using exploding wires is strong: a simple device produces a high-density plasma in a large variety of materials. This plasma has found recent application in a wide variety of fields: opening switches,[1] ion beam propagation,[2] radiation sources,[3] and as a laser pump.[4]

Devices addressing the aforementioned difficulties have been discussed in the literature: a thick (0.76-mm diameter) multiple wire loader for a chemical reactor[5] and a die extrusion system for thin, lithium wires[6] are two examples. The device described in this paper permits the loading of successive, thin (diameter ~25 μm) metallic wires in vacuum. This device allowed the shot-to-shot times to be dictated by considerations other than wire insertion and pump down. An improvement in the reproducibility of the explosion was noted. In addition, the wire may be accurately and repeatedly positioned. Hundreds of 25-μm tungsten and 50-μm-high purity aluminum wires were exploded with this device. An extension to other materials is a trivial one.

I. DESCRIPTION OF APPARATUS

The wire loader (Fig. 1) is an integral part of an exploding wire system. It contains a long—many times the length consumed per shot—piece of wire that is attached to a solid rod—the pusher which passes through a sliding vacuum seal. The wire is manipulated by moving the pusher. The metal of the vacuum flange is lined with glass tubing to reduce friction between the wire and the wall of the flange. The wire passes through a thin channel in the end of the loader which also forms the upper electrode of the discharge. The upper electrode was machined to allow a hypodermic needle to form the channel. A new wire can be lowered between the electrodes after each shot, until the wire in the loader is consumed, i.e., the number of shots is determined by the length of wire in the loader, in our case 30 cm. Ten shots per loading have been successfully exploded with this device.

The loading process is facilitated by applying a dc potential between the electrodes as the wire is lowered. The electrostatic force pulls the wire toward the lower electrode

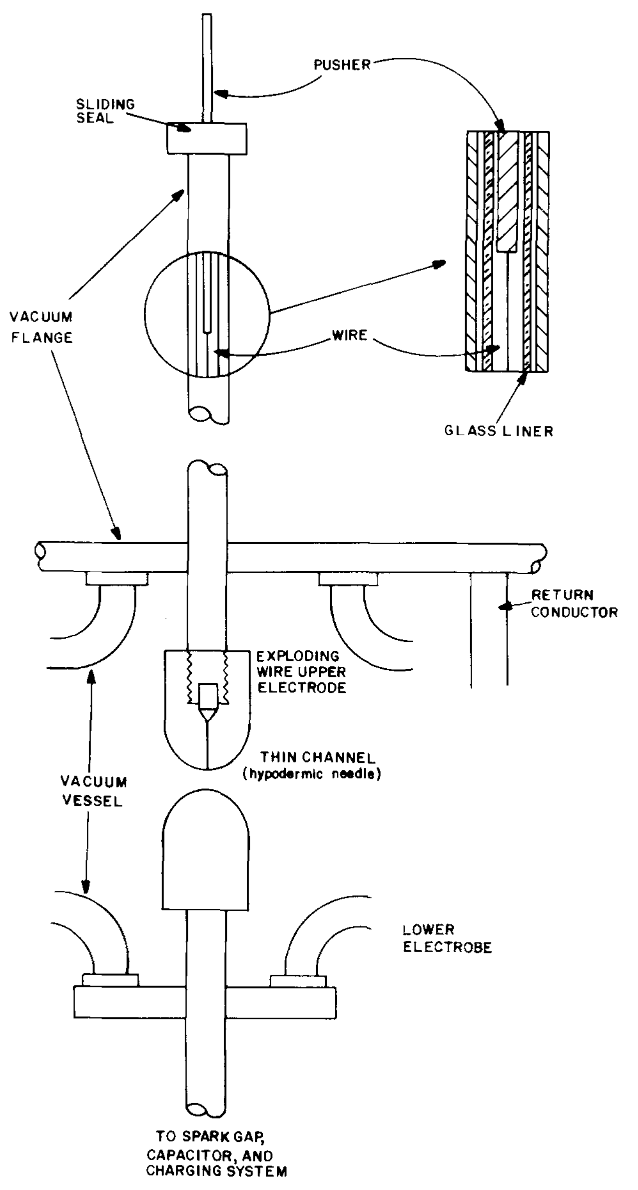

FIG. 1. An overview of the exploding wire system.

 0034-6748/84/010039-03$01.30

keeping it straight. This is similar to the method employed by Leonard with lithium wire.[6]

II. OPERATION

To load the device a suitable length of wire is passed through the thin channel with the electrode disconnected and then through the glass liner [Figs. 2(a) and 2(b)]. It is then attached to the pusher. Glass blowers wax was used to bond the wire to the pusher. The pusher is retracted through the vacuum flange, the electrode replaced, and the entire device placed on the discharge chamber and positioned with an alignment flange [Fig. 2(c)].

The system is evacuated to less than 10^{-4} Torr to permit the application of the dc potential (0–10 kV) without corona or breakdown. The applied voltage pulls the wire toward the lower electrode. The wire is lowered by simultaneously rotating and depressing the pusher, until the wire contacts the lower electrode. If the wire is bent or too much wire has been introduced, the pusher can be retracted, pulling the wire up, and the loading process may be repeated [Fig. 2(d)]. After a wire is exploded, a short pull upward will release any residual contact in the thin channel and loading may proceed.

The application of the dc potential affords an additional advantage: a positive and repeatable connection with the electrodes. Materials such as aluminum and tungsten bonded very well to a copper electrode and inside the thin channel. The repeatability of the contact was verified by measuring the dc resistance of the wire assembly. Adherence to this procedure has improved the reproducibility of the wire explosions.

In addition, the wire may be accurately positioned and repositioned, if necessary. By using an alignment laser, the

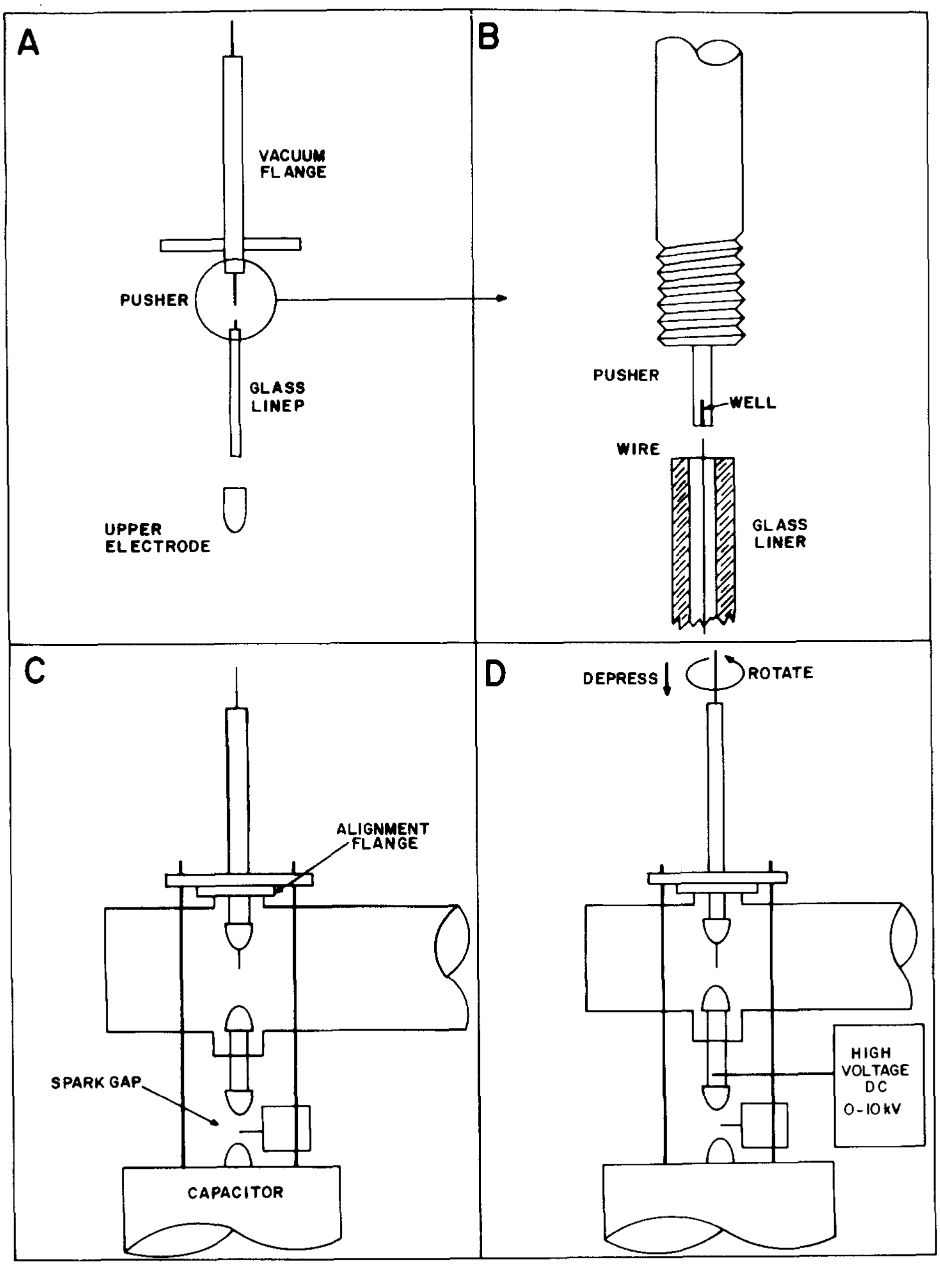

FIG. 2. Step by step operating procedure for the wire loader.

wire may be positioned with submillimeter accuracy. An alignment flange allows the upper electrode free movement and may be locked when appropriate positioning has been achieved.

III. RESULTS

The device described in this paper was used to repeatedly load 25-μm-diam tungsten and 50-μm aluminum wires for wire explosion experiments in vacuum. The wires could be inserted with a very high reliability, straight, and unkinked. Accurate positioning may also be obtained. In addition to simplifying EW operation, an improvement in reproducibility was noted. It is believed that the use of similar techniques could be extended to multiple wire and imploding foil systems. The catenary deformation characteristic of thin cylindrical foils and surface wrinkling may be eliminated.[7]

ACKNOWLEDGMENTS

Many thanks to Dr. David Bach and Dr. John G. Ackenhusen for their support during this work.

This work was supported by Air Force Office of Scientific Research Grant No. AFOSR 79-0030.

[a] Present address: Los Alamos National Laboratory, Los Alamos, NM 87545.

[1] I. M. Vitovitsky and V. E. Scherrer, J. Appl. Phys. **52**, 3012 (1981).

[2] K. Yatsui, K. Masugsta, T. Nakayama, and M. Matsui, Phys. Lett. A **89**, 235 (1982).

[3] P. G. Burkhalter, C. M. Dozier, and D. J. Nagel, Phys. Rev. A **15**, 700 (1977).

[4] I. M. Isalov and A. G. Leonov, Sov. Phys. Tech. Phys. **25**, 73 (1980).

[5] R. L. Johnson and B. Siegel, Rev. Sci. Instrum. **41**, 854 (1970).

[6] T. A. Leonard and D. R. Bach, Rev. Sci. Instrum. **40**, 1964 (1969).

[7] F. W. Kindel, R. Reinovsky, and M. C. Clark, Rev. Sci. Instrum. **50**, 1550 (1979).