Title
SUMMARY OF REMARKS MADE AT THE SHERWOOD MEETING. EXPERIMENTS WITH THE LINEAR PINCH

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Author
Riedel, Jack.

Publication Date
1955-03-15
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EXPERIMENTS WITH THE LINEAR PINCH

Jack Riedel

March 15, 1955
The Experimental Electronics group under W. R. Baker at the University of California Radiation Laboratory resumed on January 1, 1955 its investigation of the linear pinch effect, which had been interrupted in 1953. A plywood and copper box 6 by 6 by 2.5 feet housing twenty-five 0.5-μf Cornell Dubilier 50-kv pulse-type capacitors was constructed (see Fig. 1). The energy (1.5 x 10^4 joules) from these capacitors was sparked into a 4-ft-long 4-in.-diameter Corning glass pipe. A coaxial shunt at the top was used to measure the current, and a resistance divider at the bottom gave a measure of the voltage.

For the purpose of checking the monitoring equipment, the Corning pipe was temporarily replaced by a 1-in.-diameter copper rod. Figures 3A, 3B show the voltage and current for this case. The peak voltage is 60 kv, peak current is 360 ka, and the rise time is 4.5 μsec (1μs/div). This rise time would be 2.5 μsec for a 4-in.-diameter copper rod.

An extensive series of measurements was made of discharges using air, argon, helium, deuterium, and hydrogen at various pressures. Linear pinches could be obtained with air and argon at pressures of 2 to 50 microns. With the lighter gases the pressure range for pinches was 100 to 1,000 microns. Figures 3C and 3D are typical of the voltage and current wave forms observed for these gas pinches. Here the gas was argon at 30 microns. Observe the flattening of the current wave form during the second microsecond of the discharge. This presumably means that the inductance of the circuit is increasing rapidly with time, and that the current-carrying medium is shrinking to a small diameter. Analysis of these wave forms together with evidence from light pictures indicates that the final pinch diameter may be of the order of 1/16 in. The average velocity of the particles needed to travel the necessary 2 in. in μsec is 5 x 10^6 cm/sec, which for D_2 corresponds to a final energy of 80 ev. A fast scintillation counter was used to look for neutrons, and some counts were obtained at times indicated by the vertical lines in Fig. 3C. The counts occur 0.3 μsec after the voltage appears across the tube, but before current actually starts flowing. Further, collimating experiments show that the neutrons
came from the negative electrode of the pinch tube. All this merely proved that the pinch temperature was too low for significant thermal neutron production.

A 0.01-in. pinhole drilled into the copper return pipe housing the pinch tube offered a convenient method of photographing the pinch, without appreciably disturbing the otherwise perfect axial symmetry. Photographs obtained so far show the integrated picture over the entire discharge time and are therefore not too satisfactory. The introduction of a Kerr cell shutter to obtain time resolution of the optical pinch is planned for the near future. Time resolution has been achieved by using a photomultiplier tube in conjunction with a collimator. Figures 1E and 1F show the photomultiplier output when the collimator was pointed at the center and 1.5 in. from the center, respectively. All the wave forms in Fig. 3 have the same time scale and the current in each case starts at 1 div. The last two wave forms show that the light pulse appears first in the center of the tube, 1.5 µsec after the current starts, and that the light pulse at a larger radius occurs later in time.

Figure 2 shows a pinch tube assembly, which has just been completed. It employs a water dielectric condenser of 0.1 microfarad. More properly speaking, it is a coaxial transmission line with $Z_0 = 0.75$ ohm. The dielectric spacing is 3/8 in. Tests show that this spacing will hold 350 kv. The measured rise time is 0.1 microsecond. At 350 kv the current will be 450 ka. The expected pinch energy is 3,000 ev, which should be high enough to give us a measurable quantity of thermal neutrons.

By reducing the length of the Corning glass pipe from 2 ft. to 6 in. we should theoretically expect a pinch energy of 12,000 ev. Even if this model does not perform this well, we have every reason to believe that an improved version will. Here we are using only 0.4 cubic feet of water dielectric. More ambitious models on the drawing board call for ten times this energy storage, with the same time constant for energy release. Furthermore, it is planned to add a long-time-constant energy sump to this fast pinch initiator in order to study the possibility of holding the heated gas away from the walls for long times. Theorists point out that various instabilities will prevent long-time containment, but we feel that the importance of this matter is sufficient to justify some experimental proof.

The fact that our integrated light pictures show no light near the walls indicates that we are possibly getting some containment now.
FIG. 1

TO MARX GENERATOR

4" CORNING GLASS PIPE

GAS LEAK

FIG. 3

TO PUMP

2 1/2'

6'

3/6" SPACE

FIG. 2

TO PUMP

GAS LEAK