UCRL-16972

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DIMINUTION OF SENSITIVE TIME OF SPARK CHAMBERS

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To be submitted to
Review of Scientific Instruments

UCRL-16972
Preprint

UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

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ABSTRACT

The sensitive time of a thin-gap spark chamber immersed in a magnetic field was measured. The magnetic field was normal to the electric field of the chamber, and various amounts of Freon 12(CCl_2F_2) were used to decrease the sensitive time. A concentration of 100 parts per million of Freon 12 was sufficient to make the sensitive time less than 1/2 μsec, with good efficiency.

The Lorentz force on the ion pair produced in a spark chamber placed in a magnetic field causes a displacement of the spark relative to the actual trajectory of the charged particle. The inherent delay in the "logic" required to trigger the high voltage of the spark chamber, and the crossed electric clearing field and magnetic field caused an alternating right and left displacement of the spark-chamber tracks. If the magnetic field is large and the delay is a few tenths of a microsecond, a clearing field of 100 V/cm causes a displacement of a few mm. To decrease the sensitive time, the chamber can be "poisoned" by inserting approximately 1 % concentration of SO_2 in the neon-helium mixture.[1,2]

In wide-gap spark chambers, various kinds of poison have been used to reduce sensitive time. Approximately 100 ppm of Freon 12 (CCl_2F_2) have been found quite effective without reducing the efficiency too seriously.[3]

Spark efficiency for the various concentrations of Freon 12, magnetic fields, and clearing fields are presented in this report. An 18-by 60-in. 4-gap spark chamber (3/8-in. gap) was inserted between the 60-in.-diam pole tips of a large electromagnet. The plates of the "hollow-plate" chamber were made by stretching and gluing 0.001-in.-thick aluminum foil over a metal picture frame. A monitor chamber similar to the above was placed ahead of the test chamber, and the chambers were exposed to a beam of 1.5-BeV/c negative pions. The chambers were photographed with 90-deg stereophotography.

Since the spark-chamber efficiency for two simultaneous tracks was of interest, the pion beam was incident on a 2-in.-thick Pb target.

The interactions would frequently give events of two or more charged particles. They were selected by a system of scintillation counters and a coincidence circuit, Fig. 1. The delay time after the detection by the scintillation counters of charged particles was varied, and the results for various operating conditions are shown in Figs. 2, 3, and 4.

The chambers were normally filled with 1 atmos of 90% neon and 10% helium. The Freon 12 was added to the test chamber in various experiments to concentrations of 0, 45, 90, and 150 ppm by volume. Four different values of clearing field were used — 0, 20, 50, and 100 V/cm. The magnetic field was either, 0, 12, or 17.5 kG. The trigger delay to the spark chamber was varied from 280 nsec to 2.1 μsec. This is the absolute delay from the time of passage of a particle through the chamber.

Scanning consisted of selecting the two-track events with three or four sparks each, within a restricted region (10 in.) near the middle of the reference chamber, and noting the number of sparks in the test chamber. The efficiency for four spark events was computed, and all the graphs refer to the 4-gap efficiency. There was internal consistency by the efficiencies computed from 3- and 4-gap events.

RESULTS AND CONCLUSION

Results are plotted as a family of curves for efficiency vs delay, with two of the three variables kept fixed. Figures 2, 3, and 4 clearly indicate the effectiveness of Freon poisoning. For high beam intensities, where chambers must be cleared within a few hundred nanoseconds, about 100 ppm of Freon seems sufficient. Also, the clearing field is ineffective with the poison, even though at high clearing fields there is a slight reduction in the efficiency for large delays. With the use of high magnetic fields, in case there is no poison, the sensitive times are a few microseconds even with very large clearing fields of the order of 200 to 400 V/cm. The long sensitive time is probably due to the ions being captured in the $\underset{\sim}{E} \times \underset{\sim}{B}$ fields. In addition, the staggering of the sparks becomes enormous, hindering the accuracy of track location. However, with poison the efficiency falls rapidly with delay, so that the ions can be cleared within a short interval of time, and the staggering can be avoided as well. Concentrations of up to 100 ppm of Freon 12 do not decrease the intensity of light from the sparks by a significant amount, and good efficiencies were observed for prompt events.

FOOTNOTES AND REFERENCES

*Work performed under the auspices of the U. S. Atomic Energy Commission.

†On leave of absence from Tata Institute of Fundamental Research, Bombay, India.

1. F. V. Murphy and G. K. O'Neill, Nuovo Cimento Suppl. 26, No. 2 286 (1962).
2. S. Miyamoto, Nuovo Cimento 27, 1325 (1963).
3. Stanford Linear Accelerator Report SLAC-48, August 1965, p. 88.

FIGURE LEGENDS

Fig. 1. (a) Arrangement of scintillation counter S_1 through S_6 and spark chambers SC_1 and SC_2 in the 60-in. diam pole-tip electromagnet.

(b) Coincidence circuit C and spark-chamber pulsers. A timing pulse from the Bevatron magnet, the I pip, was used to reset the trigger system so that 10 photographs per minute were taken.

Fig. 2. Spark-chamber efficiency in chamber No. 2. Two charged particles in chamber No. 1 were required.

Fig. 3. Spark-chamber efficiency for various values of clearing field. With 90 ppm of poison, the clearing field does not have a significant effect on the sensitive time of the chamber. The plotted data are for a clearing field of 50 V/cm and 90 ppm of Freon 12.

Fig. 4. Effect of magnetic field on sensitive time of thin-gap spark chamber.

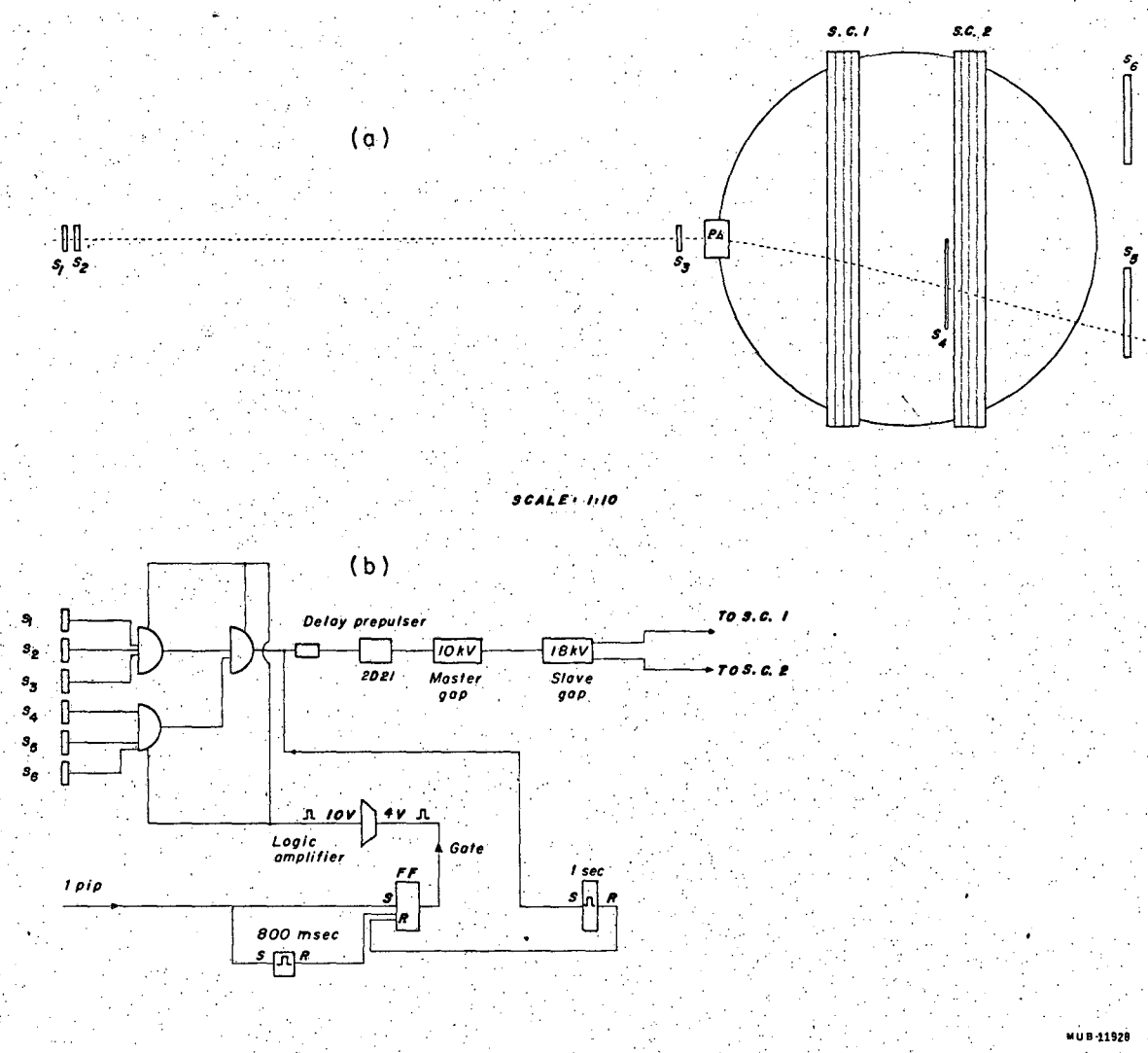
(a)
S.C. 1
S.C. 2
S_1 S_2
S_3
Pb
S_4
S_5
S_6
SCALE: 1:10
(b)
S_1
S_2
S_3
S_4
S_5
S_6
Delay prepulser
2D21
10kV
Master gap
18kV
Slave gap
TO S.C. 1
TO S.C. 2
10V
4V
Logic amplifier
Gate
FF
S
R
1 pip
1 sec
800 msec
MUB-11928

Fig. 1

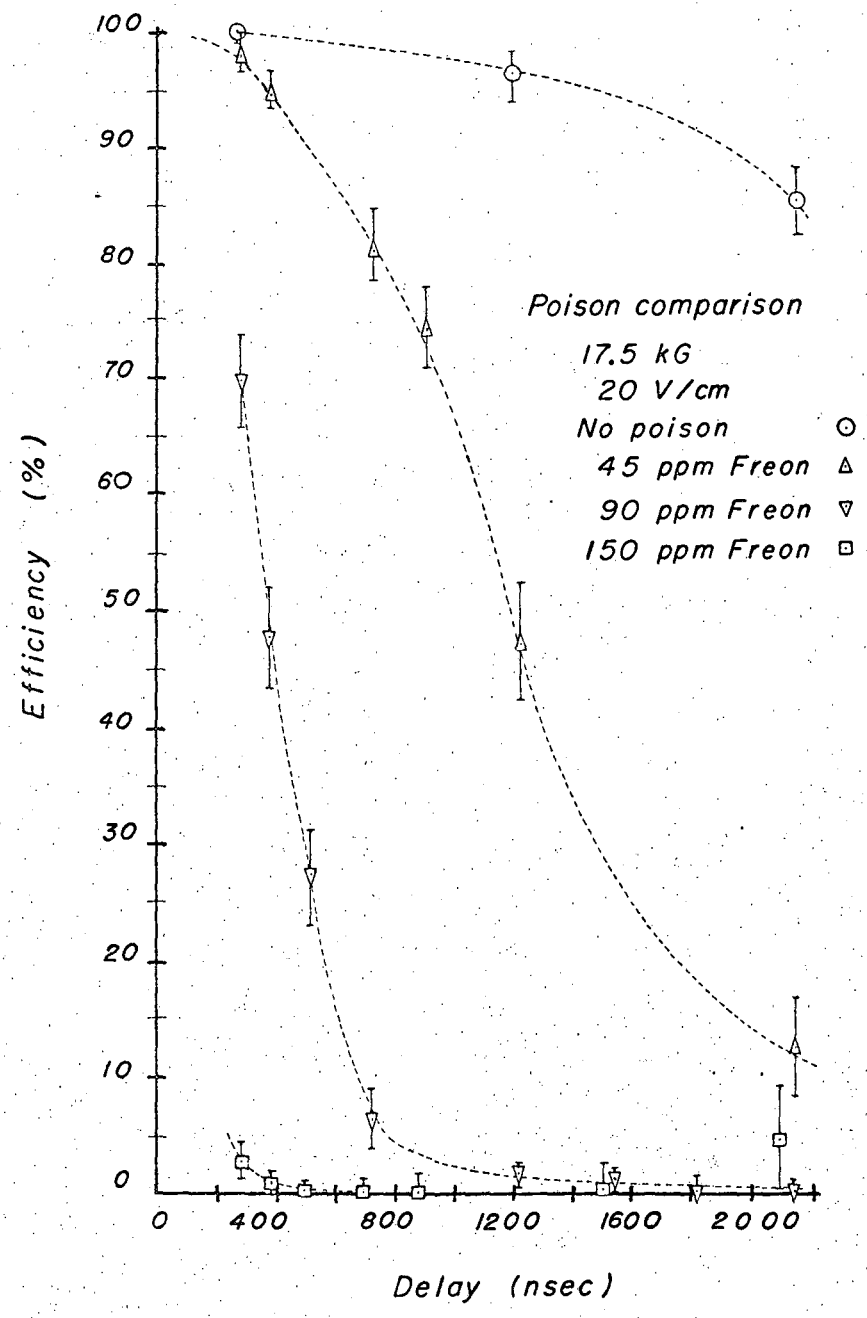

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Fig. 2

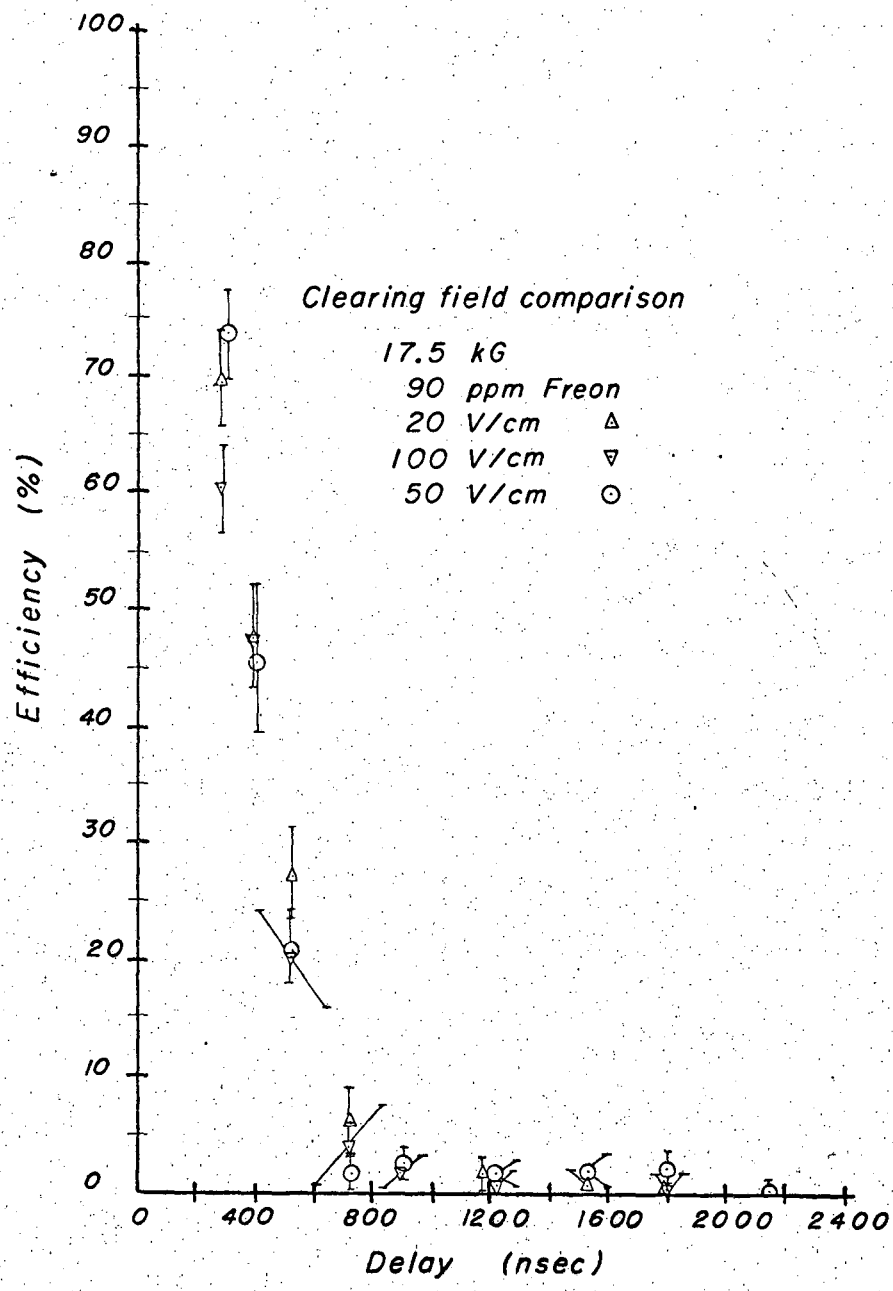

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Fig. 3

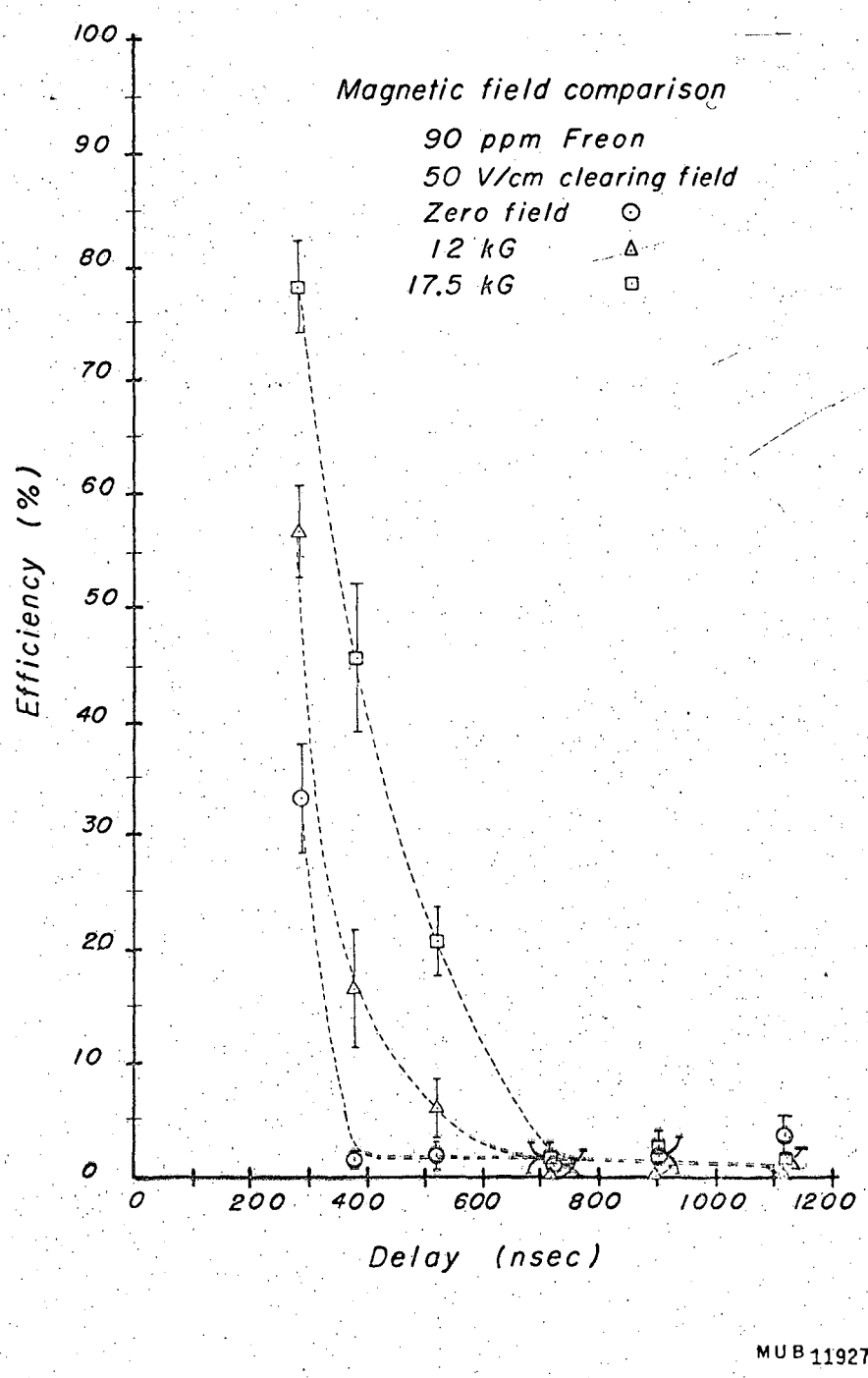
Magnetic field comparison
90 ppm Freon
50 V/cm clearing field
Zero field
12 kG
17.5 kG
Efficiency (%)
Delay (nsec)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
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Fig. 4

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