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Use of Electroluminescent Panels as Pulsed Fiducial Marks in a Spark Chamber Experiment*

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ABSTRACT

Performance of pulsed electroluminescent panels with a total lighted area of 200 cm^2 in a spark chamber experiment of 600,000 exposures is described. Data on light intensity and lifetime, and a description of the transistorized 5-kW pulsed square-wave generator are given.

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I. INTRODUCTION

Electroluminescent panels can provide convenient and relatively inexpensive means of placing fiducial marks on spark chamber pictures.[1,2] These panels consist of a sandwich of a transparent electrode, a phosphor imbedded in a dielectric, and a metal electrode. Light is produced when a varying electric field is applied to the phosphor.[3]

The main advantages of using pulsed electroluminescent panels over the usual system employing reticles illuminated by flash tubes are:

(1) They improve accuracy, since the edges determined by the fiducial marks are very well defined.

(2) They are convenient for experiments designed to use automatic film reading systems.

(3) In many cases they allow a more flexible arrangement of the fiducials.

(4) Under suitable operating conditions they are extremely reliable.

The panels are available in a variety of sizes and shapes; the ones used here[4] were 0.8 mm thick with 0.8-mm copper leads along two edges, and a 3-mm unlighted perimeter.

II. LIGHT INTENSITY

In order to measure the relative light intensity as a function of the operating conditions, a 1-cm by 5-cm panel was mounted on the face of a 53AVP photomultiplier tube with 12 layers of masking tape attenuating the light. The panel was driven through a current limiting resistor by a pulsed square-wave generator described below; the output signal of the tube was displayed on an oscilloscope. For square-wave bursts of 5 msec to 10 msec, it was found that the light intensity increased with the square of the applied voltage, and as a function of frequency the intensity exhibited a flat maximum between 4 kc/sec and 8 kc/sec.

III. LIFE TESTS

Two series of life tests were performed. In the first one, a 12-cm^2 panel was flashed 10 times a second by a 500-V, 10 kc/sec square-wave burst of 4 msec duration; the maximum current was limited to 25 mA/cm^2 by a series resistor. Using Polaroid film, only a small decrease in the light intensity was observed after 1.5 million flashes, and there was no further noticeable change for an additional 5.5 million flashes.

A second test was performed on four parallel 5-cm^2 panels driven by a square-wave burst with a length of 10 msec, voltage of 500 V, and a frequency of 5 kc/sec; the maximum current was limited to 25 mA/cm^2. Pulsed at a rate of 1.5 pulses per second, the light output observed by a photomultiplier tube decreased to 80% of its original value in 50,000 pulses and to 68% after 170,000 pulses. No panel tested could withstand dc voltages in excess of 750 V, or a 600-V, 20-kc/sec square-wave burst of 1 second length.

IV. SQUARE-WAVE GENERATOR

A schematic diagram of the transistorized square-wave generator capable of delivering 10 A at 500 V with a risetime of < 5 μsec is shown in Fig. 1. Power supplies, low-power square-wave source, and gating circuitry are not shown.[5]

Transistors Q6, Q7, and Q9 are 30-W units[6] with $\beta > 100$ and gain-bandwidth products of 30 Mc/sec at collector currents of 1 A. Transistors Q8 and Q10 are 150-W units[7] with $\beta > 10$ at collector currents of 10 A; the gain-bandwidth product is in the vicinity of 1 Mc/sec. At collector voltages of 500 V these transistors are specified to have maximum collector leakage currents of 5 mA at 125°C; they were, however, selected to have leakage currents of less than 0.5 mA at 500 V at 25°C.

In the quiescent condition at least one of the inputs is held at zero voltage, cutting off Q4, which in turn saturates Q5 and cuts off Q6 and Q7. The 0.46 A available current supplied by Q11 and Q12 cuts off Q8, and no significant current is drawn from the +500-V supply. When the base of input transistor Q4 is driven positive, Q11 and Q12 will cut off, and Q7 will drive Q8 into saturation. As a result the output will be pulled negative via diode D1 and capacitors C1 and C2. At the end of the square-wave pulse, the output will be pulled back to zero voltage by resistor R1 via transistors Q9 and Q10 and capacitors C1 and C2.

V. PERFORMANCE

During a recent spark chamber experiment at the Bevatron of the Lawrence Radiation Laboratory, 44 panels with a combined lighted area of 200 cm^2 were masked and utilized as fiducial marks. The panels were pulsed by 500-V, 4.5-kc/sec square-wave bursts of 8-msec duration, with the maximum current[8] limited to approximately 25 mA/cm^2 by resistors placed in series with each panel. The spark chambers and the fiducial marks were photographed on Linagraph Shellburst film from a distance of 10 meters using a 15-cm lens with an opening of f/8. A typical photograph is shown in Fig. 2.

High humidity seemed to shorten the lifetime of the panels, therefore care had to be exercised so that the seals around the leads were not damaged. Panels in the close vicinity of the spark chambers were placed on grounded plates and were protected by individual current limiting resistors. When these precautions were observed, only a few failures occurred during the experiment while the panels were pulsed approximately 600,000 times.[9]

FOOTNOTES AND REFERENCES

1. A. Saulys and E. Meanley, Rev. Sci. Instr. 36, 1053 (1965).

2. M. N. Kreisler, "Plastic Luminescent Panels Used as Pulsed Fiducials," Report SLAC-TN-65-37, Stanford Linear Accelerator Center, Stanford University (May 1965) (unpublished).

3. Measurements using a photomultiplier tube observing the light intensity indicate that the phosphor has two time constants: a short one (less than 100 μsec), and a longer one of about 2 msec.

4. Sylvania Type PPF plastic "Panelescent" lamps with green phosphor, rated at 115 VAC.

5. Detailed documentation is available on request.

6. Honeywell Type MHT 6316.

7. Delco Radio Type 2N2583 (selected).

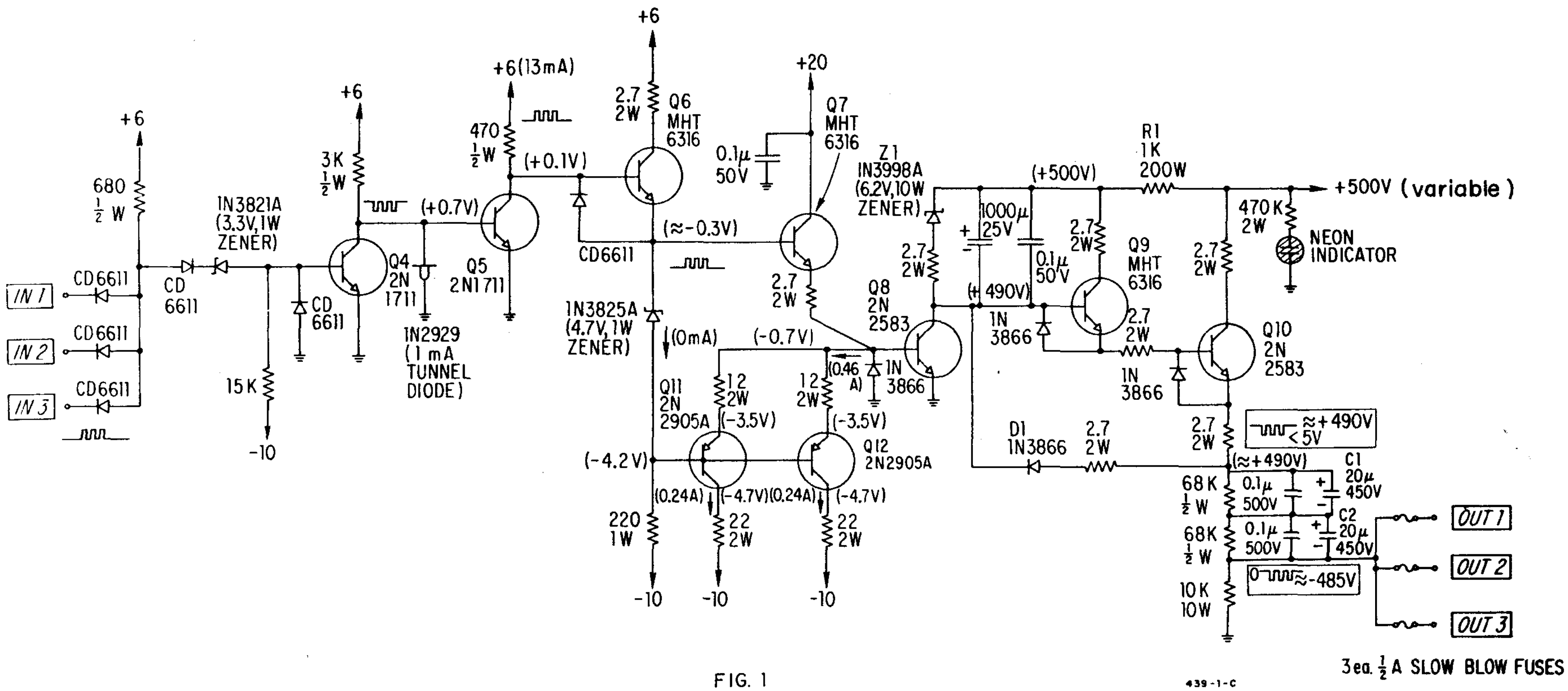
8. The capacitance of the panels is 600 pf/cm^2, thus the current decays from its maximum value approximately exponentially with a time constant of $\tau = CV/I_{max} = (600\ \text{pf/cm}^2)\cdot(500\ \text{V})\cdot(15\ \text{mA/cm}^2)^{-1} = 20\ \mu\text{sec}$.

9. In another experiment where the panels were operated continuously on 115 VAC, no failures were observed.

FIGURE CAPTIONS

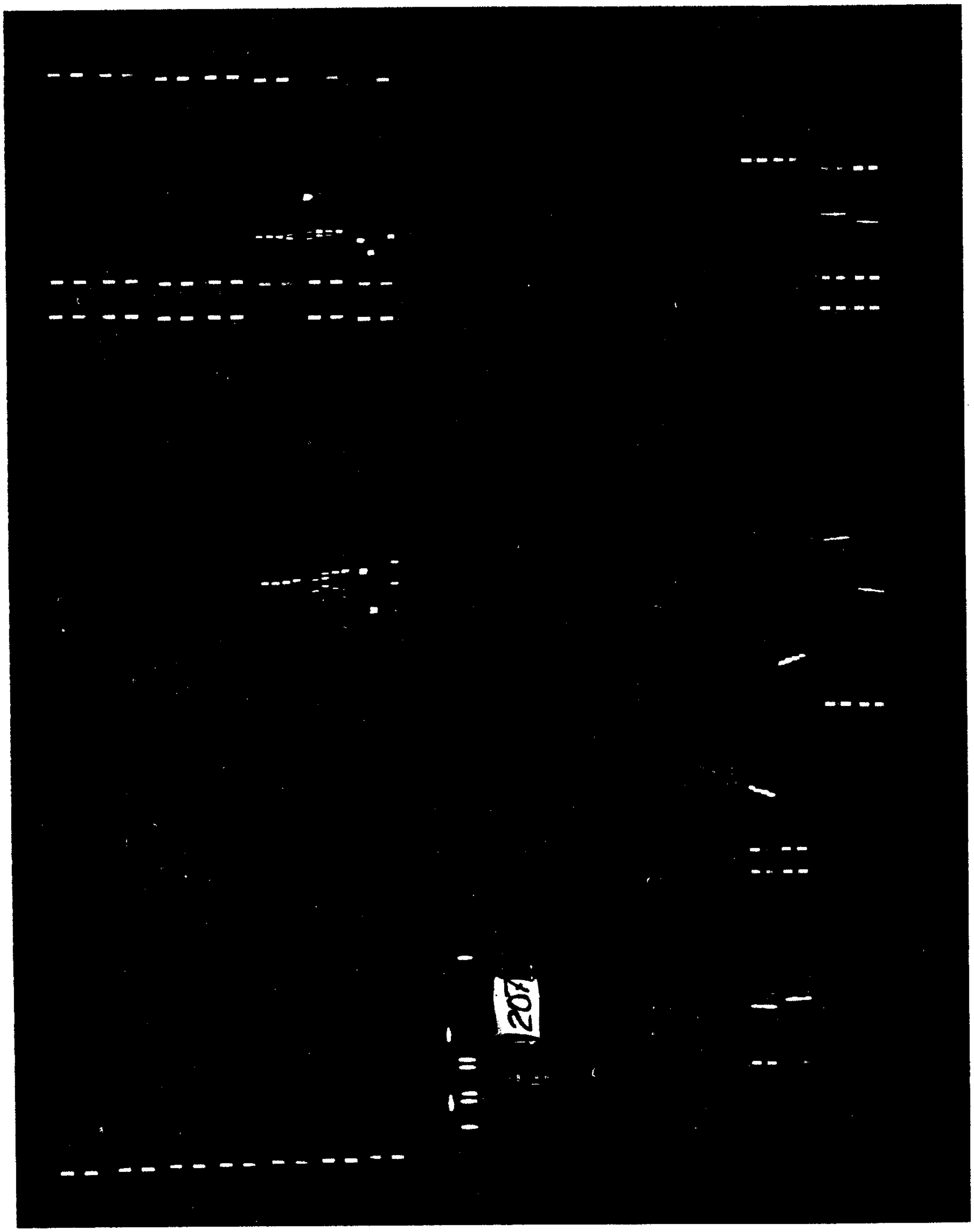
Fig. 1. Schematic diagram of the square-wave generator. Not shown are power supplies, low-power square-wave source and gating circuitry. Quiescent currents and voltages are noted in parentheses. Transistors Q7 through Q12 and zener diode Z1 are mounted on heat sinks. Transistors Q8 and Q10 are selected to have I_{cbo} of less than 0.5 mA at V_{cb} = 500 V at 25°C.

Fig. 2. Photograph of a typical event taken from a distance of 10 meters using a 15-cm lens with f/8. Eastman Kodak Linagraph Shellburst film was used and developed at 7.5 m/min in DuPont Extra Fast X-Ray Developer at 28°C.



IN 1
IN 2
IN 3
CD6611
CD6611
CD6611
680
½ W
+6
CD
6611
1N3821A
(3.3V,1W
ZENER)
15K
-10
CD
6611
3K
½W
+6
Q4
2N
1711
(+0.7V)
1N2929
(1 mA
TUNNEL
DIODE)
Q5
2N1711
470
½W
+6(13mA)
(+0.1V)
CD6611
2.7
2W
+6
Q6
MHT
6316
(≈-0.3V)
1N3825A
(4.7V,1W
ZENER)
(0mA)
(-4.2V)
220
1W
-10
Q11
2N
2905A
12
2W
(-3.5V)
(0.24A)
(-4.7V)
22
2W
-10
(-0.7V)
12
2W
(-3.5V)
Q12
2N2905A
(0.24A)
(-4.7V)
22
2W
-10
0.1μ
50V
+20
Q7
MHT
6316
2.7
2W
Z1
1N3998A
(6.2V,10W
ZENER)
(0.46
A)
1N
3866
Q8
2N
2583
2.7
2W
1000μ
25V
(+490V)
0.1μ
50V
(+500V)
1N
3866
2.7
2W
Q9
MHT
6316
2.7
2W
R1
1K
200W
D1
1N3866
2.7
2W
1N
3866
2.7
2W
Q10
2N
2583
2.7
2W
470K
2W
NEON
INDICATOR
+500V (variable)
≈+490V
<5V
(≈+490V)
68K
½W
0.1μ
500V
C1
20μ
450V
68K
½W
0.1μ
500V
C2
20μ
450V
≈-485V
10K
10W
OUT 1
OUT 2
OUT 3
3ea. ½ A SLOW BLOW FUSES
439-1-C

FIG. 1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