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TECHNICAL REPORT

"A NOVEL HIGH VOLTAGE PULSE GENERATOR"

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A NOVEL HIGH VOLTAGE PULSE GENERATOR*

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This note describes a high voltage pulse generator that was developed in connection with research being carried out on hypervelocity impact phenomena.[1] Our requirements were a 20-kilovolt pulse delivered to a capacitive load of 100 pf, with rise and fall times of one μsec or less, and a pulse width range of 10-100 μsec. The pulse generator contains all solid-state components, except for the output pulse tube, and is simple in design and construction. A 3-volt pulse is sufficient to drive the generator and consequently it can be driven directly from low-level solid-state circuits.

Figure 1 is a circuit diagram of the generator which consists of 2 basic stages. The first is the transistor string composed of Q_{1-3} and its associated circuitry.[2] The second is the high voltage pulse tube. The biasing arrangement composed of R_{1-5}, while quite simple, achieves two very important results. It allows the switching action of the transistors to occur as described below, and at the same time prevents the voltage across any transistor Q_α from exceeding that across its bias resistor R_α. This prohibits transistor breakdown due to excessive collector-emitter voltage. Diodes D_{1-2} protect the string from spurious pulses fed back from the pulse tube grid, etc., which might destroy the string by exceeding the maximum BV_{CEO} of the transistors. The protection afforded by D_{1-2} depends only upon their turn-on time, and since this is quite rapid for any diode, ordinary rectifier diodes may be used.

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*This circuit developed in connection with work being conducted on hypervelocity impact phenomena under NASA Contract NASw-936.

[1] J. F. Friichtenicht, "Micrometeoroid Simulation Using Nuclear Accelerator Techniques", Nuclear Inst. and Methods (1964) Vol. 28 pp 70-78.

[2] D. O. Hansen, "Solid State High Voltage Pulser", 4158-6005-TU-000, Contract No. NASw-936, TRW Space Technology Laboratories, Redondo Beach.

A positive rectangular pulse is applied to the base of Q_1 which turns it on. As Q_1 comes on its collector voltage falls, carrying the emitter of Q_2 down also. This turns on Q_2 because of the base current drawn through R_3. Q_3 is turned on in a similar fashion. When this switching action is complete, all of the transistors are in saturation. Upon termination of the pulse at the base of Q_1, the reverse procedure takes place. Therefore, the signal at the collector of Q_3 is a negative rectangular voltage pulse with an amplitude nearly equal to the supply voltage. This pulse is delivered to the grid of the high voltage pulse tube by an inverting 1:1 pulse transformer.

The high voltage pulse tube is conventional in all respects. The pulse from the transistor string is delivered to the grid, driving it positive and saturating the tube. The plate falls essentially to ground with a rise time determined by the time required to charge the load capacitance with the plate current. When the pulse is removed from the grid, the plate returns to the supply voltage with a fall time determined by the RC time constant of the effective load resistance and the load capacitance.

The rise and fall times of the output pulse were about 900 nsec which was adequate for our purposes. If shorter rise and fall times are required, both stages of the pulse generator can be improved. Pulse tubes rated at 75 amperes or more are readily available and these are capable of providing rise times of 50 nsec or less into a 100 pf load. The switching time of the transistor string can be improved also. It will be noted that Q_2 and Q_3 are turned on with emitter drive, and therefore their switching times are limited only by their f_α. Q_1 is switched with base drive and almost entirely limits the rise and fall times of the string. If transistors with high f_α are chosen for Q_2 and Q_3 and a fast switching transistor is chosen for Q_1, short rise and fall times may be obtained from the transistor string. Fast switching high voltage transistors are rare, but it is not necessary that the voltage division across the transistors be equal. Q_1 may be given a small collector-emitter voltage of perhaps 20 volts. Transistors are available with very fast switching speeds at these voltage ratings. The pulse transformer which also limits the output rise times, may be completely eliminated as shown in Fig. 2 by the use of PNP transistors in the string. Their output is then a positive pulse which may be capacitively coupled to the grid. This also removes the limitation on maximum pulse length which the transformer imposes.

vw

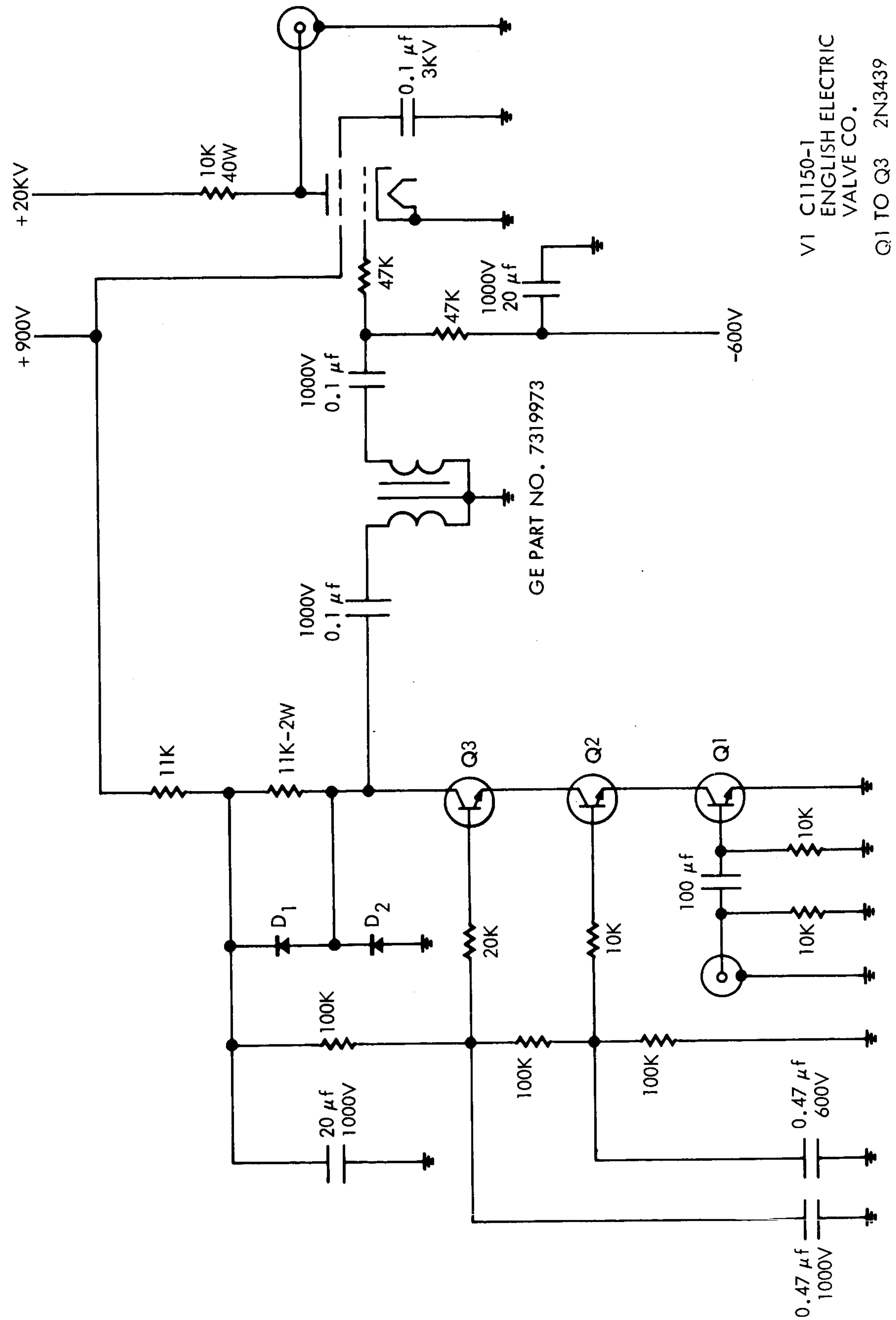
+20KV
10K
40W
0.1 µf
3KV
+900V
47K
47K
1000V
20 µf
-600V
1000V
0.1 µf
GE PART NO. 7319973
1000V
0.1 µf
11K
11K-2W
Q3
Q2
Q1
10K
100 µf
10K
D1
D2
20K
10K
100K
100K
100K
20 µf
1000V
0.47 µf
600V
0.47 µf
1000V
V1 C1150-1
ENGLISH ELECTRIC
VALVE CO.
Q1 TO Q3 2N3439

Figure 1.

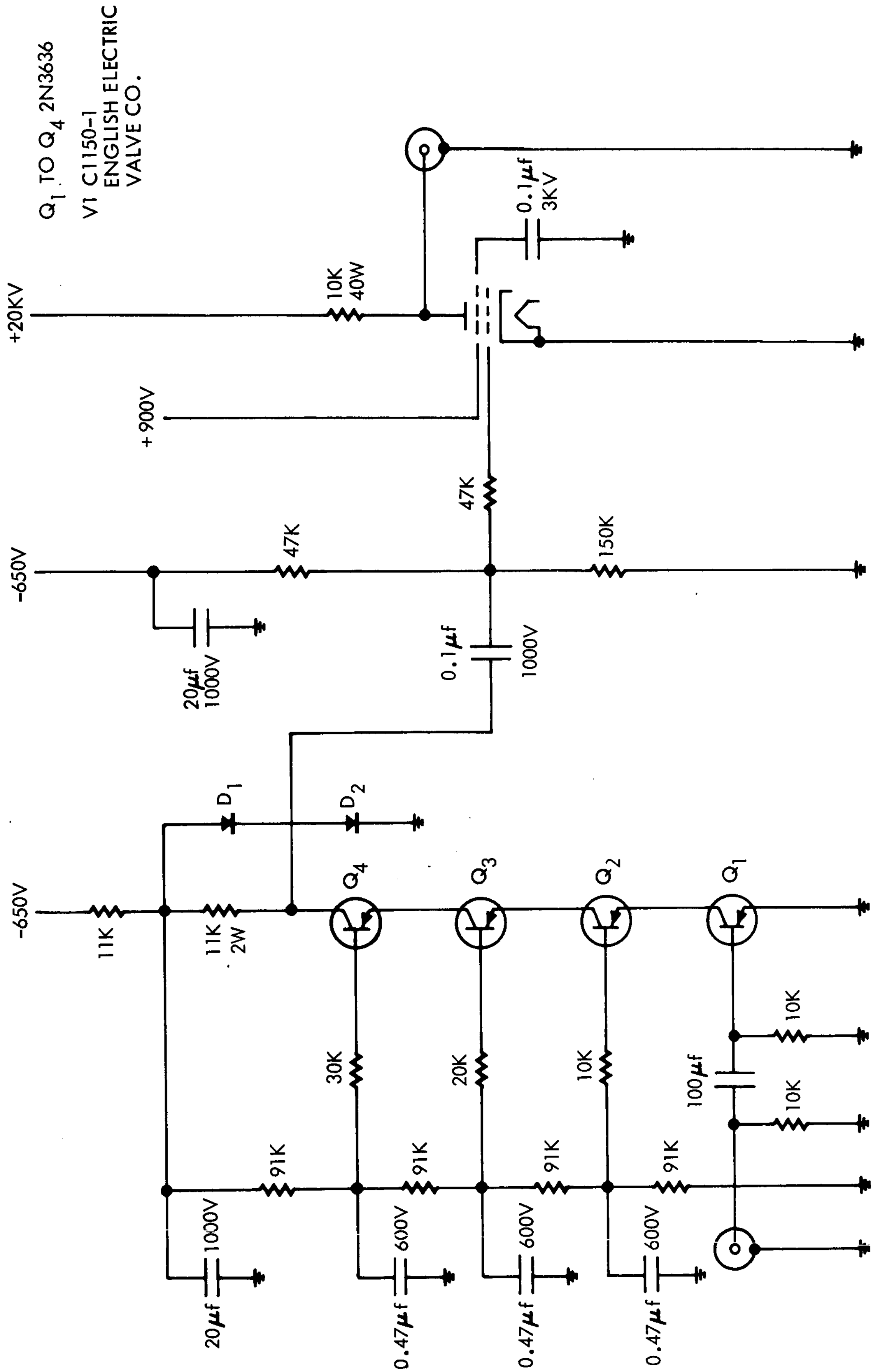
Q1 TO Q4 2N3636
V1 C1150-1
ENGLISH ELECTRIC
VALVE CO.
+20KV
10K
40W
0.1µf
3KV
+900V
-650V
47K
47K
150K
20µf
1000V
0.1µf
1000V
D1
D2
-650V
11K
11K
2W
Q4
Q3
Q2
Q1
30K
20K
10K
10K
100µf
10K
91K
91K
91K
91K
20µf
1000V
0.47µf
600V
0.47µf
600V
0.47µf
600V

Figure 2.