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17 SEPTEMBER 1976

MILITARY STANDARD

CHARACTERISTICS OF 28 VOLT DC ELECTRICAL SYSTEMS IN MILITARY VEHICLES

FSC 2920

DEPARTMENT OF DEFENSE
WASHINGTON, D. C. 20201

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2. Recommended corrections, additions or deletions should be addressed to the Commanding General, U.S. Army Tank-Automotive Materiel Readiness Command, ATTN: DRSTA-GSES, Warren, Michigan 48090.

FOREWORD

The intent of this document is to provide a standard limiting voltage characteristics of 28 Volt DC electric circuits on Military vehicles.

Conformance to the requirements of this standard provides for greater compatibility between power supply and utilization equipment. Power characteristics will be confined within definitive limits. The requirements imposed on the power supply by the utilization equipment will be restricted. It shall be the responsibility of the vehicle manufacturer to provide for conformance to this standard.

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FIGURES

1. SCOPE

1.1 Purpose. The purpose of this document is to provide for compatibility between vehicular electric power supply and utilization equipment by confining electric power characteristics within definitive limits and restricting the requirements imposed on the electric power by the utilization equipment.

1.2 Scope. This standard prescribes the limits of transient voltage characteristics and steady state limits of the 28 volt DC electric power circuits of Military vehicles.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on the date of invitation for bids or request for proposal form a part of this standard to the extent specified herein.

STANDARDS
Military
MIL-STD-461 - Electromagnetic Interference Characteristics Requirements for Equipment.

(Copies of specification, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

3. DEFINITIONS

3.1 General. For the purposes of this standard, the following definitions shall apply:

3.1.1 Vehicle power supply system. The generating equipment, storage batteries and distribution equipment normally fitted to the vehicle comprise the power supply system. Power is supplied from this system to the utilization equipment.

3.1.2 Fault. A fault is any malfunction or misoperation of the power supply system or utilization equipment. An unserviceable battery is a single fault. Any non-standard switching sequence is a single fault. A single fault is a relatively common occurrence. A multi-fault occurs rarely (e.g. failure of the battery connection occurring in conjunction with a generator voltage regulator failure).

3.1.3 Transients. Transients are the changing conditions of a characteristic. These usually go beyond the steady-state limits and return to and remain within the steady-state limits within a specified time period. The transient may take the form of either a surge or a spike.

3.1.3.1 Surge. A surge is a variation from the controlled steady-state level of a characteristic, resulting from the inherent regulation of the electric power supply system and remedial action by the regulator, except for battery only operation. Surge may also occur due to the application of loads in the battery only condition.

3.1.3.2 Spike. A spike is a high frequency oscillatory variation from the controlled steady-state level of a characteristic. It results from very high frequency currents of complex wave form produced when reactive loads are switched. An individual spike generally lasts less tha 50 micro-seconds but may take up to one milli-second to decay to the steady-state level.

3.1.4 Steady-state. The condition in which circuit values remain essentially constant, occurring after all initial transients or fluctuating conditions have subsided. It is also definitive of the condition where, during normal system operation, only inherent or natural changes occurr: i.e, no fault occurs and no deliberate change is made to any part of the system.

3.1.5 Recovery time. The interval between the time a characteristic deviates from the steady-state limits and the time it returns and remains within the same range (see Figure 1).

3.1.6 Ripple. The regular or irregular variations, or both, of voltate about a fixed DC voltage level during steady-state operation of a DC system. The upper and lower limits of the oscillations are called "upper peak of ripple voltage" and "lower peak of ripple voltage" respectively (see Figure 2).

3.1.7 Starting disturbances. These are undervoltage variations from the steady-state level and are caused by engine starter engagement and cranking. A typical profile showing "Initial Engagement Surge" (I.E.S.) and "Cranking Level" is given in Figure 3. The duration of the initial engagement surge is measured from the instant at which it departs from the steady-state value to the instant at which it reaches and remains at the cranking level. The cranking level lasts from the end of the initial engagement surge until the starter is disengaged.

4. GENERAL REQUIREMENTS

4.1 Temperature conditions. The limits stated in circuit characteristics shall be determined at the extremes of 52°C and -32°C.

4.2 Circuit characteristics point of measurement. These characteristics apply at the utilization equipment terminals.

4.3 Equipment compatibility. All electrical equipment shall be able to withstand spikes of up to ± 250 volts amplitude. Equipment shall provide protection against polority reversal as a result of slave starting or other improper connection.

4.4 Polarity. The negative of the DC power supply shall be grounded to the vehicle metal structure and this ground shall normally be considered the second conductor of the circuit. When required a supplementary ground wire may be used.

5. DETAILED REQUIREMENTS

5.1 Fault free condition.

5.1.1 Electromagnetic interference. The equipment of the vehicle power supply system and the utilization equipment shall meet the requirements of MIL-STD-461 for conducted emissions and susceptibility as applicable for the vehicle and type of equipment.

5.1.2 Combined generator-battery power supply.

5.1.2.1 Steady-state voltage. Circuit steady-state voltage shall be between 25 and 30 volts.

5.1.2.2 Ripple. The upper and lower peaks of ripple voltage (see Figure 2) shall each be less than 2 volts. The frequency components of the ripple shall be within the range 50 Hz to 200 kHz.

5.1.2.3 Surges. All surges resulting from system operation shall fall within the loci shown in Figure 4.

5.1.2.4 Spikes. All spikes resulting from system operation shall fall within the loci shown in Figure 5.

5.1.2.5 Starting disturbances. Fully charged battery shall be used (Battery drawing less than 5 amperes from a 28-volt charging source with electrolyte temperature between 27°C and 38°C).

5.1.2.5.1 Initial engagement surges. During this disturbance, the voltage shall not be below 6 volts and the duration shall not exceed 1 second.

5.1.2.5.2 Cranking level. The steady voltage during cranking shall not be below 16 volts (No more than 3 cranking attempts of 30 seconds each with 2-minute cranking level pauses between attempts). This characteristic applies to starting the second engine of a multi-engine vehicle, or slave starting another vehicle.

5.1.3 Battery only condition.

5.1.3.1 Steady-state voltage. Circuit steady-state voltage shall be between 20 and 27 volts.

5.1.3.2 Ripple. The upper and lower peaks of ripple (see Figure 2) shall each be less than 2 volts. The frequency components of the ripple shall be within the range 50 Hz to 200 kHz.

5.1.3.3 Surges. (Any switching action resulting in a surge which takes the voltage outside steady-state limits will be considered as a fault condition for the duration of the excursion.)

5.1.3.4 Spikes. All spikes resulting from system operation shall fall within the loci shown in Figure 5.

5.1.3.5 Starting disturbances. Fully charged battery shall be used (Battery drawing less than 5 amperes from a 28-volt charging source with electrolyte temperature between 27°C and 38°C).

5.1.3.5.1 Initial engagement surges. During this disturbance the voltage shall not fall below 6 volt and the duration shall not exceed 1 second.

5.1.3.5.2 Cranking level. The steady voltage during cranking shall not be below 16 volts (No more than 3 cranking attempts of 30 seconds each with 2-minute cranking level pauses between attempts).

5.2 Single fault condition. (Vehicle system operates with generator only i.e. no battery).

5.2.1 Steady-state voltage. The voltage shall be less than 33 volts.

5.2.2 Ripple. The upper and lower peaks of ripple voltage (see Figure 2) shall each be less than 7 volts. The frequency components of the ripple shall be within the range 50 Hz to 200 kHz.

5.2.3 Surges. All surges resulting from system operation shall fall within the loci shown in Figure 6. (A lower steady-state limit of 23 volts shall be used to establish the recovery time of negative-going surges.)

5.2.4 Spikes. All spikes resulting from system operation shall fall within the loci shown in Figure 7.

5.3 Compatibility of power supply system and utilization equipment. It is the responsibility of the appropriate authority to specify how the equipment shall function during and after the disturbances quoted in the detailed requirements. There shall be no influence by utilization equipment which would cause the electrical system to depart from the limits specified in the detailed requirements. In a multi-fault condition the output voltage is a function of generator speed and can be higher than 100 volts DC or equal to zero (0).

6. TEST METHODS

6.1 Vehicle electrical system. Measuring equipment and test procedures shall have the following minimum standards:

a. Ripple
   (1) Measuring equipment
   Oscilliscope or portable recorder having an input impedance of not less than 0.1 megohm and a bandwidth of not less than 30 megahertz.

(2) Test procedure
Operate vehicle in fault-free and single-fault modes.

b. Spikes
(1) Measuring equipment
(Same as for ripple measurement)
(2) Test procedure
Operate vehicle in fault-free and single-fault modes. For test purposes, voltage spikes shall be produced by inductive load switching including, as a minimum, blowing the horn, operating the bilge pumps, (if any), starting and stopping the engine and rotating the turret (if any).

c. Surges
(1) Measuring equipment
(Same as for ripple measurement)
(2) Test procedure
Same as for spike test procedure with the addition of the following: Voltage surges shall also be produced by load switching from 10 percent to 85 percent and 85 percent to 10 percent of system current rating. In small systems (e.g. 25 and 40 amperes) where it is impossible to achieve a minimum of 10 percent load, the minimum load shall be used.

6.2 Vehicle equipment.

6.2.1 General. It is the responsibility of the appropriate authority to specify the following:

a. Which of the following tests, if any, shall be applied to the equipment to determine whether it is compatible with an electrical system whose characteristics are defined in this standard.
b. How the equipment shall function during and after these tests.
c. The electrical and environmental conditions under which these tests are carried out.

6.2.2 Spikes exported from equipment. Using the test circuit shown in Figure 8 the equipment shall be operated over its specified ranges of functions. Any switching operation capable of producing spikes shall be repeated a sufficient number of times to give a reasonable probability that the maximum spike voltage is recorded (say 20 operations). In addition, where the power supply to the equipment is normally provided via an independent vehicle mounted switch, the test shall be repeated using this switch connected as shown in Figure 9.

No spike voltage recorded during these tests shall exceed ± 250 volts. No spike, or combination of spikes arising from a single event, shall have an energy content exceeding 15 millijoules. (Method of measuring energy content to be specified later.)

6.2.3 Spikes imported into equipment.

a. An acceptable circuit is shown in Figure 10. The 5 uH coil and 50Ω resistor provide a stabilized source impedance with a frequency characteristic typical of that of a vehicle power supply circuit. The energy for the spike is stored in the 0.1 uF capacitor charged from a high voltage DC source through the 100 kilohm resistor. When the switch is closed a voltage step is produced, followed by a damped sinusoidal oscillation. The risetime of the voltage step is largely determined by the inductance of the series circuit of the capacitor and switch. To obtain the specified short risetime the inductance must be kept to a low value by the use of suitable components. A feed-through capacitor and a coaxial mounted mercury-wetted reed switch together with short coaxial cables for the connecting leads are suggested. The peak amplitude of the spike is controlled by the DC charging voltage.

b. For these tests, simulated voltage spikes shall be applied to the equipment while it is operating at nominal voltage. The test spike shall have an amplitude of 250 volts, a risetime not exceeding 50 nanoseconds, a frequency of oscillation greater than 100 kHz and less than 500 kHz and an energy content of not less than 15 millijoules. Measuring equipment specified in 6.1 shall be used to monitor the spike voltage.

c. Tests shall be carried out with both polarities of spike voltage. The number of applications of spikes will depend upon the equipment under test. However, a minimum of fifty 250-volt spikes of each polarity shall be applied at one second intervals. The voltage spikes so imposed shall not cause any damage nor affect the normal operation of the equipment.

6.2.4 Voltage surges imported into equipment.

a. For these tests, simulated voltage surges shall be applied to the equipment while it is operating at nominal voltage. The vehicle electrical system shall be represented in both the fault-free and the single fault conditions. An acceptable circuit is shown in Figure 11.

b. To simulate a voltage surge in the fault-free condition, a surge of 40 volts total amplitude lasting for 50 milliseconds from a source impedance of 20 milliohms shall be applied. Both before

and after each surge the nominal supply voltage shall be maintained. This test shall be applied five times at intervals of 1 second. The equipment shall continue to operate normally throughout these tests without damage to any components.

c. To simulate a voltage surge in the single fault condition, a surge of ±100 volts total amplitude lasting for 50 milliseconds from a source impedance of 500 milliohms shall be applied. Both before and after each surge the nominal supply voltage shall be maintained. This test shall be applied five times at intervals of 1 second. The equipment shall function as specified.

d. The voltage surges specified in b and c shall have the amplitude stated before connection of the equipment. The voltage shall be sensibly constant during the surge. The rise and fall times shall be approximately 1 millisecond.

NOTE: INTERNATIONAL STANDARDIZATION AGREEMENT

Certain provisions of this standard are the subject of international standardization agreement, QSTAG-307. When amendment, revision, or cancellation of this standard is proposed which will affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

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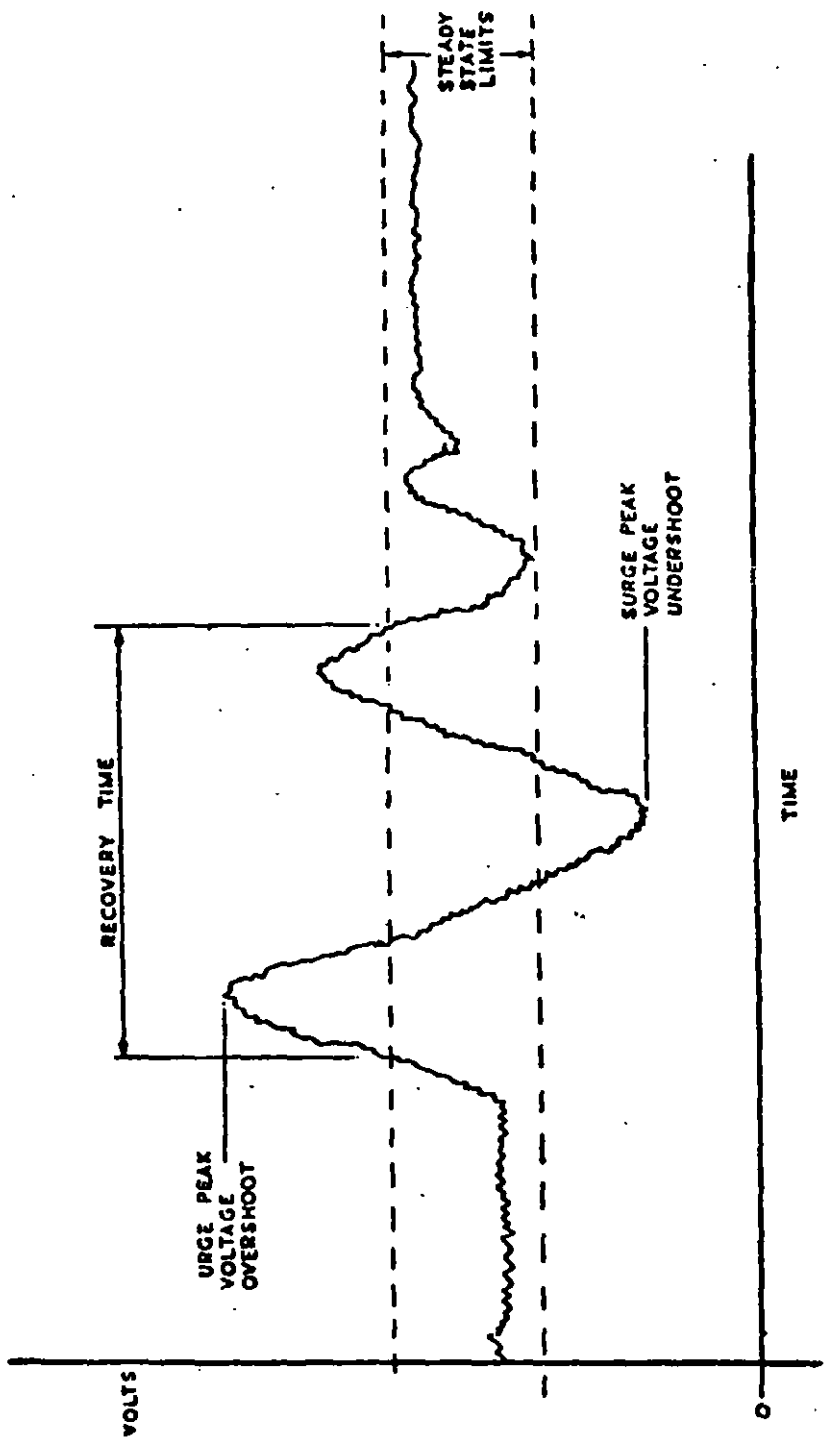


FIGURE 1

ILLUSTRATIVE SURGE WITH RECOVERY TIME

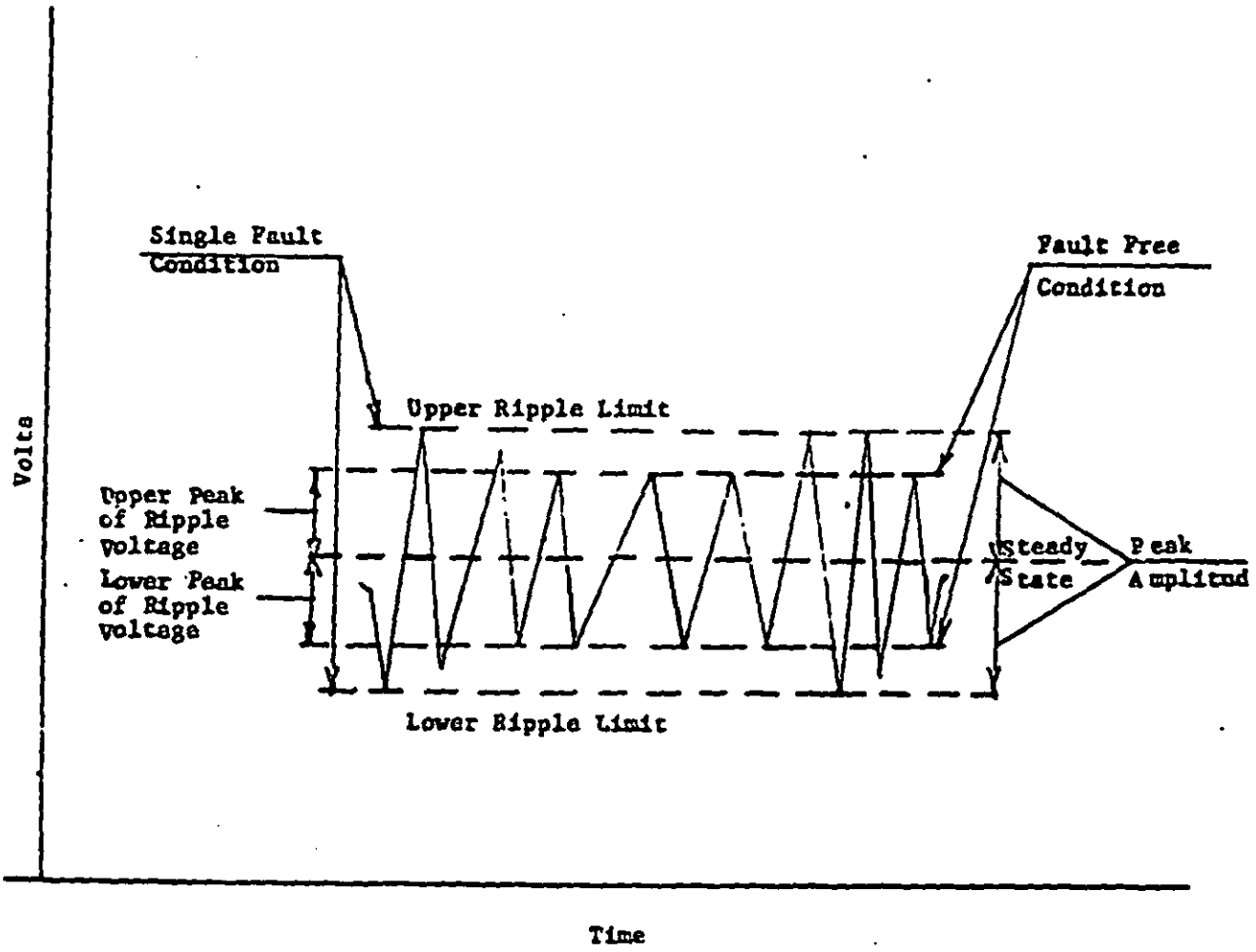


FIGURE 2

ENLARGED VIEW OF RIPPLE

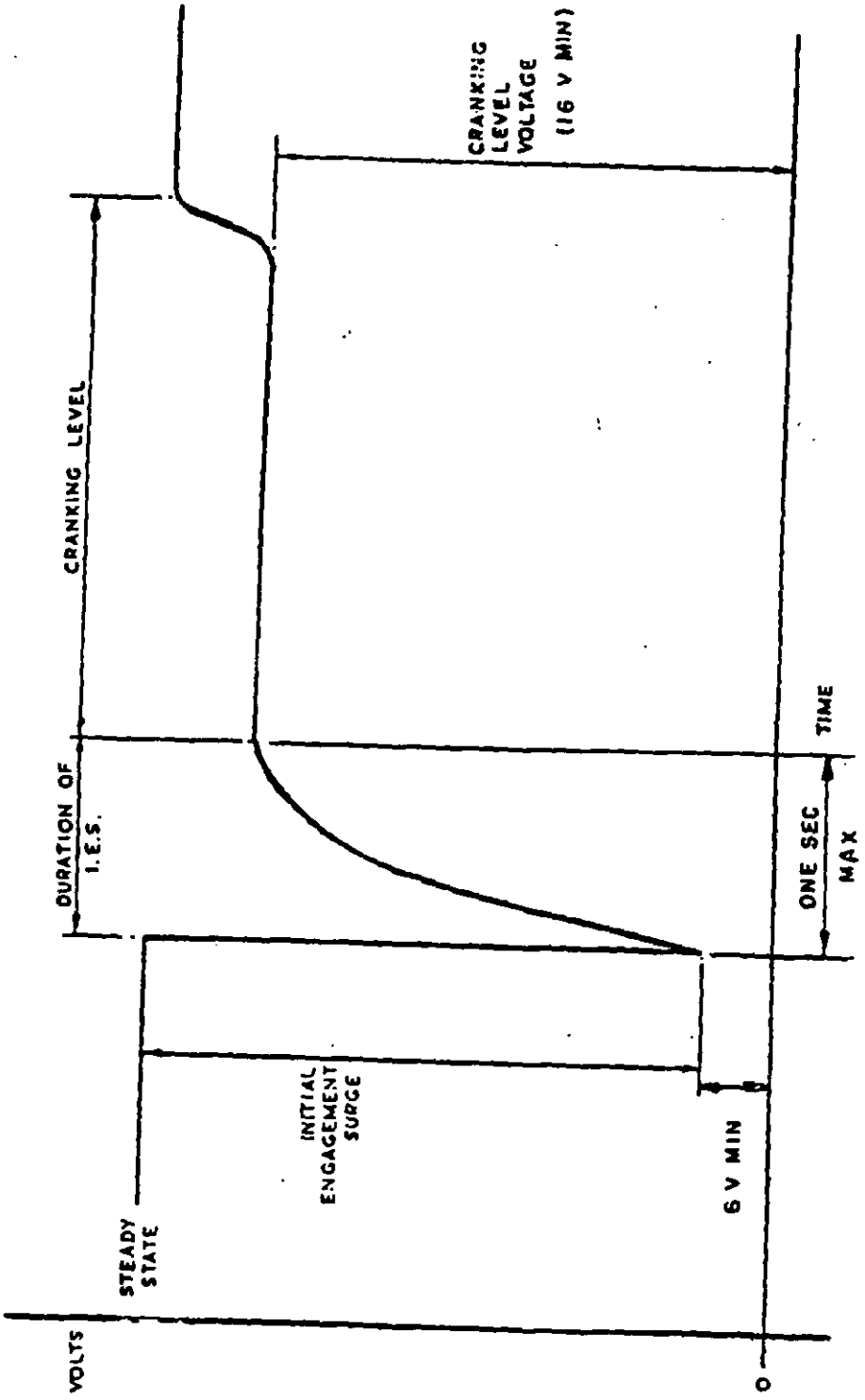


FIGURE)

STARTING DISTURBANCES

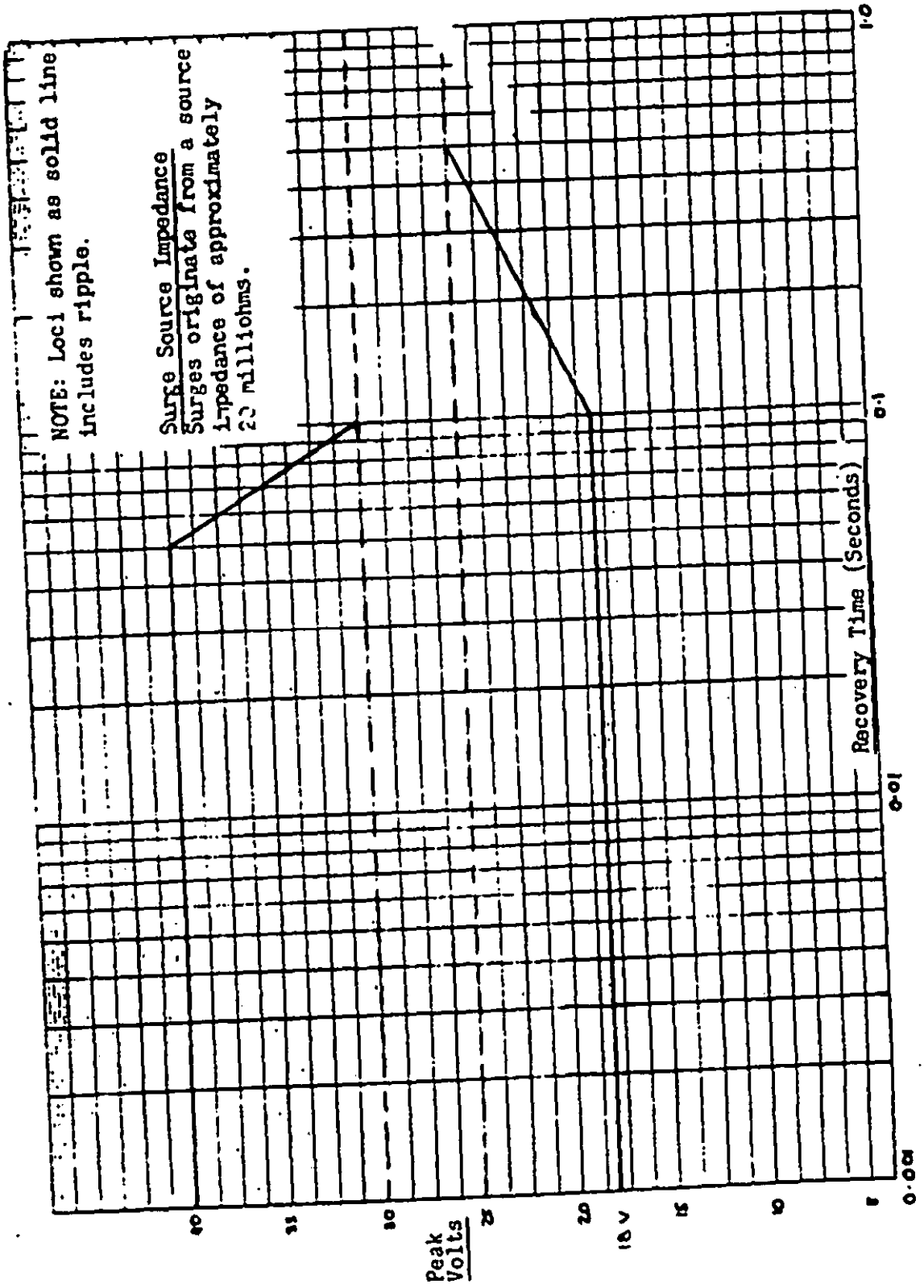


FIGURE 4

LOCI OF [illegible]

FAULT FREE CONDITION

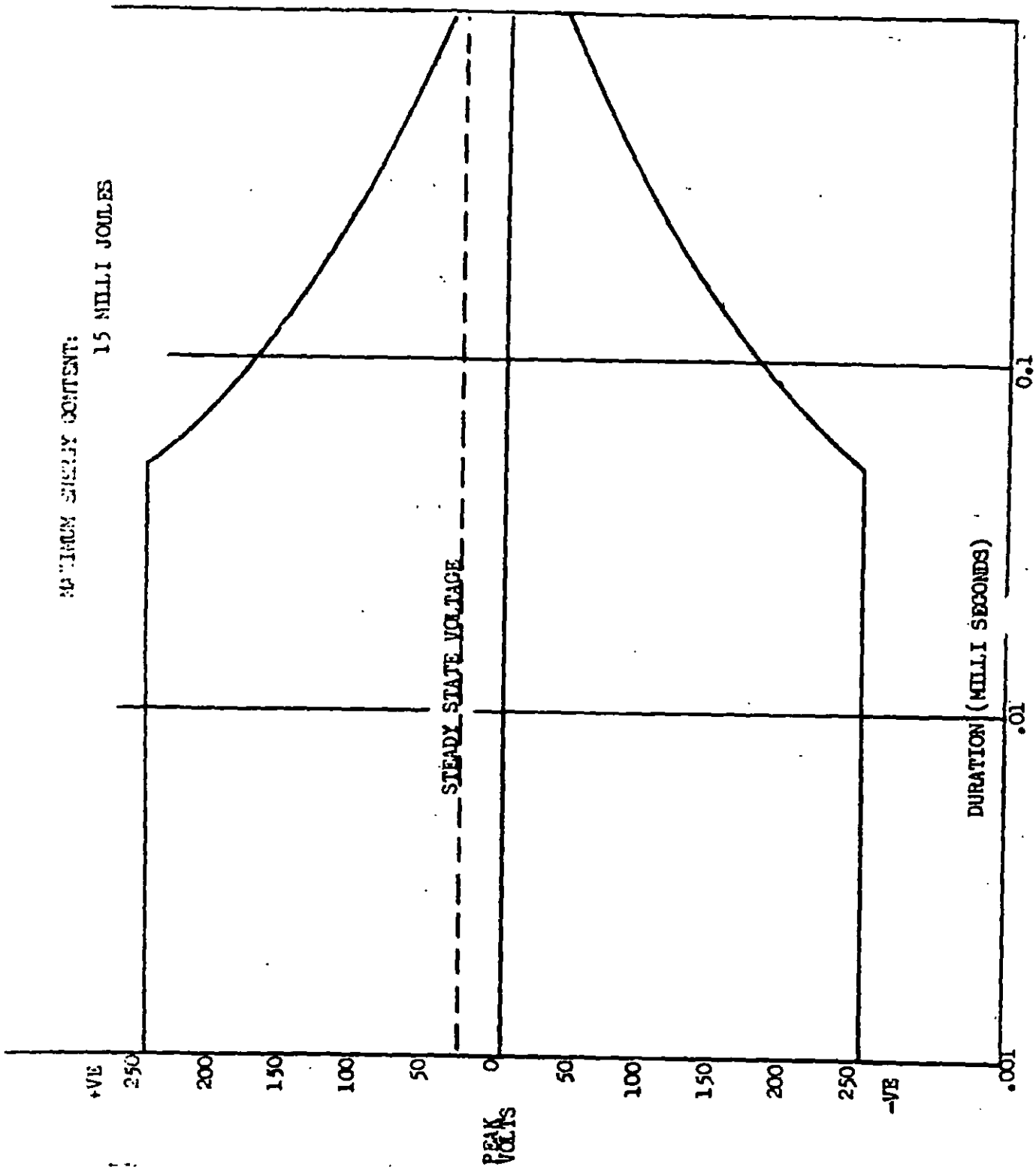


FIGURE 5
LOCI OF SPIKES
FAULT FREE CONDITION

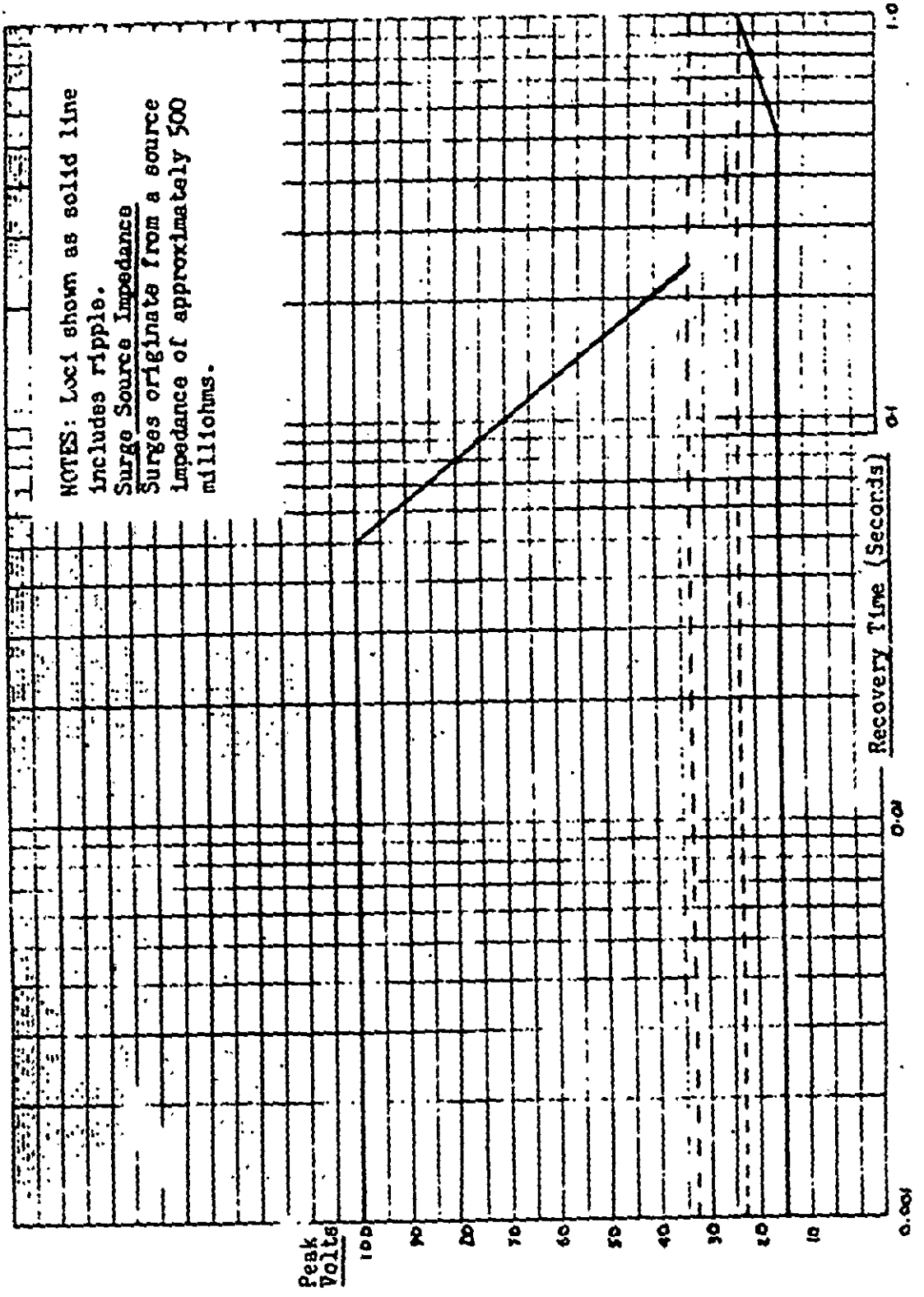


FIGURE 6

LOCI OF SURGES

SINGLE FAULT CONDITION

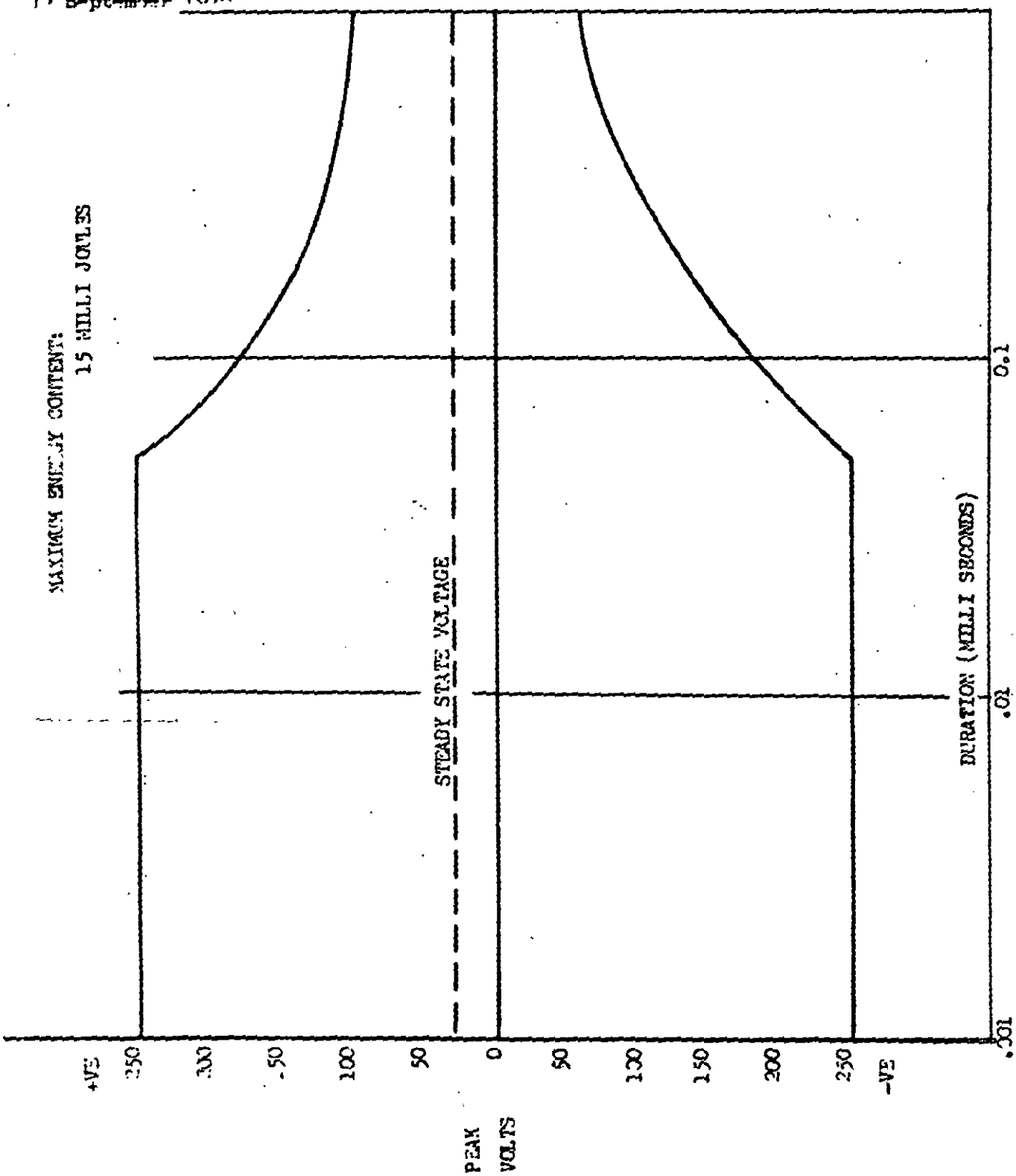


FIGURE 7
LOCI OF SPIKES
SINGLE FAULT CONDITION

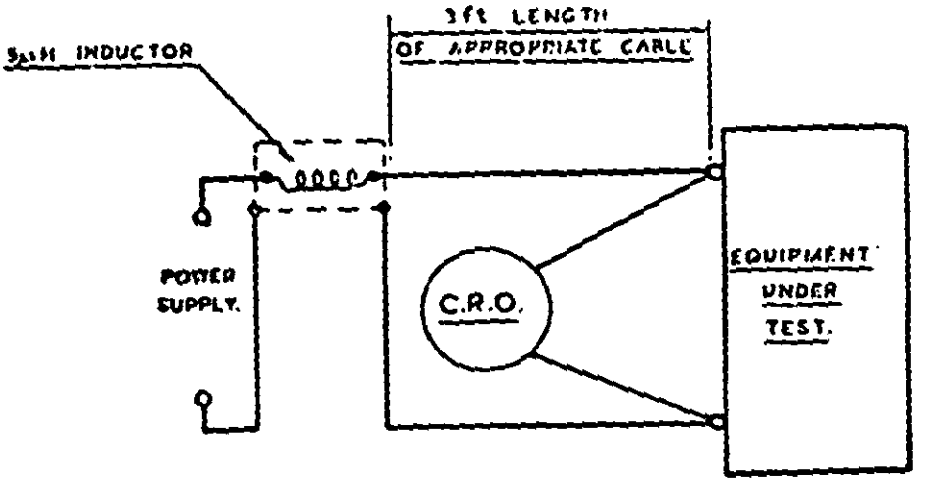


FIGURE 8

EXPORTED SPIKE TEST CIRCUIT

(ALL EQUIPMENT)

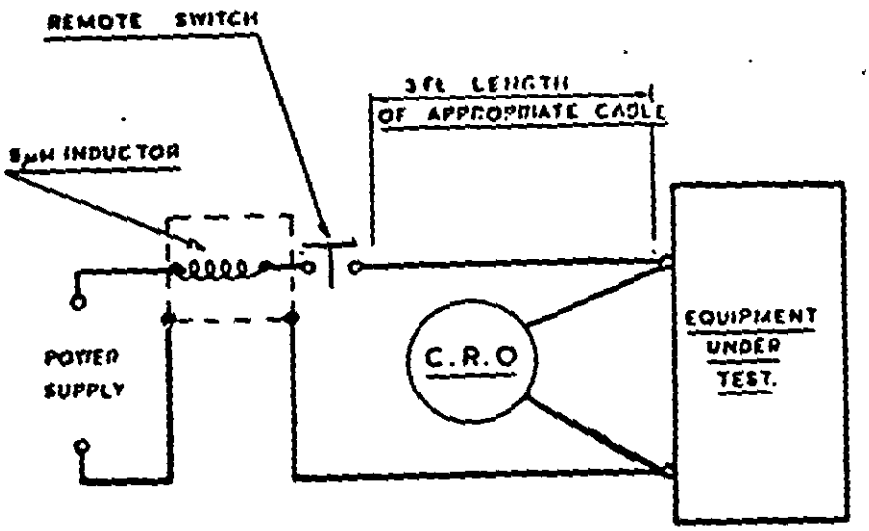


FIGURE 9

EXPORTED SPIKE TEST CIRCUIT

(EQUIPMENT WITH REMOTE SWITCH)

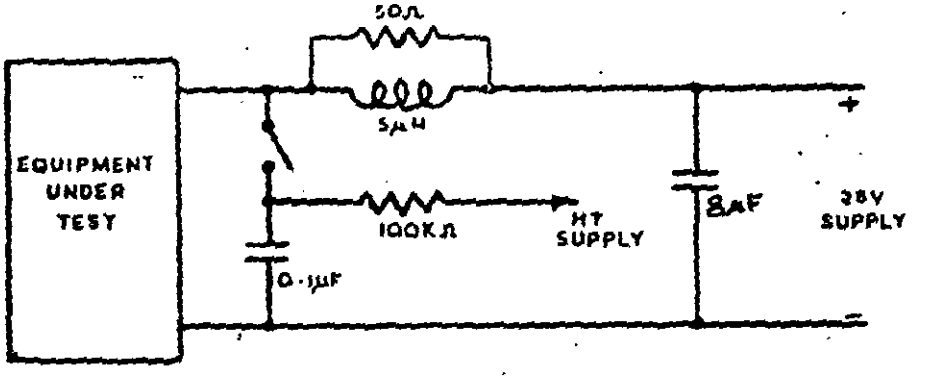
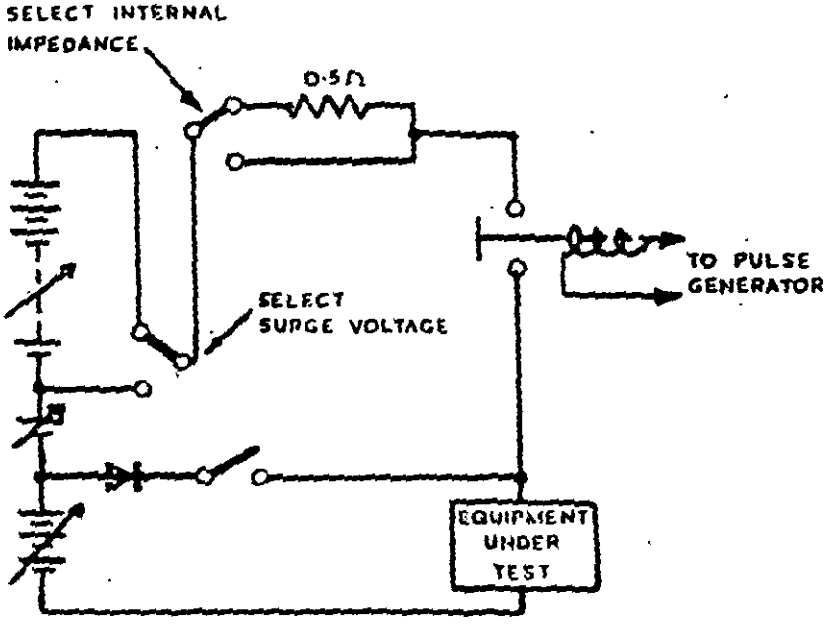


FIGURE 10

IMPORTED SPIKE TEST CIRCUIT



NOTE: ALL BATTERIES TO HAVE MIN. CAP. OF 100 A-HR.

FIGURE 11

IMPORTED SURGE TEST CIRCUIT

NOTE PULSE GENERATOR PRODUCES A TRAIN OF FIVE 5μm. SEC PULSES AT ONE SEC INTERVALS.

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