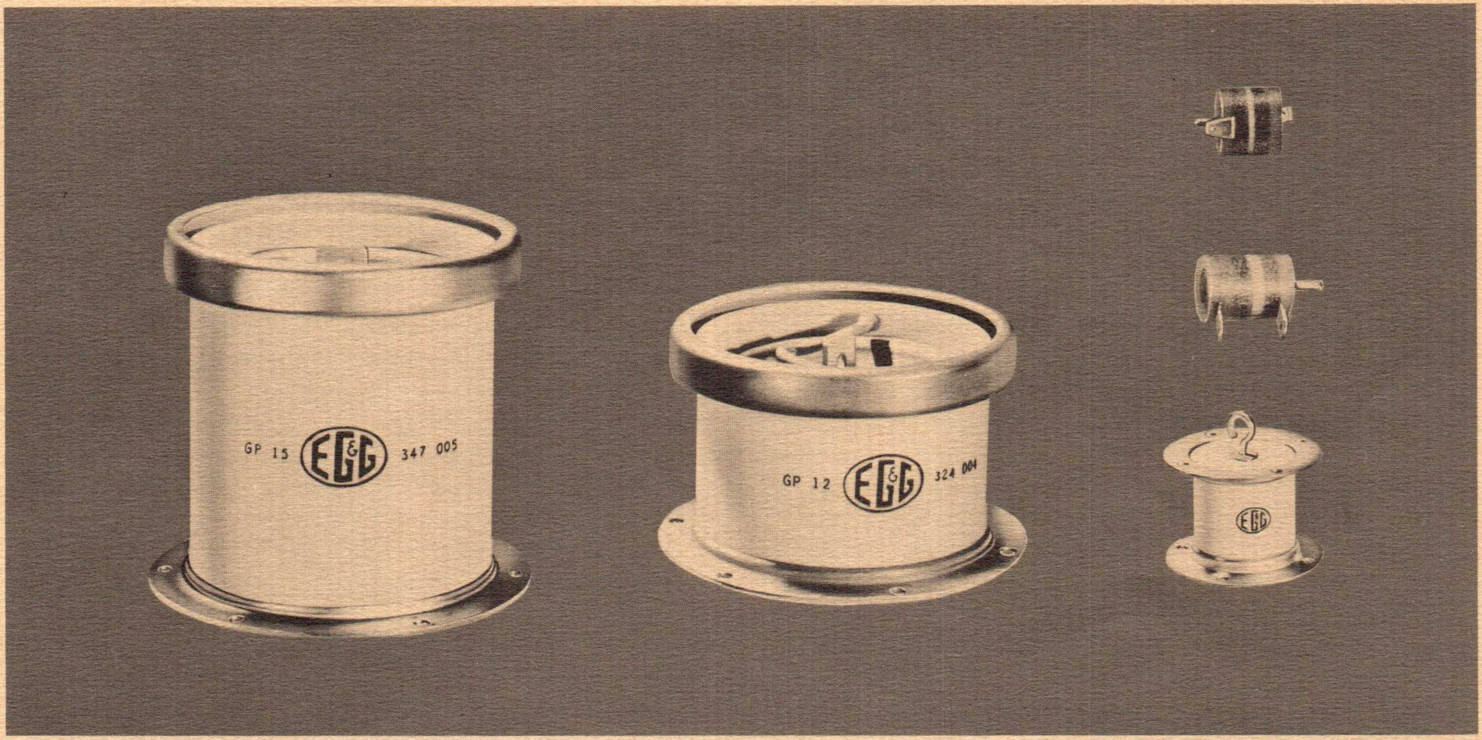
EDGERTON, GERMESHAUSEN & GRIER, INC. DATA SHEET TSG-100

TRIGGERED SPARK GAPS



FEATURES:

- *High Peak Current*
- *Reliable Holdoff Voltage*
- *Low Inductance*
- *Low Energy Triggering*
- *Wide Electrical Operating Range*
- *Wide Range Temperature Operation*
- *Rugged Construction*

Edgerton, Germeshausen & Grier, Inc. has a wide selection of standard ceramic-metal and ceramic-glass triggered spark gaps. EG&G spark gaps provide excellent hold-off capability for crow-bar protection of TWT's, Klystrons and Tetrodes. Precise triggering and nanosecond delay times make gaps ideal for high energy switching in such applications as EBW's, Triggering Xenon flashtubes, gas plasma discharge, spark chambers and Kerr cells.

DESCRIPTION:

EG&G Triggered Spark Gaps are of extremely rugged construction. In general most of the EG&G Gaps have hemispherical dome shaped electrodes. Exceptions to this are the GP-19 and other non-listed types that are offered only in special applications. Dome shaped electrodes provide a symmetrical transition of the distributed electric (E) field in that area of maximum intensity immediately surrounding the trigger probe to either the outer contact area or the vertical side walls of the Gap. Such a transition becomes important at higher voltages where E fields of greater intensity are incurred.

The large ceramic gap types such as the GP-12 and GP-15 utilize a corona ring on the opposite electrode terminating area. This characteristic design is particularly valuable for applications where the voltages exceed 20KV. The corona ring is of a smooth rollover construction so that the terminating metal edge folds in on the stressed E field.

The adjacent electrode assembly contains the trigger probe and ceramic insulator. The probe, manufactured from a material of high refractory characteristics, which provides long reliable life, is sealed to this subassembly.

The mounting flange for the large ceramic gaps is part of the adjacent electrode assembly and is designed for bulk-head or deck mounting. This flange, like the opposite electrode, provides a smooth transition from the internal electrode to the mounting surface.

The small ceramic-glass gaps, GP-11, 16, 17, 26 and 27, feature all ceramic dielectric material in the electrical operating area. This includes the main gap spacer and the trigger probe insulator. The gap assembly is encapsulated in a sintered glass envelope providing a rugged sealed structure that can operate under extreme environmental conditions. The main electrodes are of a material that has optimum refractory characteristics providing long life with negligible erosion. A small amount of radioactive material, a beta emitter, is contained within the gap to provide a sharply defined ionization point. This additive is most valuable with a trigger voltage having long rise time.

SUMMARY CHART

Spark Gap Model No.	Operating Range		Static Breakdown Potential	Peak Current Amplitude	Peak Current Duration	Energy Discharge	Trigger Potential	Mode	Delay Time Typical	Application	Gap Construction	Recommended Trigger Transformer	Reference Drawing
	Min. KV	Max. KV	Nominal KV	Maximum Amperes	Typical usec	Joules	KV		µs	Reference No.	C-Ceramic CG-Ceramic Glass		
GP-11	1.8	3.5	4.2	5,000	20	25	5.5	C	.10	1 & 5	C-G	TR-36/TR-104	1
GP-12	10.0	24	30.0	100,000	10	2500	15.0	A	.05	1, 2, 3	C	TR-60	6
GP-14	12.0	36.5	42.0	100,000	10	2500	20.0	A	.05	1 & 2	C	TR-60/TR-69	6
GP-15	25.0	70	86	100,000	10	4000	25.0	A	.10	1 & 2	C	TR-60/TR-129	7
GP-16	1.0	2.0	2.6	5,000	20	25	5.0	C	.20	1 & 5	C-G	TR-36/TR-104	1
GP-17	4.4	10.0	12.5	5,000	20	25	7.0	A	.02	1, 2, 3, 5	C-G	TR-36/TR-104	2
GP-19	2.5	5.0	7.0	75,000	10	150	5.0	A & C	2.0	1 & 4	C	TR-132	5
GP-20	3.5	11.0	14.0	15,000	20	200	10.0	A	.06	1, 2, 3, 4	C	TR-132	4
GP-22	6.0	16.0	19.0	100,000	10	2500	15.0	A	.04	1, 2, 3, 4, 5	C	TR-132	6
GP-26	2.0	3.7	4.8	5,000	20	25	6.0	A & B	.10	1 & 5	C-G	TR-36/TR-104	2
GP-27	2.0	3.7	4.8	5,000	20	25	6.0	A & B	.10	1 & 5	C-G	TR-36/TR-104	3
GP-30	2.0	5.0	7.5	100,000	10	2500	15	A	.08	1, 2, 4	C	TR-36/TR-104	6
GP-31	2.0	6.0	7.5	15,000	20	200	10.0	A	.10	1, 2, 3, 4, 5	C	TR-132	4
GP-32	20	50	70	100,000	10	4000	25.0	A	.10	1 & 2	C	TR-60/TR-69	7

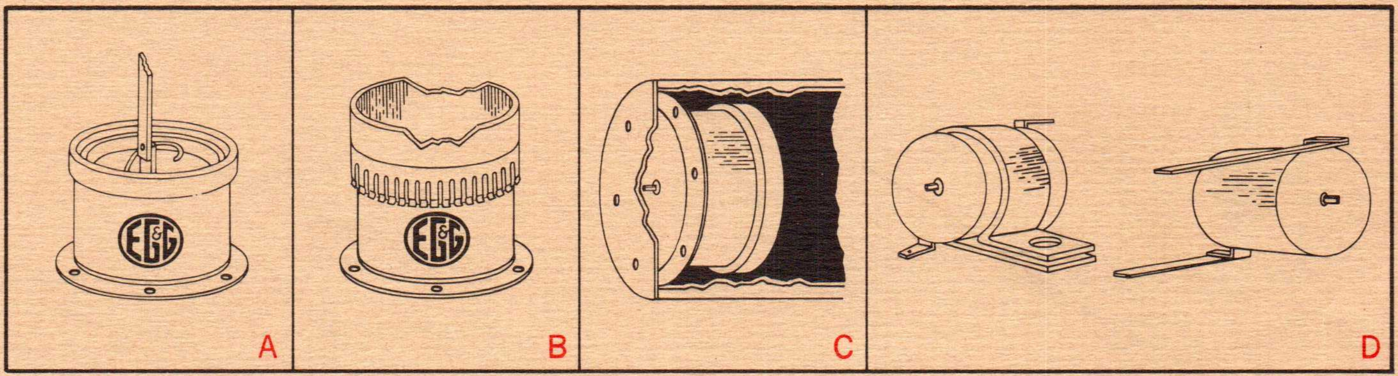
NOTES: Peak currents, pulse widths and energy levels are values that are not necessarily switched simultaneously but represent independent conditions. Values of trigger potential contain an adequate safety factor providing a level adequate to meet end of life requirements.

APPLICATIONS

High Energy Switching for:

- *Crowbar Protection of TWT's, Klystrons, UHF Tetrodes, and Capacitors*
- *Multiple Pulse Light Systems*
- *EXPLODING BRIDGE WIRE Single and Multiple (simultaneous) operation*
- *Kerr Cells*
- *Spark Chambers*
- *Gap Light Source*
- *High Speed Triggers*
- *Marx Generator Switch*
- *Gas Plasma Discharge*

APPLICATION DATA



MOUNTING AND CONNECTIONS TO THE GAP

Spark gaps in most applications switch relatively high peak currents of one thousand to several hundred thousand amperes, therefore, it is important to make proper connections to the gap. Loose or high resistance connections usually disintegrate with life due to arcing or heating at the joint. Small wire size of circular shape increases circuit inductance; hence, in applications where optimum rise times are desired attention should be given to conductors of proper size, length and shape that would provide minimum reactance. (Fig. A)

A coaxial circuit will provide the ultimate in rise time with minimum circuit inductance. The opposite electrode connection for the large ceramic gaps can be made into a coaxial circuit with contact spring finger ring assemblies similar to ones used on microwave tubes and components. A 10,000 ampere maximum peak current should be considered for this type of application. Proper line impedance to match the load and storage capacitor can be achieved with dielectric materials such as teflon. (Fig. B and C)

The trigger probe connection is usually made direct with a wire wrap-around and soft solder bond. Other types of mechanical clamps or nonstandard terminals can be obtained on request.

Mounting of the smaller triggered spark gaps, GP-11, 16, 17, 26 and 27, can be accomplished by a nylon or similar dielectric mounting strap. This tie down method is more secure than the alternate form of using the electrode connecting leads soldered to the buss or main conducting leads. When the spark gap is supported by only its electrode terminals the gap should not be subjected to any type of environmental testing where vibration and shock may be encountered. For low inductance circuits with the larger ceramic gaps, it is recommended that lead lengths be short and properly shaped. The trigger probe connection should be made with a flexible wire wrap-around and soft solder joint. (Fig. D)

FIGURE 1

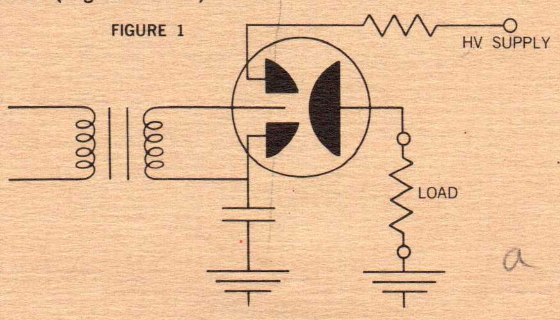
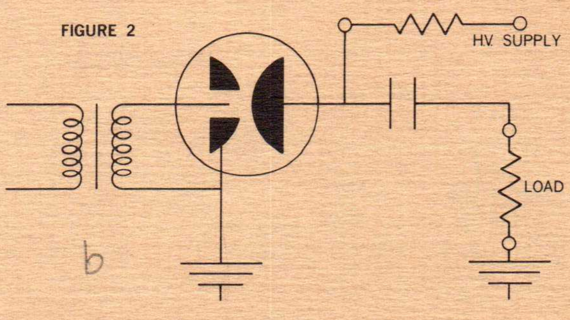


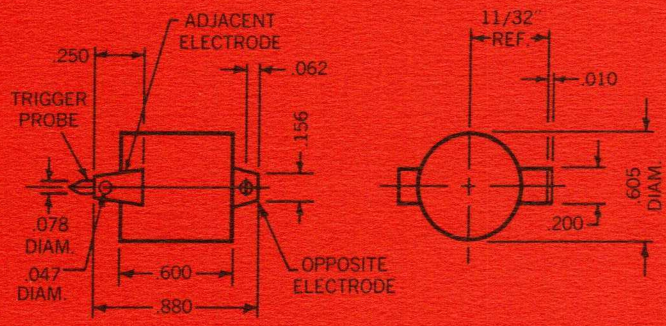
FIGURE 2



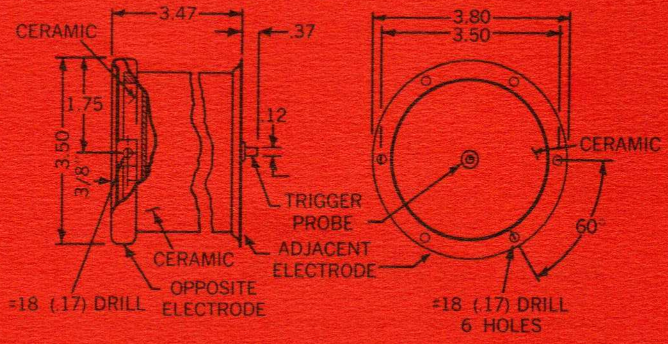
The Triggered Spark Gap switch can be connected in one of 3 ways, 2 of which are illustrated here. The other method would be an interchange between the load and energy storage capacitor in figure 2. Figure 1 demonstrates the necessity of the Trigger Transformer to hold-off the main gap voltage from primary to secondary.

OUTLINE DRAWINGS

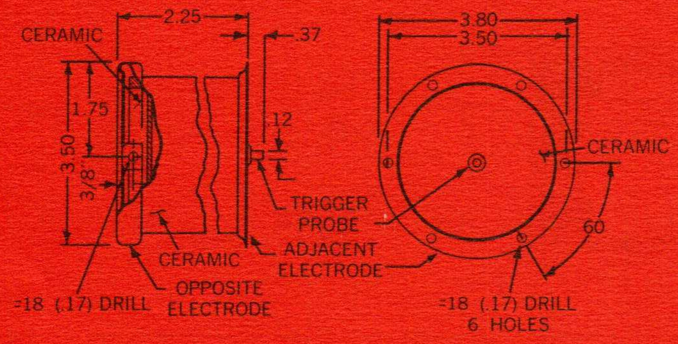
GP-11 AND GP-16



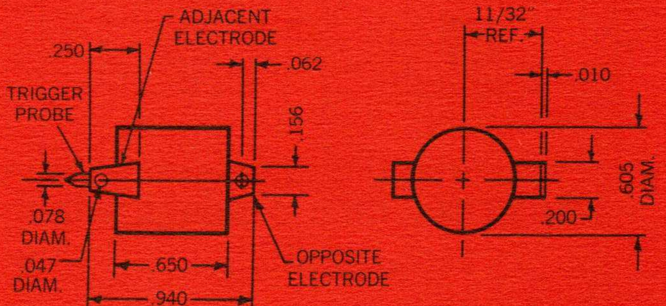
GP-15 AND GP-32



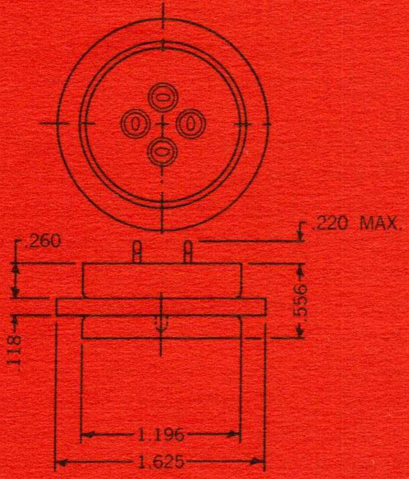
GP-12, GP-14, GP-22 AND GP-30



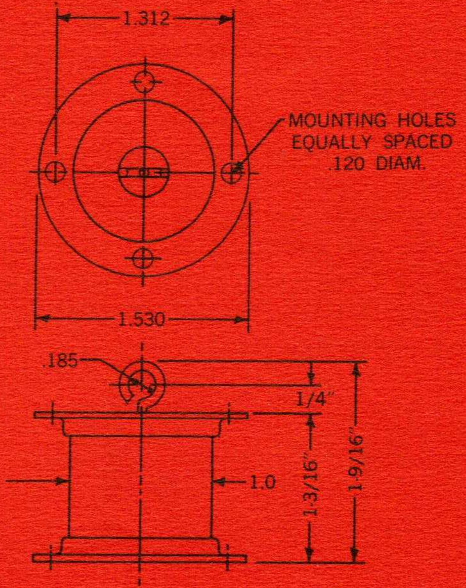
GP-17 AND GP-26



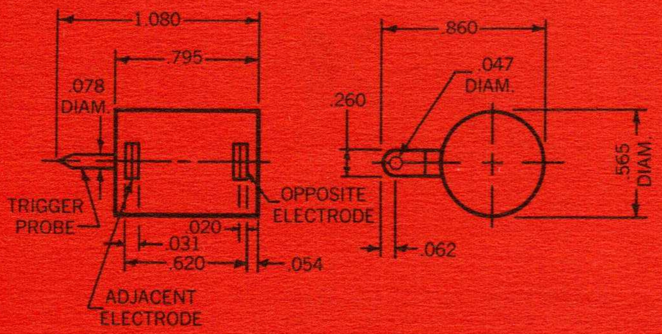
GP-19



GP-20 AND GP-31



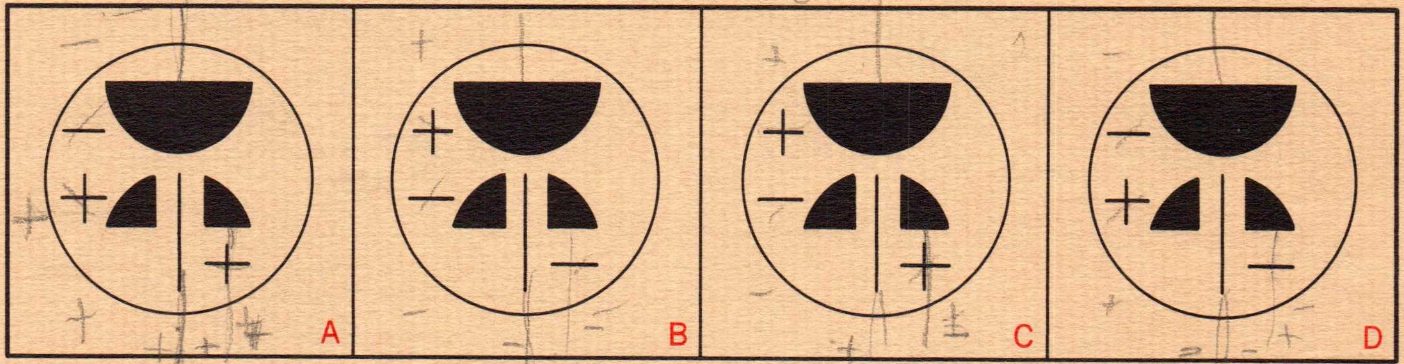
GP-27



NOTE: All dimensions are in inches

GAP CHARACTERISTICS

MODES OF OPERATION



Gap modes are defined as voltage modes; polarities are referenced in the accompanying figures. The summary chart on page 2 indicates the following characteristics: (1) optimum modes in which the spark gap will operate, (2) the mode in which delay time is minimum and (3) the maximum operating voltage range; range extension is achieved in the cut-off region.

Therefore, when a gap is listed for one or more modes, it means operation is functionally better than the unlisted modes. Note, there are no gaps listed for operation in Mode D; delay time is considerably lengthened and the voltage operating range can be severely shortened. Note the difference between Mode A and D is only in the polarity of the trigger pulse.

TRANSFER CHARACTERISTIC

A transfer characteristic is a curve that illustrates main gap operating voltage as a function of trigger voltage. There are 5 significant points on the curve: (1) the cut-off point on the curve is that point which describes the minimum, main-gap voltage that will cause the gap to commute with a given trigger potential. (This is normally higher than that trigger voltage which established the plateau of the curve.) (2) The minimum operating voltage is defined as that point on the curve which is the minimum main gap voltage that requires a nominal trigger potential as in the standard operating range described in area (3) of the transfer characteristic of the curve. Through the operating range, the triggering voltage remains relatively constant and does not change until point (4) the maximum operating voltage is reached. This point on the curve is also called the maximum hold-off voltage and is normally derived by taking 80% of the Self Breakdown Voltage which is point (5). The 80% figure is further substantiated by having a high reliability against prefire. As the main gap potential approaches point (5) the possibility of self fire increases.

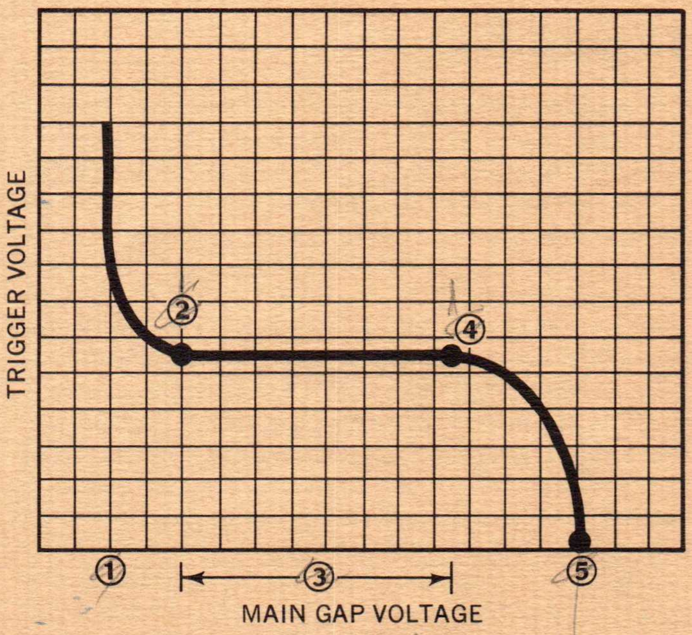
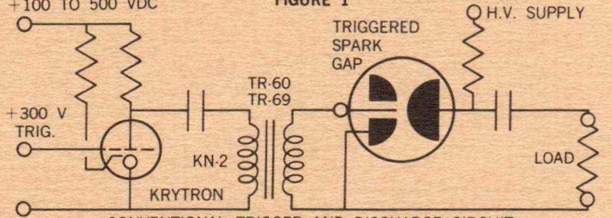
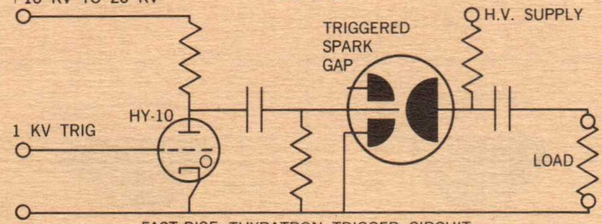


FIGURE 1



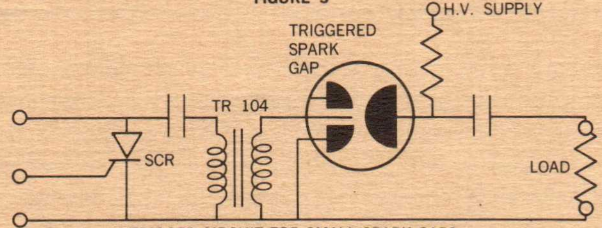
CONVENTIONAL TRIGGER AND DISCHARGE CIRCUIT

FIGURE 2



FAST RISE THYRATRON TRIGGER CIRCUIT

FIGURE 3

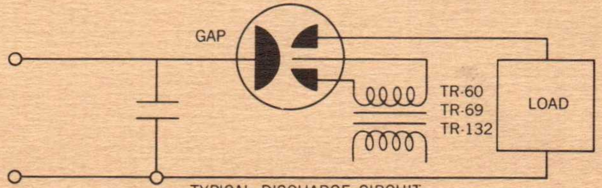


TRIGGER CIRCUIT FOR SMALL SPARK GAPS

TRIGGER CIRCUITS

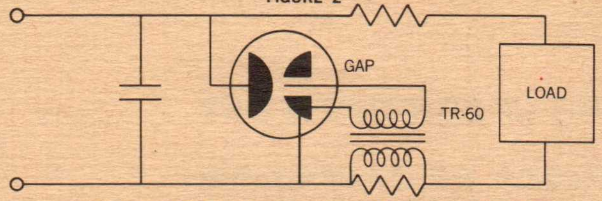
The illustrated circuits show most of the predominant methods for triggering spark gaps. Transformers are the simplest and most convenient way of developing adequate trigger potential. A type such as EG&G's Trigger Transformer, TR-104, which has a turns ratio of 300 to 1 will provide an output of up to 6KV from a low voltage source of 20 to 30VDC. This is compatible for operating gaps such as the GP-11, 16, 17, 26 and 27. High voltage transformers such as EG&G's TR-69 provide trigger pulses up to 40KV to operate the GP-12 and GP-15 type gaps. Transformers have certain limitations in delay time and maximum rate of rise. To achieve the ultimate in breakdown time with a rapid rising pulse, it is recommended that a Thyratron such as EG&G's HY-1 or HY-2 be used. The thyratron when operated under special conditions can have a delay time in the order of 20 to 40ns and simultaneously provide up to 20 times voltage gain in triggering. Other special combinations of trigger transformers with low inductance and very fast rise time (less than 100ns) can be obtained on request.

FIGURE 1



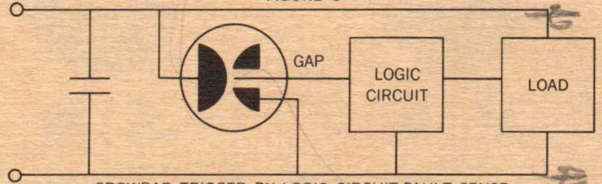
TYPICAL DISCHARGE CIRCUIT

FIGURE 2



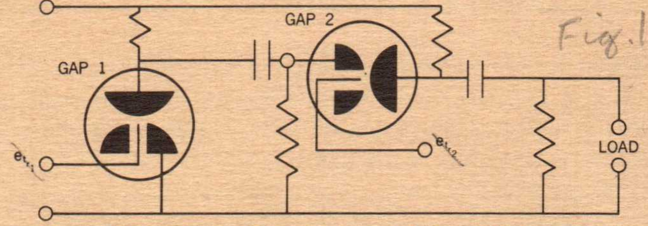
FAULT CURRENT TRIGGERED CROWBAR FOR PROTECTION OF MICROWAVE TUBES AND CAPACITORS

FIGURE 3



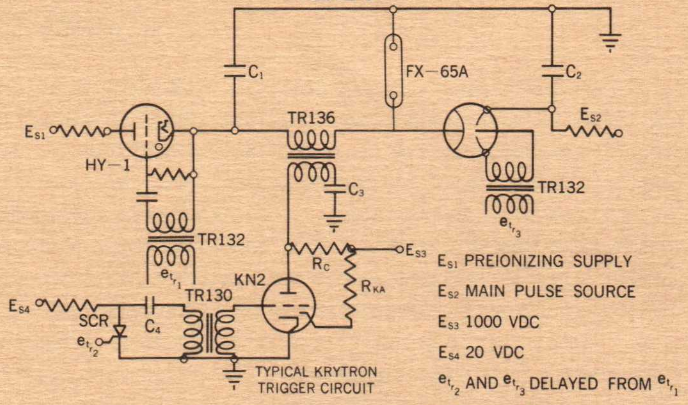
CROWBAR TRIGGER BY LOGIC CIRCUIT FAULT SENSE FROM RF OVERLOAD OR ARCING

FIGURE 4



PARALLEL CHARGE-SERIES DISCHARGE MODIFICATION OF MARX GENERATOR

FIGURE 5



MULTIPLE PULSE LIGHT SYSTEM TYPICAL CIRCUIT

TYPICAL CIRCUITS

The above schematics illustrate several of the more widely used typical circuits. There are variations in general type; as examples: the polarity (Mode of Operation), precise method of triggering, and the exact nature of the load (EBW, plasma discharge tube, capacitor, etc.). The purpose of these application schematics is to demonstrate the versatility of the triggered spark gaps.

DELAY TIME

In general EG&G Triggered Spark Gaps are designed to have short delay times normally measured in the order of a few to several hundred nanoseconds. Delay is defined as the interval between trigger pulse breakdown to the beginning of main gap commutation. There are several factors which effect low delay time in EG&G Gaps; these center around two main categories mainly the gas fill and electrode structure. For an individual gap the delay time is usually at a minimum value when the operating voltage is at or near maximum hold-off. It is at this point where the E field within the gap is approaching its maximum intensity and hence commutes most easily. A trigger of a fast rise time reduces the delay particularly if the time is measured from t_0. Delay times indicated in the Summary Chart on page 2 are typical values and do not indicate the ultimate. As an example, the GP-17 has been tested in a special test fixture in the Laboratory where it has demonstrated a breakdown in 5 to 7 nanoseconds. In low inductance circuits the standard GP-12's exhibited delay characteristics in the order of 25ns when operating in Mode A. Breakdown time is always minimum when the gap is operated in its favored mode as indicated on the Summary Chart on page 2.

DEIONIZATION TIME & RECOVERY TIME

The time immediately adjacent to an energy discharge or switch function where commutation has decayed to zero is the deionization time. Physically, in this period, the gases return to their normal state with the removal of the voltage which previously existed at the main gap terminals. The voltage may not be at zero but at a point where extinction has occurred within the gap. An adequate time period to allow sufficient deionization must be allowed for the gap to recover the capability of holding off full anode potential. This is the recovery time. Reignition can occur at some potential less than the normal hold-off value during this recovery time period.

There is limited data available on tests conducted at moderate energy levels of 2 to 3 kilojoules on the GP-12 type of gap. These tests do indicate that recovery time is in the order of $100\mu s$. Where this type of switch has the ability to sustain several refires spaced at an appropriate time of not less than $100\mu s$, the gap tube can be recommended for more exotic types of crowbar service. This may be where a "hunt" and "test" sequence system may require a triggered spark gap to refire (crowbar) in rapid order for detection before final shutdown is accomplished.

Although triggered spark gaps have been operated as modulator switch tubes, it is not normally recommended because life is several magnitudes less than a thyratron. For relatively short life applications where the spark gap requires no heater power, the switch tube has some applications.

In modulator service it must be remembered that a spark gap is bidirectional in current conduction, whereas other soft and hard (vacuum) tubes are usually undirectional.

SPECIAL SPARK GAPS

If a standard gap is not available to meet the requirements of a system, please contact EG&G's Products Department. Test data on development models can be furnished and demonstrations or special tests can be arranged.

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