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[54] **SHORT PULSE GENERATOR**

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[52] **U.S. Cl.** **307/106,** 313/325, 315/36

[51] **Int. Cl.** **H03k 3/00,** H03k 3/64

[58] **Field of Search** .... 313/325, 198; 315/207, 315/209, 36; 333/31 C; 317/69, 70; 307/106, 108, 109, 110

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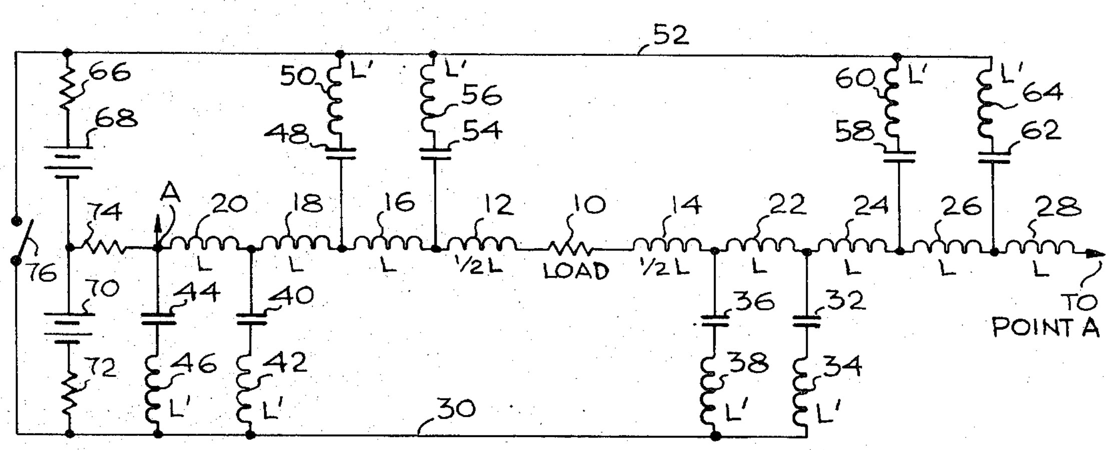
Attorney, Agent, or Firm—Lindenberg, Freilich & Wasserman

[57] **ABSTRACT**

A spark generator is provided which is reentrant, can deliver all output to a single load while being either balanced or unbalanced to ground, as desired. The structure is operable over a wide frequency and power level range.

8 Claims, 6 Drawing Figures



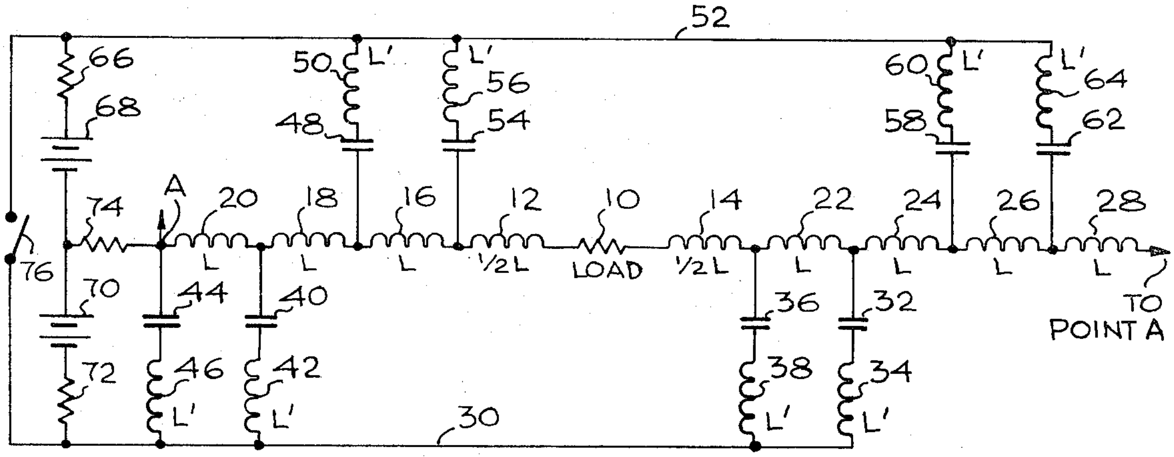


Fig. 1

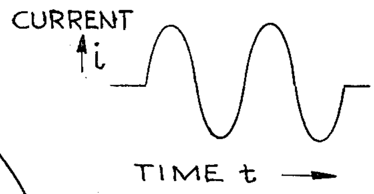


Fig. 1A

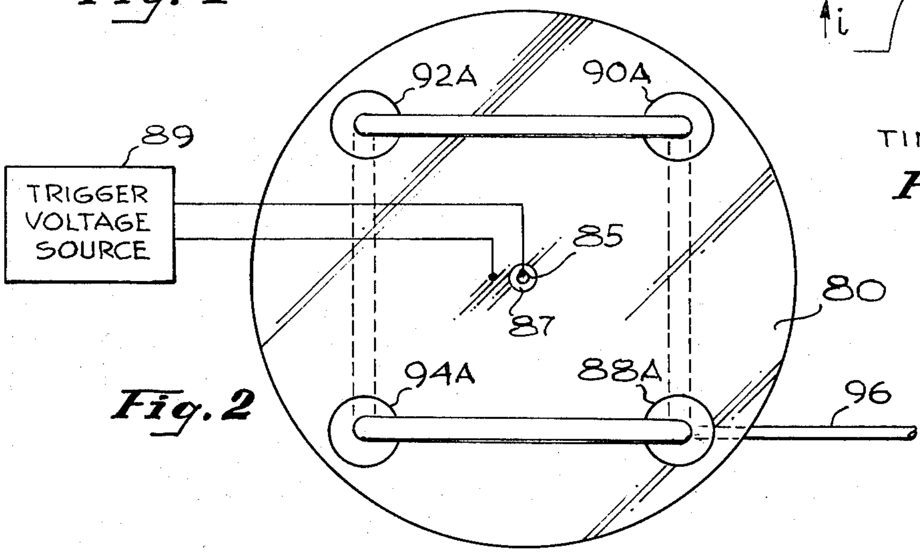


Fig. 2

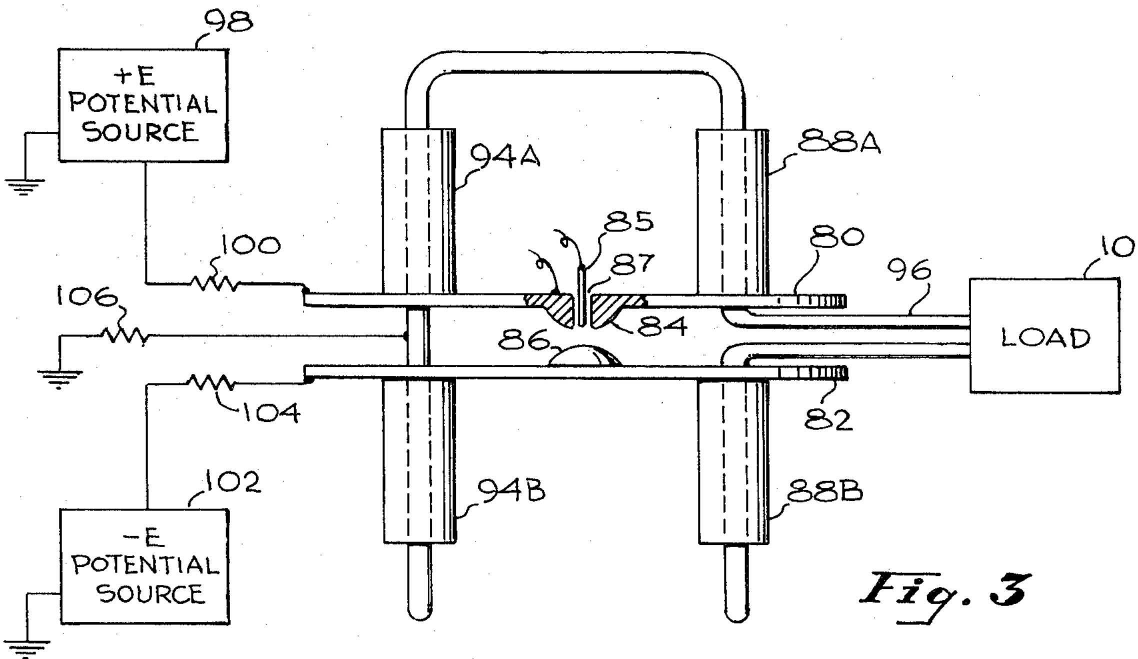


Fig. 3

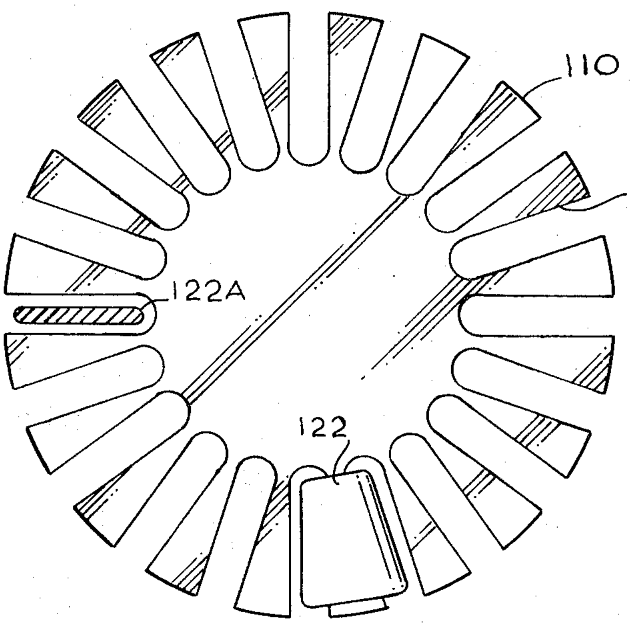

110
114
122A
122

Fig. 4

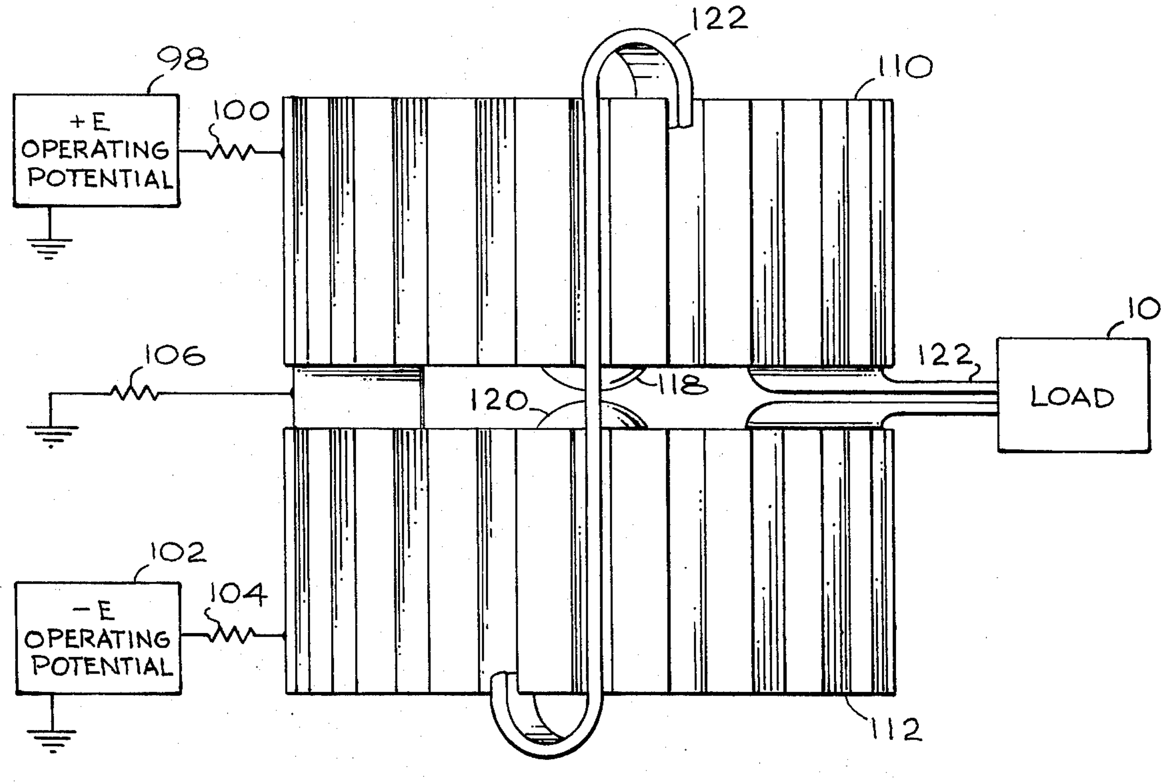

98
+E
OPERATING
POTENTIAL
100
122
110
10
106
122
118
120
LOAD
102
-E
OPERATING
POTENTIAL
104
112

Fig. 5

SHORT PULSE GENERATOR

BACKGROUND OF THE INVENTION

This invention relates to spark pulse generators and, more particularly, to improvements in the construction thereof.

Spark pulse generators are circuits comprising inductances, capacitors and resistors connected in the manner of a filter or transmission line. The capacitors are first charged, then discharged into the inductances. The inductances thereafter discharge into the capacitors. Thus, a number of cycles or oscillations occur providing pulses which can be applied to a load. Examples of such pulse generators are shown in a patent to Samsel, U.S. Pat. No. 2,792,508, or in articles by Hellar and Holter, on Pages 161–170 of the 1953 Proceedings of the National Electronics Conference, entitled, "A Transmission Line Oscillatory Pulse Generator," or in an article by Weibel in the Review of Scientific Instruments, Pages 173–175, February 1964, entitled, "High Power Pulse Generator."

Spark gap generators normally find use in radar, ionosonds and other applications, where very short, high power, rf pulses are required.

OBJECTS AND SUMMARY OF THE INVENTION

An object of this invention is the provision of a simpler and more compact construction for a spark gap pulse generator, then has been available heretofore.

Another object of this invention is the provision of a unique construction for a spark gap pulse generator.

Still another object of this invention is the provision of a spark gap pulse generator which is operable over a wide frequency range and can be operated over a wide power level range.

These and other objects of the invention may be achieved in an arrangement wherein a spark gap pulse generator comprises, in one embodiment, a pair of spaced parallel discs having centrally positioned opposed protuberances or bosses, which form a spark gap therebetween. The discs have a purality of opposed openings disposed around their surfaces out of which tubes extend outwardly. A conductor is threaded through the tubes without touching their walls. A load is attached to the ends of the conductor. The tubes and conductors are coaxially related. A voltage is applied to the discs until a spark occurs across the spark gap formed between the two opposed bosses. In a second embodiment, a pair of opposed spaced drums have opposed bosses therebetween defining a spark gap. A plurality of radial notches are formed in the periphery of each drum. A conductor threads through all of the radial notches of both drums without touching the walls and a load is connected to the ends of the conductor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of an embodiment of the invention employing lumped circuit components.

FIG. 1A is a waveform representative of the load current available with the structure shown in FIG. 1.

FIG. 2 is a top view of one embodiment of the invention.

FIG. 3 is a side view of the embodiment of the invention as seen in FIG. 2.

FIG. 4 is a top view of another embodiment of the invention.

FIG. 5 is a side view of the embodiment of the invention shown in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there may be seen a circuit diagram of a lumped constant arrangement of this invention. A load **10** is represented by a resistor. On either side of the resistor are inductances **12, 14,** which are connected in series therewith. Each of these inductances has the value 1/2L. Connected in series with the inductance **12** are three other inductances respectively **16, 18, 20,** which have the value L, or twice that of the inductance **12.** Connected in series with the inductance **14** are inductances **22, 24, 26** and **28** which have the value L. The inductance **28** is connected back to the end of the inductance **20** at the point designated by the letter A.

Between the junction of the inductances **22** and **24,** and a bus line **30,** there is connected in series a capacitor **32,** and an inductance **34.** Connected in series between the junction of an inductance **14** and **22** and the bus **30,** is a capacitor **36,** and an inductance **38.** Connected between the junction of inductances **18** and **20** and the bus **30** are the capacitor **40** and the inductance **42.** A serially connected capacitor **44** and inductance **46,** are connected between the point A and the bus **30.**

A serially connected capacitor **48,** and inductance **50,** are connected between the junction of inductances **16** and a bus **52.** A serially connected capacitor **54** and inductance **56,** are connected between the junction of inductances **12** and **16.** A serially connected capacitor **58** and inductance **60,** are connected between the junction of inductances **24** and **26,** and the bus **52.** A serially connected capacitor **62** and inductance **64,** are connected between the junction of inductances **26** and **28** and bus **52.**

Capacitors **32, 36, 40, 44, 48, 54, 58** and **62** all have the value C. Inductors **34, 38, 42, 46, 50, 52, 60, 64** all have the value L'. The function of the eight capacitors designated C and numbered **32, 36, 40, 44, 48, 54, 58** and **62** is to store energy provided by voltage sources **68** and **70** for subsequent delivery to the load resistor **10.** The associated inductances designated L' are unavoidable parasitic elements, recognized and integrated into the design in such a way as to be harmless.

Between the busses **30** and **52,** there are serially connected a current limiting resistor **66,** a voltage source **68,** another voltage source **70,** and another current limiting resistor **72.** Voltage sources **68** and **70** are preferably equal. Between the point A and the junction between the two voltage sources, there is connected a resistor **74.** A normally open shorting switch is connected across the busses **30** and **52.** Energy stored in the capacitors C is delivered to the load **10** when the switch is closed. The resulting current has the waveform shown in FIG. 1A.

To operate the line shown in FIG. 1, a switch **76** is open until such time as the capacitors become charged up. At that time, the switch is closed, whereby the shunt capacitors discharge into the series connected inductances, which thereafter again discharge into the capacitors. The oscillation which is thereby generated continues over a number of cycles determined by the values and the number of sections selected in the construction of the line. The frequency of the oscillation is also determined by the values of the components which have been selected. Those skilled in the art know how to select the inductance, capacitance, and resistance values required to produce the desired frequency of oscillation in a desired number of cycles. It should be noted that the inductors L' are provided to accommodate any parasitic elements that may be present.

The transmission line circuit shown in FIG. 1 is reentrant; therefore, a single load represented by the resistor **10** will absorb all of the power stored in the line. The arrangement is such that the output is balanced to ground and no blocking capacitors are required. The arrangement shown generates an even number of half-cycles. The waveform for the load current is represented in FIG. 1A. By altering the number of capacitors employed, that is, by substituting a load in place of one of the shunt capacitors, an unbalanced output can be obtained, but at a lower impedance level.

FIGS. 2 and 3 respectively, show top and side views of a coaxial line and disc structure which has distributed circuit components and which realizes the circuit arrangement shown in FIG. **1.** It comprises a pair of conductive discs respectively **80, 82,** which are parallel with one another and spaced from one another. At the centers of the discs, at their opposite faces, lumped protuberances or bosses, respectively **84, 86** are provided. These bosses and the spacing therebetween constitute a spark gap switch.

To assist in triggering a discharge between the bosses provision may be made at one or both of the bosses for a trigger electrode. By way of example, this can constitute a pin **85** extending into an opening **87** in the boss **84.** A voltage applied between the trigger electrode **85** and the disc **80** from a trigger voltage source **89,** which causes an arc discharge between the electrode and the edge of the opening **87,** in the boss. This arc triggers a discharge in the main gap between bosses **84** and **86.**

Both top and bottom discs have openings, from which conductive tubes extend at right angles from the plane of the discs. In the top view, these tubes have reference numerals **88A, 90A, 92A** and **94A,** applied thereto. In the side view of these tubes, only **88B** and **94B** may be seen.

A single conductor **96,** extends into the space between the two discs, thereafter extends upward through the tube **88A** and across and downward through the tube **94A,** through **94B,** then across and upward through tube **92B** (not shown), upward through tube **92A,** across to tube **90A** through which it proceeds downwardly through tube **90B** (not shown), then across, upward through tube **88B** and then out adjacent to the input lead. The ends of the conductor **96** are connected to a load **10.** It should be recognized that the conductor and tubes form a series of coaxial lines connected to the discs which form a spark gap switch.

A source of potential **98** is connected through the upper disc **80** through a charging resistor **100.** A second and preferably equal source of potential **102** is connected to the upper disc through a charging resistor **104.** The lead **96** is connected to ground through a resistor **106.**

In operation, the sources of charging potential are connected across the discs. When the potential between the protuberances **84, 86** attains a sufficient value, and with the assistance of the trigger electrode **85,** a discharge is made to occur, which has the same effect as the shorting switch **76** in FIG. **1.** The inductances designated with the values L in FIG. **1,** are distributed throughout the length of the zigzag circuit formed by the conductor **96.** The capacitors are formed by the spacing between the conductor **96** and the tubes **88–94,** A and B. Additional design flexibility is available by tapering the diameters of the conductors that make up the inductances and coaxial capacitance. At relatively high frequencies, it may prove desirable to add tubular conductors that shield the open inductive connections which bridge between the tubes, for example **94A, 88A.**

By way of example, and not to serve as a limitation upon the invention, for operation at a frequency of 30 MHz, the spark gap section was made about 50 percent larger than that shown. The coaxial sections were made of flexible coaxial cable each about 10 feet long. The cable was of a type designated as "RG8", now widely used for cable TV. A second model, was made and tested in which cable lengths were doubled (as well as stored energy) and the frequency of operation was lowered by the same ratio.

In many situations, it is possible and desirable to enclose the entire structure shown in FIGS. **2** and **3** in a sealed vessel containing a liquid of gaseous dielectric. Nitrogen at high pressure is an excellent dielectric that is favorable for high speed, high power spark switching.

FIGS. **4** and **5** show a variation of the structure shown in FIGS. **2** and **3,** and differs in that a parallel strip transmission line is substituted for the coaxial arrangement shown in FIGS. **2** and **3.** FIG. **4** is a top view and FIG. **5** is a side view. The two discs **80** and **82** in FIG. **5,** are thickened to essentially resemble two drums, respectively **110, 112.** A plurality of radial notches exemplified by notch **114** are formed in the periphery of the upper and lower drums, respectively **110, 112.** Bosses, **118, 120** are formed opposite one another at the centers of the drums **110, 112,** and establish a base therebetween which is the spark gap. A trigger electrode (not shown) such as is shown in FIGS. **2** and **3,** may also be employed at one or both of the bosses to insure the occurrence of timely discharges and also, since energy from the trigger generator is used to form the spark that makes the gap conductive, a larger fraction of the energy stored in the transmission line is available for conversion into the useful oscillatory wave delivered to the load.

Only fragments of the line, **122,** which threads through the twenty slots in the drums is shown in order to avoid confusion in the drawings. In FIG. **4,** reference numeral **122A** is applied to an illustration of a cross-section of the line. It may be seen that the line is broadened to extend approximately parallel to the surface of a slot. The geometry of the structure shown in FIGS. **4** and **5** is that of a parallel strip transmission line in place of the coaxial arrangement shown in FIGS. **2** and **3.** This geometry is especially attractive when the number of cycles to be generated is moderately large. The structure shown in FIGS. **4** and **5** has twenty slots and is therefore appropriate to form a pulse that is ten cycles long. The length of the radial path from each line section to the switch can be made small compared to a wavelength without seriously reducing the stored energy.

The charging potential sources and the load are given the same reference numerals, as in the previous drawings.

It should be noted, by way of example, and not as a limitation upon the invention that the size of the embodiment of the invention shown in FIGS. 4 and 5 is correct for operation at a frequency near 1,200 MHz, corresponding to a wavelength of about 10 inches.

There has accordingly been described and shown herein, a novel and useful structure for a spark gap transmission line.

What is claimed is:

1. A spark gap pulse generator comprising:
a pair of spaced, conductive, circular structures which are opposite and coaxial with one another,
a raised boss positioned at the center of each of said circular structures and on the surface which is opposite the surface of the other circular structure to establish a spark gap space therebetween,
each said circular structure having openings therethrough which are distributed thereover and which are aligned with the openings in the other circular structure, and
a conductor extending in between said spaced circular structures and serially threading through all of the said openings therein.

2. A spark gap pulse generator as recited in claim 1 wherein each of said spaced conductive circular, structure constitutes a disc, and
a conductive hollow tube extends away from each openings in said discs,
said conductor passing through the center of all of said tubes.

3. A spark gap pulse generator as recited in claim 1 wherein each of said spaced conductive circular structures constitutes a drum,
said openings constitute elongated slots in the periphery of each said drum,
said conductor has a cross sectional area such that the surface substantially parallels the surface of said elongated slots.

4. A spark pulse generator comprising:
a pair of spaced parallel conductive discs,
each disc having a raised boss mounted at the center thereof on the surface opposite the other disc whereby a spark gap is established in the space between the two bosses,
a plurality of aligned openings disposed over the surfaces of said discs,
a hollow tube extending from each opening and right angles thereto, and
a conductor extending into the space between said disc, threading through all of the tubes on both of said discs, and then extending outwardly from the space between said discs.

5. A spark gap pulse generator as recited in claim 4 wherein there is included:
a source of operating potential,
means for applying potential from said source to said discs,
a load, and
means for connecting the ends of said conductor extending from between said two discs to said load.

6. A spark gap generator comprising:
a first and a second conductive drum spaced from one another and aligned with one another,
each drum having a raised boss at the center of the surface which is opposite the surface of the other drum whereby a spark gap is defined by the space between said two bosses,
each drum having radial notches in its periphery which are aligned with the radial notches of the other drum, and
a conductor which extends from one end thereat into the space between said two spaced drums and extends through all of the notches of said two drums, finally extending to its other end out through the space between said two drums.

7. A spark gap generator as recited in claim 6 wherein said conductor has a surface area which substantially parallels the surface area of each notch in said circular drum periphery.

8. A spark gap pulse generator as recited in claim 7 wherein there is included a load which is connected to the two ends of said conductor,
a source of operating potential, and
means for applying potential from said source to said drums.

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