

Dec. 11, 1951

J. R. PERKINS

2,578,263

SPARK GAP MODULATOR

Filed Dec. 18, 1945

FIG. 1

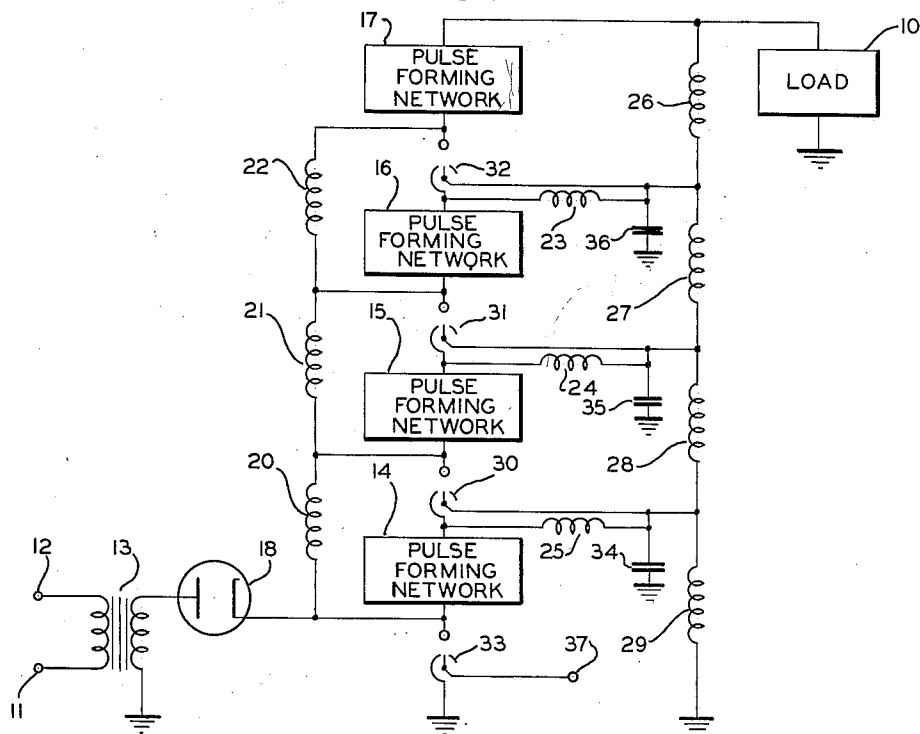


FIG. 2

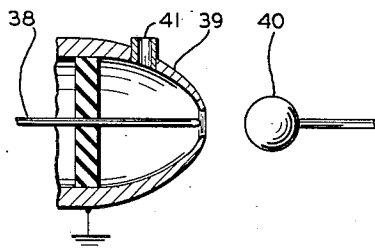
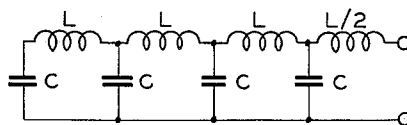


FIG. 3



INVENTOR
JOSEPH R. PERKINS

BY

M. Hayes

ATTORNEY

UNITED STATES PATENT OFFICE

2,578,263

SPARK GAP MODULATOR

Joseph R. Perkins, Upper Montclair, N. J., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Application December 18, 1945, Serial No. 635,790

7 Claims. (Cl. 171-97)

1

This invention relates to modulator circuits particularly those producing relatively high voltage rectangular pulses of short duration, such as are required to pulse a magnetron.

Magnetrons as used in present day electromagnetic object detectors and the like require a pulsing voltage of rectangular wave form, having a relatively high intensity up to 50 kilovolts and a short duration of sometimes less than one microsecond. To secure a rectangular waveform, pulse forming networks have been used, which comprise in their elementary form a capacitor for storing electrical energy together with a circuit for producing a wave of desired shape during the discharge of the capacitor. To secure the necessary high voltage to pulse the magnetron the network must be charged to a relatively high voltage with a resulting high voltage source. To overcome this difficulty a plurality of these networks may be connected to be effectively in parallel during charge and effectively in series during discharge. This permits a reduction in the voltage source, but requires some form of switching means such as a plurality of spark gaps operative in synchronism to produce a short circuit. To simultaneously trigger a plurality of spark gaps to produce a pulse of say one microsecond duration requires an accuracy within a fraction of a microsecond. This is accomplished in the instant invention by a circuit which practically instantaneously produces a triggering of all spark gaps in response to the triggering of one.

It is an object of this invention to provide a modulator circuit capable of producing a rectangular voltage wave of high intensity and short duration from a relatively low voltage source.

It is a further object of this invention to provide a modulator circuit whose pulse forming networks are charged in parallel and discharged in series by a plurality of spark gaps operative simultaneously.

It is a further object of this invention to provide a modulator circuit having a plurality of spark gaps which utilize the voltage change in the circuit produced by the triggering of one of said gaps to trigger the remainder of the gaps.

These and other objects will be apparent upon consideration of the following description together with the accompanying drawing in which:

Fig. 1 is generally a circuit diagram of the invention; and

Figs. 2 and 3 are details of certain elements in Fig. 1.

In Fig. 1 is disclosed a modulator circuit which is used to pulse a load 10 which may be a mag-

2

netron from a source of pulsating or alternating voltage impressed on terminals 11 and 12. A transformer 13 is provided to step this voltage up to a value somewhat in excess of that to which it is desired to charge pulse forming networks 14, 15, 16 and 17 to allow for losses. The voltage output from transformer 13 is passed through a half way rectifier 18, in the instant embodiment a diode, and impressed on pulse forming networks 14 through 17. Inductors 20 and 29 have each a magnitude of inductance such as to offer a low impedance which is essentially a short circuit at the frequency of the voltage impressed on terminals 11 and 12. For a frequency of 400 cycles a value of 10 millihenries was found satisfactory. Charging paths may be traced from the cathode of diode 18 through network 14 and inductors 25 and 29. Similarly, paths may be traced from this cathode through inductor 20, network 15, and inductors 24, 28, and 29; and from this cathode through inductors 20, 21, network 16, and inductors 23, 27, 28, and 29; and so forth. With inductors offering a low impedance at the frequency of the impressed voltage, networks 14 through 17 will be effectively in parallel across the output of rectifier 18, and during the charging half cycle will be each charged substantially to the peak voltage occurring there.

Between each of the networks 14 through 17 spark gaps 30, 31, and 32 are connected in alternate manner therewith as shown. Also a spark gap 33 is connected between network 14 and ground. One of these gaps, namely 33, is disclosed in Fig. 2, and comprises two separate curved surfaces 39 and 40 to form the main electrodes of the gap, and a trigger 38. If a voltage insufficient to break down the gap is applied between the main electrodes at 39 and 40, the gap will hold. If, however, a discharge between trigger 38 and the electrode at 39 is caused by a trigger pulse the resulting ions will break down the gap between surfaces 39 and 40. An opening at 41 is provided through which a blast of air is forced to drive the ions to the space between surfaces 39 and 40.

Blocking condensers 34, 35, and 36 form a connection with the triggers of the respective gaps 30, 31, and 32 to ground, their purpose being to retard any voltage change at these triggers with respect to ground. Assume that the networks 14 through 17 have been charged and a trigger pulse is applied to terminal 37 to break down gap 33. This effectively grounds the end of network 14 adjacent gap 33 to make the end adjacent gap

30 negative, with rectifier 18 having a direction of current flow as shown. Since condenser 34 retards a change in voltage at the trigger of gap 30, a difference in voltage will occur between the trigger and the electrode of gap 30 adjacent line 14. This voltage difference is sufficient to break down gap 30. In similar manner a voltage difference now occurs between the electrode of gap 31 adjacent network 15 and its trigger to break down this gap. In like manner gap 32 is broken down.

Thus networks 14 through 17 are effectively connected by the switching action of the spark gaps in series with load 10 to discharge their stored energy therethrough as a pulse depending on the electrical characteristics of the networks. The harmonic components of this pulse will have frequencies in the order of megacycles for a pulse of a microsecond duration. At these frequencies inductors 20 through 29 have each a reactance so high that they may be considered essentially open circuits, and the effects of any currents carried by the inductors during discharge of the networks may be ignored. Upon completion of the discharge from the networks, the spark gap will extinguish to permit recharging of the network from the source.

For continued operation the trigger pulse applied to terminal 37 will be synchronized with the frequency of the alternating voltage source applied at terminals 11 and 12 to fire the gaps preferably on the half cycle that rectifier 18 is non-conducting. A "kicker" may be employed for this purpose, which may be any of many well known circuits which produces a sharp pulse at any desired time in each cycle of an alternating voltage.

In Fig. 3 is disclosed a pulse forming network for a one microsecond pulse which may be used in the instant invention. A suitable value for each condenser C is .0008 microfarad with the inductances L having each a value of about 20 microhenries.

It is to be understood that while four pulse forming networks with their associated circuits have been disclosed, some other number either greater or less may be used depending on the amount of voltage increase from the transformer output desired.

The invention is only to be limited by the appended claims.

What is claimed is:

1. A modulator circuit comprising, a plurality of pulse forming networks, a like plurality of spark gaps connected in series with said networks in alternate manner, a source of pulsating voltage, means effectively connecting said network in parallel during the application of voltage from said source, a trigger for each of said spark gaps, and means for producing a voltage difference between each of said spark gaps less one and its respective trigger, whereby when said one spark gap is triggered the remaining spark gaps will be also triggered to effectively connect said networks in series for discharge.

2. A modulator circuit comprising, a plurality of pulse forming networks, a like plurality of spark gaps connected in series with said networks in alternate manner, a source of voltage, a plurality of inductors effectively connecting said networks in parallel with said source, and of magnitudes such as to be essentially short circuits at the frequency of the voltage source to permit charging of said networks from said source, and essentially open circuits at the frequency of the components of the pulse formed by said network,

a trigger for each of said spark gaps, and means for retarding voltage change in each of the triggers of the respective gaps less one, whereby triggering said one gap will produce a voltage difference between each of the remainder of said gaps and its respective trigger to trigger the remainder of said gaps to effectively connect said network in series.

3. A modulator circuit comprising a source of alternating voltage, a half wave rectifier, and a spark gap all in series; a plurality of pulse forming networks, a spark gap connected between each of said networks, and a load, all connected in series across said first mentioned spark gap; a plurality of inductors of magnitudes such as to be essentially short circuits at the frequency of the alternating voltage and essentially an open circuit at the frequencies of the components of the pulse formed by said network, said inductors connecting said networks in parallel across said first mentioned gap at the frequency of said alternating voltage to permit charging of said networks from said source through said rectifier; a trigger for said first mentioned gap synchronized with the alternating voltage to short circuit said first mentioned gap on the half wave corresponding to non-conduction of said rectifier; a trigger for each of the remainder of said spark gaps and including each a condenser for retarding voltage change thereat, whereby triggering of said first mentioned gap will produce a voltage difference between each of the remainder of said gaps and the respective triggers to trigger remainder of said gaps to connect said networks in series with said load for discharge there-through.

4. A modulator circuit comprising, a plurality of pulse forming networks, a like plurality of spark gaps connected in series with said networks in alternate manner, a source of pulsating voltage, means effectively connecting said network in parallel during the application of voltage from said source, a trigger for each of said spark gaps, means for producing a voltage difference between each of said spark gaps less one and its respective trigger, and means for introducing quantities of ions into said spark gaps for facilitating breakdown of said spark gaps.

5. A modulator circuit comprising, a plurality of pulse forming networks, a resistive load, a plurality of spark gaps connected in series with said networks in alternate manner, means for charging said networks to a relatively high value, a trigger electrode for each of said spark gaps, means for retarding voltage change between each of said gaps less one and its respective trigger electrode, and means for energizing said trigger electrodes for causing serial discharge of said networks through said resistive load.

6. A modulator circuit comprising, a plurality of pulse forming networks, a plurality of spark gaps connected in series with said networks in alternate manner, a source of voltage, reactive means for effectively connecting said networks in parallel with said source during charging of said networks and effectively disconnecting said source from said networks during discharging of said networks, a trigger for each of said spark gaps, and means for triggering a single one of said spark gaps successively to produce a voltage difference between each of the remainder of said gaps and the respective trigger thereof whereby the remainder of said gaps are fired to effectively connect said networks in series.

5

7. A modulator circuit comprising, a plurality of pulse forming networks, a plurality of spark gaps connected in series therewith in alternate manner, a source of voltage, a plurality of inductors effectively connecting said networks in parallel with said source, said inductors being of magnitude sufficient to be substantially short circuits at the frequency of said voltage source and substantially open circuits at the frequency of the components of pulses formed by said networks, a trigger electrode for each of said spark gaps, and means for introducing an abundance of ions into said spark gaps for facilitating

6

breakdown in response to energization of said trigger electrodes.

JOSEPH R. PERKINS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

10	Number	Name	Date
	1,997,064	Lusignan	Apr. 9, 1935
	2,405,069	Tonks	July 30, 1946
	2,408,824	Varela	Oct. 8, 1946