Dec. 31, 1946. G. L. USSELMAN 2,413,391

POWER SUPPLY SYSTEM

Filed June 20, 1942 2 Sheets-Sheet 1

Fig. 1.

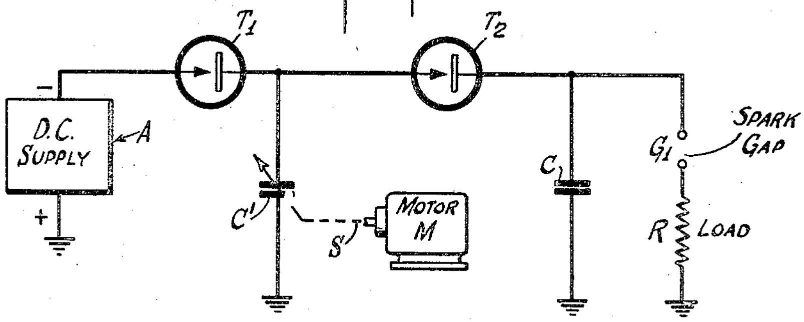


Fig. 2.

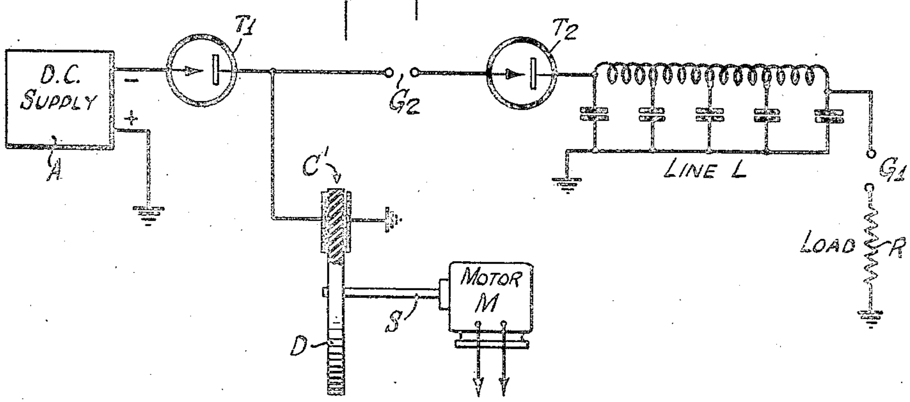
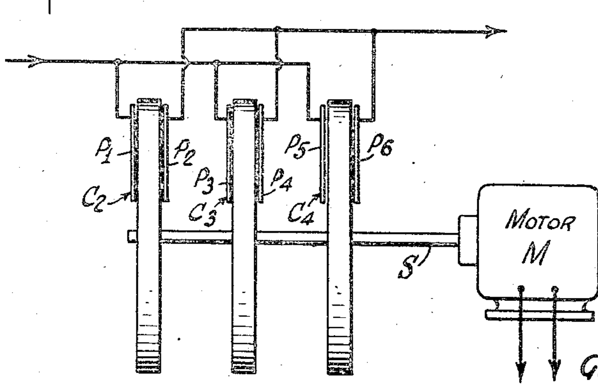


Fig. 3.



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2 Sheets-Sheet 2

Fig. 4.

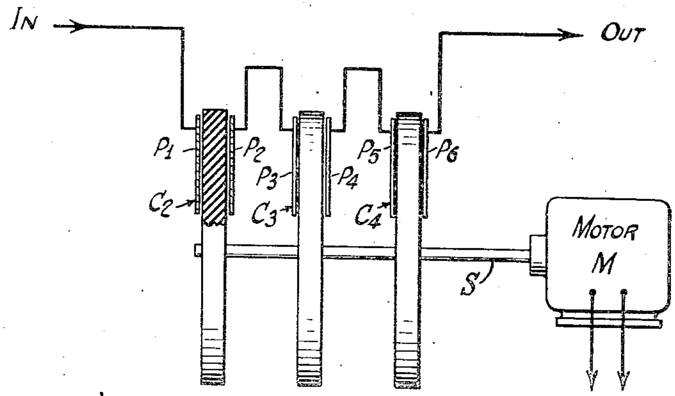
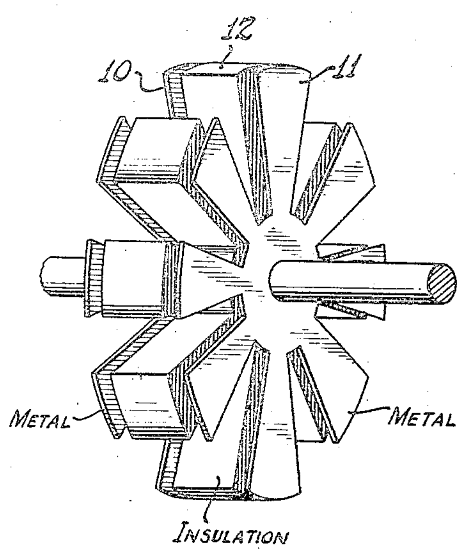


Fig. 5.



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Patented Dec. 31, 1946

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UNITED STATES PATENT OFFICE

2,413,391

POWER SUPPLY SYSTEM

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Application June 20, 1942, Serial No. 447,783

2 Claims. (Cl. 171—97)

1

The present invention relates to an electric pump or charging means for supplying a high voltage direct current from a low voltage direct current from a low voltage direct current source.

The invention is especially suited for operating radio pulse generators of the type employed in radio locating apparatus, sometimes referred to as obstacle detection radio systems. In such apparatus, it is required that the transmitter send out periodically repeated radio wave pulses of extremely short duration. In order to produce radio wave pulses, it has been proposed to excite periodically the ultra short wave oscillator of the transmitter through a spark gap device which is in series with the oscillator and the charging voltage source and to which is supplied at periodic intervals a voltage of sufficient value to break down the gap. Reference is herein made to copending confidential applications of Clarence W. Hansell, Serial No. 427,266, filed January 19, 1942, and Nils E. Lindenblad, Serial No. 441,311, filed May 1, 1942, for descriptions of the radio pulse generators to which the invention is particularly applicable.

One of the objects of the present invention is to eliminate the use of a very high voltage direct current source in radio pulse generators.

Another object is to operate efficiently, a radio pulse generator which transmits periodically repeated pulses of short duration and of ultra short wave energy from a low voltage direct current supply.

A more general object of the present invention is to provide a power supply system which transforms the output from a relatively low voltage direct current source to a high direct current voltage by means of apparatus which is simple and inexpensive to construct.

Briefly stated, the invention makes use of a continually variable capacitor for receiving a low voltage current charge and for converting or transforming this low voltage to a higher voltage current charge which is stored on another capacitor until its value is high enough to discharge across a spark gap. Rectifier circuits are employed for preventing the energy stored on both capacitors from returning to the originating point of supply. A line of predetermined constants in series with the spark gap may be used for assuring a definite time duration of discharge across the spark gap.

A short wave oscillator in series with the spark gap constitutes a load which produces ultra short wave energy solely during the time of discharge across the spark gap. Means are preferably employed to prevent the discharge from being prolonged beyond the desired time interval, thus assuring the transmission of short and sharply defined pulses of energy from the oscillator without undesired trailing effects.

2

A more detailed description of the invention follows, in conjunction with the drawings wherein:

Figs. 1 and 2 illustrate two embodiments of the invention; and

Figs. 3, 4 and 5 illustrate details of condenser constructions which can be employed for the variable capacitor of Figs. 1 and 2.

The principles underlying the invention are explainable from the following well-known electrical relations:

$$\frac{Q}{C}=E \tag{1}$$

$$\frac{dQ}{uA}=E \tag{2}$$

where

Q is the amount of condenser charge,
C is the electrostatic capacity of the condenser,
E is the potential difference across the condenser, and

$$C=\frac{A}{du} \tag{3}$$

where

u is the constant of the dielectric in the condenser,
A is the area of the dielectric, and
d is the thickness of the dielectric.

It can be seen from the relation of Equation 1 that if C is varied with Q remaining constant, E must also vary. Capacity C may be varied by changing, according to Equation 3, either the dielectric constant, the dielectric (or condenser plate) area A or the dielectric thickness d (i. e., the distance between condenser plates).

Referring to Fig. 1 in more detail, there is shown a low voltage direct current source of supply A, indicated diagrammatically, for supplying a unidirectional high voltage to a load R for satisfactory operation. Load R constitutes, in the radio pulse generator for which the invention is particularly designed, an ultra short wave oscillator such as a magnetron which requires a voltage on one of its electrodes (the anode, for example) to operate it satisfactorily. This oscillator R will oscillate only during the application of voltage pulses from the system, and because it functions momentarily it is possible to obtain a higher output than during a normal or continuous steady state. We thus apply a much higher voltage than normally applied to a magnetron electrode but for a very short period of time, and take from the oscillator R a short wave at high power which is then radiated by an antenna (not shown). In series with the load R there is provided a spark gap G_1 having in circuit therewith a voltage multiplying means comprising a pair of serially connected rectifiers T_1, T_2, variable condenser C_1 and a fixed condenser C. The rectifiers T_1, T_2 are indicated diagrammatically and are preferably thermionic rectifiers each of which includes the usual heated filament element and a cold electrode within an evacuated envelope. The capacity of the condenser C_1 is continuously varied by means of a motor M through a drive shaft S. Condenser C_1 is charged from direct current source A through the rectifier T_1, while the fixed condenser C is charged through the rectifier T_2. As the motor M rotates, the capacitor C_1 will vary between a small capacity condition and a large capacity condition. When the condenser C_1 is in the small capacity condition, its voltage will rise; but since the charge current applied thereto through the rectifier T_1 cannot flow backwards through the rectifier T_1 to the source A, it will of necessity flow through the rectifier T_2 into the storing condenser C. When the condenser C_1 is varied to the large capacity condition, the voltage thereon falls. Current cannot return from the condenser C to the condenser C_1 because of the action of the rectifier T_2 which acts as a check valve.

It will thus be seen that the condenser C_1 obtains a low voltage charge from the direct current supply A when its capacity is large and by virtue of its change in capacity to the small capacity condition produces an increase in the voltage on the condenser which is then transferred to the fixed condenser C where it is stored. As the value of the capacity of the condenser C_1 is varied continuously by the motor M, the variable condenser will transfer increments of high voltage charge to the fixed condenser C until the latter reaches a value determined by the input voltage from source A and the variable capacity ratio of the variable condenser C_1, and by the ultimate breakdown strength of the various parts of the system. In general, the voltage developed on fixed condenser C will be the voltage of the direct current source A multiplied by the ratio of maximum to minimum capacity of the condenser C_1. When the condenser C is charged to a predetermined critical value, the spark gap G_1 will break down and the condenser C will discharge across this gap, sending a surge of current through the load R (in this case a short wave radio transmitter).

Fig. 2 is a modification of the system of Fig. 1 and operates generally upon the principle described above. In Fig. 2 the capacity of the condenser C_1 is varied by changing the dielectric constant u. The dielectric material between the plates of the condenser comprises a wheel D, which is preferably a serrated wheel composed of alternate sections of Titanium dioxide having a very high dielectric constant and air, or some other material of low dielectric constant. This wheel D is rotated between the electrode plates of condenser C_1 by means of shaft S, in turn linked to the motor M. A second spark gap G_2 is shown inserted in series between the two rectifiers T_1, T_2. Gap G_2 is set just above the sparking voltage of the direct current supply source A in order to prevent the voltage from the source A from following through to prolong the spark of the gap G_1 when the latter gap breaks down. In Fig. 2, the line L replaces the condenser C of Fig. 1. This line is made up of sections of series inductance and shunt capacitance, of such constants that it provides a discharge of definite time duration across the gap G_1.

In the operation of the system of Fig. 2, the condenser C_1 serves to supply pulses or trickles of higher voltage to the line L than the voltage applied to the condenser from the direct current source. Line L is then charged to a critical value determined by its constants. When this critical value is reached, the spark gap G_1 breaks down and the line discharges across the spark gap G_1 sending a surge of current through the load R. Rectifier T_2 in Fig. 2 as in Fig. 1 acts as a check valve and prevents the voltage on line L from returning to the condenser C_1. In practice, in using a radio pulse generator or obstacle detection system with the system of Fig. 2, the gap G_1 is synchronized by means not shown so that it sparks over during the time condenser C_1 is being recharged. The spark gap G_2 serves to prevent trailing effects which might be caused in conventional systems by the prolongation of the spark beyond the desired time of discharge of gap G_1. If desired, the spark gap G_1 in both Figs. 1 and 2 may be synchronized to spark after every charge from condenser C_1 or after a certain number of charges from the condenser C_1.

Figs. 3 and 4 show a plurality of variable condenser arrangements which may be employed for the condenser C_1 in either Fig. 1 or 2. In Fig. 3 the variable condenser arrangement comprises a plurality of condensers C_2, C_3 and C_4, whose plates are connected in parallel relationship. In Fig. 4, the variable condenser arrangement constitutes three condensers C_2, C_3, C_4, whose condenser plates are arranged in series relationship.

Fig. 5 shows a practical variable condenser which can be used for condenser C_1 in either Fig. 1 or 2. This condenser is composed of two spaced metallic plates 10 and 11 with teeth or vanes, and between these plates a rotating dielectric disc 12 having toothed or serrated sections of alternating dielectric constants as shown.

In one embodiment actually constructed to prove the principles of the invention, the variable condenser C_1 had a maximum capacity of about .005 mf. and a minimum capacity of about .0001 mf. with $\frac{1}{32}$ inch spaced plates. The potential of the source A was 600 volts and the voltage impressed on condenser C was about 5,000 or 6,000 volts.

What is claimed is:

1. In a pulse generator system, a circuit for transforming direct current of low voltage to direct current of higher voltage comprising a low voltage source of direct current, a variable capacitor in series with a rectifier connected across said source, and a series circuit of spark gap, rectifier and an energy storage unit connected across said variable capacitor, means for continually varying the value of said variable capacitor, said rectifiers being so poled that current can flow from said source through said first rectifier to said variable capacitor and current can flow from said variable capacitor through said second rectifier to said storage unit, said spark gap having such spacing as to pass only voltages of values higher than the value of said source, said storage element comprising a network having a

multiplicity of sections of series inductance and shunt capacitance, and a load in series with another spark gap connected to the output of said network, whereby the charging of said network to a critical value appreciably higher than the value of said source causes a surge of current to flow through said load of a time duration determined in part at least by the constants of said network, and the spacing of said first spark gap prevents undesired prolongation of the discharge of said network.

2. In a voltage multiplier circuit, a source of relatively low voltage direct current, a variable capacitor in series with a rectifier connected across said source, means for continually varying the value of said capacitor, and an energy storage circuit in series with another rectifier connected across said variable capacitor, said rectifiers being so poled that current flows through both said rectifiers in the same direction relative to said source, whereby a voltage of higher value is applied to said storage circuit by said variable capacitor than that applied to said capacitor by said source of low voltage direct current, said energy storage circuit comprising a network having a multiplicity of sections of series inductance and shunt capacitance, said network having predetermined constants for assuring a definite time duration of discharge, a spark gap at one end of said network, and a load connected to said spark gap and adapted to be energized when said spark gap breaks down.

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