Nov. 12, 1946. N. E. LINDENBLAD 2,411,140

PULSE TRANSMISSION SYSTEM

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Fig. 1.

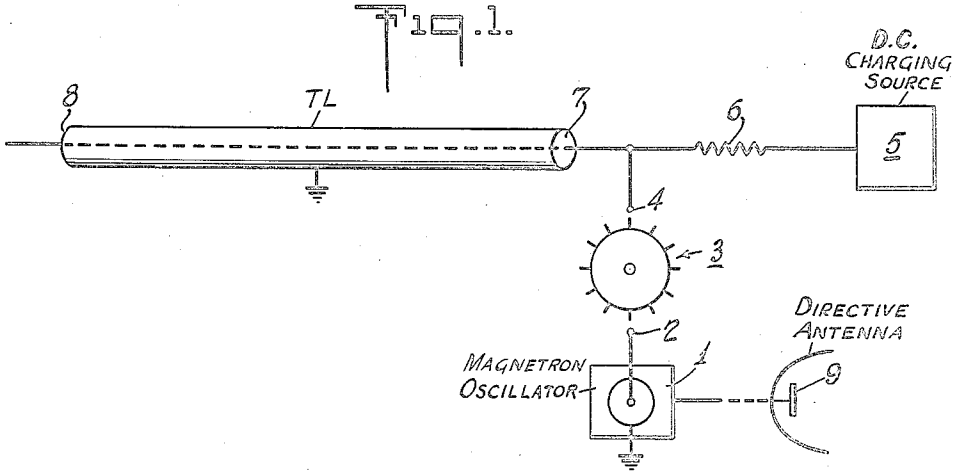


Fig. 1a.

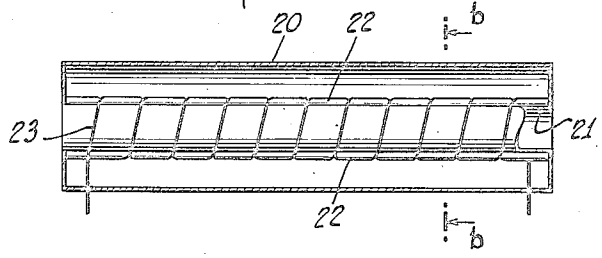


Fig. 1b.

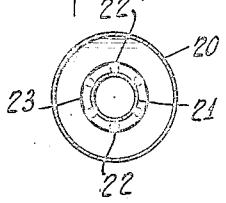
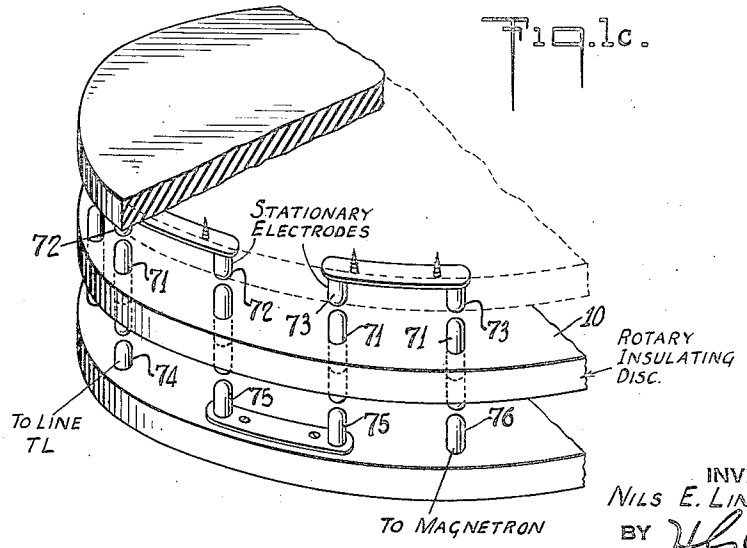


Fig. 1c.



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Fig. 2.

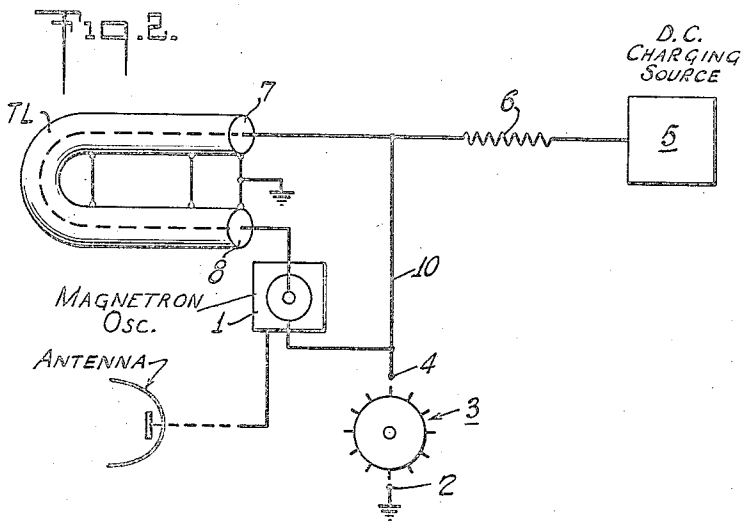


Fig. 3.

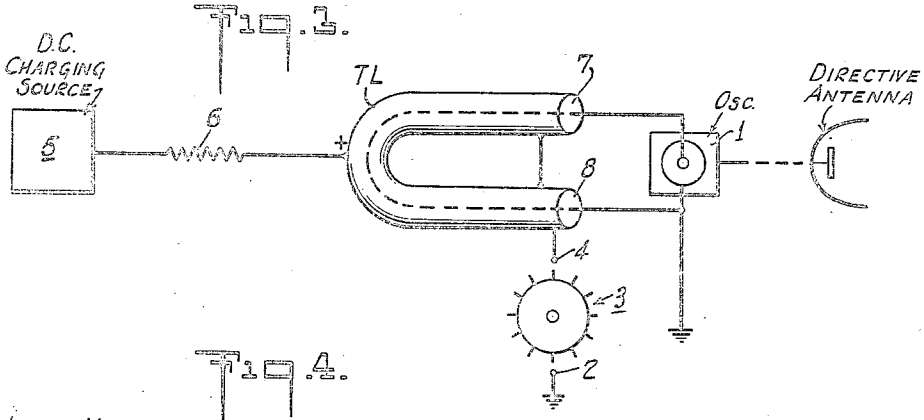
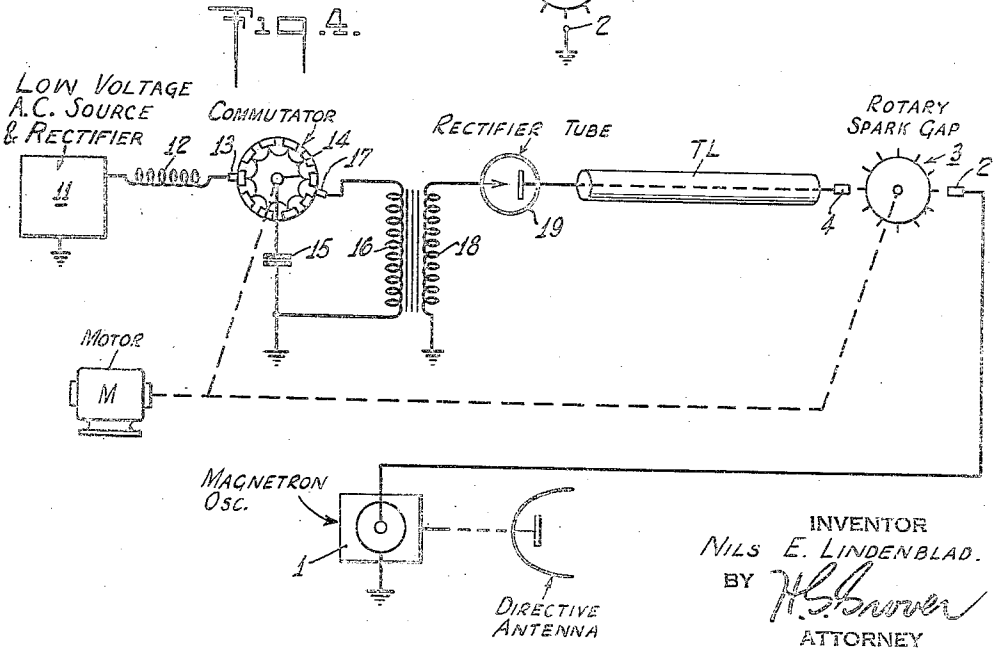


Fig. 4.



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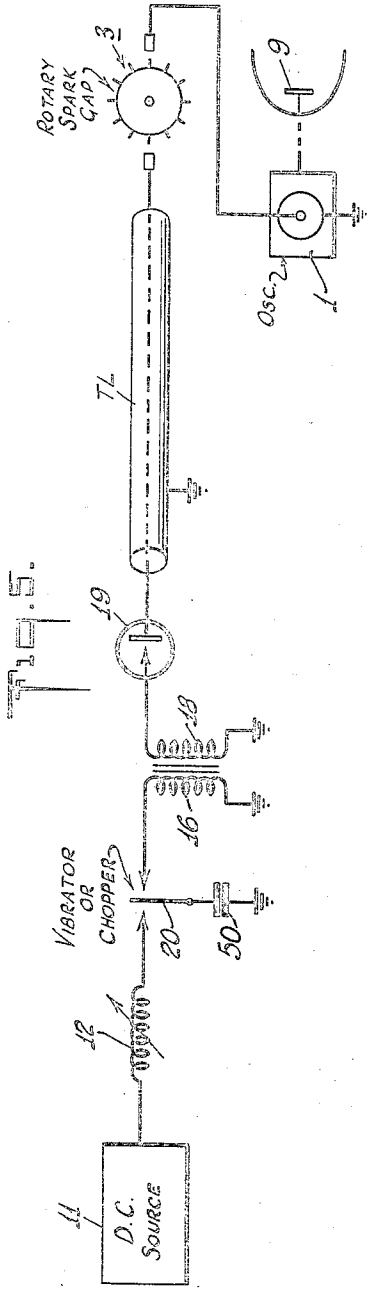


FIG. 5.

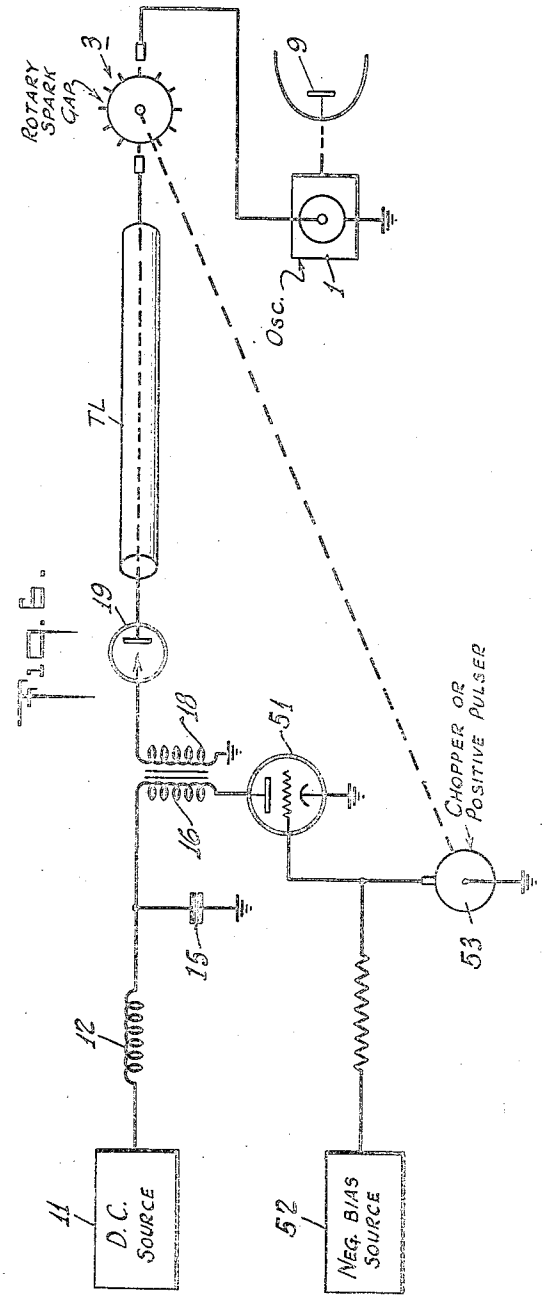


FIG. 6.

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PULSE TRANSMISSION SYSTEM

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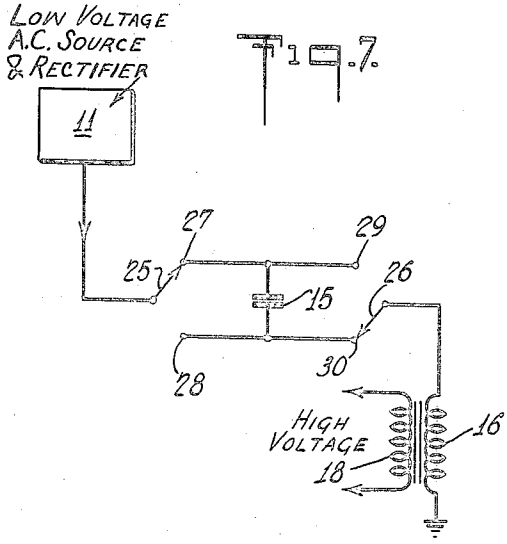


Fig. 7.

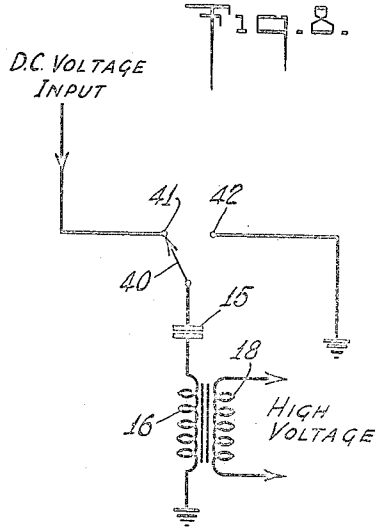


Fig. 8.

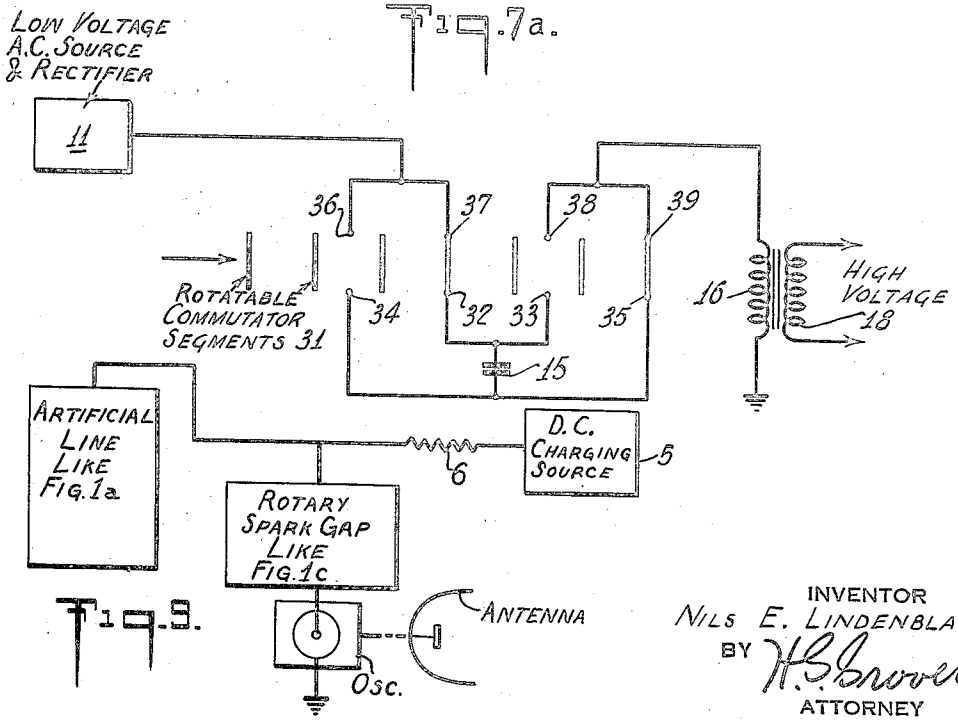


Fig. 7a.

Fig. 9.

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2,411,140

UNITED STATES PATENT OFFICE

2,411,140

PULSE TRANSMISSION SYSTEM

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Application May 1, 1942, Serial No. 441,311

10 Claims. (Cl. 250—36)

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This invention relates to improvements in obstacle detection radio systems.

It is known in obstacle detection radio systems (sometimes referred to as radio locators) to employ a transmitter for transmitting periodically repeated radio wave pulses of extremely short duration, and a receiver for receiving the pulses which are reflected by the obstacle to be detected. Such systems preferably employ directive antennas and other expedients for both transmitter and receiver by means of which the indications are confined to objects lying within a narrow range of angles. The antennas are sometimes given a continuous motion to scan a certain range of solid angles somewhat after the fashion of scanning a television image and these antennas are linked to a potentiometer which controls the voltage on the horizontal deflection plates of an oscilloscope. In order to produce the radio wave pulses, it has been proposed to excite periodically the oscillator of the transmitter through a spark gap switching 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.

One difficulty experienced with the aforesaid known systems has been due to the trailing effects caused by insufficient deionization of the spark gap, as a result of which the carrier or radio wave pulses from the oscillator are not as sharply defined as desired. This trailing condition occurs because an undesired continuing arc in the spark gap causes a current to flow through the oscillator to produce a continued output from the oscillator. This continued output from the oscillator is of less intensity than that of the pulse produced during the early part of the discharge.

The present invention provides a system by means of which an undesired continuing arc, due to insufficient deionization of the spark gap, has no effect on the oscillator of the transmitter.

Among the features which contribute to the improved system of the present invention are the following: The rotary spark gap switching device having a multiplicity of electrodes in spaced series relation for improving the accuracy of the firing and the speed of disruption, the compact transmission line, the circuit for assuring a sharp break in the discharge across the spark gap, the circuit for preventing trailing effects in the oscillator despite insufficient deionization of the spark gap, and the circuit for obtaining the necessary high pulse voltage for the

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oscillator from a relatively low voltage alternating current source.

Other features and objects of the present invention will appear from a reading of the following description, which is accompanied by drawings wherein the same parts are labeled with the same reference characters.

Figs. 1, 2, 3, 4, 5 and 6 show different embodiments of the present invention for producing sharply defined periodically repeated radio wave pulses;

Fig. 1*a* shows, in perspective, the novel compact transmission line arrangement which can be employed in the circuits of Figs. 1 to 4, inclusive;

Fig. 1*b* is a cross-sectional view of the compact line of Fig. 1*a* along the line *b*—*b*;

Fig. 1*c* shows a perspective view of the improved rotary spark gap switching device of the invention;

Figs. 7 and 7*a* illustrate diagrammatically an improved form of chopper circuit which can be used in place of corresponding parts of Figs. 4, 5 and 6 for converting energy obtained from a low direct current voltage source to pulses of high voltage;

Fig. 8 is a modification of my improved chopper circuit for use in more general applications; and

Fig. 9 shows the arrangement of Fig. 1 employing the artificial line of Fig. 1*a* and the rotary spark gap of Fig. 1*c*.

Referring to Fig. 1 in more detail, there is shown one embodiment of the invention for producing sharp, periodically repeated radio wave pulses. The oscillator for producing ultra short waves below one meter in length (preferably of the order of ten centimeters) is represented conventionally by box 1. This oscillator may be any suitable device, but is preferably a magnetron of the type shown and described, for example, in Hansell Patent 2,217,745, granted October 15, 1940. The anode of magnetron 1 is shown connected to ground, while the cathode is shown connected to one stationary electrode 2 of a rotary spark gap arrangement 3. For certain conditions of operation, the cathode and anode connections (as shown) can be reversed. The other stationary electrode 4 of the rotary spark gap is connected to one end 7 of a transmission line TL of predetermined length, to which is also connected, through a high resistance 6, a source of continuous direct current charging voltage 5. Line TL is open at the other end 8 in order to enable the reflection therefrom, with a desired

polarity, of a pulse of voltage initiated at the end nearest the spark gap. The oscillator 1 (which is the load for the line TL) has a resistance or impedance, during operation, equal to the characteristic impedance of the line TL.

A suitable antenna 9, preferably a directive antenna such as a dipole in the focus of a paraboloid reflector, is coupled to the output of the oscillator 1 for radiating the radio wave pulses toward the object to be detected.

In the operation of Fig. 1, the line TL is charged to potential +E from the direct current source 5 through the high resistance 6. When the charge on line TL reaches a potential equal or slightly in excess of the break-down potential across the rotary spark gap, it discharges through the spark gap and the load 1 which matches the impedance of the line TL and as a result of which the potential across the conductors of coaxial line TL at terminal 7 drops to a value equal to one-half the potential of the charge. This means that a wave is initiated at the terminal 7 of a potential opposite to that of the charging potential and having a value equal to half that of the charging potential. This initiated wave, ahead of which the potential is still +E and behind which it is E/2, travels down the length of the line TL to its other end 8, where it is reflected back as a wave ahead of which the potential is E/2 and behind which it is zero. Thus, when the reflected wave returns to terminal 7 where there still remains a voltage of one-half E sustaining the discharge, it reduces the sustaining voltage to zero. A constant discharge has thus been maintained from the time the spark gap broke down until the arrival of the reflected wave. Looking at it from another point of view, it can be shown that a voltage ½E across the load (oscillator) will deliver to the load in the time required for a pulse to travel one round trip on the line an amount of energy exactly equal to the total electrostatic energy stored in the line by the potential E. It can thus be seen that the total phenomenon involved is equivalent to splitting the charging potential in half and obtaining a discharge period the time of which is twice as long as the wave traversed in one direction of the line. The length of line TL thus determines the time duration of the discharge or direct current pulse applied to the oscillator to make it momentarily operative to produce a carrier wave pulse. Thus, if the line has a length corresponding to the wave travel of half a microsecond, the pulse obtained from this line will have a duration of a whole microsecond.

Now, if the load 1 is a magnetron oscillator which requires the voltage from the line TL to run it, it will be obvious that it will oscillate only during the application of voltage pulses from the line. Because the oscillator 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 employed by a magnetron electrode but for a very short period of time, and take out from the oscillator a short wave at high power. As an example, with 20,000 volts applied to the input of the line TL as a continuous charging voltage from the source 5 (which can be a rectifier) we may get an output from the oscillator of about 20 kw. at a frequency of 300 megacycles (10 cm.) for an interval of about one microsecond. The radio wave pulses from the oscillator are spaced apart in time an amount which is large compared to the time of each pulse. For

periodically repeated pulses of one microsecond length, the interval between pulses can be as high as 500 microseconds.

The resistance 6 inserted between the direct current source and the pulse line TL should have a value much greater than the characteristic impedance of the line TL or of the load resistance, so that when the rush of current produced by the act of discharging the line TL is over, there is not enough flow from the direct current source 5 to maintain the spark. By using a quenched spark gap, or a rotary spark gap, or one having an air-blast, the resistance 6 may be permitted to have a smaller value than would be the case if the spark gap were constituted merely by a pair of spaced electrodes. Under all circumstances, the value of resistor 6 should be considerably greater than the characteristic impedance of the line TL and the load resistance.

Accordance to the invention, it is preferred that the rotary spark gap arrangement be of the type illustrated in Fig. 1*c*, wherein use is made of a plurality of spark gaps in series. This rotary gap arrangement comprises a rotating insulating disc 10 having a plurality of studs or electrodes 71 located in a circle near its periphery, each of these studs extending through the disc. Two pairs of stationary electrodes 72, 72 and 73, 73, respectively, are placed on one side of the disc and on the arc of a circle having the same radius as the circle of the rotating electrodes. These stationary electrodes are suitably spaced apart from each other the same distance as are the electrodes on the rotary disc, the electrodes of each pair being connected together. On the opposite side of the disc 10 there are located stationary electrodes 74, 75, 75 and 76, also on an arc of a circle having the same radius and axis as the circle of the rotating electrodes. Electrodes 75, 75 are connected to each other, while electrode 74 is connected to line TL and electrode 76 connected to the load (in this case the magnetron oscillator). The rotary electrodes 71, 71 are spaced apart from the stationary electrodes to provide small gaps therebetween. In one position of the disc, it will be evident that there will be a discharge path through the rotary spark gap system over a path including in series the electrodes 74, 71, 72, 72, 71, 75, 75, 71, 73, 73, 71 and 76. The distances between the rotary and stationary electrodes are now considerably smaller than would be the case if only a single spark gap arrangement were employed, and the rate of change of sparking distance increases with the number of gaps. Such a rotary gap scheme as is disclosed herein prevents possible spurious discharges and improves the accuracy of firing and the speed of disruption. Obviously, the speed of the disc is related to the timing of the pulse length.

In the example given above of the production of pulses having a time duration of one microsecond, it will be apparent that if line TL were a straight line it would require a length of 150 meters. In order to reduce the overall length of this line, it may be coiled, or preferably take the form of the line of Fig. 1*a*. The line of Fig. 1*a* may occupy a space of only six feet and give the same results as a straight coaxial line of 150 meters. More specifically, the line of Fig. 1*a* is composed of a pair of hollow conductors 20 and 21 of good electrical conducting material connected together at their ends. The inner conductor 21 is provided with a plurality of parallel insulating rods 22 arranged parallel to the axis of the con-

ductor, each rod being notched to enable a coiled conductor 23' to be wound around the inner conductor but spaced therefrom by the rods 22. The inner conductor 21 reduces the mutual inductance between adjacent turns of the coil, and the outer conductor 20 serves as a shield which also reduces the mutual inductance between adjacent turns.

Fig. 2 illustrates another embodiment of the invention for producing sharp ultra short wave pulses. The line TL, which is the same as shown in Figs. 1 and 1*a*, or any equivalent frequency, is here shown folded back on itself in order to more clearly indicate that the connection from the magnetron oscillator 1 to the terminal 8 of the line is very short and has no time determining factor. Here again the line TL is charged through the resistance 6. However, in this figure one end of the line TL (the inner conductor at terminal 7) is directly connected to the spark gap arrangement, whereas the other end of the inner conductor at terminal 8 is connected to the same spark gap through the load resistance of the magnetron 1. As mentioned in connection with Fig. 1, the spark gap is preferably of the type shown in Fig. 1*c*, although it may be a quenched spark gap or an unquenched spark gap. The possibility of current passing through the oscillator 1 because of a continuing arc across the spark gap is avoided in Fig. 2 by virtue of the direct connection 10 which shunts line TL and the oscillator load 1. Charging voltage from source 5 is applied to the inner conductor line TL, as described before in connection with Fig. 1. The resistance or impedance of oscillator 1 is the same as the characteristic impedance of line TL, and resistance 6 has a value considerably greater than the characteristic impedance of line TL.

In the operation of Fig. 2, the following happens when the charge on the line TL is of such value as to cause a discharge across the spark gap. The voltage across terminal 7 becomes zero or near zero, by virtue of the fact that the outer shell of the line is grounded and the inner conductor is connected through line 10 to ground through the extremely low resistance path of the spark gap in its condition of discharge. As a result of the voltage across 7 becoming zero or near so, a negative wave is initiated at terminal 7 and travels down the line toward terminal 8, and as it goes reduces the line potential by the amount of the stored or charged voltage E. At the same time, the potential at terminal 8 drops to a potential half that of the charged or stored potential, thereby launching from 8 toward terminal 7 a wave which reduces the line potential by one-half E as it goes, thereby leaving the potential at terminal 8 at the value one-half E. When the zero or short circuited wave initiated at terminal 7 arrives at terminal 8, it reduces the potential at terminal 8 by the amount E, thus causing the potential at 8 to become $-\frac{1}{2}E$, which means that the potential across the load resistance (magnetron) has been reversed. Since, however, the magnetron 1 is a rectifying device, this reversal will stop current already flowing through the magnetron. The direct current pulse obtained by the magnetron from the line TL can thus be said to be clipped or extinguished by this phenomenon. At the same time and the time immediately following this phenomenon, the spark gap current through 3 will drop in the same manner as described in connection with Fig. 1.

Fig. 3 illustrates a modification of the system of Fig. 2, and in general has a principle of operation very similar thereto. The circuit of Fig. 3 illustrates an arrangement whereby the voltage from the charging source 5 reverses its effect upon the magnetron 1. This feature is sometimes useful because the rectifier in the direct current charging source 5 is made to provide a fixed polarity with respect to ground, and furthermore because it may be desirable to ground one or the other electrons (anode or cathode) of the magnetron 1. In the system of Fig. 3, the charging source 5 instead of charging the central conductor of the transmission line, as in the case of Figs. 1 and 2, now charges the shell of the same line, which shell is connected to the spark gap 3. The two connections from the terminals of center conductor of the line TL instead of going to the spark gap as in Fig. 2, are now directly connected to opposite sides of the oscillator load 1, one of these connections going to ground. Although the direct current charging source 5 is here shown connected to the center of the shell of the line TL, it should be understood that it may be connected to any point on the shell of the line, such as at one end. A comparison of Figs. 2 and 3 will show this main difference: Whereas in Fig. 2 the spark gap is connected to the inner conductor of the line TL and the charging source 5 also connected to this inner conductor, in Fig. 3 the spark gap is connected to the outer conductor or shell of the line TL and the charging source 5 also connected to this shell. Further, whereas in Fig. 2 the outer conductor of the line TL is grounded, in Fig. 3 the inner conductor of the line TL is grounded at one end.

The same remarks hereinbefore mentioned in connection with the relative values of the load resistance of oscillator 1 and the characteristic impedence of the transmission line, as well as the value of resistor 6 also apply in the case of Fig. 3.

Fig. 4 illustrates another embodiment of the invention and which avoids the use of a high voltage continuous direct current source shown in Figs. 1, 2 and 3 (trickle charge method), or the need of a low frequency input of high voltage according to known systems.

In Fig. 4 the numeral 11 represents a rectifier which rectifies the current from a 400 volt alternating current 60 cycle source and applies the same through an inductance coil 12 to a stationary brush 13 associated with a commutator 14. The segments on the commutator are connected to one electrode of condenser 15, the other electrode of which is connected to ground and to one terminal of an inductance coil 16. The other terminal of inductance coil 16 is connected to a stationary brush 17. Brushes 13 and 17 are so arranged on commutator 14 that when one brush is in contact with a segment, the other brush is resting on an insulating bar, and vice versa. Inductance 16 forms one coil of an open core transformer whose other coil 18 is connected between ground and an electrode of rectifier tube 19. A transmission line TL of the type shown in Figs. 1 or 1*a*, or any equivalent structure, is connected between the rectifier tube 19 and the spark gap arrangement 3. The other side of the spark gap ararngement is connected to the magnetron oscillator load 1. By means of the commutator 13, condenser 15 and transformer arrangement 16, 18, it is possible to produce a pulse of 20,000 volts which is applied to the line TL. Putting it in other words, the arrangement of circuit elements 14, 15 and 16, together with their asso-

ciated features, converts the 400 volt charging potential to periodic pulses of 20,000 volts. The inductance coil 12 serves to tune the condenser 15 to the pulse frequency for a more efficient transfer of energy from the source 11 to the line TL; that is, coil 12 tunes condenser 15 not at the repetition rate of the pulses but rather to the time that the contact is closed in such a way that when the contact opens there is, for the moment, no current to be interrupted. In this way a clean break is obtained without deleterious arcing.

The shaft of the commutator 13 is linked to the shaft of the rotary spark gap 3 and to a single motor M, so that there is a synchronous operation by means of which the spark gap will be in discharging position at the time that the transformer T is inactive. The spark gap is made to discharge at the time that the transformer is inactive because the active period of the transformer is much longer than the desired active period of the spark gap and it is desired to avoid any trailing effects on the spark gap. For this reason also, the spark gap is made to be operative for a much shorter period of time than the active period of the transformer. In Fig. 4 the line TL is charged, and its length again determines the length of the pulse, in substantially the same manner as hereinbefore described in connection with Fig. 1. Here again, the impedance or resistance of oscillator 1 is the same as the characteristic impedance of line TL.

Figs. 5 and 6 show modifications of the system of Fig. 4. In Fig. 5 the commutator 14 and associated brushes is replaced by a vibrator or chopper 50 having a suitable rate of operation, preferably synchronized with the operation of the rotary gap. In Fig. 6, the switching performance is achieved by a vacuum tube 51 whose grid is biased so negatively by source 52 as to be nonconducting until such time as the rotary chopper or positive pulser 53 provides a positive pulse on the grid of tube 51 of such magnitude as to overcome the negative bias and thus cause the tube to become conductive. The speed of rotation of chopper 53 is synchronized with the speed of rotation of rotary gap 3. It will thus be seen that the important concept in Figs. 4, 5 and 6 lies in the use of a condenser which is charged and later discharged through the primary of an induction coil.

Figs. 7 and 7*a* illustrate diagrammatically only a preferred form of chopper circuit for converting the low direct current voltage in the systems of Figs. 4, 5 and 6 to periodic pulses of high voltage, the latter to be impressed upon the rectifier tube of the circuits of Figs. 4, 5 and 6. Fig. 7*a* is the same circuit as Fig. 7, except that the contact making device is shown in more detail as constituting part of a rotatable commutator device.

Referring to Fig. 7 in more detail, there is shown the low direct current voltage source 11 which supplies energy to a condenser 15, this condenser being charged and discharged through the primary winding 16 of a transformer whose secondary winding 18 delivers periodic high voltage pulses to the rectifier tube (not shown) of the circuits of Figs. 4, 5 and 6. Putting it in other words, the arrangement of Fig. 7 can replace that portion of the circuits of Figs. 4, 5 and 6 immediately to the left of the rectifier tube 19. Switches 25 and 26 function simultaneously to change the position between their respective contacts. Switch 25 has associated therewith contacts 27 and 28, while switch 26 has associated therewith contacts 29 and 30. In the position shown in the drawing of Fig. 7, the condenser 15 is charged from the low voltage source 11 through the primary winding 16 of the transformer. After the condenser 15 is charged, the switches 25 and 26 operate simultaneously to change their positions from engagement with contacts 26 and 30, respectively, to contacts 28 and 29, respectively, in which last position the condenser 15 will discharge through primary winding 16. The charging and discharging of the condenser 15 through primary winding 16 will cause current pulses to flow through the induction coil. The particular arrangement of the switches 25 and 26 assures that the current pulses through the primary 16 are in the same direction, and this is important because the oscillation set up in this circuit is extremely highly damped, and the output of the secondary winding 18 passes through the rectifier tube. It will thus be seen that by reversing the connections of the condenser between each charge, I assure the fact that the current pulses through the primary winding do not change their direction. In this way a pulse corresponding to twice that of the voltage of the source 11 and always of the same direction passes through the primary of the induction coil.

Fig. 7*a* illustrates in more detail one way of achieving the reversals of the connections to the condenser 15 between each charge. A rotating commutator having a plurality of equally spaced commutator segments 31 serves to achieve this result. The condenser 15 has its upper armature connected to a plurality of contacts 32 and 33, while the lower armature of condenser 15 is connected to a plurality of contacts 34 and 35. The low voltage source 11 is connected to a plurality of contacts 36 and 37, while the upper terminal of the primary winding 16 is connected to a plurality of contacts 38 and 39. In one position of the commutator, one segment 31 will bridge contacts 37 and 32, while at the same time another segment 31 will bridge contacts 39 and 35, thus producing a complete circuit from the charge source 11 through the condenser 15 and primary winding 16. It should be noted that in this position there is no direct connection between contacts 36 and 34, or between contacts 38 and 33. In another position of the commutator, a segment 31 will bridge contacts 36 and 34, while simultaneously another segment 31 will bridge contacts 38 and 33. At this particular time, there will be no direct connection between contacts 37 and 32 and 39 and 35, by virtue of the fact that the segments which bridged them have now passed beyond these contacts in their path of travel. In this last position, the circuit will again be complete from the low voltage source 11 through the condenser 15 and through the primary winding 16; but, it should be noted, that the connections to the condenser 15 have now been reversed relative to the first position. As the commutator revolves, this cycle of operations will be repeated, thus producing alternate charges and discharges of the condenser through the primary winding 16 in the same direction.

One advantage of the chopper circuit of Figs. 7 and 7*a* is that the contact device is not subjected to any current breaking and consequent arcing, which may occur in the circuits of Figs. 4, 5 and 6, and against which measures were taken in the circuits of Figs. 4, 5 and 6 by the use of a resonance inductance 12.

It should be understood that my improved chopper circuit shown in Figs. 7 and 7*a* is not

limited to the particular pulse transmission system shown in the other figures of the drawings, since this chopper has application to other systems wherever it is desired to use an arrangement for transforming a low voltage direct current to a much higher voltage in the form of pulses. In applications of the improved chopper of the invention to other systems where it may not be important that the current pulses from the primary do not change their direction, I can use a simplification of the systems of Figs. 7 and 7*a*. This simplification is shown in Fig. 8 and comprises the use of condenser **15** permanently connected in series with inductance coil **16**, the armature of the condenser furthest away from the inductance coil being connected to a switch **40** which can alternate between two contacts **41**, **42**. One of these contacts **41** is connected to the low direct current voltage source, while the other contact **42** is connected to ground. In this last case, however, the charging and discharging of the condenser **15** as the switch **40** alternately engages its contacts **41** and **42**, will cause current reversals in the primary of the induction coil or transformer.

The term "ground" used in the specification and claims is deemed to include any point or surface of fixed alternating potential or of zero radio frequency potential.

It should be understood that the spark gap arrangements described herein are illustrative of any suitable switching systems.

What is claimed is:

1. A system for producing equal length pulses comprising a source of charging voltage, a storing circuit in the form of a line of predetermined electrical length, an oscillator whose resistance during operation is the same as the characteristic impedance of said line, a connection from an electrode of said oscillator to one terminal of said line, a spark gap in said connection, a connection from ground to another electrode of said oscillator, whereby the flow of current through said spark gap polarizes said first electrode to cause said oscillator to produce oscillations, and a resistance whose value is appreciably greater than the characteristic impedance of said line connected between said source of charging voltage and said line, said spark gap being a rotary arrangement having a multiplicity of serially arranged gaps greater than two.

2. A system for producing equal length pulses comprising a source of charging voltage, a storing circuit in the form of a line of predetermined electrical length, an oscillator whose resistance during operation is the same as the characteristic impedance of said line, a connection from an electrode of said oscillator to one terminal of said line, a spark gap in said connection, a connection from ground to another electrode of said oscillator, whereby the flow of current through said spark gap polarizes said first electrode to cause said oscillator to produce oscillations, and a resistance whose value is appreciably greater than the characteristic impedance of said line connected between said source of charging voltage and said line, said line comprising a coil wound around a hollow conductor but insulated therefrom, there being a hollow conductor surrounding said coil and insulated therefrom and connected at its ends to said other hollow conductor.

3. A system for producing equal length pulses of carrier wave energy, comprising a source of charging voltage, a storing circuit in the form of

a compactly arranged line of predetermined electrical length, said line having a conductor element and a shell element surrounding the same, a carrier wave generator whose resistance during operation is the same as the characteristic impedance of said line, connections from a pair of electrodes of said generator to opposite terminals of said conductor element, a spark gap one terminal of which is connected to ground, a direct connection from the other terminal of said spark gap to one element of said line, and a connection from said charging source to the same element of said line, the other element of said line being grounded, whereby the flow of current through said spark gap caused by a critical value of charge on said line completes a circuit for rendering said generator operative.

4. A system for producing equal length pulses of carrier wave energy comprising a source of charging voltage, a storing circuit in the form of a compactly arranged line of predetermined electrical length, said line having a conductor element and a shell element surrounding the same, a carrier wave generator whose resistance during operation is the same as the characteristic impedance of said line, connections from a pair of electrodes of said generator to opposite terminals of said conductor element, a spark gap one terminal of which is connected to ground, a direct connection from the other terminal of said spark gap to a terminal of said conductor element of the line, and a connection from said charging source to the same terminal of said conductor element of said line, and a connection from ground to said shell, whereby the flow of current through said spark gap caused by a critical value of charge on said line completes a circuit for rendering said generator operative.

5. A system in accordance with claim 3, characterized in this that said generator is a magnetron, and an antenna is coupled to the anode of said magnetron.

6. A system for producing equal length pulses of carrier wave energy comprising a source of relatively low direct current charging voltage, a storing circuit in the form of a compactly arranged line of predetermined electrical length, said line having a conductor element and a shell element surrounding the same, a carrier wave generator whose resistance during operation is the same as the characteristic impedance of said line, connections from a pair of electrodes of said generator to opposite terminals of said conductor element, a spark gap one terminal of which is connected to ground, a direct connection from the other terminal of said spark gap to one element of said line, and a connection from said charging source to the same element of said line, the other element of said line being grounded, whereby the flow of current through said spark gap caused by a critical value of charge on said line much greater than said charging voltage completes a circuit for rendering said generator operative.

7. A system for producing equal length pulses of carrier wave energy, comprising a source of relatively low voltage alternating current, means for rectifying said alternating current, a commutator having a pair of brushes so arranged that when one brush contacts a segment on the commutator the other is insulated from said commutator segments, and vice versa, a connection including an inductance element between one of said brushes and the output of said rectifier, an open core transformer having primary and secondary windings, a connection from one point on said primary

winding to the other brush, and a connection from another point on said primary winding to the segments of said commutator through a condenser, a connection from said last point to ground, connections from separated points on the secondary winding of said transformer to ground and to a rectifier circuit, respectively, whereby rotation of said commutator causes said transformer system to translate the rectified low voltage applied to said commutator to high voltage energy which is rectified by said last rectifier circuit to produce direct current pulses, said inductance element having a value which tunes with said condenser, a storing circuit in the form of a line of predetermined length, a connection from one end of said line to the output of said last rectifier circuit, an oscillator whose resistance during operation is the same as the characteristic impedance of said line, a connection from an electrode of said oscillator to the other end of said line, a rotary spark gap in said connection, a connection from ground to another electrode of said oscillator, whereby the flow of current through said spark gap polarizes said first electrode to cause said oscillator to produce oscillations, said spark gap being so constructed and arranged that it is operative for a much shorter period of time than the active period of said transformer, and means for synchronously driving said commutator and rotary gap, whereby said spark gap is in discharging position at the time said transformer is inactive.

8. In a system for producing equal length pulses of carrier wave energy, a source of relatively low voltage alternating current, means for rectifying said alternating current, a commutator having a pair of brushes so arranged that when one brush contacts a segment on the commutator the other is insulated from said commutator segments, and vice versa, a connection including an inductance element between one of said brushes and the output of said rectifier, an open core transformer having primary and secondary windings, a connection from one point on said primary winding to the other brush, and a connection from another point on said primary winding to the segments of said commutator through a condenser, a connection from said last point to ground, connections from separated points on the secondary winding of said transformer to ground and to a rectifier circuit, respectively, whereby rotation of said commutator causes said transformer system to translate the rectified low voltage applied to said commutator to high voltage energy which is rectified by said last rectifier circuit to produce direct current pulses, said inductance element having a value which tunes with said condenser.

9. In a system for producing equal length pulses of carrier wave energy, a source of relatively low voltage alternating current, means for translating said low voltage current into high voltage current pulses, said means including a condenser and circuit elements for charging said condenser from said low voltage source and circuit connections for periodically discharging said condenser through the primary of an induction coil after said condenser has been charged, a rectifier coupled to the secondary winding of said induction coil for producing high voltage direct current pulses, an oscillator, and means for periodically applying said high voltage direct current pulses to said oscillator for exciting the same to produce interrupted trains of carrier wave energy.

10. In a system for producing equal length pulses of carrier wave energy, a source of relatively low voltage alternating current, means for translating said low voltage current into high voltage current pulses, said means including a condenser and circuit elements for charging said condenser from said low voltage source and circuit connections for periodically discharging said condenser through the primary of an induction coil after said condenser has been charged, a rectifier coupled to the secondary winding of said induction coil for producing high voltage direct current pulses, an energy storage circuit coupled to said rectifier and adapted to be charged to a critical value, an oscillator, a path from an electrode of said oscillator to said energy storage circuit, whereby said storage circuit discharges through said oscillator upon exceeding said critical value to supply a polarizing potential to said oscillator, to thereby cause it to produce oscillations.

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