

C. I. ZIMMERMAN, DEC'D.
J. G. ZIMMERMAN, ADMINISTRATOR.
SYSTEM FOR PRODUCING HIGH TENSION CURRENTS.
APPLICATION FILED AUG. 25, 1909.

1,139,623.

Patented May 18, 1915.

4 SHEETS—SHEET 1.

TRANSLATING DEVICE.

Fig. 1.

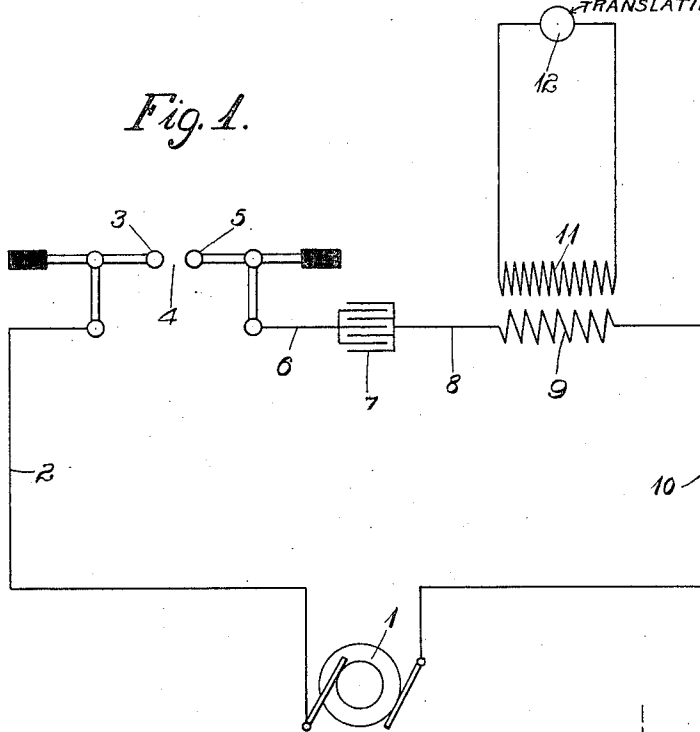
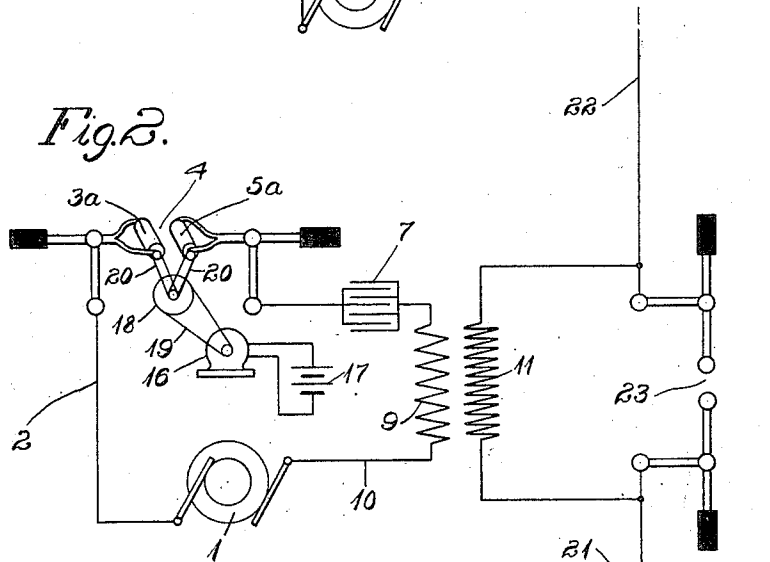


Fig. 2.



Witnesses

George E. Higham.
Leonard W. Novander

Inventor:
Clarence I. Zimmerman, Deceased
by James G. Zimmerman, Administrator,

By Brown & Alliman
Attorneys

J. G. ZIMMERMAN, ADMINISTRATOR.

SYSTEM FOR PRODUCING HIGH TENSION CURRENTS.

APPLICATION FILED AUG. 25, 1909.

Patented May 18, 1915.

4 SHEETS—SHEET 2.

1,139,623.

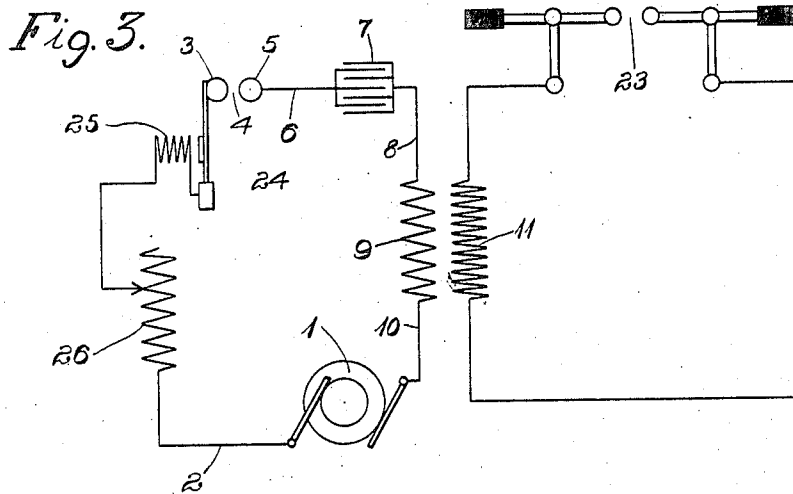
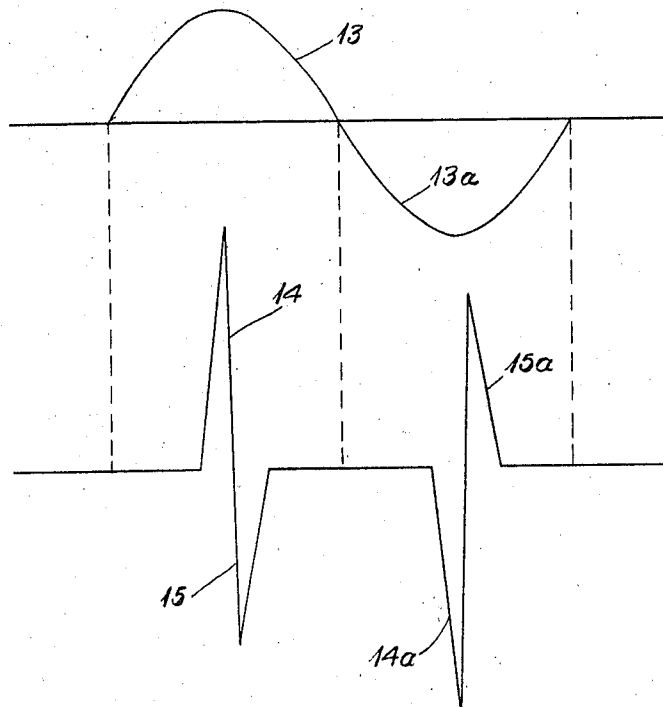


Fig. 5.



Witnesses

George E. Higham.
Leonard W. Novander

Inventor: Clarence I. Zimmerman,
by James G. Zimmerman, Administrator, ^{Deceased,}

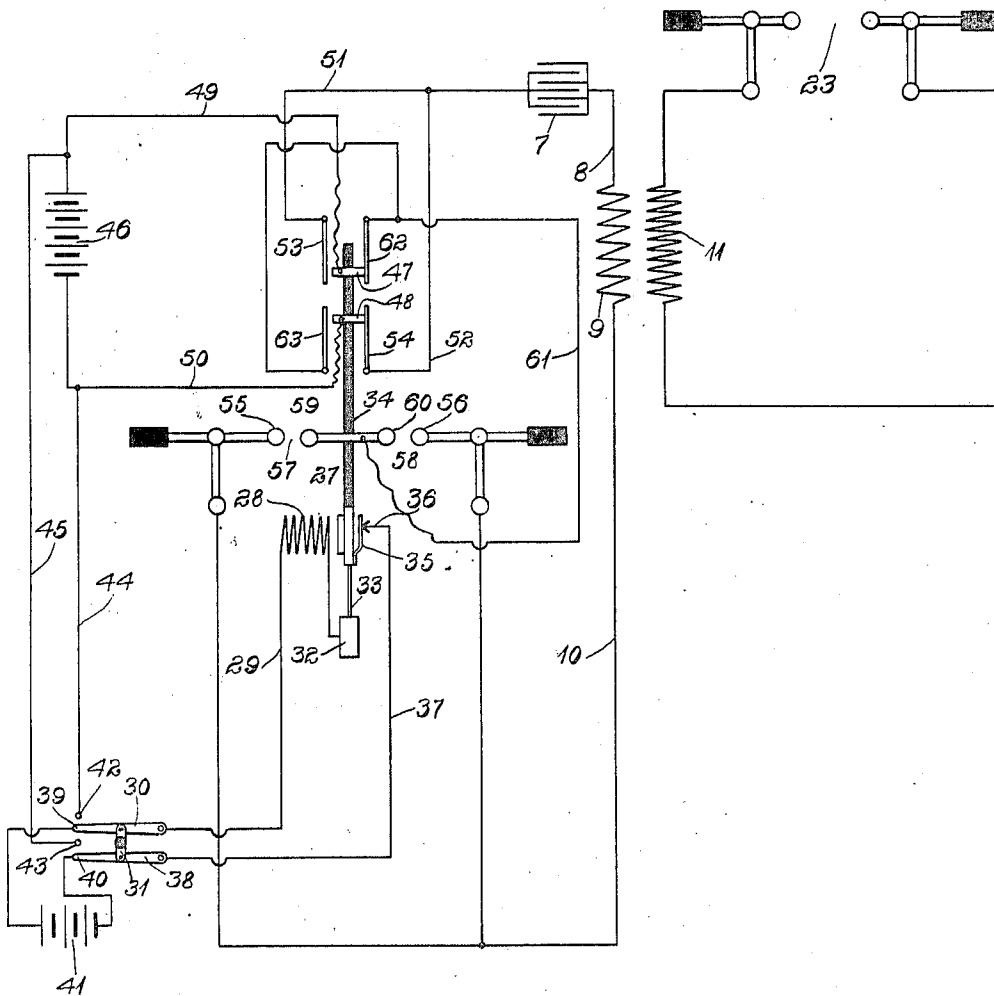
By Brown Williams
Attorneys

C. I. ZIMMERMAN, DEC'D.
J. G. ZIMMERMAN, ADMINISTRATOR.
SYSTEM FOR PRODUCING HIGH TENSION CURRENTS.
APPLICATION FILED AUG. 25, 1909.

1,139,623.

Patented May 18, 1915.
4 SHEETS—SHEET 3.

Fig. 4.



Witnesses

George C. Higham.
Leonard W. Novander

Inventor: Clarence I. Zimmerman,
Deceased
by James G. Zimmerman, Administrator,

By Brown & Williams
Attorneys

C. I. ZIMMERMAN, DEC'D.
J. G. ZIMMERMAN, ADMINISTRATOR.
SYSTEM FOR PRODUCING HIGH TENSION CURRENTS.
APPLICATION FILED AUG. 25, 1909.

1,139,623.

Patented May 18, 1915.

4 SHEETS—SHEET 4.

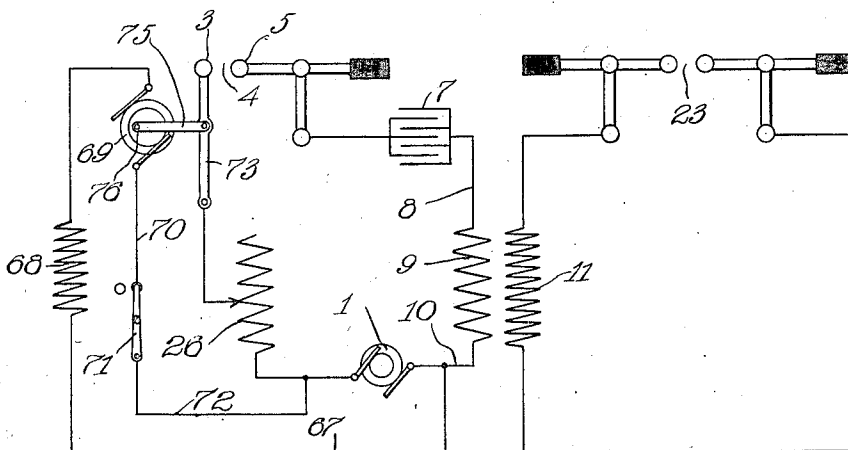
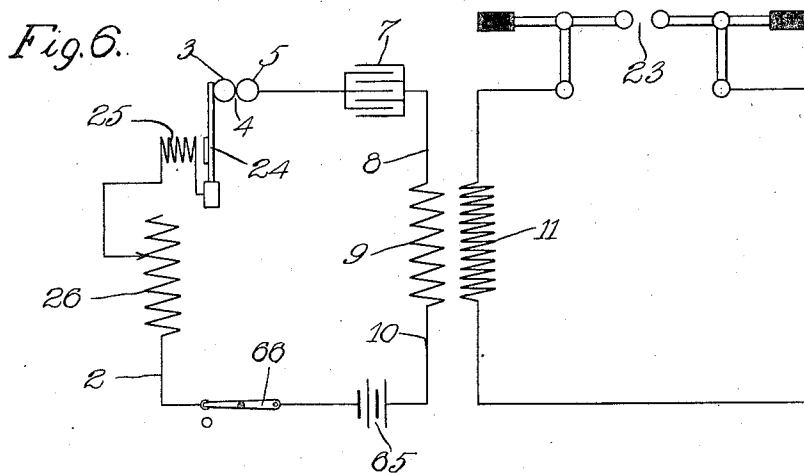


Fig. 7.

Witnesses

George E. Higham.
Frank J. Shlen

Inventor: Clarence I. Zimmerman,
deceased,
by James G. Zimmerman, Administrator,

By

Brown William
Attorneys

UNITED STATES PATENT OFFICE.

CLARENCE I. ZIMMERMAN, DECEASED, LATE OF MADISON, WISCONSIN, BY JAMES G. ZIMMERMAN, ADMINISTRATOR, ASSIGNOR, BY MESNE ASSIGNMENTS, TO SAID JAMES G. ZIMMERMAN, OF CHICAGO, ILLINOIS, INDIVIDUALLY.

SYSTEM FOR PRODUCING HIGH-TENSION CURRENTS.

1,139,623.

Specification of Letters Patent.

Patented May 18, 1915.

Application filed August 25, 1909. Serial No. 514,548.

To all whom it may concern:

Be it known that CLARENCE I. ZIMMERMAN, deceased, late a citizen of the United States, residing at Madison, in the county of Dane and State of Wisconsin, did invent a certain new and useful Improvement in Systems for Producing High-Tension Currents, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

This invention relates to an improved means for modifying the form of current waves delivered to a circuit by means of a source of electric energy whether intermittent, pulsating or alternating in type.

The invention has for its object so transforming such waves of current that the electromotive forces producing them are comparatively high and that the current waves thus produced are of comparatively short duration. This change may be accomplished in the electric circuit whether use is made of transforming means or not, as a result of which the invention affords a desirable means for the production of intermittent currents of extremely high voltage. These currents are particularly adapted for use in connection with wireless telegraphy and also for use in X-ray work, the ignition apparatus of gas engines, etc.

It will be understood that "high" tension is a relative term and that this invention may be useful in connection with the production of currents of any tension so long as the same mode of operation and result is maintained. "High" is herein intended to designate a current under tension sufficiently high to jump a gap and those skilled in the art are hereby advised that this invention is applicable to uses where tensions lower than those in the uses above outlined are desired.

This invention is applicable to currents produced either by alternating current generators, pulsating current generators or currents produced by means of pole-changers from sources of direct current.

The several drawings illustrating the invention are as follows:

Figure 1 is a diagrammatic view of the invention in one of its simplest forms, showing the mechanism employed in connection with an alternating current generator for producing currents as described; Fig. 2

shows in diagrammatic arrangement apparatus similar to that shown in Fig. 1, with the addition that the terminals of the spark gap employed in the generator circuit are specially constructed to stand excessive wear; Fig. 3 shows in diagrammatic arrangement apparatus similar to that shown in Fig. 1, the difference being that means are shown in this figure for more easily starting and breaking the current flow across the spark gap employed than is possible with the apparatus shown in Fig. 1; Fig. 4 shows in diagrammatic arrangement the circuits used in the invention in producing currents of the character described by means of a pole-changer from a direct current source; Fig. 5 shows diagrammatically the relation between the voltage delivered by the alternating current and the voltage produced as a result of the arrangement of mechanism shown in Fig. 1; Fig. 6 is a diagrammatic arrangement of a modification similar to Fig. 3, the difference being that the alternating current source of supply is replaced by a direct current source; Fig. 7 shows a diagrammatic arrangement of a modification similar to Fig. 3, the difference being that a motor is used to synchronously operate the spark gap instead of the electromagnet shown in Fig. 3.

Similar numerals refer to similar parts throughout the several views.

As shown in Fig. 1, an alternating current generator 1 is connected by wire 2 with one terminal 3 of a spark gap 4, the other terminal 5 of which is connected by wire 6 with a condenser 7. The other terminal of the condenser is connected by wire 8 with the primary winding 9 of an induction coil, the other terminal of which is connected by wire 10 with the other terminal of the generator 1. The secondary winding 11 of the transformer is connected with a suitable translating device 12, which may be of any form, as for instance, a spark gap or the sending apparatus of a wireless telegraph or a similar mechanism. The alternating current generator 1 is assumed to be adapted to produce an electromotive force which it impresses upon the wires 2 and 10 of the circuit described of the form shown at 13 in Fig. 5. As a result, during a positive impulse, a difference of potential is impressed upon the spark gap 4, increasing in amount and having a con-

stant tendency to send current across the gap in one direction. When the potential of the positive wave reaches a value sufficient to rupture the air between the terminals 3 and 5, current jumps across the gap and begins the charging of the condenser 7. As soon as the gap 4 is bridged by the current the resistance of the gap is much reduced, as a result of the vaporization of a small portion of the positive one of the electrodes 3 and 5. This produces a momentary flow of current of high voltage such that the condenser 7, which is of such a capacity to permit it, is almost instantaneously charged. When this condition is nearly reached, the potential upon the terminals 3 and 5 is brought to nearly the same value, and therefore current ceases to flow across the gap 4. From this it follows that the current flowing through the primary winding 9 is of very short duration and of practically the maximum value that the generator 1 can cause to flow through the circuit described, and that therefore the core of the transformer is practically instantaneously magnetized. Since, the ratio of the transformer windings being determined, the voltage developed by the secondary winding 11 depends upon the rate of change of the magnetic flux through the transformer core, it follows that a voltage of extremely high value is produced at the instant when the current flowing momentarily through the primary winding 9 accomplishes the magnetization of the transformer core. The voltage thus produced is indicated in Fig. 5 by the peak 14 of the electromotive force wave. The gap 4 and the condenser 7 are so adjusted that the complete magnetization of the transformer core and the cessation of current flow across the gap 4 occur before the end of the positive wave of electromotive force 13 producing such current flow. As a result, immediately upon the cessation of current flow through the primary winding 9, the magnetization of the transformer core at once drops to its zero value and thus produces a negative impulse 15 of induced electromotive force in the secondary winding 11 of the transformer. This negative impulse will, however, be of somewhat smaller value than the positive impulse 14, and the length of the two impulses 14 and 15 will depend largely upon the magnetic constants of the transformer used in Fig. 1. The succeeding negative wave 13^a of electromotive force developed by the generator 1 will operate in a manner similar to the wave 13 to produce impulses 14^a and 15^a similar to impulses 14 and 15, but of opposite sign. The cycle of operation indicated in Fig. 5, it is to be understood, is indefinitely repeated as the generator 1 rotates.

As shown in Fig. 2, the terminals 3^a and 5^a of the gap 4 consist of rollers which are formed of material adapted to resist the arc-

ing action produced by the current, as for example, carbon. These rollers are arranged to be rotated slowly by means of a motor 16 driven from a suitable source of electric energy 17. The motor 16 is connected with the rollers 3^a and 5^a by means of a counter-shaft 18 and suitable belting 19 and 20. In this way a maximum amount of surface is presented to the points of arcing in order to extend as much as possible the life of the terminals of the spark gap. If desired the motor 16 may be dispensed with and the rollers 3^a and 5^a may be rotated by hand. In this figure the secondary winding 11 of the transformer is connected with the ground 21 and the serial conductor 22 in parallel with the spark gap 23, as might be the case for the sending of wireless messages.

In the modification shown in Fig. 3, the terminals 3 and 5 of the spark gap 4 are normally in nearer position than they could be placed with the arrangement shown in Fig. 1, and are adapted to be moved apart by the current flow through the primary winding of the transformer. In this modification, the terminal 3 is secured to a vibratory member 24, rigidly mounted at its lower end and adapted to be vibrated by the coil 25 connected in circuit with the generator 1. The circuit in this modification also includes an adjustable resistance 26. The secondary winding 11 is connected in circuit with the spark gap 23, which constitutes the load upon the secondary circuit. The operation of this modification is as follows: When the waves of alternating electromotive force produced by the generator 1 reach a sufficient value to cause the current to flow between the terminals 3 and 5 of the gap 4, the coil 25 operates to attract the vibratory member 24 and thus draws the terminals 3 and 5 apart. This results in a condition found desirable in connection with the use of a condenser 7 of comparatively small capacity that the initial resistance of the gap 4 may be in a measure maintained, since the reduction in resistance due to the partial vaporization of the positive contact is compensated for to some degree by the greater length of the arc, and in this manner the duration of current flow across the gap 4 may be shortened and thus the inductive effect upon the secondary winding 11 may be increased.

As shown in Fig. 4, a pole-changer 27 is arranged so that its motor-winding 28 is connected by wire 29 to the pivotal point of one member 30 of the double switch 31. The other terminal of the winding 28 is connected to the block 32, forming the rigid support of the spring 33 of the vibrating member 34 of the pole-changer. The spring 33 carries in electrical contact therewith a spring 35, constituting one terminal of the make and break mechanism of the pole-

changer, the other terminal 36 of which is connected by wire 37 with the pivotal point of the other member 38 of the double switch 31. The members 30 and 38 are arranged to engage the contacts 39 and 40 connected with the terminals of battery 41 when in one position, or the terminals 42 and 43 when moved to their other position, such terminals 42 and 43 being connected by wires 44 and 45 with the terminals of the battery 46. The vibratory member 34 of the pole-changer carries two circuit-changing contacts 47 and 48, insulated from each other and from the spring 33, and connected by flexible conductors and wires 49 and 50 with the terminals of the battery 46. The condenser 7 is connected by wire 8 with one terminal of the primary winding 9 of the transformer, as in Fig. 1, and the other terminal of such condenser is connected by wires 51 and 52 with contacts 53 and 54 adapted to be engaged one at a time by contacts 47 and 48, respectively. The other terminal of the primary winding 9 is connected by wire 10 with the terminals 55 and 56 of spark gaps 57 and 58, respectively, the other terminals of which 59 and 60 are connected to a common bar and carried by the vibratory member 34 of the pole-changer. The terminals 59 and 60 of the spark gaps 57 and 58 are connected by a wire 61 with the contacts 62 and 63, which are adapted to be engaged one at a time by the contacts 47 and 48, respectively, carried by the vibratory member 34. From the apparatus and connections just described, it will be seen that when the switch 31 is moved to connect the winding 28 either with the battery 41 or 46, as desired, that the arm 34 is vibrated so as to bring the contacts 47 and 48 into engagement with the contacts 53 and 63, respectively, when the arm is moved to the left and with the contacts 62 and 54, respectively, when the arm is moved to the right, thus alternately closing the circuit from the battery 46 through the wires 49 and 50 in reverse directions through the primary winding 9 of the transformer. When the vibratory arm 34 is in the position shown in the drawings, the circuit may be traced as follows: battery 46, wire 49, contact 47, contact 62, wire 61, terminal 60, gap 58, terminal 56, wire 10, primary winding 9, wire 8, condenser 7, wire 52, contact 54, contact 48, wire 50, back to battery 46. When the vibratory arm 34 is moved to the left by the action of the winding 28 to bring the contacts 47 and 48 into engagement with the contacts 53 and 63, respectively, the circuit from the battery 46 may be traced as follows: battery 46, wire 49, contact 47, contact 53, wire 51, condenser 7, wire 8, primary winding 9, wire 10, terminal 55, spark gap 57, terminal 59, wire 61, contact 63, contact 48, wire 50, back to battery 46. From this

it appears that each impulse of current delivered by the battery 46 to the primary winding 9 passes over one of the spark gaps 57 and 58, and that the spark gap operating for any particular impulse serves the same purpose as described in connection with Fig. 1. It is to be observed that each spark gap also performs the function of interrupting the current flow before the circuit is broken at the corresponding contacts closed by the vibratory arm 34, as a result of which the wear upon such contacts, which occurs almost entirely upon breaking the circuit rather than making the circuit in ordinary practice, is eliminated. The modification produced in the waves of electromotive force in this modification of the invention, while similar to that produced in connection with the apparatus shown in Fig. 1 as described above, may, however, differ in degree, depending upon the arrangement of the apparatus and the adjustment of the pole-changer and condenser 7.

In the modified arrangement shown in Fig. 6 the connections are similar to those used in Fig. 3, with the exception that the alternating current generator 1 is replaced by a battery 65 and a switch 66. In this modification, in order to start the operation of the device, it may be desirable that the terminals 3 and 5 of the spark gap 4 be normally in contact. For this condition, when the switch 66 is closed current at once flows under the full potential of the battery 65 through the primary winding 9 and the resistance 26 to charge the condenser 7. At the time that this current flow occurs, magnet 25 is energized and the terminals 3 and 5 of the spark gap 4 are separated, thus almost immediately after the closing of the circuit causing an arc and rupture of the circuit. As soon as the current flow is interrupted, the magnet 25 is deenergized and the terminals 3 and 5 again come in contact and the cycle is repeated, the frequency of operation depending largely upon the natural rate of vibration of the vibratory member 24 carrying the terminal 3. The operation of this modification will give results similar to those produced by the modification in Fig. 4, the difference being that with the modification shown in Fig. 6 current pulsations are directed through the primary winding 9 constantly in the same direction, while in the modification shown in Fig. 4 these pulsations are directed through the primary winding 9 alternately in reverse directions. For the modification shown in Fig. 6 the form of current waves produced in the primary winding would be as indicated at 13 in Fig. 5, while the induced current waves produced in the secondary winding would all be as shown at 14 and 15 in Fig. 5. The operation of the modification shown in Fig. 7 is similar to that shown in Fig. 3,

with the exception that the vibratory member 24 is replaced by a lever 73, to the upper end of which the terminal 3 is secured. The lever 73 is connected by a link 75 with a crank 76 carried by a synchronous motor 69, the arrangement being such that the rotation of the motor will serve to alternately bring the terminals 3 and 5 nearer together and farther apart in a manner similar to the operation of the vibratory member 24 by the electromagnet 25, shown in Fig. 3. As shown in Fig. 7, the motor 69 may be supplied with current from the generator 1, through the wires 67 and 72, suitable resistance 68 being included in circuit to properly control the current supplied to the motor 69. A switch 71 is provided between the wires 70 and 72 to start or stop the motor 69 as desired. In this way the length of the spark gap 4 is varied synchronously with the alternations produced by the generator 1 and the resultant effect upon the primary winding 9 is substantially the same as that already described in connection with Fig. 3.

While the invention is shown in the particular embodiments herein described, it is not, however, limited to these constructions, but any equivalent that may suggest itself to those skilled in the art is claimed broadly.

The following is claimed:

1. In an electrical translating system, a circuit, a source for impressing upon such circuit a periodic electromotive force, a translating device in such circuit, a spark gap and condenser in series with said source and said translating device in such circuit for developing in the translating device an electromagnetic force wave, the complete active portion of each period of which is of shorter duration than the period of the applied force, and means for varying the length of the spark gap by the current flowing through the circuit.

2. In an electrical translating system, a circuit, a source for impressing upon such circuit a periodic electromotive force, a translating device in such circuit, a spark gap and condenser in series with said source and said translating device in such circuit for developing in the translating device an electromagnetic force wave, the complete active portion of each period of which is of shorter duration than the period of the applied force, and a magnet in such circuit for increasing the length of the spark gap when current flows across such gap.

3. In an electrical translating system, a source of alternating current, a circuit extending from such source, an inductive device in such circuit, a spark gap and a condenser in series with said source and said inductive device in such circuit, such spark gap and condenser together adapted to

change the effect of the alternating current in such inductive device to vary the inductive effect of such device, and means for varying the length of the spark gap by the current flowing through the circuit.

4. In an electrical translating system, a source of alternating current, a circuit extending from such source, an inductive device in such circuit, a spark gap and a condenser in series with said source and said inductive device in such circuit, such spark gap and condenser together adapted to change the effect of the alternating current in such inductive device to vary the inductive effect of such device, and a magnet in such circuit for increasing the length of the spark gap when current flows across such gap.

5. In an electrical translating system, a circuit including in series arrangement a prime source of current, a translating device, spark terminals, and a condenser.

6. In an electrical translating system, a circuit including in series arrangement a prime source of current, a primary winding of a transformer, a spark gap, and a condenser.

7. In an electrical translating system, a circuit including in series arrangement a source of current, a translating device, spark terminals, and a condenser, and a magnet for separating the terminals.

8. In an electrical translating system, a circuit including in series arrangement a source of current, a primary winding of a transformer, a spark gap, and a condenser, and means for varying the gap synchronously with the periodicity of the current.

9. In an electrical translating system, a circuit including a source of current, a translating device, and spark gap terminals variable as to the distance between them with and dependent upon the periodicity of the current in the circuit.

10. In an electrical translating system, a primary circuit including in series a prime source of current, a spark gap, a condenser, and the primary winding of an induction coil, and a secondary circuit including the secondary winding of the induction coil, and a translating device.

11. In an electrical translating system, a primary circuit including in series a prime source of current, a spark gap, a condenser, and the primary winding of an induction coil, and a secondary circuit including the secondary winding of said induction coil, and a spark gap.

In witness whereof, I hereunto subscribe my name this 12th day of August, A. D. 1909.

JAMES G. ZIMMERMAN,

Administrator for Clarence I. Zimmerman.

Witnesses:

MARY A. DISCH,
HENRY G. DISCH.