No. 780,999. PATENTED JAN. 31, 1905.

P. C. HEWITT.

METHOD OF TRANSFORMING ELECTRICAL ENERGY.

APPLICATION FILED APR. 25, 1902.

Fig. 1.

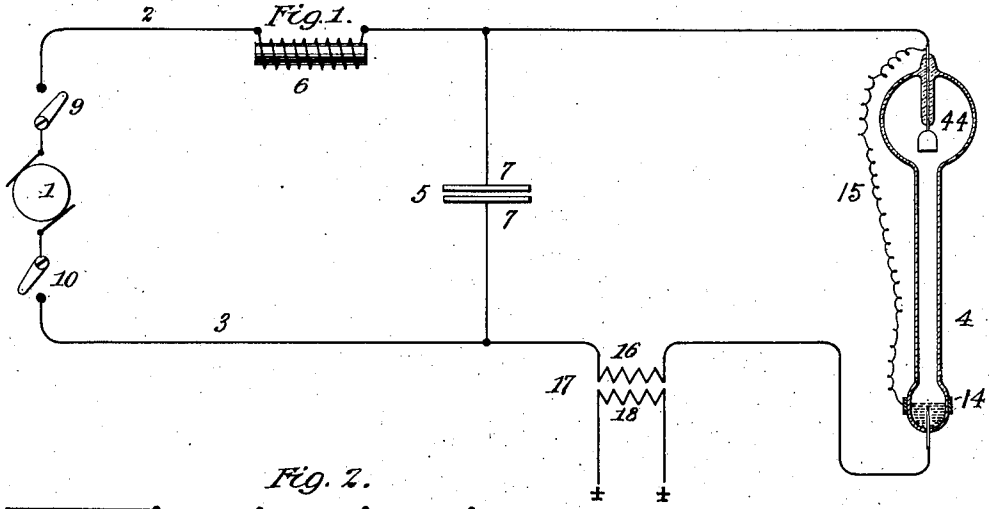
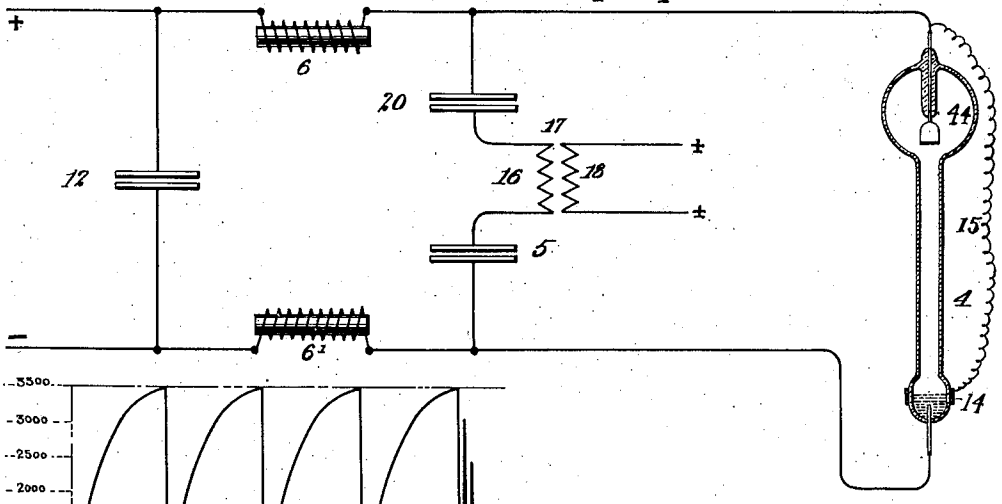


Fig. 2.



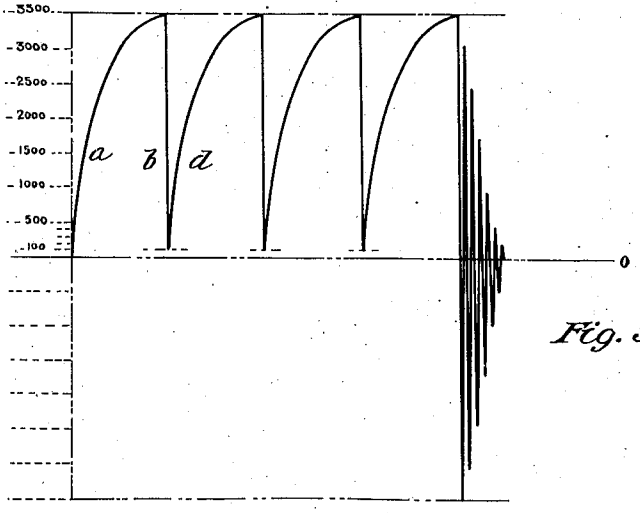


Fig. 3.

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UNITED STATES PATENT OFFICE.

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METHOD OF TRANSFORMING ELECTRICAL ENERGY.

SPECIFICATION forming part of Letters Patent No. 780,999, dated January 31, 1905.

Application filed April 25, 1902. Serial No. 104,607.

To all whom it may concern:

Be it known that I, PETER COOPER HEWITT, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Methods of Transforming Electrical Energy, of which the following is a specification.

I have found that when an inclosed gas or vapor of suitable character and density contained within a holder of suitable character and dimensions and having appropriate electrodes is connected in an electric circuit there will be opposed to the passage of electric current an initial resistance which may be overcome by an electromotive force of sufficient value, the gas or vapor then serving as a conductor across the gap in the metallic circuit when the proper conditions of current are supplied. This initial resistance appears as if a self-created electrical-resistance phenomenon at the negative electrode, which on being overcome removes itself without any appreciable energy loss. The resistance which the gas or vapor shall offer to the current during the period of discharge may be made of practically any desired value within wide limits, while the initial resistance above referred to can also be made of any desired value, each independently of the other. In other words, it is possible to so construct an apparatus of this sort as to present initially a very high resistance to the passage of the current and to present a very low resistance to the current after it has once been established through the apparatus. Should other conditions be required, both these factors may be varied by altering the construction of the apparatus in the first instance. Assuming, however, a low resistance during the discharge period and a desired initial resistance, the amount of work done in the vapor-gap is practically very small. Accordingly an apparatus of the kind described can be economically used in place of a spark-gap, possessing by reason of the features above mentioned a very great advantage over the ordinary air-gap and a still greater advantage over a Wehnelt interrupter. The described factors having once been fixed may be kept at their normal value by maintaining a constant temperature of the inclosed gas or vapor. The means for maintaining such a temperature, as well as the means for controlling and determining the other factors hereinbefore mentioned, are fully set forth in certain patents issued to me on the 17th day of September, 1901. If desired, special means for maintaining a constant temperature may be applied to the apparatus when it is used in place of a spark-gap. Inasmuch as the electrodes remain practically unchanged by repeated use and the whole apparatus is substantially unaltered, a single apparatus will operate without any need of attention or repair. Should it be desired to provide a higher initial resistance, so as to increase the rise of potential in the discharge-circuit, a new apparatus can be substituted calling for such higher potential at the start; but this new apparatus may, like the first, consume little or no current during the discharge period. These electric circuit-breakers may be used in series or parallel, and in case it is not desired to have the initial resistance to starting so great it may be modified by starting-bands at the electrodes, as described in my patents, and in case it is desired to operate several breakers in parallel they may be timed by connecting the starting-bands or groups thereof together. In these respects the described apparatus is superior to the ordinary air-gap, in using which it is necessary to keep the terminals of the conductors or balls smooth and polished and in which any increase in the initial resistance (as by the separation of the balls or conductors) also entails an increase of resistance during the period of discharge, and, further, the resistance during the discharge period may be lower and is far better than a Wehnelt interrupter on account of the great loss of energy in the Wehnelt interrupter.

Another feature of my apparatus is that the gas between the electrodes acts as a true vapor-conductor after the circuit is once established through the vapor, and when this con-

ductor is made of very low resistance practically a short circuit is formed. Since the vapor-resistance factors are known and the conditions they are subject to, the action can always be depended upon. By the passage of current the electrical pressure or voltage is lowered to a point where the resistance to starting re-forms, whereupon the checked current rebuilds or reëstablishes itself, its electrical pressure rising until the breaking-down pressure is again attained, after which the same succession of actions is repeated.

By utilizing the described apparatus in the manner indicated periodic currents of high frequency can be produced, by reason of the fact that its action is very quick and uniform. It is especially adapted to the work of creating currents of definite time periods and rapid alternations. I have found, for instance, that with a device consisting of an inclosed mercury-vapor organized in the manner described in my patents above referred to and provided with a condenser and a reactive device suitably placed and adjusted with reference thereto it is possible to produce such currents, the action being in the first instance to apply to the terminals of the vapor-gap a potential difference sufficient to overcome the initial resistance, whereupon a rapid fall of potential takes place until it reaches a point where it is insufficient to overcome the reduced resistance at the vapor-gap. At this point the current ceases to flow, the break in current-flow being abrupt on account of the immediate reëstablishment of the initial resistance of the vapor. Thereafter the applied potential rises until it reaches the breaking-down pressure of the initial resistance, and then the same cycle of operations is repeated.

The intermittent or vibratory currents produced in the circuit by the circuit-breaker thus described may be applied to use in the vapor or gas gap itself, or they may be applied to other apparatus, or to both simultaneously. For example, one application of the present invention would be to serve the purposes of furnishing a periodic current for wireless telegraphy and another for producing rapidly-varying currents for the purpose of producing light by induction, and still another application would be that of producing light—say in the vapor-gap itself—by means of successive electrical impulses of relatively high electromotive force, causing a high illumination of the vapor or gas at such rapid intervals that the physiological impression is that of continuous illumination. In making the last-named application of my invention I cause the intermittent currents produced by the intermittent action of my apparatus to act upon the vapor in the gap in such a way as to produce a brilliant light. To this end the density of the vapor and the dimensions of the container are suitably proportioned to each other for this purpose, as set forth in a general way in my patents of September 17, 1901; but whereas in the inventions set forth in the said patents the vapor is intended to be affected by a flow of current of given value at a certain potential the purpose in the present instance is to affect the gas or vapor by an intermittent flow of a current of practically the same value, but of higher potential, the energy represented by the intervals between the impulses being intermittently withdrawn from action and reappearing in the form of an increased quantity in the rapid periodic currents. The result is an increased brilliancy on the part of the lamp due to this increased consumption of energy per unit of time, while the effect upon the eye becomes that of a light due to a continuous flow of current of greater quantity.

In the accompanying drawings, illustrating an application of my invention, Figure 1 is a diagram showing a general organization of the apparatus. Fig. 2 shows a modification, and Fig. 3 is a theoretical diagram.

Referring to the drawings, 1 represents any convenient source of electrical energy—say, for instance, a continuous-current generator (which for convenience it may be assumed in this particular instance to be of three thousand five hundred volts.)

2 and 3 represent main conductors leading from the generator.

4 represents an electric device of the character described in my patents hereinbefore referred to. This is connected at any convenient point between the conductors 2 and 3. A condenser 5 or other suitable device or means for affording an electrical capacity is connected across the terminals of the device 4. An inductive resistance 6 is connected in the line 2 between one plate 7 of the condenser 5 and the source 1 of current. It is to be understood that by referring to a condenser I mean to include other suitable means for securing the requisite electrical capacity.

Assuming that the circuit of the generator is closed by the switches 9 and 10, there will be a sudden rush of current through the lines 2 and 3, tending to charge the plates 7 7 of the condenser 5. The inductor resistance 6 opposes a counter electromotive force to the applied electromotive force, thus temporarily resisting the flow of current beyond that resistance. The condenser 5 thus becomes gradually charged as the electromotive force at its terminals rises. Assuming that the device 4 will be traversed by a current under the influence of a difference of potential of three thousand five hundred volts, then as soon as the condenser 5 has attained its charge a current will traverse the device; but the moment such current does traverse the device the difference of potential at its terminal is enormously reduced. Practically it may be made to drop as low as one hundred volts or even below twenty volts. Thereupon the condenser 5 discharges or feeds the circuit be-

tween itself and the device. The reactive coil 6 may serve to prevent at this time too great a discharge from the source of current. On the discharge of the condenser the passage of current through the device will cease and the operation be repeated, causing rapidly-succeeding impulses of current to traverse the device. Each succeeding impulse will be at a potential of, say, three thousand five hundred volts, and the light emitted by the device will be of a brilliancy due to the product of the average voltage into the current during the successive time intervals of current-flow. It is characteristic of these devices that they may be constructed not to pass an appreciable amount of current below a given voltage which can be predetermined, and therefore at the end of certain definite periods the current ceases to pass. Accordingly the device has a definite consumption period between the extreme higher limit of applied electromotive force and the lowest limit at which the device will take current. What is perceptible to the eye is the luminous vibrations due to these successive passages of current, the intervals of no current being undiscernible by reason of the rapidity with which the intervals follow each other. It is also characteristic of apparatus of this type, whether used as a lamp or as a discharge-gap, that it may be so dimensioned with relation to the vapor-column that the heat radiation will be equal to the heat absorbed under ordinary conditions—that is to say, the temperature may be maintained constant—thus securing constant density in the gas or vapor. The enlargement represented by the chamber 44 at the top of the devices 4 in Figs. 1 and 2 is usually employed as contributing to the maintenance of stable temperature and density. The period of the condenser may be further retarded by an inductance device placed in the condenser-circuit. An additional condenser, 12, placed between the source and the condenser 5, may serve to assist the speed of charge and discharge through the inductance 6. A similar inductance 6′ may be included in the branch 3, if desired.

In my devices the starting is usually facilitated by the use of a band 14, placed in the neighborhood of the negative electrode upon the exterior of the device and connected by a conductor 15 with the positive electrode or the conductor leading thereto, and is useful where lower initial voltages are to be used. Action of this band may be that of producing an electric strain at or near the negative electrode, such strain tending toward causing a discharge to pass between the electrodes. In any case it is found that the presence of a starting-band in the position indicated in the drawings makes it possible to start the apparatus by the application of a lower electromotive force than would be the case if the band or some equivalent thereof were not present.

By inserting the primary coil 16 of a converter 17 in one of the conductors—for instance, 3, as shown in Fig. 1—an alternating current may be produced in a secondary circuit 18, which in turn may be used for any desired purpose. The primary coil 16 in this case may be utilized as the inductance device referred to above for retarding the period of the condenser-circuit.

In Fig. 2 I show the primary 16 of the converter 17 connected up between two condensers 5 and 20, connected in series across the terminals of the device 4.

In Fig. 3 I have shown in diagram the theoretical curve illustrative of the differences of potential and the changes therein which may occur in a circuit such as shown in Fig. 2. When the circuit is closed, there is a rise of potential at the terminals of the device from zero to three thousand five hundred volts, as shown by the portion *a* of the curve. Thereupon current traversing the device the condenser discharges, dropping the current to one hundred volts, as indicated by the portion *b* of the curve. The voltage then again rises to three thousand five hundred volts, as indicated by the portion *d* of the curve, the rate of charging being dependent upon the amount of self-induction or resistance in the circuit between the condenser and the source. By varying this self-induction the portion *d* of the curve may be made more or less abrupt, and by varying the inductive capacity of the circuit between the condenser and the device the portion *b* of the curve representing the operation of the device may be more or less prolonged. The lines drawn above and below the zero-line near the end of Fig. 3 are designed to illustrate the gradually-decreasing surgings of the condenser-current during the interval of discharge in its circuit.

By properly adjusting the capacity of the condenser, the circuit, and also the inductance almost any required definite period of charge and discharge may be secured. The condenser 5 may be made to act either by reason of its own natural period of oscillation or governed by the charge which it receives from the line as controlled by the line.

The currents developed in the circuit and hereinbefore described as utilized for increasing the luminosity of one of my lamps may in addition be used for other purposes, or the quality of my apparatus as a light-giving body may be fully subservient to the development of currents for other purposes. In other words, I may in some instances construct a gas or vapor apparatus having the primary object of controlling the rate of currents developed in the system, which currents may or may not operate to give light in the apparatus.

In distinction from the ordinary air-gap the

apparatus herein described as being used for an analogous purpose is so constructed and the material forming the path for the discharge is of such a character that no injurious effect is caused by the operation of the apparatus for long periods. Moreover, the conditions under which the vapor constituting the path is placed make it possible to predetermine and control the voltage required to break down the resistance of the gap, which always remains the same in any given apparatus under the same conditions. The apparatus can be so constructed that the loss of energy during the passage of the discharge will be practically negligible—that is to say, the medium through which the discharge passes may be of such high conductivity that no material waste of energy will take place in the operation of the device. By virtue of the same quality the apparatus imposes no material limitation upon the natural number of useful oscillations of the circuit. These features, which render the apparatus controllable, avoid the suppression of useful oscillations, prevent waste of energy, and render the resistance of the device independent of the current flowing after the initial resistance has been overcome, are among the features which differentiate the present apparatus from what is usually known as the "spark-gap" or "air-gap." A further differentiation is that the device when constructed with high conductivity operates without developing inertia characteristics—that is to say, the initial high resistance is immediately reconstructed as soon as a discharge passes, whereas there is no such sudden cessation of action when an air-gap is traversed by a discharge.

It is incidental to the character of my apparatus that I am at liberty to construct the electrodes either of volatile or non-volatile material. The electrode material may conveniently be a conducting liquid, in which case the electrode will present a clean liquid-surface, and in case the liquid is volatile the electrode will possess the property of never becoming heated beyond the boiling-point of the liquid. Such material as volatilizes from the electrode may be condensed—say in the cooling-chamber 44—and in returning in the condensed state to the electrode will unite with the latter, thus replacing the loss due to vaporization. The intensity of certain characteristic electrode phenomena may be increased or diminished by devices external to the electrode, such as the action of the starting-band or the effects of temperature on the electrode.

In a companion application, Serial No. 104,608, filed April 25, 1902, claims are made upon certain features of the apparatus herein described; in another application, which is a division thereof, Serial No. 124,624, filed September 24, 1902, claims are made upon certain other features described herein, and in another application, which is a division of the present application, Serial No. 214,901, filed July 1, 1904, claims are made upon a method of producing light described in this specification.

I claim—

1. The method of producing a periodic flow of electric current through a medium which opposes a practically prohibitive resistance to potential below a given value, which resistance may be overcome by a difference of potential materially greater than said value, and is of a determinate amount through the intermediate values, which consists in first applying to the terminals of said medium a potential of the higher value, thereby starting the flow of current, opposing to the flow a predetermined resistance so low as to render the energy loss practically negligible, thereby causing a sudden drop of potential below the lower value and interrupting the flow of current, and successively repeating this operation.

2. The method of producing intermittent or vibratory electric currents in a circuit containing a circuit-controller which has a high initial resistance and possesses the quality of taking no current below a definite low limit of electromotive force, which consists in periodically impressing upon the circuit an electromotive force higher than that at which the controlling device starts, and successively opposing to the electromotive force thus impressed upon the circuit the high initial resistance of the circuit-controller and a predetermined lower resistance, continuing the application of the lower resistance through a definite period until the lowermost operative limit has been reached, and then repeating this cycle of operations.

3. The method of producing intermittent or vibratory electric currents in an electric circuit, which consists in periodically impressing on the said circuit currents of definite electromotive force, and interposing in the said circuit in series with each other a high resistance and a resistance which is independent of the current flowing, causing the said impressed currents to break down the high resistance and to traverse the lower resisting medium for a definite period.

4. The method of producing intermittent or vibratory electric currents in a successively charged and discharged circuit, which consists in utilizing as the breaker in the discharge-circuit, the transition resistance between a confined gaseous electric conductor and a non-gaseous conductor.

5. The method of producing intermittent or vibratory electric currents in a successively charged and discharged circuit, which consists in utilizing as the breaker in the discharge-circuit the transition resistance between a confined gaseous electric conductor and a non-gaseous conductor, the gaseous conductor being of such a nature as to be rendered luminous by the passage of the current after the spark-gap is bridged or broken down.

6. The method of producing intermittent or vibratory electric currents in a successively charged and discharged circuit, which consists in utilizing as the breaker in the discharge-circuit the electrode resistance at the contact between a confined gaseous electric conductor and a non-gaseous conductor.

7. The method of operating an electrical translating device having a high initial resistance and a subsequent resistance not adapted to disturb the natural rate of vibration of the circuit in which it is included, and having the quality of taking no current below a definite low limit of electromotive force, which consists in charging a source of relatively high electromotive force, periodically discharging this source through the translating device, regulating the charging period by interposing suitable impedance, the period being so timed as to permit the current in the discharge-circuit to pass to or below the lowermost operative limit of the translating device before the source of high-potential currents is again discharged.

8. The method of periodically making and breaking a discharge-circuit, which consists in passing the discharge through a circuit-interrupter which maintains the natural rate of oscillation of the circuit.

9. The method of periodically making and breaking a discharge-circuit, which consists in passing the discharge through the circuit, and controlling the discharge by periodically interposing in the circuit a conductor having such relation to the electrical energy as to render the loss of energy in the conductor practically negligible.

10. The method of periodically making and breaking a discharge-circuit, which consists in passing the discharge through a circuit-interrupter wherein the loss of energy maintains the natural number of oscillations in the circuit.

11. The method of periodically making and breaking a discharge-circuit, which consists in interposing periodically in such circuit a resistance which is practically independent of the current flowing.

12. The method of operating an electrical translating device having a high initial resistance and having the quality of taking no current below a definite low limit of electromotive force, which consists in periodically breaking down the initial high resistance by means of a source of relatively high electromotive force, choking down the potential applied to the translating device to or below the lowermost limit of operation by devices entirely independent of the translating device, recharging the source of relatively high electromotive force, and repeating the cycle as often as desired.

13. The method of operating an electrical translating device having a high initial resistance and having the quality of taking no current below a definite low limit of electromotive force, which consists in periodically charging a source of relatively high electromotive force, periodically discharging this source through the translating device, and regulating the charging period by the development of a retarding force external to the translating device.

14. The method of producing intermittent or vibratory electric currents in a successively charged and discharged circuit, which consists in passing the discharge through a conducting gas or vapor of predeterminable resistance and intermittently interrupting the flow by interposing the transition resistance between such gaseous conductor and a non-gaseous conductor.

15. The method of producing intermittent or vibratory electric currents in a successively charged and discharged circuit, which consists in passing the discharge through a conducting gas or vapor of practically negligible resistance and intermittently interrupting the flow by interposing in the circuit the transition resistance between such gaseous conductor and its electrode.

16. The method of producing intermittent or vibratory electric currents in an electric circuit, which consists in impressing upon the said circuit alternately a high electromotive force and a lower electromotive force resulting from the subsequent flow of current, lowering the electromotive force below the effective carrying-point of the circuit within a predetermined period of time, and repeating these operations.

17. The method of converting an electric current of approximately constant difference of potential into intermittent or vibratory currents, which consists in accumulating successively charges of electric energy, and successively opposing to such charges an electrical resistance capable of being overcome by the accumulated potential, and a resistance of predetermined lower value.

18. The method of converting an electric current of approximately constant difference of potential into intermittent or vibratory currents, and of applying the currents thus produced, which consists in successively accumulating charges of electrical energy, successively opposing to such charges an electrical resistance capable of being overcome by the accumulated potential, and a resistance of predetermined lower value, and translating the effects of the successive accumulations and discharges.

19. The method of rapidly charging and discharging an electric circuit, which consists in causing the discharge to pass through a gas or vapor and suppressing the development of inertia characteristics.

20. The method of producing and utilizing alternating or intermittent electric currents in a system of electrical distribution, which con-

sists in continuously generating electric currents in a portion of the system, periodically discharging the energy of the same through another portion of the system, causing a sudden diminution in the resistance of the latter portion of the system and a consequent drop of potential therein, thereupon causing an automatic interruption of the flow of currents through that portion, and transforming into useful energy the intermittent current-flow thus produced.

Signed at New York, in the county of New York and State of New York, this 23d day of April, A. D. 1902.

PETER COOPER HEWITT.

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