No. 774,138. PATENTED NOV. 1, 1904.

H. LEMP.

EXCITING VACUUM TUBES.

APPLICATION FILED MAR. 28, 1902.

NO MODEL.

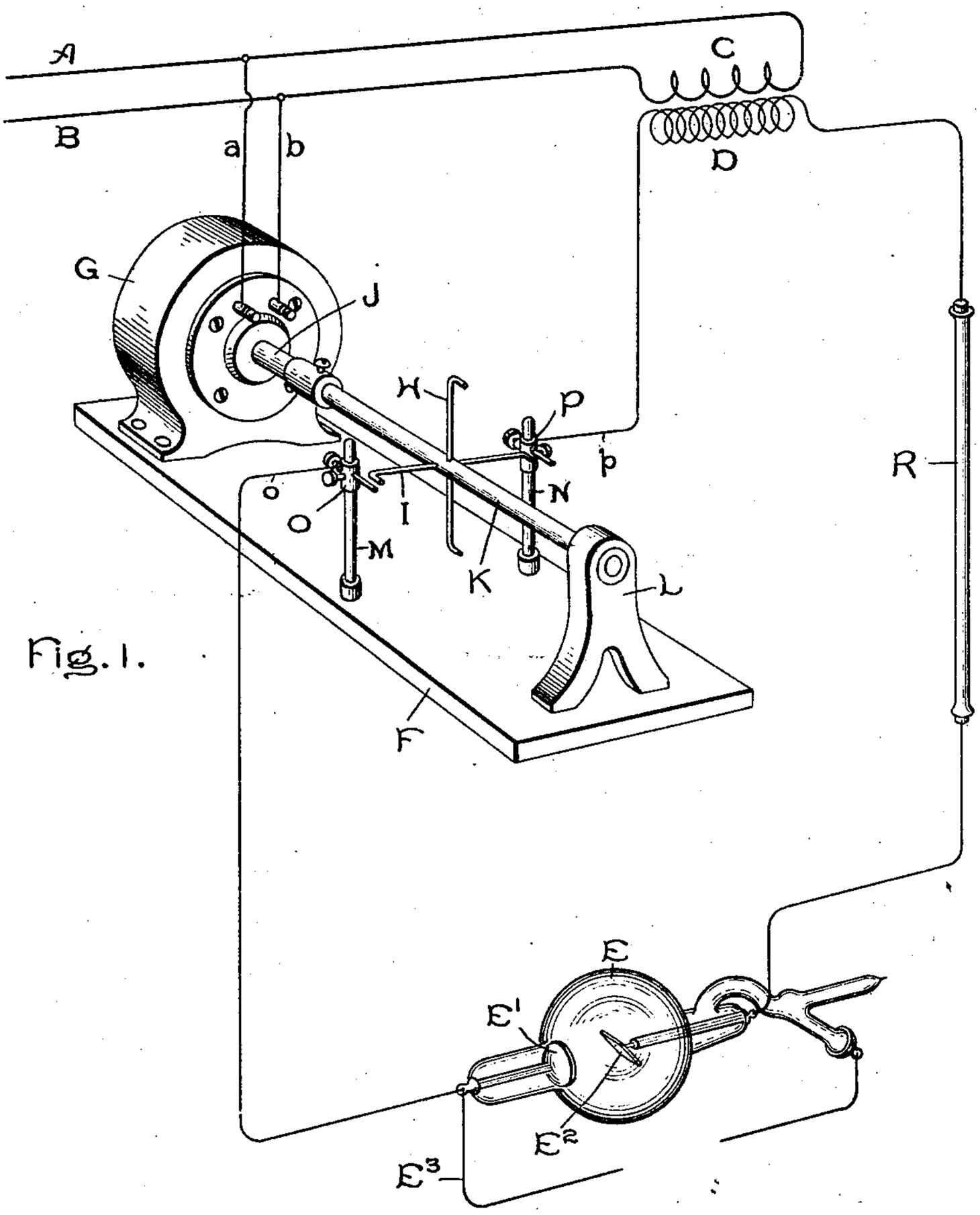


Fig. 1.

Fig. 2.

Witnesses:
Marcus R. Byng.
Alex. F. Macdonald.

Inventor:
Hermann Lemp,
by Albert G. Davis
Att'y.

No. 774,138. Patented November 1, 1904.

# UNITED STATES PATENT OFFICE.

HERMANN LEMP, OF LYNN, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

## EXCITING VACUUM-TUBES.

SPECIFICATION forming part of Letters Patent No. 774,138, dated November 1, 1904.

Original application filed December 1, 1897, Serial No. 660,431. Divided and this application filed March 28, 1902. Serial No. 100,480. (No model.)

*To all whom it may concern:*

Be it known that I, HERMANN LEMP, a citizen of the United States, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Exciting Vacuum-Tubes, of which the following is a specification.

The present case is a division of my pending application, Serial No. 660,431, filed December 1, 1897, which division is made under the requirements of Rule 41 of the United States Patent Office.

For exciting Roentgen-ray and similar tubes it is considered highly desirable to employ a unidirectional current. For this current a continuous-current source of supply has been almost universally used. An alternating-current source of supply has certain advantages, notably because of the readiness with which the necessary high potential may be secured; but the difficulty of rectifying alternating currents to secure a unidirectional current has heretofore been so great that alternating-current generators have not been used with success.

I have discovered a method of operation whereby a source of alternating current may be rendered available for exciting Roentgen-ray tubes or other apparatus requiring unidirectional currents of high potential.

When employing an alternating-current generator, I propose to utilize only fractions of the waves, preferably the wave-crests, when the potential is at a maximum. By selecting the wave fractions so utilized from points of like sign in the electromotive-force waves unidirectional discharges through the tube or other apparatus are secured. In this way the tube may be excited by a unidirectional current, and I avoid the heating of the tube which would take place if current corresponding to parts of correspondingly low voltage in electromotive-force waves were allowed to flow through the tube. In the ordinary types of X-ray tubes practically no rays are produced until the voltage has risen to ten thousand volts. Above this the ray is increased as the voltage rises. The most satisfactory results are obtained when the potential is very high—as, for example, one hundred thousand to one hundred and fifty thousand volts.

In the accompanying drawings, Figure 1 is a perspective view, partially in diagram, of one form of apparatus for carrying out my invention; and Fig. 2 shows the portion of the current-wave that is utilized to excite the tube.

Apparatus capable of carrying out my invention will now be described.

Mains A and B are connected to any suitable source of alternating current of moderate voltage having a periodicity, for example, of sixty or one hundred and twenty-five cycles per second. Connected across the mains is a step-up transformer having a primary C of comparatively few turns and a secondary D, composed of a large number of turns of fine wire, which is employed to excite tube E. The secondary voltage will depend upon the voltage of mains A and B; but to obtain the best results the voltage across the secondary mains should be between one hundred thousand and one hundred and fifty thousand volts.

Mounted upon an insulating-base F is a single-phase synchronous motor G, which is connected across the primary mains by wires *a* and *b*. The motor shown in the drawings is provided with eight poles, so that there are four complete positive and negative potential waves during each revolution of the armature. I have found this to be a satisfactory arrangement; but by changing the number of arms H and I a motor having a different number of poles may be employed, provided the number of arms so corresponds with the speed of the synchronous motor that current is allowed to flow at the proper intervals.

Forming an extension of shaft J is an insulating-shaft K, revolving in bearing L and provided with metal arms H and I.

Mounted upon the base F are two vertically-extending posts M and N, of insulating material and provided at their upper ends with adjustable contacts O and P. Contacts O and

P are respectively connected to wires *o* and *p* and so adjusted that arms H and I when rotated will pass close to them without making actual contact. Arms H and I are similar in construction, each being made of wire and provided with L-shaped extensions on the ends. These wires may or may not be electrically connected. The potential of the secondary is so great that it is not necessary to have actual contact between the arms and stationary contacts. The instant an arm assumes the position shown by I in the drawings current will jump the air-spaces between the arm I and contacts O and P, and the resistance of the circuit will be so far reduced that current will flow through tube E. As arm I moves away from the position shown the resistance is increased, so that the circuit is, in effect, interrupted and remains so until arm H has moved to the position now occupied by arm I. With an eight-pole motor there will be four complete positive and negative potential waves for each revolution of the armature, and with the arms arranged as shown current is allowed to flow through tube E for an instant when the electromotive-force waves reach the maximum and are of like sign. In other words, the relation of the arms and fixed terminals is such that when a positive electromotive-force wave is at or near its maximum an arm will be opposite the terminals, and as the wave rises to its positive maximum again an arm will again be in a position to permit current-flow, the potential being great enough to jump the air-gaps, thus avoiding actual contact. This is more clearly illustrated in Fig. 2, where four complete positive and negative electromotive-force waves are shown, the negative waves being shown in dotted lines and the positive waves in broken and dotted lines. The crests of the positive waves, which are the only portions utilized, are shown in full lines and indicate approximately the length of time current flows across the arms H and I.

I have described my invention as utilizing only the crests of the positive waves; but the same effect is obtained if the crests of the negative waves are utilized. Certain features of novelty in my invention, however, are not limited to sifting out and utilizing the crests of the waves, for by a proper arrangement of the selector I may derive a current or currents corresponding to any desired point or points in the electromotive-force waves while preventing the flow of current at other points in the wave.

The tube E is what is commonly called a "single-focus" tube and may be of any desired construction, the one shown comprising a cup-shaped cathode E′ and a flat anode $E^2$. For regulating the vacuum of the tube a shunt $E^3$, having an air-gap or other resistance, is placed around the tube.

To reduce the secondary current, a resistance R is placed in series with one of the secondary leads, consisting of a rubber tube filled with water and having plugs at the ends in which the terminals are mounted. The resistance can be varied by changing the length and diameter of the tube.

It will be seen that the current passing through the tube E is always in the same direction and flows at instants when the potential in the circuit is at a maximum, also that the discharge takes place across the air-gaps between the arms and the terminals, all of which are favorable to the production of X-rays in large quantities.

It will be understood that the resistance R is for the purpose of preventing the secondary current rising to too high a value. It is not at all necessary if the secondary winding D has of itself a sufficiently high resistance. It may also be dispensed with if the transforming apparatus has the property which tends to make the secondary current of constant amount, as when considerable magnetic leakage occurs between the primary and secondary winding. The resistance R when used might be made of any very high resisting material which would tend to diminish the current.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. The method of passing current to a suitable receiving apparatus, which consists in subjecting it to an intermittent current derived from a selected fraction of a series of alternating-current waves of similar sign, and discarding the waves of opposite sign.

2. The method of passing current to a suitable receiving apparatus, which consists in selecting from points of like sign in a series of alternating-current waves a certain fraction of the wave, discarding the waves of the opposite sign, and passing the currents thus selected to the apparatus.

3. The method of passing current to a suitable receiving apparatus, which consists in generating in a circuit periodic alternating waves of current and electromotive force, selecting in a second circuit a series of intermittent unidirectional currents from the peak of the waves of corresponding sign at instants when the potential is a maximum and discarding the waves of opposite sign, and passing to the apparatus said intermittent currents.

4. The method of deriving unidirectional current from a source of alternating-current supply, which consists in periodically and successively including in the circuit of said alternating-current source, at certain predetermined intervals, an air-gap too great for the potential to overcome, and decreasing the air-gap to a point where the current will pass.

5. The method of deriving unidirectional currents from an alternating-current source of supply, which consists in developing alternating electromotive-force waves in an electric circuit, maintaining a resistance in the

circuit at all times, and varying the amount of said resistance in circuit synchronously with the electromotive-force waves so that at a certain point in each wave current will flow, and at other points current will not flow.

6. The method of deriving unidirectional currents from an alternating-current source, which consists in inducing periodic alternating waves of electromotive force in an electric circuit, and varying the length and resistance of an air-gap in the circuit synchronously with the rise and fall of the electromotive-force waves, in such manner that the air-gap permits a flow of current only at points of the same sign in the electromotive-force waves.

7. The method of deriving unidirectional current from an alternating-current source of supply, which consists in constantly maintaining a resistance in the circuit of said source of supply, and periodically and successively varying the amount of said resistance whereby a succession of current impulses are permitted to pass to a translating device only during the intervals when the resistance is reduced by a proper amount.

8. The method of converting alternating current into unidirectional current, which consists in selecting waves of one sign utilizing parts only of said waves, and discarding those of another sign.

9. The method of deriving unidirectional current from a source of alternating-current supply, which consists in selecting a fraction of the waves of one sign and discarding the entire waves of a different sign.

10. The method of exciting vacuum-tubes from a source of alternating-current supply, which consists in selecting a fraction of the waves of one sign, discarding the waves of a different sign, and passing said wave fractions through the tube.

11. The method which consists in impressing on a circuit a high alternating voltage, and periodically varying the opposition to flow of current so that the minimum opposition occurs synchronously with the peaks of waves of one sign only.

12. The method which consists in impressing in a circuit a high alternating voltage, and opposing the flow of current in said circuit except when waves of one polarity only are at or near their maximum value.

13. The method which consists in impressing on a circuit a high alternating voltage, and causing current to pass across an air-gap in said circuit when the waves are at or near their maximum value.

In witness whereof I have hereunto set my hand this 26th day of March, 1902.

HERMANN LEMP.

Witnesses:

DUGALD MCK. MCKILLOP,

JOHN J. WALKER.