(No Model.) 2 Sheets—Sheet 1.

D. McF. MOORE.

ELECTRIC LIGHTING SYSTEM.

No. 548,127. Patented Oct. 15, 1895.

Fig. 1.

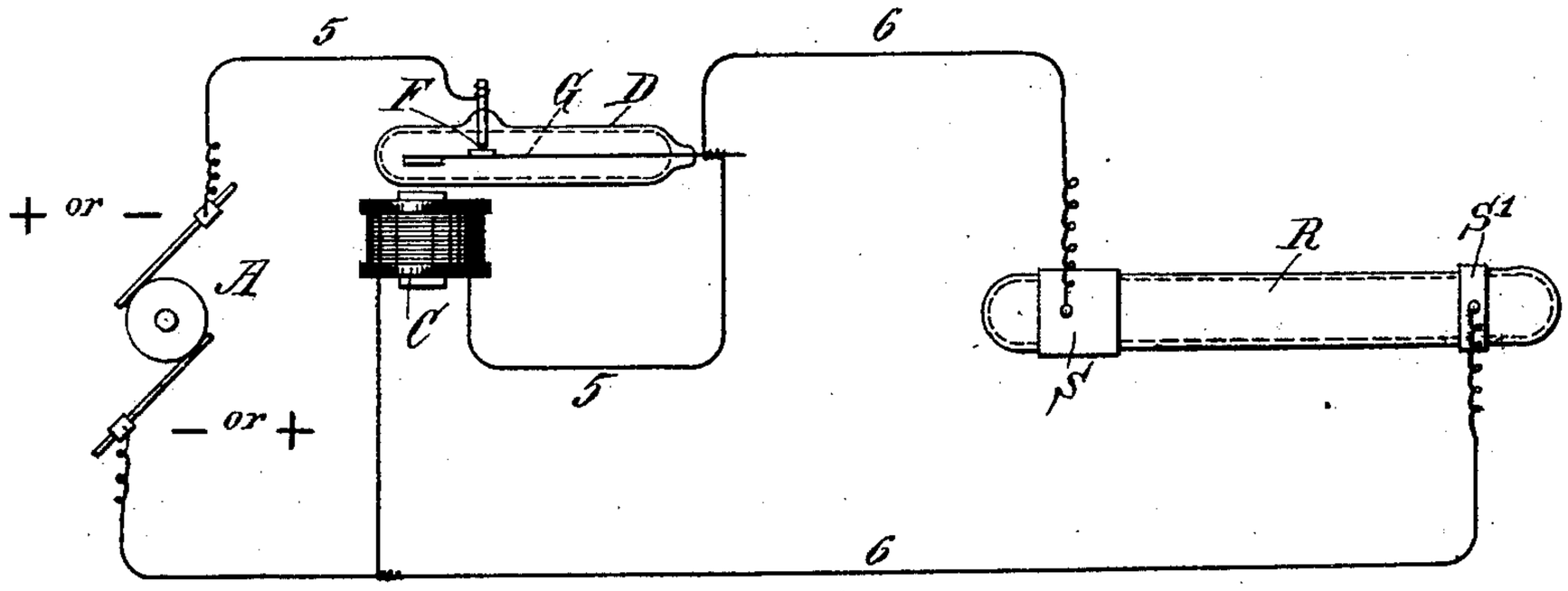
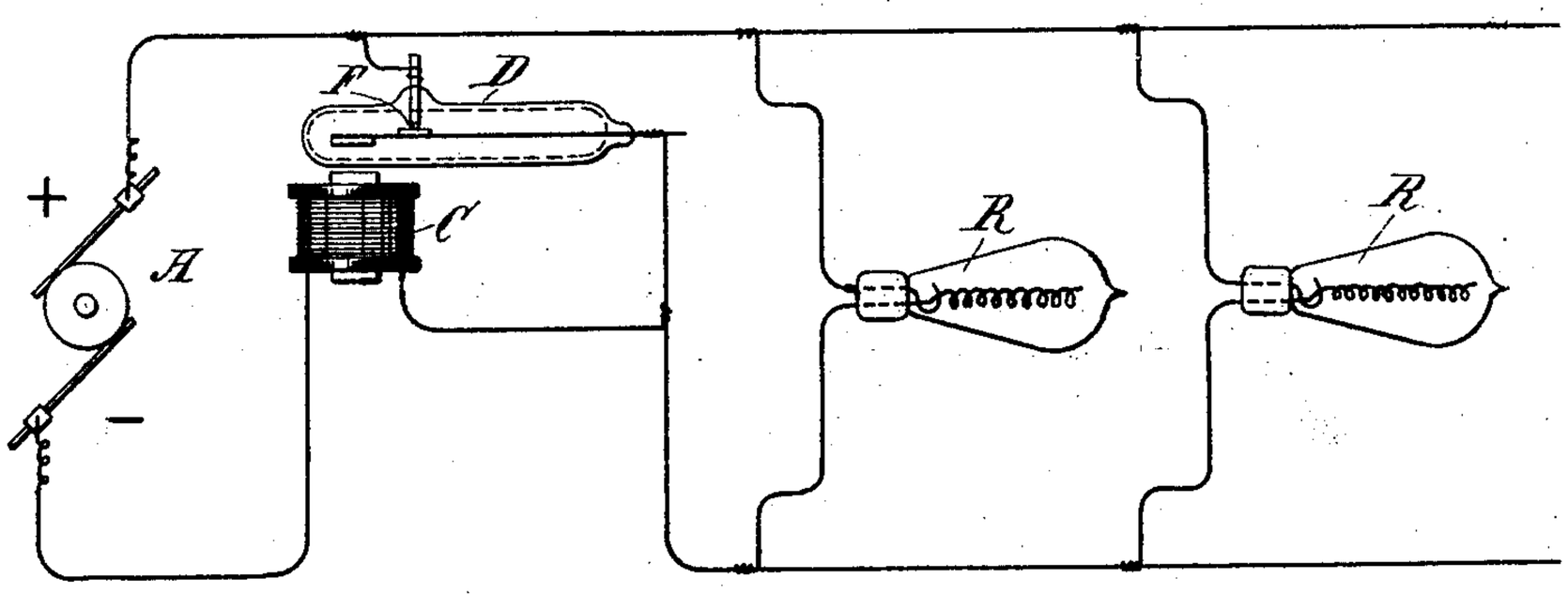


Fig. 2.



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(No Model.) 2 Sheets—Sheet 2.

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Fig. 3.

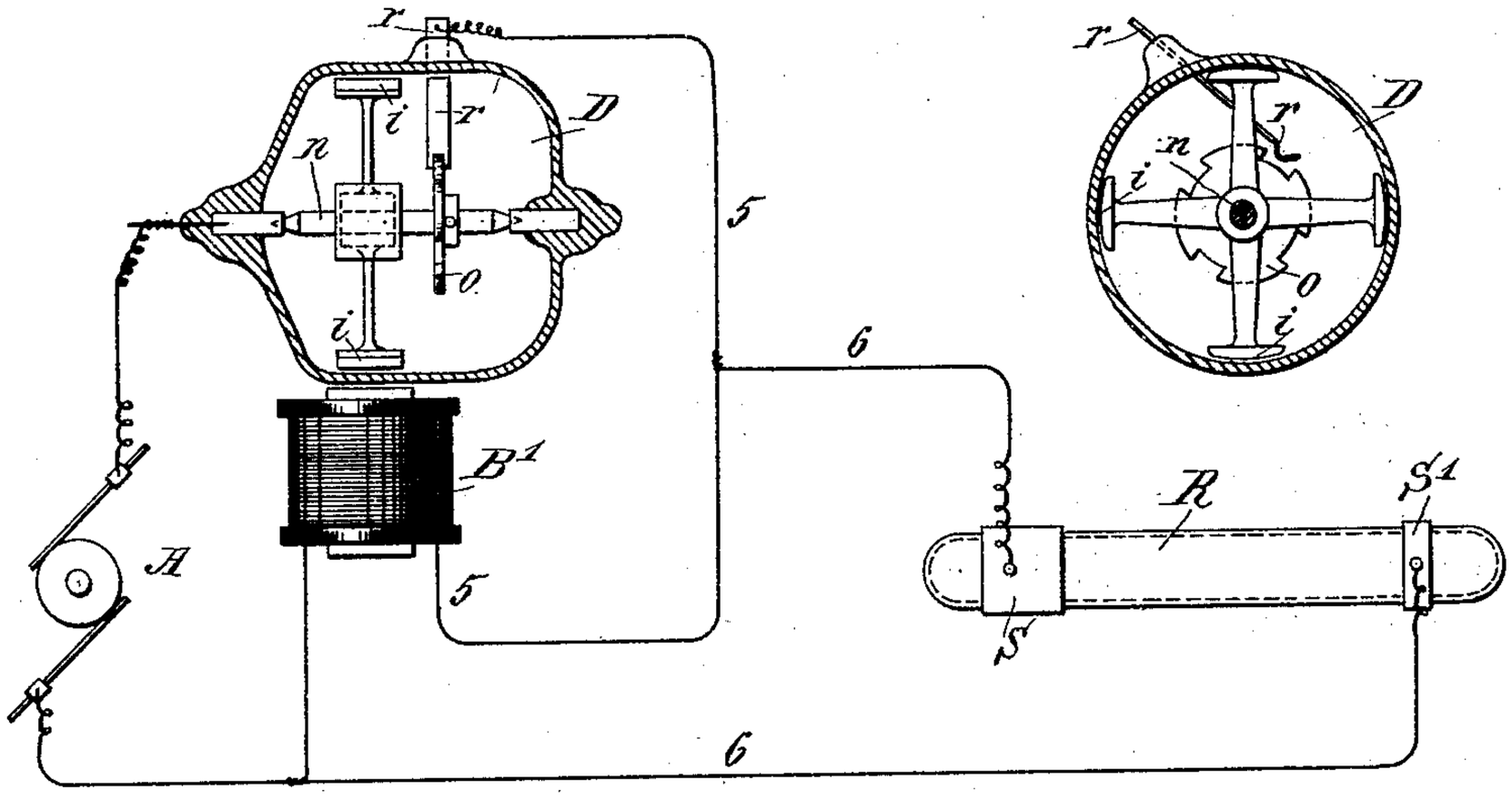
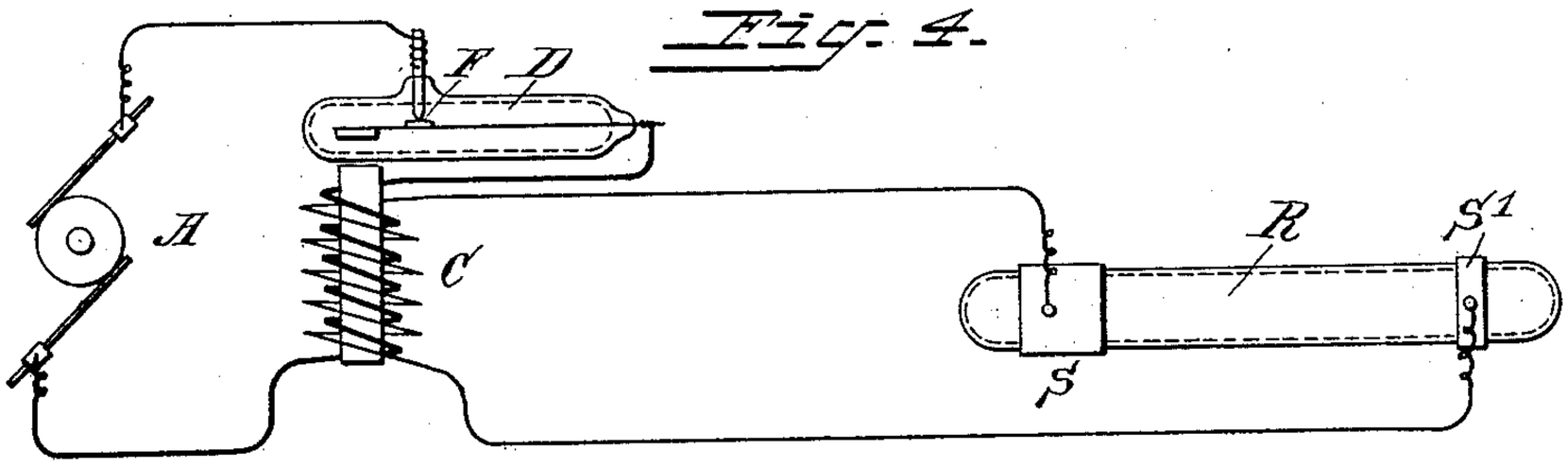


Fig. 3a.

Fig. 4.



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ELECTRIC-LIGHTING SYSTEM.

SPECIFICATION forming part of Letters Patent No. 548,127, dated October 15, 1895.

Application filed July 19, 1895. Serial No. 556,457. (No model.)

To all whom it may concern:

Be it known that I, DANIEL MCFARLAN MOORE, a citizen of the United States, and a resident of East Orange, in the county of Essex and State of New Jersey, have invented a certain new and useful Electric Lamp, of which the following is a specification.

My invention consists of a novel method of and apparatus for electric lighting.

It has lately been proposed to produce light by incandescence of conductors in a highly-rarefied receiver subjected to the action of electric currents of enormous frequency and excessively-high potential. At an earlier stage of the art others employed electric energy of considerable potential acting upon a rarefied gas or vapor, rarefied to the degree best suited to exhibiting luminous effects under the action of the electric vibrations or undulatory disturbances conveyed to it through conductors connected with the secondary of an induction-coil.

In my invention I do not depend upon an excessively-high electric stress or potential. In fact, so far as potential is concerned, experiment seems to indicate that the disturbances generated in my system, as indicated by the length of spark in dry air, do not necessarily have as great a potential as that employed heretofore in efforts to produce luminous effects by electric energy derived from induction-coils, Leyden jars, &c., wherein the attempt was to get a high potential, with the idea that the higher the potential the greater the intensity of the light produced.

My present invention consists, essentially, in generating electric waves or vibrations suitable for producing luminous effects by interrupting the flow of electric current or currents through a circuit of induction in a high vacuum as contradistinguished from a partial vacuum or one in which the rarefaction has not been carried beyond the point suitable for exhibiting luminous effects. The current or currents may be derived from any suitable source and be continuous, intermittent, pulsating, or alternating, as may be desired. The electric waves or vibrations so generated are made to produce luminous effects in any of the ways known in the art, but preferably by action in or upon a receiver containing a rarefied gas or vapor, rarefied to such degree that the whole body of contained gas or vapor will be rendered luminous, as well understood in the art. The interruptions are preferably produced, however, in a vacuum or vacuous space in which the exhaustion is carried as far as possible beyond the degree of rarefaction suitable for producing luminous effects so as to produce as nearly as possible an absolute vacuum, the luminous effects of the generated electric waves or disturbances being produced in another light-giving source consisting, preferably, of a receiver wherein the proper degree of rarefaction for producing light effects exists, such waves or disturbances being conveyed thereto through suitable electric conductors, or made to operate thereon inductively or conductively, as may be found desirable. By interrupting the circuit in an absolute or nearly as possible absolute vacuum each interruption of the continuity of the circuit at the interrupter therein results in the sudden or instantaneous interposition of what may in effect be regarded as an infinite resistance, and one part of my invention accordingly consists in generating electric disturbances or vibrations for producing luminous effects in a rarefied gas or vapor or any other suitable light-giving source by intermittent and sudden interpositions of the infinite electric resistance of an absolute vacuum in a circuit of induction supplied with currents from any suitable source.

By "circuit of induction" I mean any circuit in which electric current flows and which is adapted by its self-induction or by its induction upon a parallel circuit to generate an electromotive force of somewhat higher electromotive force than that of the current flowing upon sudden interruption of the flow of the latter; but I prefer to use the electromotive force of self-induction of the circuit as generated in a coil instead of using a secondary coil, as I find that with a self-inductive coil of very small size the whole body of rarefied gas or vapor in a receiver exhausted to the proper degree, as well understood in the art, may be rendered luminous. Where, however, it is desired to use a small prime generator of very low electromotive force and very small coils, a secondary coil may be used to get the desired potential; but even then the length of coil which it is necessary to use is much less than that

heretofore employed in rendering rarefied receivers luminous, when even the very best form of coil and circuit-breaker is employed. The sudden or instantaneous electromotive forces or disturbances thus generated by the interruption of current-flow in a vacuum are conducted in any suitable way by electric conductors to the field in which the luminous effects are to be generated, and there inductively or conductively applied. When a self-induction coil is employed, the conductors which convey away the electric currents or vibrations are simply connected in shunt to the coil or terminals thereof in the well-understood way.

It will of course be understood that the waves of energy developed by the sudden interruptions above described of the circuit of induction may undergo any desired transformation or transformations before application to the light-giving source.

When the interrupter works in an absolute vacuum, the break of circuit is necessarily very abrupt, since, owing to the difficulty or inability of the current to flow through a high vacuum, a complete interruption of current-flow is necessarily established just so soon as mechanical contact ceases. In other words, the interruption is instantaneously complete and the rate of change of electric condition in the circuit of the generator is correspondingly rapid. Moreover, when the interruptions are produced in the circuit of a coil, the extra current of which is conveyed by branch or shunt wires to the lamp, it will be obvious that the vacuum is of service in cutting off the flow of such high-potential currents across the break. It is therefore desirable to make the vacuum as high as possible when the lamp consists of a receiver containing a rarefied gas or vapor, or, in other words, to make the degree of rarefaction of the latter low, as compared with that of the interrupter, both for luminous effects and to avoid shunting of the extra current across the break in the interrupter. In general therefore I prefer to make the vacuum in which the interrupter works as high as possible, and especially when the lamp-circuit is of high resistance; but I do not wish to be understood as limiting myself to any particular degree of exhaustion of the space in which the interrupter works, provided the exhaustion is carried beyond what is known as a "partial" vacuum, in which a blue light immediately surrounding the metal portions of a hammer or interrupter of an induction-coil placed under a bell-glass receiver may be produced. The degree of exhaustion which I herein term a "high" as contradistinguished from a "low" or partial vacuum cannot be mathematically expressed, but is best explained by reference to the fact stated by previous experiments that the degree of exhaustion best suited to the rendering a body of rarefied air luminous is about one one-millionth of an atmosphere, which is far beyond what exists in any partial vacuum maintainable under a bell jar, and that the high vacuum which I employ is even greater than that best adapted for luminous effects, and resides in the further degree of exhaustion in which such luminous effects as have been heretofore produced in the whole body of a rarefied gas or vapor disappear.

I am not able to state with exactness to what the superior effects produced by breaking the circuit in the manner above described are attributable; but I believe them to be due to the fact that the abruptness of the change contributes to the production of rapid magnetic oscillations resulting in oscillatory electric currents or discharges of high frequency, the frequency of which is aided by the relatively small self-induction of the coil which it is permissible to use as compared with that of the secondary of induction-coils having the length of winding heretofore necessary to employ. It may also be that the shortness of the time required to effect the break of circuit aids in attaining the result by giving a longer period in which oscillations may take place before circuit is re-established.

Another part of my invention relates to a receiver in which light effects are produced by the electric disturbances or variations of electric energy generated as hereinbefore described. It is possible to produce the effects by the use of a receiver having metal electrodes within it; but the disintegration of the latter renders the use of them objectionable. I find, moreover, that by the improved receiver now to be described I can generally obtain higher luminous effects. In my improved receiver no interior electrodes are employed, and it is unnecessary to have, therefore, any metallic connection passing through the walls of the receiver. Instead of interior electrodes I use exterior electrodes consisting of some metallic or conducting paint applied directly to the surface of the bulb or receiver in any suitable manner and directly connected by conductors with a source of energy suitable for rendering the rarefied interior luminous.

My invention consists, further, in the combination, broadly, of a self-induction coil in the circuit of a suitable generator, a circuit-interrupter for producing rapid interruptions of said circuit in a vacuum of any desired degree of exhaustion, and a lamp or other translating device operated by the electric currents or disturbances thereby generated in said coil, and for that purpose connected as a shunt or branch to the same.

In the accompanying drawings I have shown in general diagram, in Figure 1, apparatus suitable for carrying out my invention. Fig. 2 illustrates a modification in the electric connections of the circuit of induction with the lamps. Fig. 3 shows a modified form of interrupter. Fig. 3ª is a side view thereof. Fig. 4 illustrates that modification of my invention which consists in the use of a secondary coil connected to the electric lamp.

A is any generator of electricity, either continuous, alternating, or varying, adapted to supply a current to a circuit 5 of self-induction. This circuit contains the coil C, wound upon a core of magnetic material to intensify the reactive effects produced by interruption of the circuit 5. This core is preferably well subdivided.

D is a receiver or bulb, within which is a vacuous space exhausted to the highest degree practicable to produce as nearly as may be a perfect vacuum and containing an interrupter of the circuit 5. This interrupter may be of any desired kind and may vibrate or have other motion, as found most expedient, and may be operated in any desired manner. I obtain good effects, however, by operating this vibrator or interrupter by means of an electromagnet in the circuit, which is interrupted at each movement of the vibrating portion of the device, said interrupter having a bias which tends to re-establish the circuit, as well understood in the art. I obtain good results also by using as the operating-magnet the coil of self-induction in which the electric waves or disturbances are generated by interruption of circuit 5.

F is an insulated contact, with which the vibrating spring G, carrying an armature H for electromagnet C, makes connection, the circuit 5 being carried through the parts after the manner of any rheotome.

The bulb D is conveniently made of glass and has the conductors carrying the current on circuit 5 sealed in it.

6 is a circuit by which the energy developed in the coil C by interruption of the circuit may be conveyed away in a branch around said coil for operation upon the receiver R. This receiver may be in the form of a tube, as shown, made of glass, and may take any desired form—as, for instance, the form of a letter of the alphabet for advertising purposes. It is made of glass and contains a rarefied gas or vapor of any desired character which may be varied to produce different colors, as well understood in the art. This tube or receiver is devoid of interior electrodes, but is provided with exterior electrodes S S′. These may be in the form of bands or rings to which wires 6 7 are directly connected. It is desirable that the metal electrodes should be in intimate contact or union with the glass of the bulb or tube.

I obtain superior results by using conducting-paint. I also find that the electrodes S S′ do not require to be of the same size, and that if the electrode S, connected to the end of the coil nearest the brake, be of the size which will give the highest luminosity to the rarefied gas or vapor the size of the other electrode S′ may be largely reduced in area, thus exposing a larger volume of the luminous vapor for giving light. In other words, while it is necessary to use a certain area of electrode for S to get the best effect, the other S′ does not have to be so great. Good results may be obtained if it be no more than one-third the size of S. A number of electrodes applied to the tube at intervals may be employed, thus making it possible to use a very long tube and yet obtain a uniform luminosity. It is advantageous not to make these rings or bands too narrow. It is advantageous also to construct the coil C with special reference to the potential of a generator A. With a generator of one hundred and ten volts I obtain good results by using No. 30 wire, wound upon a five-eighths inch core, which is preferably made rather short. With a one-hundred-and-ten-volt circuit a number of turns—say three thousand—sufficient to give approximately a resistance of ninety ohms in the coil, will give good results when the length of coil is, say, two inches. This applies to the form of lamp shown in Fig. 1.

In practice it will be found that the adjustment of the coil or magnet C, which operates the interrupter to and from the armature of the interrupter, will affect the degree of luminosity produced. The best degree can be obtained by trial, which seems to be due to the fact that the rate of vibration of the interrupter is changed in a way to permit the fullest charging of the circuit of self-induction, each closure of circuit thereby securing the best and strongest reactive effects at interruption.

In the arrangement of circuits shown in Fig. 1 it will be seen that the electric waves or disturbances induced at each interruption by the circuit breaker or interrupter flow in a circuit independent of the generator A, and I find in practice that the best results are obtained by this arrangement. Fig. 2, however, represents another arrangement, in which the waves or disturbances produced by the interruption of the circuit of induction must flow through the generator. The diagram explains itself. In this figure I have also shown a form of lamp having interior electrodes within the rarefied space, which form of lamp is specifically described and claimed in my prior application, filed April 10, 1895.

When a lamp having interior electrodes is employed with an arrangement such as shown in Fig. 1, experiments seem to indicate that a lower-resistance coil C—say as low as fifty ohms in the circuit of the generator A—will produce better results, though there are many conditions affecting the degree of luminosity of which it is difficult to take account, and I only state quantities herein as approximating those which my experiments seem to indicate will give the best results. It is, of course, to be understood that with a change in the potential of the generator a corresponding change in the winding and proportioning of the reactive portion of the circuit would be made. With such an arrangement as shown in Fig. 1, very superior luminous effects can be obtained, and without the use of the cumbersome dynamo-machines, induction-coils,

condensers, &c., which have heretofore been used in this art for producing currents of enormous frequency and excessively-high potential.

It is obvious that my invention is not confined to the use of a vibrating interrupter working in the vacuum. Thus, as indicated in Fig. 3, a rotary interrupter may be employed. In this case the interrupting portions are, as before, closed in an exhausted bulb D, and rotation is effected, preferably, by some exterior device. In the form shown the rotation is effected by the action of a motor-magnet exterior to the bulb, the circuit-interrupter for the circuit of induction operating as a commutator therefor. R is the interrupter-spring, engaging with contact-wheel O, mounted upon a rotary shaft *n*, suitably supported within the bulb. The electromagnet B′, outside the bulb, is in the circuit of the generator C, which circuit includes the bearing of shaft *n*, the wheel *o*, and the spring *r*, as indicated. The magnet B′ is placed in proper relation to the armatures *i*, carried by shaft *n*, to attract the same and give rotation to the shaft, the circuit being broken by the interrupter as each armature approaches the pole of the magnet, and the momentum carrying the shaft around to make circuit again. As in the case of Fig. 1, the extra currents or electric waves of disturbances generated in the coils B′ by the interruptions of circuit within the vacuous space, produces the luminous effects preferably by circulating over wires or conductors independent of the generator C to the bulb after the same manner as indicated in Fig. 1.

It will be observed that in the form of interrupter herein shown the circuit-breaking parts alone are placed in the exhausted receiver and the magnets or other devices for operating the same are exterior to the said receiver. This is important as reducing to a minimum the presence of parts within the receiver from which the occluded gases may escape to gradually impair the vacuum.

In Fig. 4 of the accompanying drawings I have merely indicated diagrammatically that modification of my invention which consists in the use of a secondary circuit parallel to the circuits of induction, whereby the electric waves or disturbances are transformed, and, if desired, may be raised in potential. It will be understood that in this case the interrupter works in a high vacuum as contradistinguished from a low vacuum—that is to say, the exhaustion is carried not only beyond the degree at which a luminous haze may appear at or around the metal points within the vacuous space, but also beyond that higher degree of exhaustion in which the whole body of rarefied gas or vapor may be made luminous. These transformed and intensified waves or disturbances may be used for producing the light; but in this case it will be found that, owing to the vigor of the disturbances which may be produced by the absolute and instantaneous interruption of the primary circuit of induction, the luminous effects may be obtained by the use of a secondary coil far less in length than has heretofore been employed for similar purposes.

Other forms of circuit-interrupting devices will readily occur to those skilled in the art as applicable to the purposes of my invention.

By the term "mechanical interrupter" as claimed herein I mean any device acting by make and break of mechanical contact between two bodies of conducting material.

What I claim as my invention is—

1. The herein described improvement in producing light by electricity, consisting in causing repeated absolute interruptions of a circuit of induction by sudden interpositions of an infinite resistance substantially such as described and utilizing the electric waves or disturbances so generated to produce luminous effects.

2. The herein described improvement in the art of electric lighting, consisting in setting up electric waves or pulsations by repeated mechanical interruptions of a circuit of induction in a high as contradistinguished from a partial vacuum, as described, and utilizing the electric energy so generated to produce luminous effects.

3. The herein described improvement in the art of electric lighting, consisting in producing a succession of interruptions in a circuit of induction by rapidly repeated sudden interpositions of an infinite resistance therein and leading off the electric disturbances or effects so produced through a separate circuit connected to said circuit of induction for operation on the light giving source.

4. The combination, substantially as described, of an electric generator, a circuit interrupter in a high as contradistinguished from a partial vacuum, a generator of electromotive force arising from induction placed in the circuit, and a light giving source consisting substantially of a receiver containing a rarefied gas or vapor.

5. As a means for developing electric energy suitable for producing luminous effects, a circuit interrupter connected with a source of electricity and operating in a vacuous space exhausted as described beyond the degree at which the contained body of rarefied air or gas may be rendered luminous.

6. The combination, substantially as described, of a circuit of induction containing an interrupter working in a high vacuum, and a light giving source in the circuit of the waves or disturbances of electric energy generated by the operation of said interrupter and consisting of a receiver having a lower degree of exhaustion.

7. The combination with a self-inductive coil, of a circuit interrupter therefor working in a high vacuum, and a shunt to said coil leading to translating devices.

8. The combination with a self-induction

coil, of a circuit interrupter therefor working in an absolute vacuum, and in a branch around said coil a lamp consisting of a receiver having a rarefied gas or vapor.

9. The combination of a circuit of induction containing a current generator and interrupter working in a high vacuum, and a lamp consisting of a receiver containing a rarefied gas or vapor and provided with electrodes both external to such receiver, as and for the purpose described.

10. The combination of a self-inductive coil, a generator having circuit therethrough, a rapidly operating interrupter placed in said circuit and having its contacts in a vacuum, and a lamp in a shunt or branch around said coil.

Signed at New York, in the county of New York and State of New York, this 18th day of July, A. D. 1895.

DANIEL McFARLAN MOORE.

Witnesses:

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