No. 632,391. Patented Sept. 5, 1899.

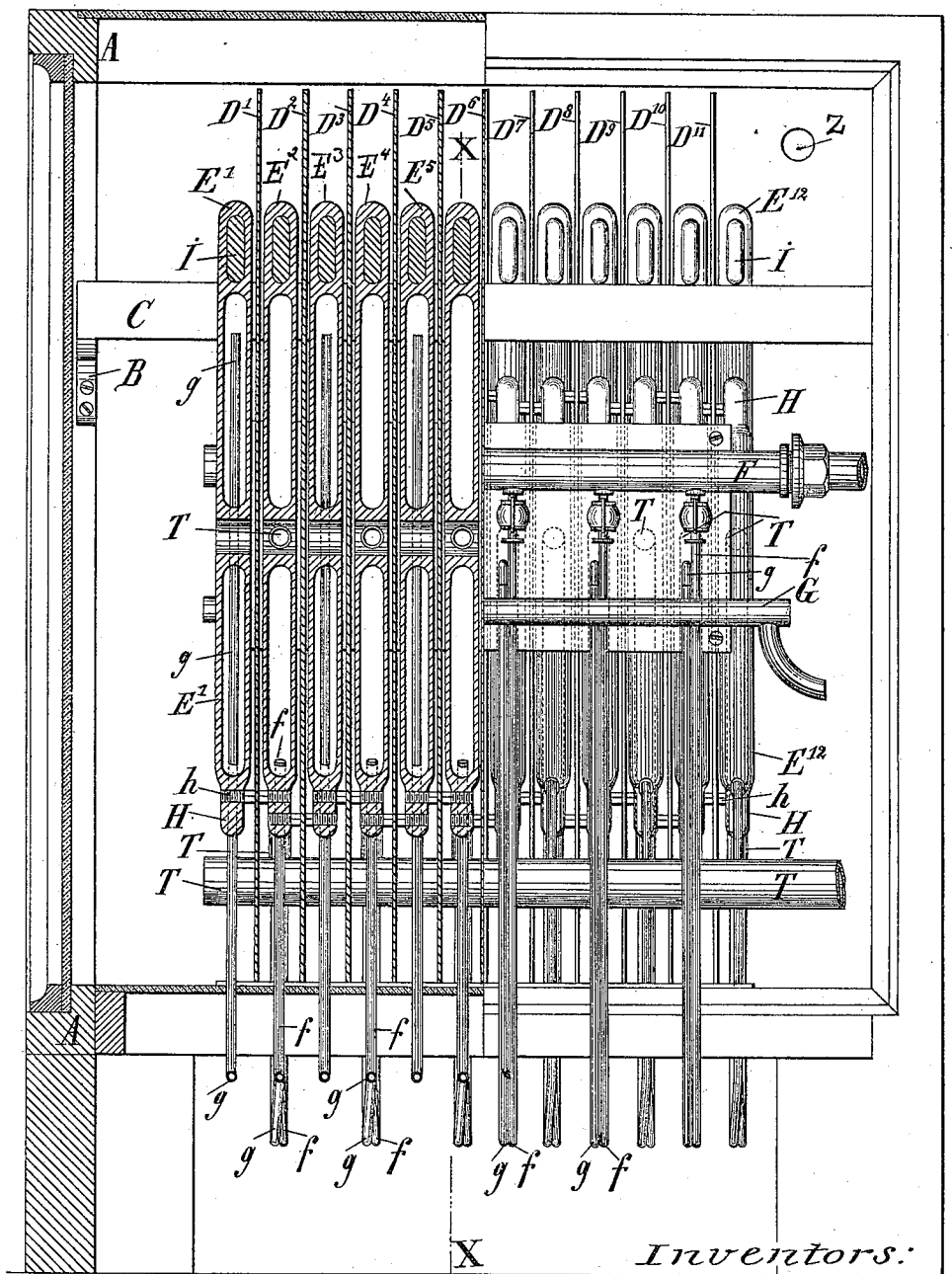
H. ABRAHAM & L. MARMIER.

OZONE GENERATOR.

(Application filed Dec. 21, 1897.)

(No Model.) 4 Sheets—Sheet 1.

FIG. 1.



Witnesses:
E. A. Bolton
Thomas C.

Inventors:
Henri Abraham
Louis Marmier
By Richards & Co.
Their Attorneys.

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(No Model.) 4 Sheets—Sheet 2.

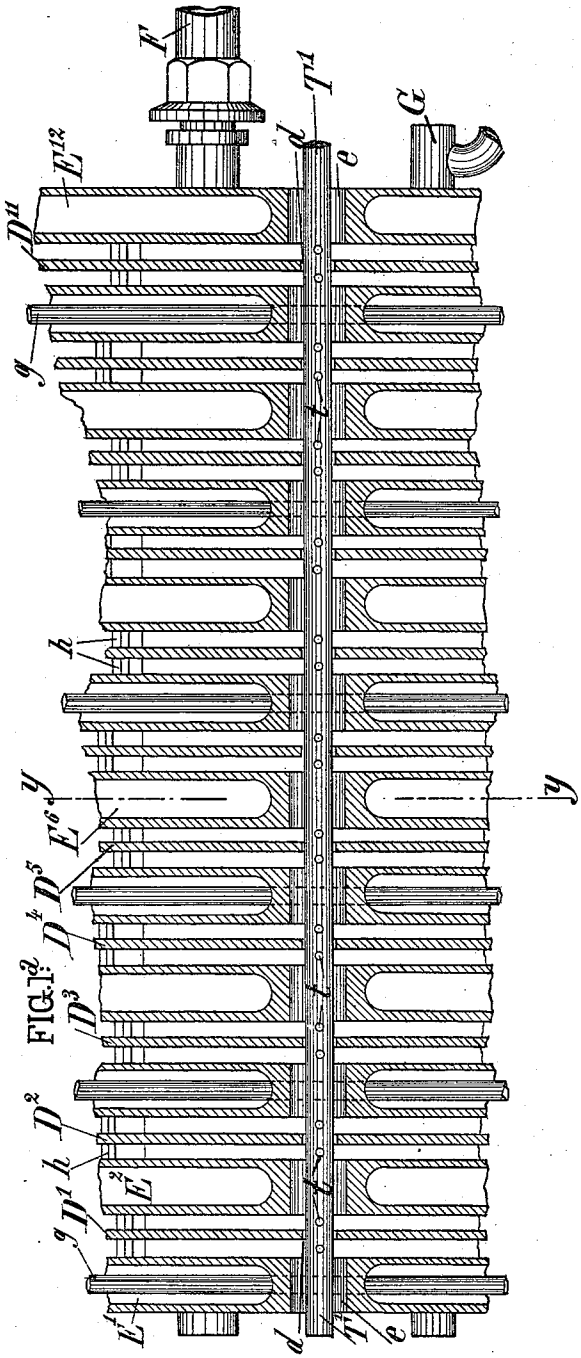

FIG. 1.

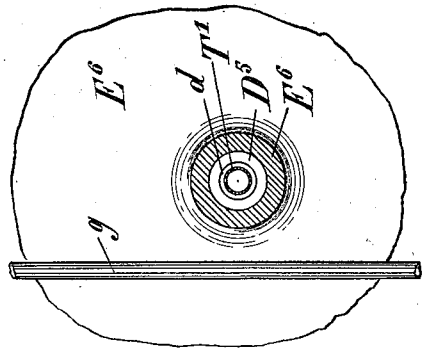

FIG. 2.

Witnesses:
E. B. Bolton
A. Dumont

Inventors:
Henri Abraham
Louis Marmier
By Reinhardt & Reinhardt
their Attorneys.

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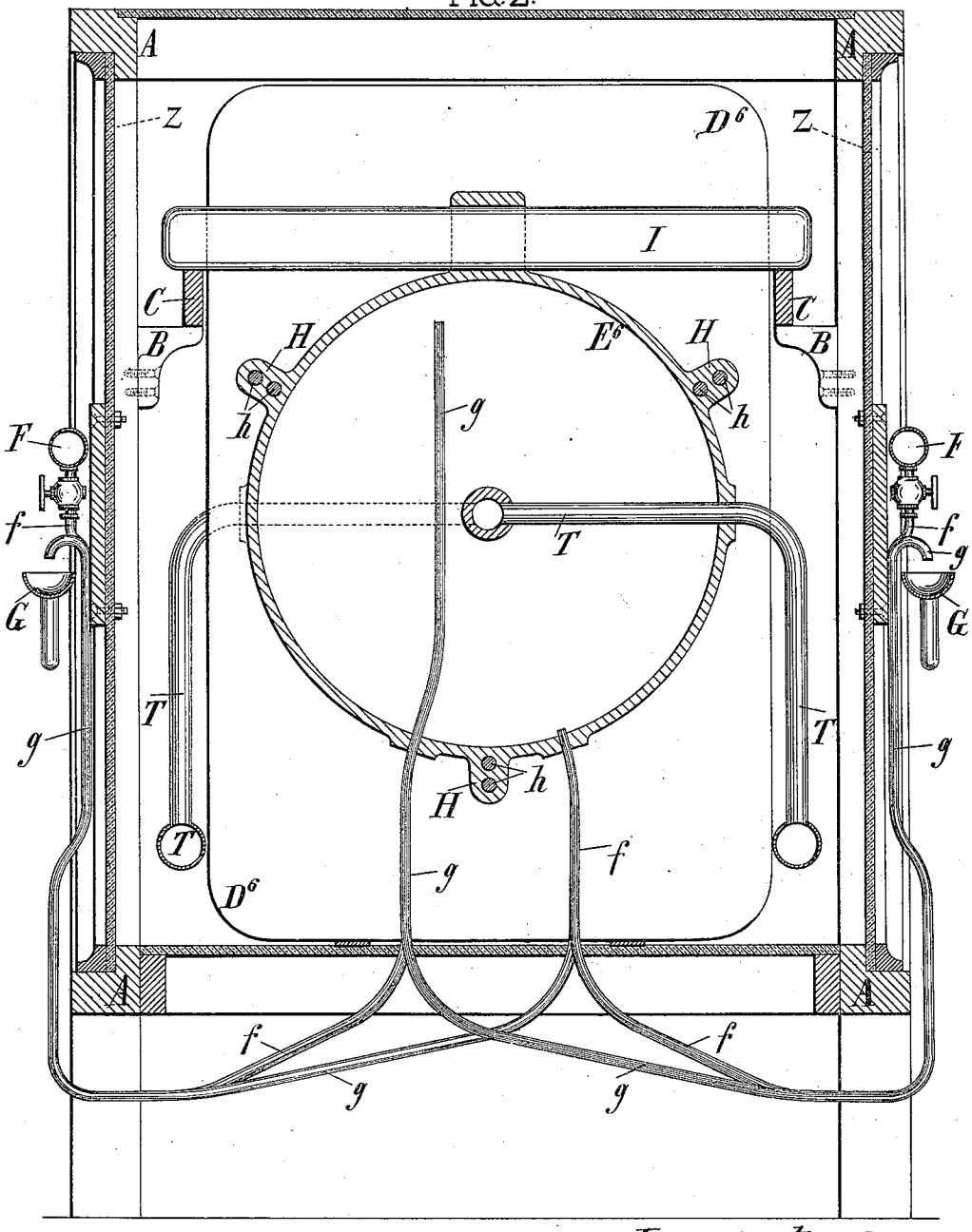
(Application filed Dec. 21, 1897.)

(No Model.) 4 Sheets—Sheet 3.

FIG. 2.



Witnesses:
E. B. Bolton
A. D. Mumk

Inventors:
Henri Abraham
Louis Marmier
By Richards & Co.
their Attorneys.

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(No Model.) 4 Sheets—Sheet 4.

FIG. 7.

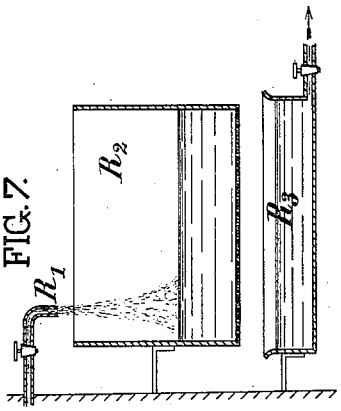


FIG. 8.

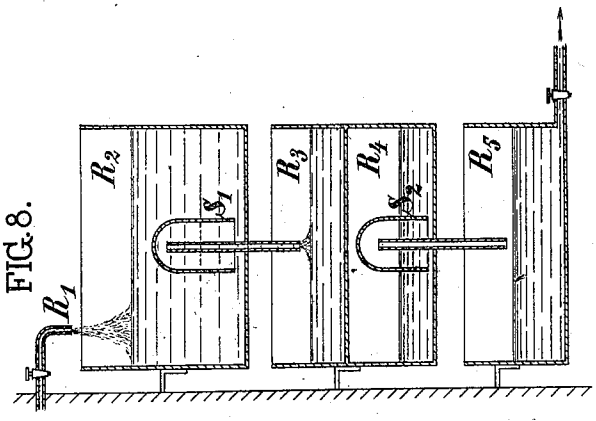


FIG. 5.

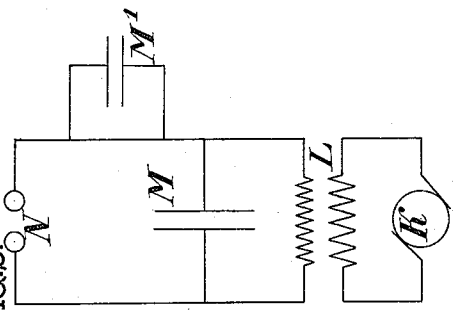


FIG. 4.

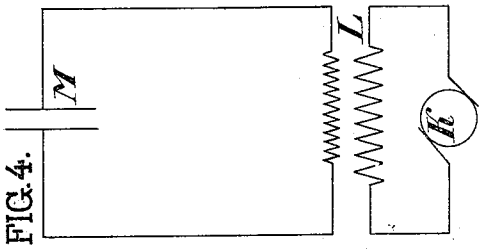


FIG. 3.

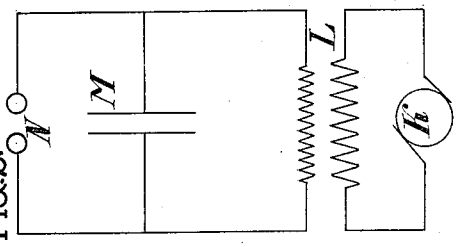
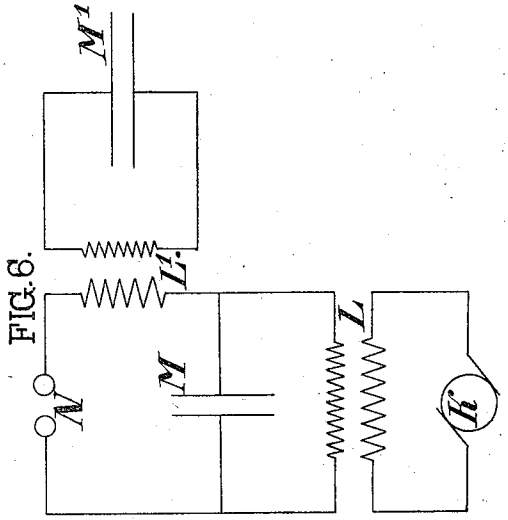


FIG. 6.



Witnesses:
C. K. Bolton
A. Munnic

Inventors:
Henri Abraham
Louis Marmier
By Richards & Co
their Attorneys

UNITED STATES PATENT OFFICE.

HENRI ABRAHAM AND LOUIS MARMIER, OF PARIS, FRANCE.

OZONE-GENERATOR.

SPECIFICATION forming part of Letters Patent No. 632,391, dated September 5, 1899.

Application filed December 21, 1897. Serial No. 662,900. (No model.)

To all whom it may concern:

Be it known that we, HENRI ABRAHAM and LOUIS MARMIER, citizens of the Republic of France, residing at Paris, France, have invented new and useful Improvements in Ozone-Generators, of which the following is a specification.

For a long time past ozone-generators, consisting of dielectric plates placed between metallic electrodes having sufficient space between them to admit the circulation of the gas it is desired to submit to the electric effluvia, have been known; but up to the date of our investigations these different apparatuses have presented two serious disadvantages which have rendered their use very difficult. In the first place, their electrodes get hot, and, secondly, their dielectrics are frequently pierced by sparks. A good ozone-generator should be free from both the defects. We have succeeded in making an ozone-generator in which these two disadvantages are avoided.

As regards the cooling of the electrodes, some twenty-five years ago the idea was conceived of making water circulate in the electrodes, which were formed of deep metallic boxes, and more recently the idea has been taken up again by others; but all have been hampered by the difficulty of getting the water to circulate simultaneously in both electrodes (or series of electrodes) on account of the great potential difference existing between the same and the fact that water conducts the electric current and compromises the insulation. They therefore contented themselves with passing water through only one of the electrodes or one of the series of electrodes or by supplying water to the electrodes from separate reservoirs, as shown in patent to Andreoli, No. 577,636, dated February 23, 1897.

It is the object of the present invention to provide a construction by which these objections or defects are overcome.

As regards the rupture of the dielectric, we believe that as yet no special arrangement has been made in order to obviate this in ozone-generators. We have obtained the results by means of a discharger, which is the indispensable complement of our apparatus of which it forms an essential part.

We will explain farther on the characteristic differences between this arrangement and that which, for instance, Tesla employs to produce currents of so-called "high frequency."

In the accompanying drawings, illustrating the description of our invention, Figure 1 is side view and longitudinal section of the ozone-generator. Fig. 2 is a section following line $x\,x$ of Fig. 1. Figs. 1^a and 2^a illustrate a modification. Fig. 3 is a diagram showing the electric adjustment we employ. Fig. 4 is a diagram showing the electric adjustment usually employed. Figs. 5 and 6 are diagrams showing various methods of our adjustment. Figs. 7 and 8 are two apparatuses which we employ to insure cooling without compromising the insulation.

Referring to Figs. 1 and 2, the ozone-generator comprises flat parallel elements arranged in the following successive order—namely: electrodes E′, dielectric D′, space, electrode E^2, space, dielectric D^2, space, electrode E^3, and so on. The electrodes paired evenly ($E^2\,E^4$, &c.) are metallically connected, and the same is the case with the uneven electrodes (E′ E^3 E^5, &c.;) but the two groups are electrically insulated the one from the other, and the gases are submitted to the electric effluvia in the spaces or intervals between the plates. The electrodes are metallic and covered with a non-oxidizable coating—such as paraffin-wax, silicates, red lead, enamel, or some other product not affected by ozone. Their form is preferably annular, but their shape can be varied at will. The electrodes could be made square. The chilling is effected by means of water, (or some other fluid,) which enters through the tubes F and f and escapes by the pipes G and g.

The circulation of the gases submitted to the effluvia is radial or longitudinal. The gases pass through free openings or through perforated conduits. In Figs. 1 and 2 the gas entering by the conduit Z passes between the electrodes and the dielectric plates D′ D^2 and escapes by the pipes T. We may also utilize for the escape of the gas instead of the pipes T a somewhat different process. In Fig. 1^a, which is a longitudinal partial section of the center part of the generator, and in Fig. 2^a, which is a section on the line $y\,y$ of Fig.

1^a, *d* is a small opening made in the center of each of the dielectric plates D' D^2 opposite the central openings *e* of the electrodes E' E^2. All the electrodes and all the said dielectric plates being thus pierced, we pass through all these openings a tube T', pierced with holes *t* throughout its entire length. This single tube enables the gas to be sucked up into all the spaces subjected to the effluvia at one and the same time. The pipes T (shown in Figs. 1 and 2) are evidently in this case abolished.

For regulating, each electrode is arranged exactly parallel with the neighboring dielectric plates. The same amount of air is allowed to enter between each electrode and its corresponding dielectric plate. To this effect the plates and electrodes are adjustably spaced by screws *h*, which pass through the lugs H and rest on the dielectric plates D. The same result can also be obtained by placing small insulating-blocks of the necessary thickness between the dielectric and the electrodes.

The electrodes are supported within a main body or case A by insulating cross-pieces I and C, supported on the brackets B.

The chilling or cooling of the electrodes is obtained by means of a current of water; but as there exists between the two series of electrodes a great difference of potential they cannot all be connected directly to the water-conduits, so we have devised an arrangement enabling the water to circulate simultaneously in the two series of electrodes without compromising the insulation and without being compelled to stop the apparatus in order to replace the hot water by cold. This result is obtained by means of simple arrangement, such as shown in Fig. 7. The water which comes from the tap R passes into the non-insulated reservoir R^2. The bottom of this reservoir is perforated, and the water falls drop by drop into the insulated reservoir R^3, from whence it goes to the electrodes E' E^3 E^5 by a suitable pipe connection. A similar arrangement is used for cooling the electrodes E^2 E^4 E^6. The same method is pursued for the escape of the water. Hence in this case it is the use of these separate drops which enables the electrodes to be fed continually without compromising the insulation. Another arrangement giving the same result is shown in Fig. 8, in which the water arrives continually from the tap R' into the non-insulated reservoir R^2; but owing to the siphon S' the water can only pass from time to time from the reservoir R^2 to the insulated reservoir R^4. In the same way the water will pass from time to time away from the insulated reservoir R^4 to the insulated reservoir R^5, which feeds one of the series of electrodes. Finally, the interposition of the reservoir R^3 between the reservoirs R^2 and R^4 causes a delay in the filling of R^4, and this delay prevents the two siphons S' and S^2 from working at the same time, which would destroy the insulation of the electrodes.

Two arrangements, as shown in Fig. 7 or Fig. 8, are placed above the ozone-generator. One of these two arrangements feeds the electrodes E' E^3 E^5 and the other one the electrodes E^2 E^4 E^6 with cold water, and two arrangements of the same kind are fitted beyond the generator receiving the water which flows out.

As it has been previously explained, our ozone-generator requires an indispensable accessory—viz., a discharger. This discharger is formed by two metallic balls which are in electric communication with the two armatures of the ozone-generator. Every time the difference of potential attains a determined value a spark passes between the balls of the discharger. The quantity of ozone obtained in the generator depends upon the nature of this spark. The most effective spark is that obtained upon injecting a strong current of air or steam between the two balls of the discharger.

The ozone-generator M and the discharger N are shown in Fig. 3 with the alternator K and the high-potential transformer L.

We may also use slightly-different arrangements or modifications, being within the scope of our invention, as specified and claimed. Two of these arrangements are shown in the diagram Figs. 5 and 6. Fig. 5: Between the discharger and the chief ozone-generator M we place an auxiliary ozone-generator M' of weaker power, connected as a shunt on the discharge-circuit. The ozone-generator M' works only during the passage of the spark in the discharger. The object of this modification is to utilize for the production of a fresh quantity of ozone the greater part of the energy which would be wasted in the discharger. Fig. 6: If the auxiliary ozone-generator of Fig. 6 does not act well, its power must be increased by means of the small auxiliary transformer L'.

We will now point out the differences between our arrangement and those which have already been proposed. Our arrangement, Fig. 3, differs from the arrangement of the ordinary type, Fig. 4, in having the addition of the discharger N with its effective spark. Our adjustment is also distinguished from those used to produce the so-called "high-frequency" currents of Tesla. To get these high-frequency currents, it is necessary to first charge the condenser and then discharge it afterward in a circuit containing a solenoid. An electric shock is produced in this circuit, and this sharp shock is used or turned to account by putting the two extremities of the solenoid in communication with the apparatus through which it is desired to pass the high-frequency currents. Mr. Tesla also uses this solenoid in another way. This solenoid serves as a primary circuit to a transformer, the secondary circuit of which then supplies currents of a very high degree of potential.

There are fundamental differences between

the combinations of Mr. Tesla and those which we employ. These differences are found, essentially, in the substitution of ozone-generators for condensers. In order to show that this constitutes a characteristic difference, it will suffice to recall the nature of a condenser and that of an ozone-generator. The name "condenser" is given to the electric apparatus in which power can be accumulated by polarizing a dielectric plate placed between two metallic armatures, or, in other words, by charging the armatures. If the apparatus is discharged, it should restore in its entire integrity the electric power it has received. Its action is essentially reversible. On the contrary, an ozone-generator is an apparatus combined in such a way as to produce the electric effluvia or silent discharge at each instant—that is to say, innumerable little sparks scattered throughout the whole of the apparatus. This sparking induces the transformation of the oxygen into ozone; but it is necessarily accompanied by a transformation of the major portion of the electric energy into heat. Hence when the ozone-generator is discharged it only returns a small percentage of the power it has received. Its action is essentially non-reversible. Thus when a combination is made as an ozone-generator it is sought to transform into heat in it the greater part of the electric energy by means of the effluvia. In our opinion the transformation of oxygen into ozone is due to the heat produced by all the small sparks which compose the effluvia. On the contrary, in a condenser efforts are made and successfully to avoid absolutely the production of ozone by effluvia and the transformation of electric power into heat. Consequently a good ozone-generator makes a very bad condenser, and vice versa. These two kinds of apparatus cannot therefore be substituted the one for the other, since they obey exactly opposite laws.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, we declare that what we claim is—

1. In an ozone-generator acting by electric effluvia, a series of hollow electrodes metallically connected with one pole of a discharger, another series of hollow electrodes metallically connected with the other pole of said discharger, and a cooler comprising a top and perforated reservoir, and conduits connecting the electrodes with the cooler, substantially as described.

2. In an ozone-generator acting by electric effluvia, a series of hollow electrodes metallically connected with one pole of a discharger, another series of hollow electrodes metallically connected with the other pole of said discharger, and a cooler comprising a top and perforated reservoir designed to insulate the cooling liquid and conduits connecting the cooler with the electrode, in combination with an auxiliary ozone-generator, the electrodes of which are metallically connected to two points of the discharge-circuit of the main ozone-generator, substantially as described.

3. In an ozone-generator acting by electric effluvia, a series of hollow electrodes metallically connected with one pole of a discharger, another series of hollow electrodes metallically connected with the other pole, a cooler, comprising a top and perforated reservoir and an insulated reservoir for the cooling liquid having conduits connecting with the electrodes, an auxiliary ozone-generator having its electrodes metallically connected to the main ozone-generator, in combination with a small auxiliary transformer, substantially as described.

In testimony that we claim the foregoing as our invention we have signed our names, in presence of two witnesses, this 26th day of July, 1897.

HENRI ABRAHAM.
LOUIS MARMIER.

Witnesses:
EDWARD P. MACLEAN,
CHARLES NEULATTE.