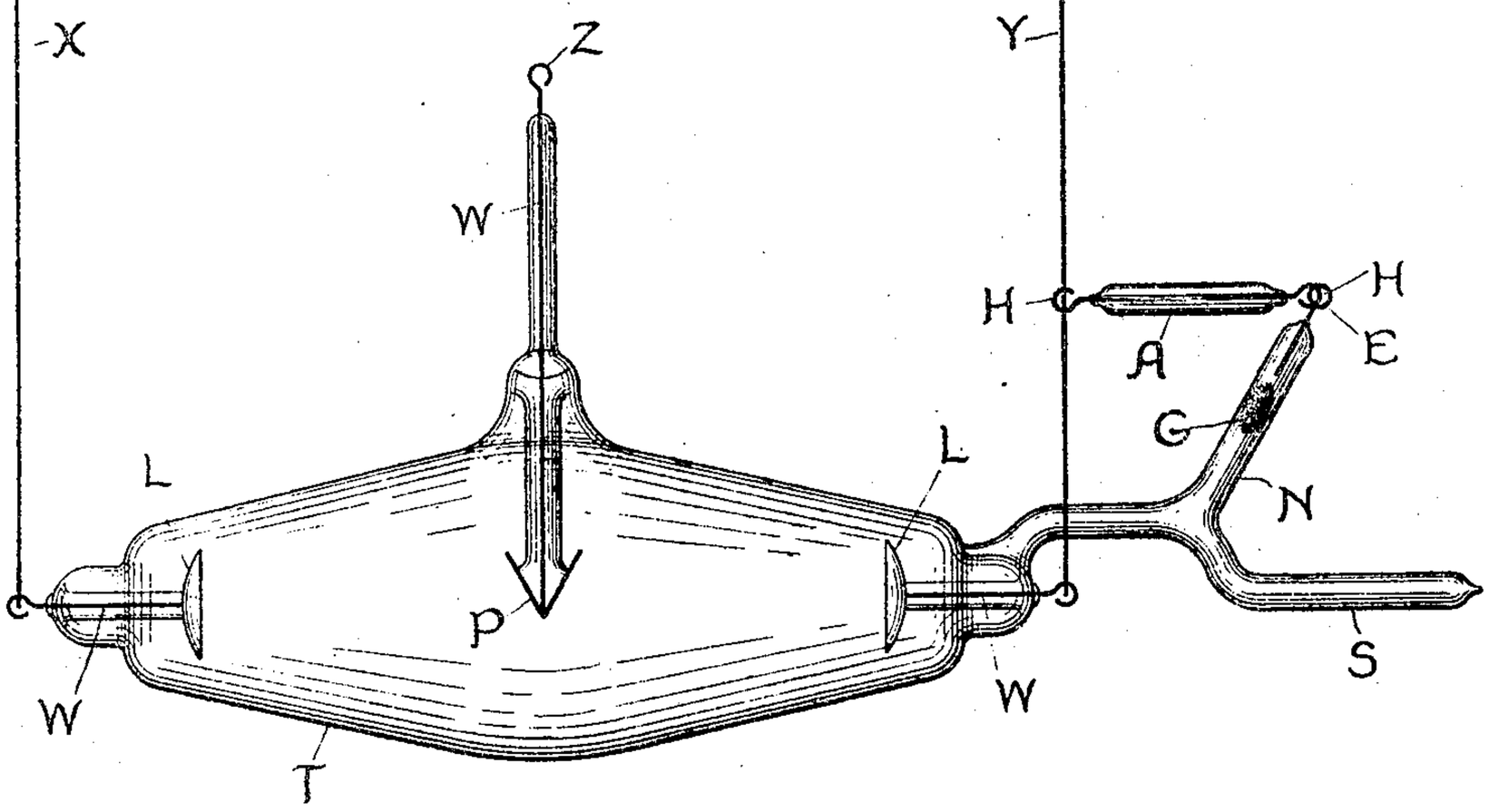
No. 798,383. PATENTED AUG. 29, 1905.

W. S. ANDREWS.

VACUUM TUBE.

APPLICATION FILED MAY 10, 1900.



Witnesses:
Lewis P. Abell.
Benjamin B. Lucas.

Inventor,
William S. Andrews,
by Albert G. Davis
Atty.

UNITED STATES PATENT OFFICE.

WILLIAM S. ANDREWS, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

VACUUM-TUBE.

No. 798,383. Specification of Letters Patent. Patented Aug. 29, 1905.

Application filed May 10, 1900. Serial No. 16,123.

To all whom it may concern:

Be it known that I, WILLIAM S. ANDREWS, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Vacuum-Tubes, of which the following is a specification.

This invention relates to an improvement in means for regulating the degree of density in vacuum-tubes of any description, but especially X-ray tubes, and is shown in the drawing in its application to the universal double-cathode tube constructed in accordance with the patent to Elihu Thomson, No. 575,772, dated January 26, 1897.

As shown in the drawing herewith, the tube T is provided with concave disks L, of aluminium or equivalent material, which are connected to the leads X and Y by wires *w*, sealed in the ends of the tubes. The V-piece P, of a metal such as platinum, is mounted on an inner extension of the tube at substantially the foci of the disks L and is connected by a wire *w* with the terminal Z. The extension N is blown in the tube in the process of formation.

S represents the usual sealing-off extension.

A tube of this construction may be operated by a high-potential alternating current of high frequency by a static machine or by an induction-coil. In the first case the leads X and Y are connected with the source and a rapid succession of alternating discharges will then pass through the tube, each concave disk becoming anode or cathode in rapid alternation, while the V-piece, of platinum, is bombarded alternately from both sides and emits X-rays in great abundance. When the tube is to be operated by an induction-coil or any source of unidirectional current static machine, the terminal Z is connected with one terminal of the machine and the leads X and Y are connected with the other terminal. In this case the platinum piece acts as an anode and the disks L L as cathodes. This construction is set forth in the patent above mentioned. In that patent was first suggested a method of increasing the degree of density of a Crookes tube when used for generating X-rays when the density becomes too low for practical operation by the prolonged passage of current, which method consisted in liberating a gas latent within the tube. My invention is an improvement on this method and will now be described.

A is a short piece of capillary glass tube having a bore of from one to three millimeters diameter. A conducting-wire is sealed in at one end, and another wire fits rather tightly within the tube at the other end, but is movable therein, providing an adjustable air-gap or resistance. The free ends of the wires may be formed into hooks, one of which is inserted in the eye-terminal E of the wire which is sealed into the end of an extension N and the other of which hooks grasps the lead Y. Thus the air-gap may be adjusted at will, and the entire attachment may be readily removed, if desired. A gas-yielding agent G, such as potassic hydrate, is located in the extension N, being also in the path of current which flows through the tube T, extension E, and tube A.

The operation is entirely automatic and is as follows: After a certain period of action the interior of the tube T has too low a density for proper operation owing to the occlusion or condensation of gases. In this case before starting the operation of the tube T the operator adjusts the movable wire in the tube A in accordance with variable conditions, such as the potential of the source, the characteristics of the individual vacuum-tube, and the degree of penetration desired. When the circuit is closed, continuous sparking occurs for a short interval at the air-gap in the tube A, owing to the high resistance of the vacuum-tube. This current passes through the agent G and through the vacuum-tube to the other terminal thereof and immediately liberates sufficient gas from the agent G to increase the density in the tube to the condition desired for the production of the rays and to decrease the tube-resistance, whereat the sparking at the air-gap ceases. The amount of gas liberated at first is sufficient to maintain the tube in a proper working condition for a certain time, when the density again slightly decreases on account of the cooling off of the tube. The resistance thereupon increases, a spark occurs at the air-gap, and a smaller quantity of gas is liberated this time, and consequently the next spark occurs after a shorter interval, and thereafter a spark occurs about once a second or thereabouts, causing the vacuum-

tube to remain constantly in the proper condition for the production of X-rays. With a proper adjustment of the spark-gap, the tube will continue to generate X-rays continuously without variation or flicker. A prolongation of the continuous sparking after the circuit is closed indicates to the operator that the air-gap in the tube A is too short, and he will therefore adjust the movable wire to increase the length of same.

The inclosure of the air-gap within the tube A serves to prevent the discharge from making an audible disturbance, which is not only disagreeable but highly objectionable, especially when the apparatus is used for surgical purposes. The inclosure of the spark-gaps within a capillary tube likewise modifies considerably the character of the surges in the alternating-current discharge as regards the effect upon the automatic regulation of the tube.

This invention has been applied in practice as above described and has been found to be the most efficient and cheapest method which has yet been devised for accomplishing the desired object.

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

1. A vacuum-adjuster for Roentgen-ray tubes, consisting of a shunt-circuit including, in the path of the current, a volatile salt within the vacuum-inclosure, and a spark-gap within a closed receptacle, substantially as described.

2. A vacuum-adjuster for Roentgen-ray tubes, consisting of a shunt-circuit including, in the path of the current, a volatile salt within the vacuum-inclosure, and an adjustable spark-gap within a closed receptacle, substantially as described.

3. A vacuum-adjuster for Roentgen-ray tubes, consisting of a shunt-circuit including, in the path of the current, a volatile salt within the vacuum-inclosure and a spark-gap inclosed in an air-tight receptacle, substantially as described.

4. A vacuum-adjuster for Roentgen-ray tubes, consisting of a shunt-circuit including, in the path of the current, a volatile salt within the vacuum-inclosure, and an adjustable spark-gap inclosed in an air-tight receptacle, substantially as set forth.

5. In a vacuum-tube, the combination with latent gas within the tube, of a circuit adapted to liberate said gas when the density of the tube decreases, and an inclosed air-gap in said circuit.

6. In a vacuum-tube, the combination with an operating-circuit through the tube, of an auxiliary circuit through the tube, through which current flows when the density of the tube decreases, an inclosed capillary air-gap in said auxiliary circuit, and latent gas in the tube, which is liberated by current flowing through the auxiliary circuit.

7. In a vacuum-tube, the combination with an operating-circuit through the tube, of an auxiliary circuit through which current flows when the density of the tube decreases, an inclosed adjustable capillary air-gap in said auxiliary circuit, and latent gas in the tube, which is liberated by current flowing through the auxiliary circuit.

8. In a vacuum-tube, the combination with an operating-circuit through the tube, of an auxiliary circuit through the tube, through which current flows when the density of the tube decreases, an inclosed adjustable capillary air-gap in said auxiliary circuit, and latent gas within the tube, which is liberated by current flowing through the auxiliary circuit.

9. In a vacuum-tube, the combination with the operating-terminals of the tube, of an extension from the tube which contains a gas-yielding agent, and is provided with a terminal; a connection from said terminal to one of the operating-circuit terminals whereby a circuit is established through said extension and gas-yielding agent and through the operating-circuit of the tube, to the operating-circuit terminal, and an inclosed air-gap in said connection.

10. An attachment for vacuum-tubes, which comprises a separate and independent closed but unevacuated capillary tube, and two electric conductors which are inserted in the tube, said conductors being separated by a regulating spark-gap within the tube.

11. In a vacuum-tube, the combination with the operating-circuit terminals, an extension from the tube which contains a gas-yielding agent and is provided with a terminal, and a glass tube provided with conductors therein adapted to form an adjustable air-gap, one of which conductors is attachable to the terminal on the extension, and the other of which is attachable to an operating-circuit terminal to establish a circuit through said extension and gas-yielding body, and through the vacuum-tube, to the other operating-circuit terminal.

12. A vacuum-adjuster for X-ray tubes, consisting of a circuit including, in the path of the current, a gas-yielding agent in the vacuum-inclosure, and a spark-gap within a closed receptacle, substantially as described.

13. A vacuum-adjuster for X-ray tubes, consisting of a circuit including, in the path of the current, a gas-yielding agent in the vacuum-inclosure, and an adjustable spark-gap within a closed receptacle, substantially as described.

14. Means for regulating the degree of density of vacuum-tubes, which comprises an unevacuated inclosing tube of uniform bore, and two conductors therein, between

which a spark-gap can be formed inside the casing.

15. Means for regulating the degree of density of vacuum-tubes, which comprises an unevacuated inclosing tube of uniform bore, a conductor fixed therein, and a second conductor therein which is adjustable with respect to the first, whereby spark-gaps of different lengths can be formed inside the casing.

16. Means for regulating the degree of density of vacuum-tubes, which comprises an unevacuated inclosing tube of uniform bore, and two conductors therein, between which a spark-gap can be formed inside the casing, each conductor extending outside the casing and terminating in a hook for convenient connection in circuit.

17. An attachment for vacuum-tubes, comprising a closed but unevacuated chamber having walls of suitable insulating material, said chamber being separate from and independent of the vacuum-tube with which it is to be used, and two electrical conductors passing through the walls of the chamber and adjustable relatively to each other so as to provide an inclosed spark-gap of variable length, said conductors practically filling said chamber except for the space between their adjacent ends.

In witness whereof I have hereunto set my hand this 7th day of May, 1900.

WILLIAM S. ANDREWS.

Witnesses:

BENJAMIN B. HULL,

EDWARD WILLIAMS, Jr.