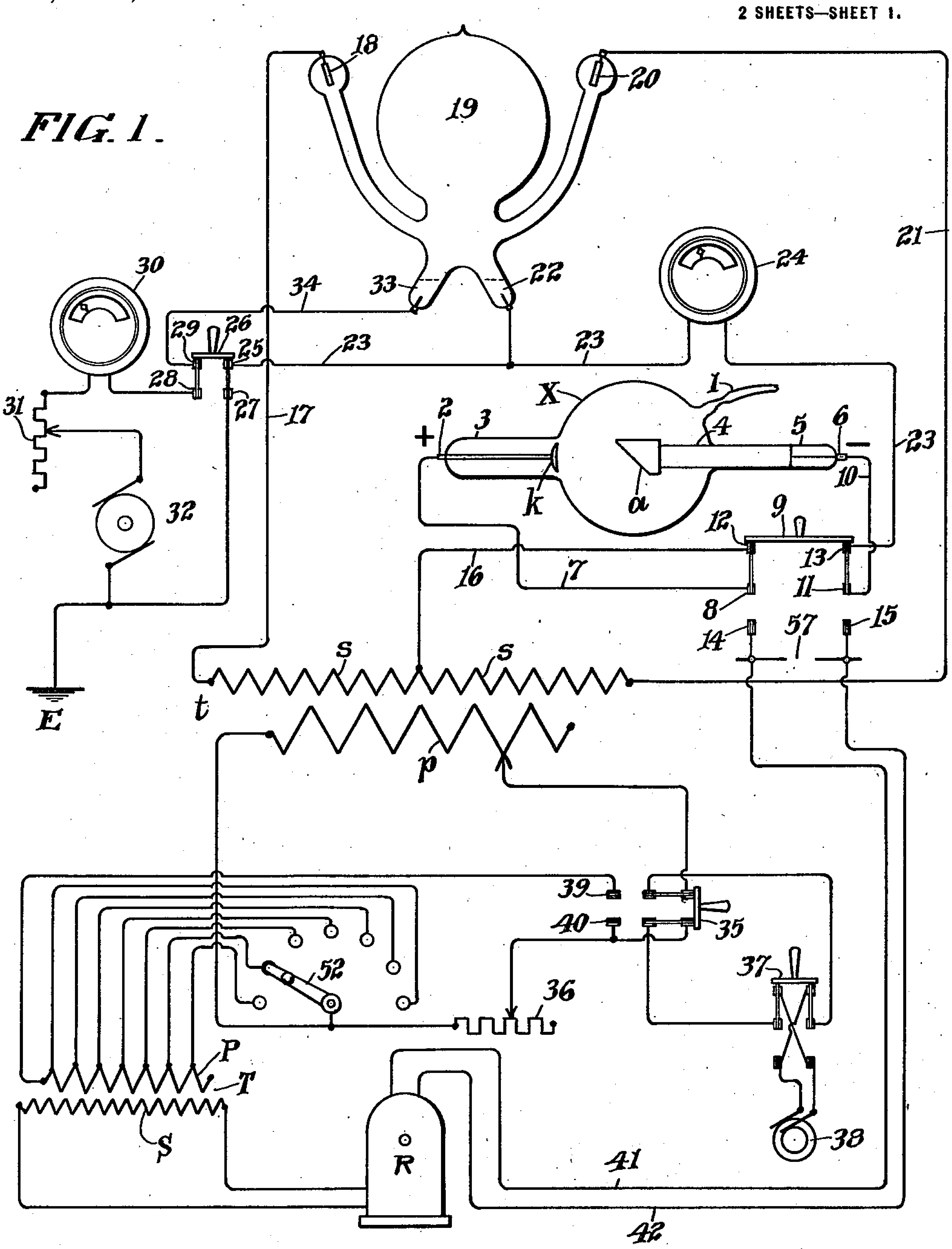
H. C. SNOOK.
EVACUATION PROCESS.
APPLICATION FILED OCT. 8, 1912.

1,166,792.

Patented Jan. 4, 1916.

2 SHEETS—SHEET 1.

FIG. 1.



WITNESSES
Daniel Webster Jr.
William Conway

INVENTOR
Homer Clyde Snook

BY
Cornelius D. Ehret
His ATTORNEY

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2 SHEETS—SHEET 2.

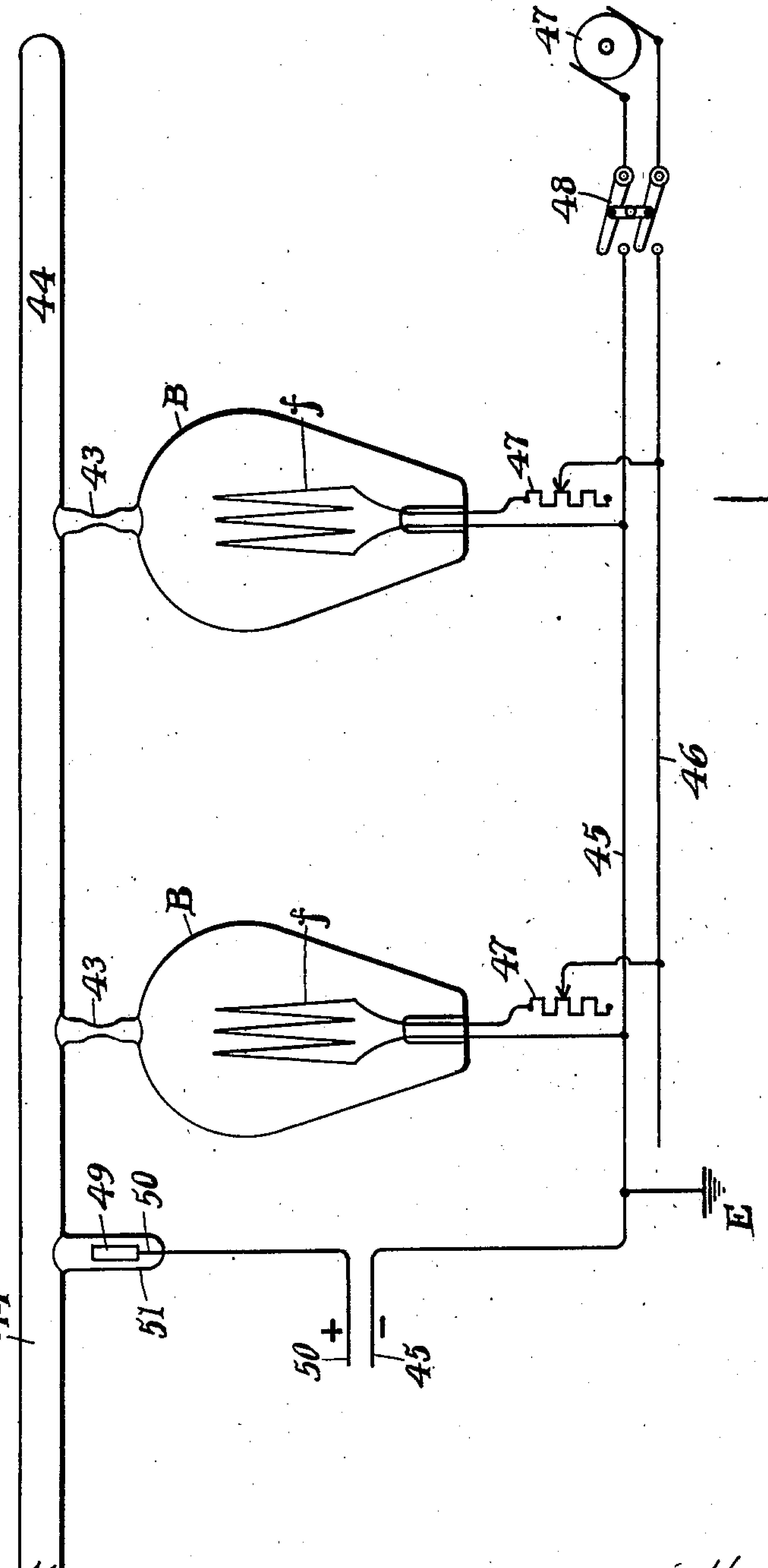

FIG. 2.

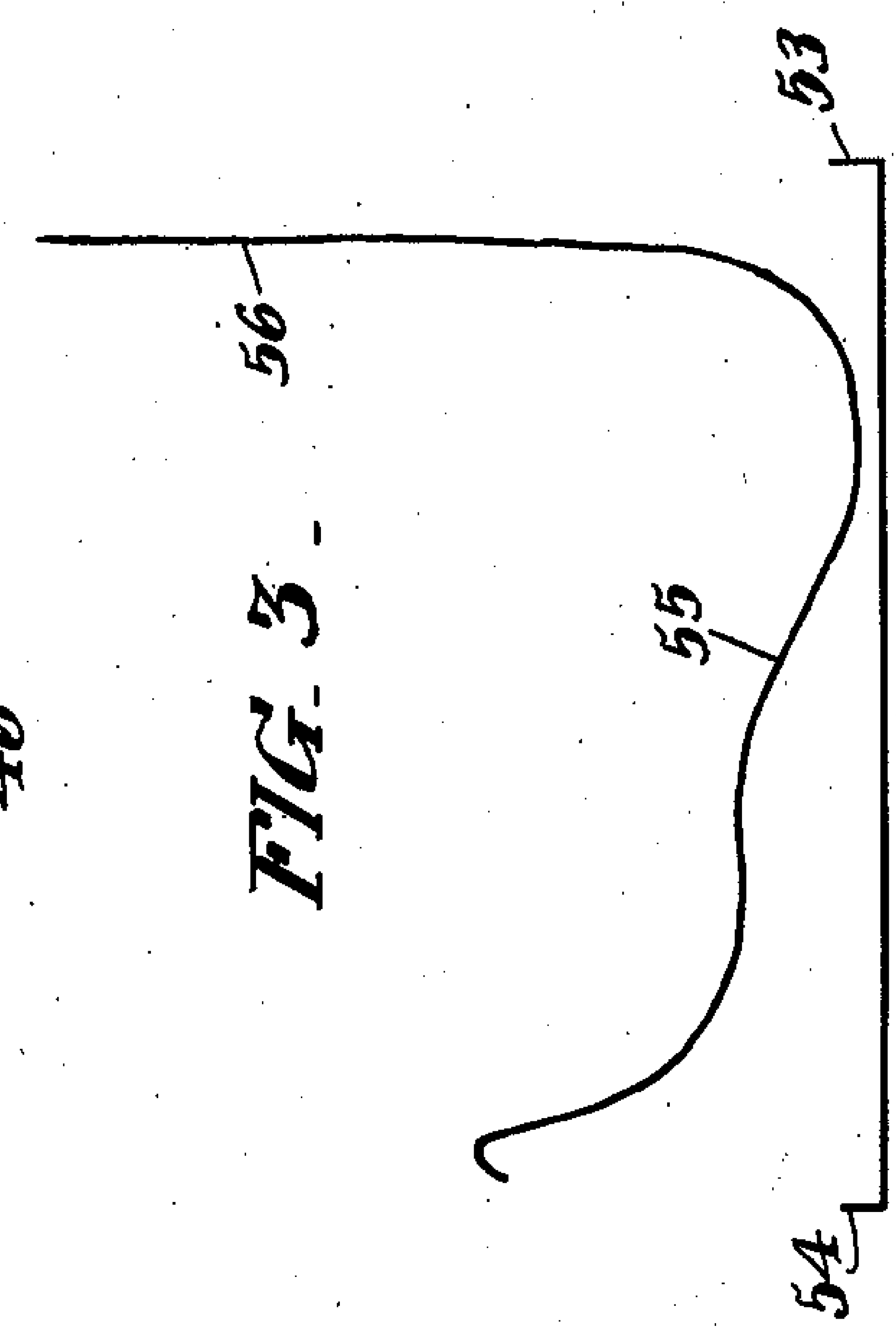

FIG. 3.

WITNESSES
Daniel Webster Jr.
William Conway

INVENTOR
Homer Clyde Snook

BY Cornelius D. Ehret
his ATTORNEY

UNITED STATES PATENT OFFICE.

HOMER CLYDE SNOOK, OF CYNWYD, PENNSYLVANIA.

EVACUATION PROCESS.

1,166,792. Specification of Letters Patent. Patented Jan. 4, 1916.

Application filed October 8, 1912. Serial No. 724,557.

To all whom it may concern:

Be it known that I, HOMER CLYDE SNOOK, a citizen of the United States, residing at Cynwyd, State of Pennsylvania, have invented certain new and useful Improvements in Evacuation Processes, of which the following is a specification.

My invention relates to a process of exhausting or evacuating X-ray tubes, Crookes tubes or other tubes through which electric discharges are to be passed in rarefied gas; and my invention relates to a like process for exhausting or evacuating other tubes or bulbs through which electric energy is passed, not through separated electrodes, but through filaments or conductors such as, for example, in incandescent electric lamps.

It is the object of my invention to provide a process for evacuating tubes, bulbs, etc., of the character referred to, which will materially shorten the time consumed in evacuation, cheapen the process of evacuation, and produce a final vacuum which will improve the operating characteristics of the tubes, bulbs or lamps.

To these ends my invention resides in the process and apparatus hereinafter described and claimed.

For an illustration of some of the forms my apparatus may take for carrying out my process reference is to be had to the accompanying drawings in which:

Figure 1 is a diagrammatic view of apparatus for carrying out my process for evacuating an X-ray tube or the like. Fig. 2 is a diagrammatic view of apparatus illustrating my process of evacuating incandescent lamp bulbs. Fig. 3 is a graphic representation of potential gradient between electrodes of a vacuum tube.

Referring to Fig. 1, X represents the bulb of an X-ray tube whose interior is in communication with a vacuum pump, not shown, through the connection 1 during the process of evacuation. The cathode *k* is in electrical communication with the exterior through terminal 2 sealed into the glass of the tube stem 3; and the anode *a* is shown, by way of example, as supported upon the conducting tube 4 in the glass tube stem 5 and communicating with the exterior through the conductor 6 sealed in the glass of the stem 5. The terminal 2 is in electrical communication through conductor 7 with the terminal 8 of the electric switch 9, and the terminal 6 is in communication through conductor 10 with the terminal 11 of the switch 9. The switch 9 may be thrown to either of two positions; in the position shown the switch brings terminals 8 and 11 into electrical communication with the terminals 12 and 13, respectively, and in its other position brings its terminals 8 and 11 into electrical communication with the terminals 14 and 15, respectively. The terminal 12 connects through conductor 16 with the mid-point of the secondary *s* of transformer *t*. One terminal of the secondary *s* connects by conductor 17 with an electrode 18 of a mercury vapor rectifier 19, another of whose electrodes 20 connects through conductor 21 with the other terminal of the secondary *s*. The main mercury puddle 22 of the rectifier connects through conductor 23 and ammeter 24 with switch terminal 13 and connects also with terminal 25 of electric switch 26 which is adapted to bring terminal 25 into communication with terminal 27, and to bring terminals 28 and 29 into communication with each other. The terminal 28 connects through ammeter 30 and adjustable resistance 31 with one terminal of the generator or source of direct current 32 whose other terminal is connected to switch terminal 27 and to earth E. The source 32 delivers low voltage direct current to maintain the ionizing arc between the mercury puddle 22 and the mercury puddle 33, the latter connected through conductor 34 with switch terminal 29, it being understood that the arc is started by causing the mercury puddles 22 and 33 to come momentarily into contact with each other, as by tilting the rectifier 19.

The transformer *t* is a step-up transformer, each half of the secondary *s* delivering an alternating current of 1500 volts, for example, the difference of potential between the electrodes 18 and 20 being therefore 3,000 volts. The primary *p* of the transformer *t* is shown in circuit through the switch 35 and adjustable resistance 36 and reversing switch 37 with the generator or source 38 of alternating current. The reversing switch 37 simply serves to change the direction of current through the primary *p* if for any reason any of the connections in the secondary circuit are reversed or wrong. The alternating current delivered by the secondary *s* to the rectifier 19 is rectified into unidirectional current which is then passed through the X-ray tube X as and for the purposes hereinafter described.

By throwing the switch 9 down into communication with contacts 14 and 15 and by throwing the switch 35 over to the left into communication with contacts 39 and 40, a source of very high tension unidirectional current is brought into communication with X-ray tube X, through the switch 9. By throwing the switch 35 to the left, as stated, the transformer t is cut out of operation, and of course therefore the rectifier 19. A current from the generator 38 will pass through the primary P of the transformer T whose high potential secondary S communicates with the rectifying switch R, the latter delivering unidirectional high tension current by conductors 41 and 42 through the switch 9 to the X-ray tube X. Any suitable means for supplying high tension unidirectional current may be provided, but the transformer T, rectifying switch R and generator 38, may be of the character and coöperating as described in my prior Patent No. 954,056. In this case the switch 52 serves to cut in more or less of the turns of the primary P for securing different potentials at the terminals of the X-ray tube X, and the adjustable resistance 36 may also be employed for current control purposes. It is to be understood also that my invention is not limited to the employment of a mercury vapor rectifier such as 19, but that any other suitable means for delivering moderately high potential unidirectional current to X-ray tube may be employed.

The bulb X of the X-ray tube having been put into communication through connection 1 with the vacuum pump, not shown, the pump is started and the air exhausted from the bulb X until a vacuum of about 1 millimeter of mercury, absolute pressure, is attained. This degree of vacuum is reached after a relatively short period of pumping and to determine when this degree of vacuum has been reached, the switch 9 may be thrown down into communication with terminals 14 and 15 and the switch 35 thrown into communication with terminals 39 and 40, the switch 52 being adjusted to such contact as to cause delivery from the secondary S a current of a tension of approximately 5,000 volts, or even less. And the switch 37 is thrown into such position as will make the anode a of the tube X the temporary cathode or negative terminal. There will occur around this temporary cathode a a cathode or negative glow of about $\frac{1}{16}$ inch thickness, if the vacuum is substantially 1 millimeter of mercury. If this glow is thicker than $\frac{1}{16}$ of an inch, it indicates that the vacuum is too high, and a slight amount of air may be readmitted to the tube X until the glow is substantially $\frac{1}{16}$ of an inch in thickness. $\frac{1}{16}$ of an inch thickness of this glow is about the minimum thickness the negative glow attains, under these conditions.

The vacuum having been determined to be substantially 1 millimeter of mercury, the switch 9 is thrown up into communication with terminals 12 and 13 and the switch 35 removed from terminals 39 and 40 and thrown into the position illustrated in Fig. 1 thereby causing the rectifier 19 to come into operation and to deliver current through the X-ray tube, the target or anode a being again the negative terminal or temporary cathode. At this time the communication between the tube X and the pump is cut off. The application of about 1500 volts to the terminals of the X tube by means of the rectifier 19 will cause a negative glow to appear at the temporary cathode a. And by adjusting the resistance 36, or the ratio of transformation of transformer t if desired, or both, the current through the tube may be increased until the cathode glow spreads and extends over the entire temporary cathode a and along the stem or tube 4 near to but not completely reaching the glass of the bulb X or stem 5. For an X-ray tube of ordinary size a current of from 1 to 2 amperes, as determined by ammeter 24, will generally suffice for this purpose. This excitation is continued for approximately 3 or 4 minutes, more or less, and the glow extending over the temporary cathode a and tube 4, as described, heats the same until they attain a red heat, causing occluded gases to be driven off. After maintaining this condition for the 3 or 4 minutes, as stated, the connection between the tube X and the pump is again opened, the pump continuing to exhaust gas from the tube X while the current continues to pass through the tube X.

As the vacuum becomes higher and higher, due to the continued pumping, the cathode glow extends farther and farther from the temporary cathode a and tube 4 and will finally fill the entire bulb X, resistance 36 or primary p, or both, having been adjusted as the glow extends, until a pressure of from 3,000 to 5,000 volts is applied to the tube X. When this state is reached, connection between the bulb X and the pump is again shut off. The cathode glow filling the tube to the walls is continued by the continued passage of current from the rectifier 19. This tube filling glow is continued for a relatively short time to heat the inner walls of the bulb to drive off gases condensed thereon, the actual bombardment of the walls by the glow itself producing a further beneficial effect by actually mechanically removing the gas molecules from the glass walls. The tube filling glow should be continued only until the glow begins to change from a bluish to a whitish color near the glass walls. If continued after the appearance of the whitish glow the glass may soften and the tube may collapse, or the local heating of the walls may be so intense as to devitrify the glass. After this whitish glow appears the strength of the current through the tube supplied by rectifier 19 is reduced, as by adjusting resistance 36, sufficiently to cause the disappearance of the whitish glow but to continue a tube filling glow of bluish color. At this stage connection with the pump is again reestablished and further evacuation occurs, removing the gases removed from the glass walls and further rarefying the original gas present in the bulb. As the vacuum rises, the current through the X-ray tube falls rapidly as will be indicated by the ammeter 24; and the evacuation is carried to a point at which the discharge ceases entirely. At this stage the temporary cathode and supports are still at red heat and the glass walls are hot. The tube X is now exteriorly heated, as in an oven, in which it may have been placed at the beginning of the process to a temperature of approximately 300° centigrade, the connection with the pump remaining open so that evacuation continues. Ordinarily the oven reaches the aforementioned temperature in approximately 20 minutes, the pumping continuing during this period and for a further period of approximately 5 minutes during which the tube is maintained at the aforementioned temperature.

While continuing the pumping operation, the temperature of the oven is gradually lowered from 60 to 80° centigrade during a period of approximately 15 to 20 minutes more. During this cooling period, the pump still continuing to evacuate the tube, the X-ray tube is connected as such by throwing the switch 9 down into communication with terminals 14 and 15 with a source of high potential unidirectional current supplied through rectifying switch R, the switch 35 having been thrown over to contacts 39 and 40. The discharges are now passed through the tube from time to time, the anode *a* being now the anode or positive electrode or terminal. These discharges serve as a test for the degree of vacuum as determined by the appearance of the fluorescence of the glass and by the color and shape of the discharge in the gas. Pumping is continued until the resistance of the tube as indicated by the spark gap 57 connected in parallel with the X-ray tube shows that the proper degree of vacuum has been reached, the vacuum at this time, because the tube is still hot or warm, is lower than the vacuum when the tube is cool. For example, when the resistance of the tube is indicated to be that of a parallel spark gap in the air of a length of from 3 to 4 inches with the tube at a temperature of from 60 to 80° centigrade, the vacuum in the X-ray tube has attained the proper degree, and now the connection 1 to the vacuum pump is sealed off, the tube being now permanently disconnected from the pump by the sealing shut of the glass connection 1. The tube is now allowed to cool to the temperature of the room and it will be found that its resistance at room temperature is indicated by a parallel spark gap resistance of 6 or 7 inches in length, this resistance of the tube being satisfactory for the production of X-rays.

By the process above described the evacuation of the tube may be accomplished in about three quarters of an hour as compared with a period of from 2 to 4 hours by prior methods.

Where an induction coil employing direct current with an interrupter in its primary circuit or other imperfect rectifier is used for supplying the current to the tube in place of the rectifier 19, the bad effects of the imperfect rectification may be more or less overcome by introducing into the X-ray tube, after initial pumping to a pressure of 1 millimeter of mercury or less, hydrogen or other gas chemically neutral with respect to the materials of the anode and cathode within the tube. After allowing the process to rest a few minutes after introduction of the hydrogen or other gas to allow the hydrogen or other gas to diffuse thoroughly through the tube, connection with the pump is again established and the vacuum again raised to a pressure approximately 1 millimeter of mercury. Then the process as hereinbefore outlined is continued. And even in cases where rectification is perfect, there is a glow at or surrounding the temporary anode *k* and if the rate of liberation of energy within the tube be sufficiently great and if the gas content of the tube is chemically active with the temporary anode material, excessive local heating at one or more points on the temporary anode occurs, and this heating may be so intense as to raise the neighboring glass to such a temperature as to cause softening or even rupturing of the glass; or, in other words, if the rate of liberation of energy in the tube be high enough to produce a certain temperature by anode glow at an excrescence on the temporary anode and if the gas content of the tube will at that temperature chemically attack the temporary anode, the local heating occurs as stated. To overcome this effect, hydrogen or other gas chemically neutral with respect to the temporary anode material may be introduced after the initial pumping to a vacuum of approximately 1 millimeter of mercury. Then after allowing the hydrogen or neutral gas to diffuse, the process is continued as hereinbefore first described.

In Fig. 2 I have shown one form of apparatus for carrying out my process of evacuating incandescent lamp bulbs, or the bulbs of any device in which an electric conductor is traversed by current while *in vacuo*. Here the plurality of lamp bulbs B may be simultaneously in communication through the tubes 43 with the tube 44 adapted to be put into communication with a vacuum pump. The lamp filaments *f* are sealed through the bulbs B in the usual manner and one terminal of each filament is connected to the conductor 45 while the other terminal is connected to the conductor 46 through an adjustable resistance 47. The conductors 45 and 46 are adapted to be thrown into electrical communication with the terminals of the source of current 47 by switch 48. Communicating with the interior of the tube 44, and therefore with the interiors of the bulbs B, is the electrode 49 to which is connected the conductor 50 sealed through the glass of the hollow projection 51 sealed to the tube 44 at any suitable point. The conductors 45 and 50 are adapted to be put into electrical communication with a source of more or less high potential unidirectional current, approximately 1500 volts pressure, such as may be delivered by a rectifier 19 or equivalent apparatus. Here the conductor 45 is shown connected to earth E, though conductor 46 may be so connected instead.

The vacuum pump having been started, the tube 44 is put into communication with it, and the air quickly exhausted from the bulbs B until a vacuum of about 1 millimeter of mercury or less is attained then hydrogen or other gas may be admitted to the bulbs B through tube 44 until the pressure in the bulbs B rises, for example, to one half atmosphere pressure. Then pumping is resumed and continued until the vacuum again attains a pressure approximately 1 millimeter of mercury or less. Then the conductors 45 and 50 are thrown into communication with the source of unidirectional current of 1500 volts pressure more or less, causing a negative glow around the filaments *f*, which are made the negative electrodes or cathodes during the process, and the pumping is continued until such negative glow fills the bulbs B. And as in the case hereinbefore described with respect to X-ray tubes such negative glow filling the bulbs acts both by this heating effect and mechanical effect to remove the gases from the inner walls of the bulbs, such gases being removed by the continued pumping. The heating oven may now be started. Connection from tube 44 to the pump is shut off and the negative glow filling the bulbs is continued until the whitish glow appears. Then pumping is resumed until the negative glow discharge entirely or substantially entirely disappears. During this time the bulbs have been rising in temperature due to the rise in temperature of the oven, and the heating by the oven is continued as is also the pumping and a current may now be passed through the filaments *f* by closing the switch 48, the current through the filaments being continued for some time. The consequent heating of the filaments drives off finally any gases condensed upon or occluded within the filaments. The current through the filaments is then interrupted by opening the switch 48 and the application of heat to the oven is discontinued and the oven allowed to cool. Pumping is continued until the bulbs are cool enough to handle and the tubes 43 are then sealed off, and the bulbs are vacuum tight and separated from the tube 44. The result is a final vacuum which is important in improving the operating and life characteristics of incandescent lamps and the like, particularly in the case of incandescent lamps having tungsten or other metallic filaments.

In Fig. 3 there is a graphic representation of the potential gradient, curve 55 representing the potential drop at different points in the gas path between negative and positive terminals or electrodes when the gas, such as air, is at a pressure in the neighborhood of 1 millimeter of mercury. This figure is not limitive of my invention but illustrative only and serves to show that the greatest potential drop is at 56 near the negative electrode whose face is represented at 53, 54 representing the face of the positive electrode, the space between indicating the distance in gas between the two electrodes. Ordinates of the curve represent potentials in the gas between the electrodes. Inasmuch as the potential drop for a given current is far greater at or near the negative electrode it follows that the greatest part of the energy is there dissipated and for that reason the negative glow is best utilizable for the purposes herein described.

What I claim is:

1. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy through the remanent atmosphere between an anode and cathode, heating said cathode by said energy, and further exhausting said bulb during passage of energy until the cathode glow fills said bulb and acts upon the inner walls thereof.

2. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy through the remanent atmosphere between an anode and cathode, heating said cathode by said energy, further exhausting said bulb during passage of energy until the cathode glow fills said bulb and acts upon the inner walls thereof, interrupting exhaustion for a period during which said

bulb filling glow continues, and thereafter resuming exhaustion until said glow is reduced.

3. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy through the remanent atmosphere between an anode and cathode, heating said cathode by said energy, further exhausting said bulb during passage of energy until the cathode glow fills said bulb and acts upon the inner walls thereof, interrupting exhaustion for a period during which said bulb filling glow continues, and thereafter resuming exhaustion until said glow disappears.

4. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy through the remanent atmosphere between an anode and cathode, heating said cathode by said energy, further exhausting said bulb during passage of energy until the cathode glow fills said bulb and acts upon the inner walls thereof, interrupting exhaustion for a period during which said bulb filling glow continues, thereafter resuming exhaustion until said glow is reduced, and exteriorly heating the bulb.

5. As an improvement in the art of exhausting bulbs, the method which consists in impressing electrical potential of three hundred volts or more upon electrodes separated in the atmosphere of a bulb, and reducing the pressure within said bulb to the order of one millimeter of mercury until said potential produces at the cathode a glow substantially one-sixteenth of an inch in thickness for heating said cathode, and thereafter further exhausting said bulb.

6. As an improvement in the art of exhausting bulbs, the method which consists in impressing electrical potential of three hundred volts or more upon electrodes separated in the atmosphere of said bulb, reducing the pressure within said bulb to the order of one millimeter of mercury until said potential produces at the cathode a glow substantially one-sixteenth of an inch in thickness for heating said cathode, maintaining said glow for a period of time, and thereafter further reducing the pressure within said bulb.

7. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy of a unidirectional current through said bulb, adjusting the amount of said energy to cause a glow spreading over an electrode within said bulb to heat said electrode and resuming exhanstion of said bulb while continuing passage of said energy through said bulb whereby said glow extends and finally fills said bulb.

8. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy of a unidirectional current through said bulb, adjusting the amount of said energy to cause a glow spreading over an electrode within said bulb to heat said electrode, resuming exhaustion of said bulb while continuing passage of said energy through said bulb whereby said glow extends and finally fills said bulb, and discontinuing exhaustion while maintaining said bulb filling glow for a period sufficient to heat said bulb.

9. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy of a unidirectional current through said bulb, adjusting the amount of said energy to cause a glow spreading over an electrode within said bulb to heat said electrode, resuming exhaustion of said bulb while continuing passage of said energy through said bulb whereby said glow extends and finally fills said bulb, discontinuing exhaustion and maintaining said bulb filling glow for a suitable period, and thereafter resuming exhaustion.

10. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy of a unidirectional current through said bulb, adjusting the amount of said energy to cause a glow spreading over an electrode within said bulb to heat said electrode, resuming exhaustion of said bulb while continuing passage of said energy through said bulb whereby said glow extends and finally fills said bulb, discontinuing exhaustion and maintaining said bulb filling glow for a suitable period, and thereafter resuming exhaustion until said glow disappears.

11. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy of a unidirectional current through said bulb, adjusting the amount of said energy to cause a glow spreading over an electrode within said bulb to heat said electrode, resuming exhaustion of said bulb while continuing passage of said energy through said bulb whereby said glow extends and finally fills said bulb, discontinuing exhaustion and maintaining said bulb filling glow for a suitable period, and thereafter resuming exhaustion until said glow disappears, exteriorly heating said bulb during continued exhaustion, and sealing off said bulb.

12. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb to a pressure of the order of one millimeter of mercury, impressing upon electrodes separated in the atmosphere of said bulb an electric potential of three hundred volts or more for produc-

ing a glow at the cathode to heat the same, and thereafter continuing exhaustion and increasing said potential until said glow fills said bulb.

13. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb to a pressure of the order of one millimeter of mercury, impressing upon electrodes separated in the atmosphere of said bulb an electric potential of three hundred volts or more for producing a glow at the cathode to heat the same, thereafter continuing exhaustion and increasing said potential until said glow fills said bulb, and dis-continuing said exhaustion and continuing said glow.

14. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting said bulb to a pressure of the order of one millimeter of mercury, impressing upon electrodes separated in the atmosphere of said bulb an electric potential of three hundred or more volts for producing a glow at the cathode to heat the same, thereafter continuing exhaustion and increasing said potential until said glow fills said bulb, dis-continuing said exhaustion and continuing said glow, and thereafter resuming exhaustion until said glow disappears.

15. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb to a pressure of the order of one millimeter of mercury, impressing upon electrodes separated in the atmosphere of said bulb an electric potential of three hundred volts or more for producing a glow at the cathode to heat the same, thereafter continuing exhaustion and increasing said potential until said glow fills said bulb, dis-continuing said exhaustion and continuing said glow, thereafter resuming exhaustion until said glow disappears, and exteriorly heating said bulb during said continued exhaustion.

16. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb to a pressure of the order of one millimeter of mercury, impressing upon electrodes separated in the atmosphere of said bulb an electric potential of three hundred volts or more for producing a glow at the cathode to heat the same, thereafter continuing exhaustion and increasing said potential until said glow fills said bulb, dis-continuing said exhaustion and continuing said glow, thereafter resuming exhaustion until said glow disappears, exteriorly heating said bulb, allowing said bulb to cool, and while cooling continuing said exhaustion.

17. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, impressing a potential of more than three hundred volts upon electrodes separated in the atmosphere of said bulb, whereby the cathode is heated while the pressure in said bulb is substantially one millimeter of mercury, and thereafter further exhausting said bulb.

18. As an improvement in the art of evacuating bulbs, the method which consists in partially exhausting a bulb, impressing an electric potential upon electrodes separated in the atmosphere of said bulb to heat the cathode, continuing exhaustion and increasing said potential to more than twenty-five hundred volts, whereby a cathode glow fills said bulb.

19. As an improvement in the art of evacuating bulbs, the method which consists in partially exhausting a bulb, impressing upon said bulb electrical potential whereby a cathode glow of bluish color fills said bulb, and adjusting said potential until a change of color of said glow to a whitish color is impending.

20. As an improvement in the art of evacuating bulbs, the method which consists in partially exhausting a bulb, impressing upon said bulb electrical potential whereby a cathode glow of bluish color fills said bulb, adjusting said potential until a change of color of said glow to a whitish color is impending, continuing said glow for a period of time, and thereafter resuming exhaustion until said glow disappears.

21. The method of exhausting an X-ray tube, which consists in partially exhausting the tube, impressing an electric potential upon electrodes within said tube, the anticathode serving as cathode to heat the same to redness with a glow confined thereto, thereafter further exhausting the tube until the cathode glow fills the tube to operate upon the inner walls thereof, discontinuing exhaustion and continuing said last named glow, and thereafter further exhausting said tube.

22. The method of exhausting an X-ray tube, which consists in partially exhausting the tube, impressing an electric potential upon electrodes within said tube, the anticathode serving as cathode to heat the same to redness with a glow confined thereto, thereafter further exhausting the tube until the cathode glow fills the tube to operate up the innner walls thereof, discontinuing exhaustion and continuing said last named glow, and thereafter continuing exhaustion of said tube and simultaneously exteriorly heating the same.

23. The method of exhausting an X-ray tube, which consists in partially exhausting the tube, impressing an electric potential upon electrodes within said tube, the anticathode serving as cathode to heat the same to redness with a glow confined thereto,

thereafter further exhausting the tube until the cathode glow fills the tube to operate upon the inner walls thereof, discontinuing exhaustion and continuing said last named glow, thereafter continuing exhaustion and simultaneously exteriorly heating the tube, allowing the tube to cool, and during cooling continuing exhaustion.

In testimony whereof I have hereunto affixed my signature in the presence of the two subscribing witnesses.

HOMER CLYDE SNOOK.

Witnesses:
FLORENCE RUSH,
ELEANOR T. McCALL.