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2,067,576

METHOD AND APPARATUS FOR OPERATING POSITIVE COLUMN DISCHARGE TUBES

Filed June 19, 1933

2 Sheets-Sheet 1

Fig. 1.

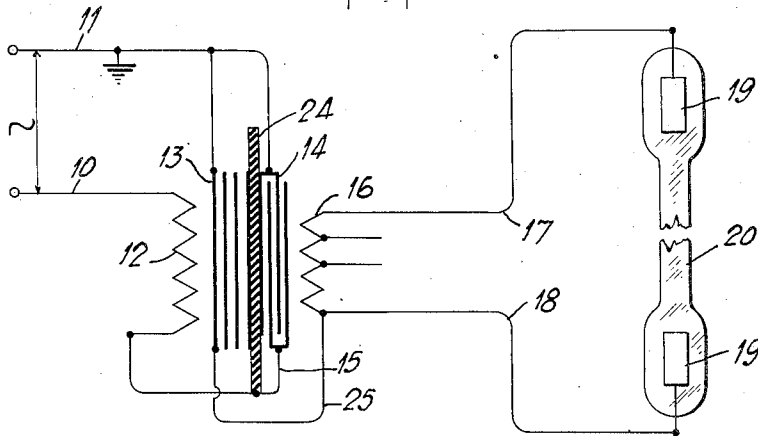


Fig. 2.

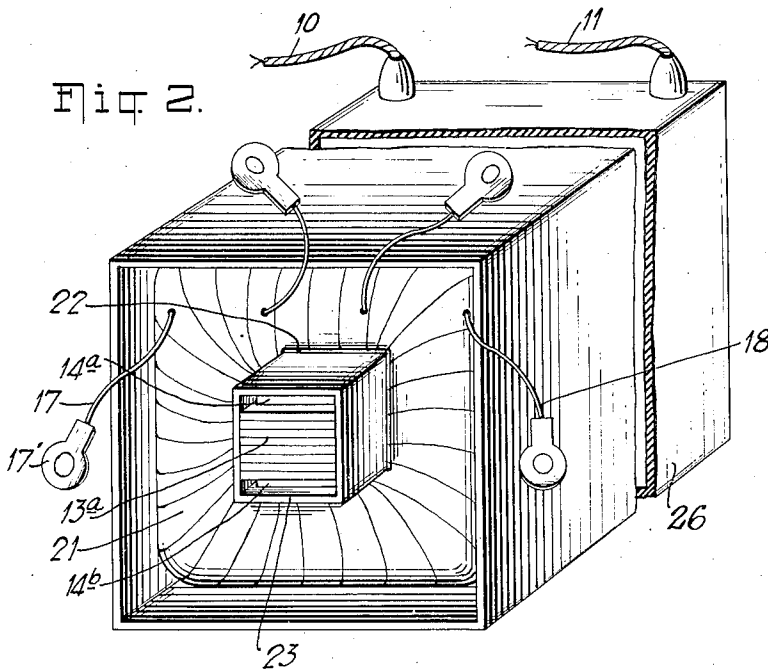
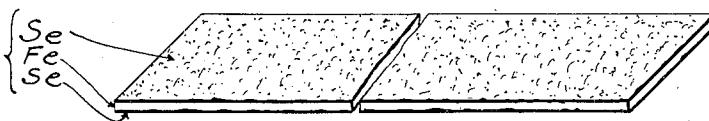


Fig. 3.



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Fig. 4.

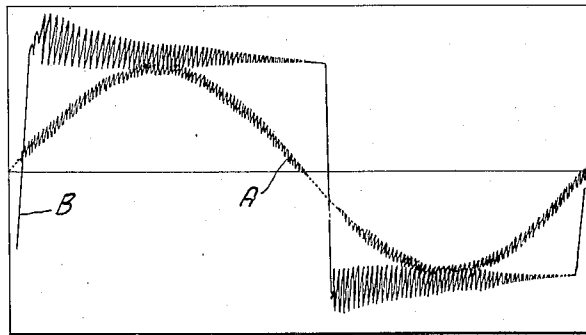


Fig. 5.

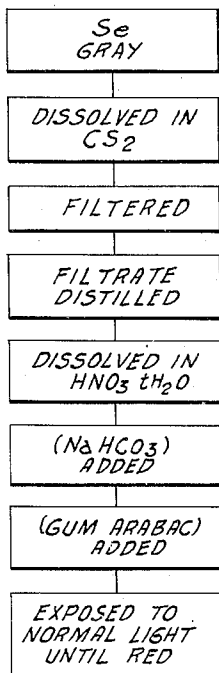
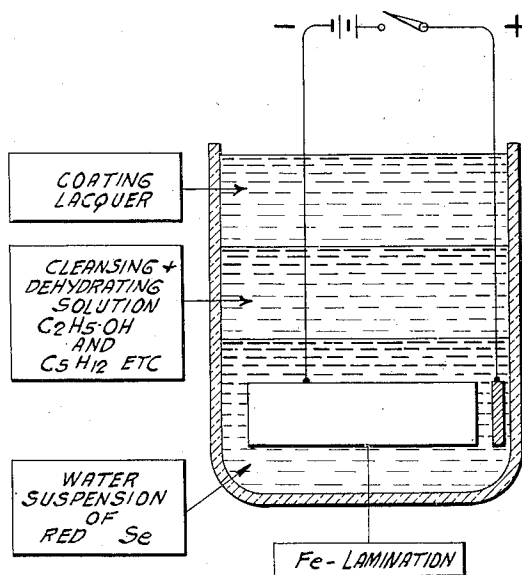


Fig. 6.



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METHOD AND APPARATUS FOR OPERATING
POSITIVE COLUMN DISCHARGE TUBES

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13 Claims. (Cl. 176—124)

This invention relates to method and apparatus for operating positive column discharge tubes and particularly to the operation of positive column discharge tubes, which are for illumination and display purposes and have a filling of one or more gases at relatively low pressure, for example a filling of helium, neon, argon, etc., or a mixture of the same.

The invention has for its object generally an improved method and apparatus therefor, whereby positive column discharge tubes may be operated with the consumption of relatively little energy and has improved characteristics whereby the apparatus avoids the necessity for and the cost of high voltage insulation, and may be readily and conveniently installed.

More specifically, the invention has for its object to provide a new and improved method of causing a positive column discharge tube to strike an arc discharge and give illumination when a relatively low voltage is impressed and when operating to suppress the power component of the current whereby heating effects are avoided; the tube, to all intents and purposes, then operating as a cold light.

Another object is to provide an improved method and apparatus for producing an alternating current of relatively high frequency which cooperates in causing the striking of an arc in a positive column discharge tube when a relatively low voltage is impressed. This method utilizes certain chemical elements such as selenium in a certain state or modification for influencing normal magnetic fields in supply apparatus of commercial frequencies to give relatively high frequencies.

Still another object is to provide a process and improved procedure for producing the desired modification of a chemical element such as selenium, in substantially any amount and having a purity and potency of predetermined value.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combinations of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken

in connection with the accompanying drawings, in which:

Fig. 1 shows schematically an arrangement of apparatus for operating a positive column discharge tube in accordance with the invention;

Fig. 2 is a view mainly in perspective, parts being broken away showing a transformer such as is included in the apparatus employed in the practice of the present invention;

Fig. 3 shows in perspective a core lamination of a character adapted to be employed in the transformer shown in Fig. 2;

Fig. 4 is a diagrammatic view showing typical voltage and current curves which may be observed in an oscillograph connected to ascertain the operation of a positive column discharge tube when arranged as shown in Fig. 1;

Fig. 5 is a flow diagram showing the steps of a process to be followed in producing selenium in a modification suitable for the practice of the present invention; and

Fig. 6 shows schematically an apparatus which may be employed for producing laminations like that shown in Fig. 3.

Positive column discharge tubes, as is well known, require a higher striking voltage than an operating voltage. This characteristic is commonly referred to as a negative voltage characteristic and may be observed in any oscillographic record of the instantaneous voltage values which are operative across such discharge tube. An oscillogram for a neon discharge tube showing this characteristic is depicted in Fig. 4, where A depicts a current curve, and B depicts a voltage curve. The curve B is seen not to be in phase with the curve A, but has nodes slightly ahead of those in curve A and is seen to rise sharply to a certain peak value before the current will pass. The curves depicted show the presence of a high frequency harmonic of small amplitude. In oscillograms, as ordinarily recorded, the actual separation of the high frequency loops of the order here employed is not discernible to the naked eye, only a broadening of the curve-portions away from the axis being seen. In this figure, however, the separation has been shown in order that the nature of the harmonic may appear. When such harmonics appear, as they do at times in oscillograms of ordinary commercial tubes operated from 60-cycle sources of alternating current, they are deemed to indicate a condition of instability and is not infrequently accompanied with a tendency to flicker.

This instability and tendency to flicker, while

in part a property of the pressure in the tube, the size and length of the same, the size and condition of the electrodes and the degree to which occluded gases are removed, has also been
 5 ascertained to be in part due to the characteristics of the gas molecule. By properly designing a tube, the tube-factors tending toward instability may be substantially eliminated or compensated for, the means to this end being known
 10 to those skilled in the art. The factors depending upon the characteristics of the gas molecules in the tube, however, cannot be eliminated, but advantage may be taken of the same to cause the tube to strike an arc and become
 15 luminous with voltages of relatively low value, provided a voltage of proper high frequency is impressed. The nature of this phenomena is not entirely clear, but it seems likely to be a property depending upon a characteristic resembling resonance in a molecule or structure whereby ionization can be induced to take place
 20 at a lower voltage and with less work than heretofore when a voltage of proper high frequency has been impressed. This phenomena of striking a discharge in positive column discharge tubes has been observed to take place with gases such as helium, neon and argon over a selected range of frequencies. The striking in commercial tubes for neon and argon takes place
 25 substantially within a band of frequencies ascertained to be in the neighborhood of from 5,000,000 cycles per second to 42,000,000 cycles per second; the tubes so struck being filled with gas of commercial purity at the pressures commonly employed for such tubes, i. e., a pressure
 30 of about 7.5 mm. of mercury for neon, and a pressure of about 12 mm. of mercury for argon.

In order readily to provide current of the frequencies desired, it is proposed to superimpose
 40 suitable harmonics on the current supplied by modifying the magnetic field of a source of current, such as a service transformer, by the presence of a chemical element that is suitably sensitive and capable of modifying the normal
 45 magnetic field. Selenium markedly exhibits this characteristic, especially when in a red-crystal-line form, which has the property of selectively absorbing light energy. In this modification or form, it seems to be activated, especially after
 50 prolonged exposure to a strong actinic light, such as sunlight. Crystals of selenium in this form when placed in the magnetic field of a transformer, for instance between the laminations of the core, have the property of producing
 55 in the normal current, harmonics which have high frequencies within the frequency band desired.

In order to suppress the power component of the current passing in the tube, the servicing
 60 transformer is made to have high values of its reactance; accordingly, an open magnetic circuit core type transformer is preferably employed, together with an arrangement of windings and other agencies productive of this end.

Referring now to the drawings, and particularly to Fig. 1, 10 and 11 denote conductors leading from a commercial source of alternating current, for example, a 110-volt, 60-cycle source. Conductor 10 is shown as leading directly to one
 70 terminal of a primary winding of a service transformer, which is constructed to have a high reactance characteristic and the ability to superpose a high frequency current upon that supplied by the secondary. The other conductor
 75 11 is grounded and connected to a lamination of

a core 13, which is shown as of the open magnetic-circuit type, in order to assist in imparting to the transformer the high reactance characteristic desired. From this lamination, the circuit is continued and is connected to one
 5 terminal of a series condenser or capacitor 14, that is conveniently made physically small, but is electrically of relatively high capacitance and assembled with the core and inserted in the winding-assembly, as shown. From the other
 10 terminal of the condenser, a conductor 15 leads to the other terminal of primary winding 12. By this arrangement, it is seen that the capacitor and the primary of the transformer are connected in series.

A secondary winding 16 is assembled over the primary winding about the core 13 and has terminals, connected by conductors, shown respectively at 17 and 18, to the electrodes 19 of a positive column discharge tube 20. This secondary winding may have one or more taps if
 20 desired. The tube 20, while depicted as straight, is shown merely conventionally and may have substantially any desired length and shape. Lengths up to 92 feet of ordinary commercial tubing have been made to strike and give illumination from transformers of the present invention, where the transformer has an output
 25 potential across the secondary of only 98 volts, the current consumption in such cases being in the neighborhood of .001 ampere. By the use of the present invention, tubes may be made to turn sharp corners and have lateral projections away from the normal axis of the tube, which illuminate fully when a discharge is taking place within the tube. This enables relatively simple constructions for letters in signs, such as E, to be employed and does not require
 30 the use of a return lap to get the middle bar of the letter E illuminated, as is now commonly practiced.

The core 13, which is of the open magnetic circuit type, comprises an assembly of laminations arranged to incorporate the chemical element depended upon to modify the magnetic field and develop harmonics producing a relatively high frequency. A physical winding assembly is shown in Fig. 2 for the practice of the invention where the primary and secondary windings are nested, but are not necessarily closely coupled magnetically. The windings, accordingly, are advantageously separated by insulation such as a cellulosic material that may be in sheet form and shellacked if desired and wrapped with an outer wrapping of insulating material 21, such as tape or cambric to form a package having a central opening 22 in which the core is inserted. As the assembled laminations generally provide a rectangular assembly, this opening is shown as rectangular and has a liner or casing 23 of insulation, of a form which fits snugly about the walls of the opening, projecting therefrom, the assembled core being indicated as disposed interiorly thereof at 13^a. At each side of the core is preferably disposed portions of the condenser 14, the portions being denoted 14^a and 14^b, respectively; the plates of the condenser which are adjacent the core being preferably separated therefrom by one or more layers of insulation, which may be relatively thick, the same being conventionally depicted at 24 in Fig. 1. While any suitable insulation may be employed, the effect of producing desired harmonics in the output current is enhanced if this insulating material is impreg-
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nated with the chemical element depended upon to modify the magnetic field. Where impregnation with such element is practiced, the conductor 15 may advantageously be connected thereto at one end, as shown. One side of the secondary winding is also advantageously connected to ground through the core, which is here shown as accomplished by a conductor 25.

When selenium, in a suitable modification, is employed to produce the desired harmonics, this may be incorporated in the core in a number of different ways. It may, for example, be deposited upon an insulating fabric such as a dry parchment paper and laminations, corresponding in size and shape to those of iron in the core, cut from the coated paper and interleaved with the iron lamination. The dryness of the paper is essential, since the presence of moisture seems to be generally deleterious to the deposited selenium and causes it to change its form and lose its potency to produce the desired effect. Paper of the desired quality is not always readily obtainable or sufficiently low in price and resort to other methods of incorporation may be had, for example, it may be deposited upon certain magnetically neutral metals, such as aluminum, that are afterwards oxidized on the surface in a manner such that the oxide envelopes and protects the deposited selenium.

A preferred method, however, involves the deposition of selenium directly upon the iron laminations to be employed in the core. A lamination of this character is depicted in Fig. 3 where opposite sides are coated with a thin layer of a red form of selenium, the selenium coated lamination being thereafter covered with a protective coating of moisture-proof non-magnetic material such as a coating of lacquer containing a phenolic-condensation product, for example, that sold under the trade-name "Bakelite".

The laminations thus produced are assembled as shown at 13^a to provide the open magnetic-circuit type of core preferred and are inserted together with one or more portions of capacitance as shown at 14^a and 14^b in the insulating or barrier tube 23. This latter may have selenium in the desired modification associated with it. Accordingly, it is preferably wrapped with paper or parchment having the desired modification of selenium upon or impregnated in it. Such paper is with advantage relatively thin, for example from .001 to .002 inch thick and may be further impregnated with wax or paraffine in order to improve its moisture resisting properties and thereby increase its protection for and preservation of the potency of the selenium employed. The transformer proper, when thus assembled, is preferably hermetically sealed in a protective casing, as shown at 26.

In order to provide selenium in the desired red crystalline modification, ordinary commercial gray selenium is the raw material employed which is first preferably purified and finally precipitated from an acid solution by means of a suitable alkaline agent. The preferred steps to be followed in achieving this end are indicated schematically in Fig. 5. Here, the gray modification is indicated as first dissolved in a suitable volatile solvent, for example, carbon bisulphide, after which the solution is filtered and the filtrate then distilled. In this way, the undesirable impurities are substantially removed. The steps of filtration and distillation are preferably practiced two or three times in succession. The selenium resulting, which is still in the gray modifi-

cation, is now dissolved in nitric acid, for example, one-tenth normal. When dissolved, the alkaline agent which may be sodium bicarbonate, potassium bicarbonate, or the like, is added. Fine particles of selenium will now precipitate. If, however, it is desired to use this selenium for electrolytic deposition, it may be converted into a suspension by the addition of a suitable amount of a suitable gum, for example, gum arabic, gum tragacanth, etc. Selenium that is either precipitated or in suspension is converted into the red modification by exposing the same to sunlight or to a light containing strong actinic rays. Exposure for a period of approximately three days has been found to yield a selenium which is almost 100% in the red crystalline form.

Where electrolytic deposition is practiced, a suspension of selenium in a gum arabic solution, which has been properly exposed to light, is placed in an electrolytic cell and the transformer element on which the selenium is to be deposited connected as a cathode in the cell. An improved arrangement for accomplishing the electrolytic deposition of selenium on the surfaces of an iron lamination for the transformer core is shown in Fig. 6. Here, the iron lamination is suspended in a gum arabic solution which contains the red modification of selenium in a state which is practically colloidal. This lamination is connected to a negative pole of a convenient source of direct current, for example, a storage cell, the electrolytic cell also having an anode connected to the positive pole of the same source of current.

A lamination of a character suitable for the transformer core 13 should be of a relatively good grade of transformer iron and is relatively thin, for example a lamination whose surface dimensions are 1 x 5½ inches, would have a thickness of approximately .02 inch, and is specially prepared in order that it will receive an even deposit of selenium in the manner desired. This has been found best accomplished by pickling the lamination in a weak acid solution, after which it is dried in a non-oxidizing atmosphere, sand-papered and finally washed in benzene so as to insure its being substantially free from oily and fatty material.

In order that the lamination may be coated with selenium, for example with a selenium coating of from .0005 to .001 inch thick, and thereafter coated with a protective lacquer, which may be of substantially the same thickness as the coating of selenium, all in one operation, it is preferable that the electrolytic cell in which the selenium is deposited on the lamination be relatively deep, so that there may be superposed above the plating suspension a suitable dehydrating and cleansing solution, for example, one consisting of alcohol plus benzene or other hydrocarbon poured into the cell to the desired depth, care being taken not to disturb the separating surface which normally intervenes between these two solutions. Superposed above the cleansing and dehydrating solution is a third solution or liquid layer, comprising the protective material, such as a lacquer from a phenol condensation product. When sufficient current has been passed from the source of E. M. F. in Fig. 6 to deposit a coating of selenium having the desired thickness on the lamination, the circuit may be opened and the lamination withdrawn. It is seen that by drawing the lamination thus coated slowly up through the two liquids above the plating suspension, the lamination is first substantially freed from moisture and then coat-

ed with a desired protective coating, after which the lamination may be dried and assembled in the transformer core.

In operation, the tube to be illuminated is connected to the secondary terminals of a transformer constructed as here indicated and current turned on in the usual manner. The tube will light up at once, all parts of the tube being illuminated without the occurrence of dead spots, even though there be portions of the tube projecting out of the central line of discharge. This illumination will be produced with a very small consumption of energy, for example, when a tube 92 feet long was illuminated from a secondary transformer whose primary was energized from 110-volt current from a 60-cycle source, and the secondary output was in the neighborhood of 98 volts, 92 feet of commercial tubing were illuminated with an energy consumption of substantially one-tenth watt.

The physical dimensions of a transformer for accomplishing the illumination of tubing in this manner is relatively small, for example, the primary and secondary windings may be wound separately and nested from No. 10 annealed copper wire, the windings being wound as layer built windings until substantially two pounds of copper wire are incorporated. The windings thus assembled may comprise a package that has dimensions of about $3\frac{1}{2} \times 3\frac{1}{2}$ inches, the windings being distributed along the winding axis that is about 5 inches in length. The sealing casing which encloses these windings can be provided to have relatively little clearance. It is thus seen that the outside dimensions of the transformer need not greatly exceed that of the winding package within. Where the ratio of primary to secondary turns is substantially 0.8, such transformer would have a secondary impedance value in the neighborhood of 6000 ohms and a straight ohmic resistance of a value in the neighborhood of 80 ohms.

A transformer thus constructed is adapted to operate tubes and does not require high voltage insulation and would, therefore, be connected to illuminate neon and other display tubes in a convenient and relatively inexpensive manner. By reason of the low energy consumption, there is substantially no heating effect. In consequence, all the parts remain at temperatures not materially different from the temperature of the atmosphere during the operation of the tube. The tube, therefore, as previously pointed out, operates as a substantially cold light when supplied with current from an alternating current supply system employing a magnetic field modifying agent in accordance with the present invention.

Since certain changes in carrying out the above process and in the constructions set forth, which embody the invention may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The method of operating positive column discharge tubes which comprises connecting the tube across a relatively low voltage source of alternating current of commercial frequency, and modifying the magnetic field of said source so as to superpose a relatively high frequency

harmonic upon said commercial frequency by the introduction of selenium in the magnetic field of said source.

2. The method of operating positive column discharge tubes which comprises connecting the tube across a relatively low voltage source of alternating current of commercial frequency, and modifying the magnetic field of said source so as to superpose a relatively high frequency harmonic upon said commercial frequency by the introduction of a red crystalline form of selenium in the magnetic field of said source.

3. The method of operating a positive column discharge tube which comprises supplying a low voltage current from a transformer supplied with commercial frequency, reactively suppressing the power component of the current supplied by said transformer, and inducing a striking voltage in the current supplied by superposing a harmonic upon the secondary current having a frequency taken from the frequency band extending from five million cycles to forty-two million cycles per second.

4. In apparatus for operating positive column discharge tubes, the combination with a positive column discharge tube, of a commercial source of relatively low voltage alternating current having a controlling magnetic field, and a chemical element incorporated in said field adapted to modify said field and superpose a high frequency harmonic on the current supplied of a character adapted to induce the striking of an arc discharge in said discharge tube at said relatively low voltage.

5. In apparatus for operating positive column discharge tubes, the combination with a positive column discharge tube, of a commercial source of relatively low voltage alternating current having a controlling magnetic field, and a light sensitive chemical element incorporated in the magnetic field of said source for modifying the same in a manner adapted to superpose a high frequency harmonic on the current supplied of a character adapted to induce the striking of an arc discharge in said tube at said relatively low voltage.

6. In apparatus for operating positive column discharge tubes, the combination with a positive column discharge tube, of a commercial source of relatively low voltage alternating current having a controlling magnetic field, laminations of magnetic material in said magnetic field, and a quantity of selenium associated with said laminations for modifying said magnetic field in a manner whereby an arc discharge may be struck in said discharge tube with said relatively low voltage.

7. In apparatus for operating positive column discharge tubes, the combination with a positive column discharge tube, of a commercial source of relatively low voltage alternating current having a controlling magnetic field, laminations of magnetic material disposed in said field, and a quantity of selenium in the red crystalline modification dispersed throughout said field in association with said laminations in a manner adapted to superpose a relatively high frequency harmonic upon the current supplied at said relatively low voltage to said discharge tube.

8. In apparatus for operating positive column discharge tubes, the combination with a positive column discharge tube, of a commercial source of relatively low voltage alternating current having a controlling magnetic field, laminations of magnetic material disposed in said field, thin

layers of red crystalline selenium interleaved with said laminations, and means for insuring the substantially complete exclusion of moisture from said layers of selenium.

5 9. In apparatus for operating positive column discharge tubes, the combination with a positive column discharge tube, of an alternating current transformer having a primary adapted to be connected to a commercial source of alternating current and a secondary adapted to supply 10 current at a relatively low voltage to said discharge tube, a core having means for imparting a relatively high reactance characteristic, and a quantity of a chemical element associated 15 with said core in a manner adapted to modify the magnetic field so as to superpose a relatively high frequency harmonic upon the secondary current supplied to said discharge tube.

10 10. In apparatus for operating positive column discharge tubes, the combination with a positive column discharge tube, of an alternating current transformer having a primary adapted to be connected to a commercial source of alternating current and a secondary adapted 25 to supply current at a relatively low voltage to said discharge tube, a core having means for imparting a relatively high reactance characteristic, and a quantity of selenium in a form activated by prolonged exposure to actinic rays 30 associated with said core and distributed so as to modify the magnetic field thereof whereby an arc discharge may be struck in said discharge tube when supplied with current at a relatively low voltage from said secondary.

35 11. In apparatus for operating positive column discharge tubes, the combination with a positive column discharge tube, of an alternating current transformer having a primary adapted to be connected to a commercial source of alternating current and a secondary adapted to supply 40 current at a relatively low voltage to said discharge tube, a core having means for imparting a relatively high reactance characteristic, a quantity of selenium in the red crys-

talline modification dispersed throughout said core and between the laminations thereof, and means for substantially completely excluding the acquisition of moisture by said selenium.

12. In apparatus for operating positive column 5 discharge tubes, the combination with a positive column discharge tube, of an alternating current transformer having a primary adapted to be connected to a commercial source of alternating current and a secondary adapted to 10 supply current at a relatively low voltage to said discharge tube, a core of the open magnetic circuit type having laminations of magnetic material, relatively thin layers of selenium in the red modification on said laminations and 15 interleaved therewith, means for excluding substantially completely the acquisition of moisture from said selenium and capacitances electrically connected in series with said primary and physically associated with said core. 20

13. In apparatus for operating positive column discharge tubes, the combination comprising a positive column discharge tube having electrodes in its ends, of a transformer having a primary 25 connected to a commercial source of alternating current and a secondary connected to said electrodes for supplying current at a relatively low voltage, a core for said transformer of the open magnetic circuit type, said core being composed of laminations of magnetic iron having 30 relatively thin deposits of selenium thereon in the red modification, said laminations having a coating of a moisture excluding lacquer thereon, layers of insulation interposed between said core and said windings and incorporating a quantity 35 of selenium in the red modification, a capacitance electrically connected in series with said primary winding and physically associated with said laminations within said layers of insulation, and a casing enclosing said windings, core and 40 capacitance in a manner which excludes substantially completely the acquisition of moisture by said selenium.

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