Aug. 20, 1935. L. L. BECK 2,012,236

LUMINOUS TUBE

Filed March 6, 1933 2 Sheets-Sheet 1

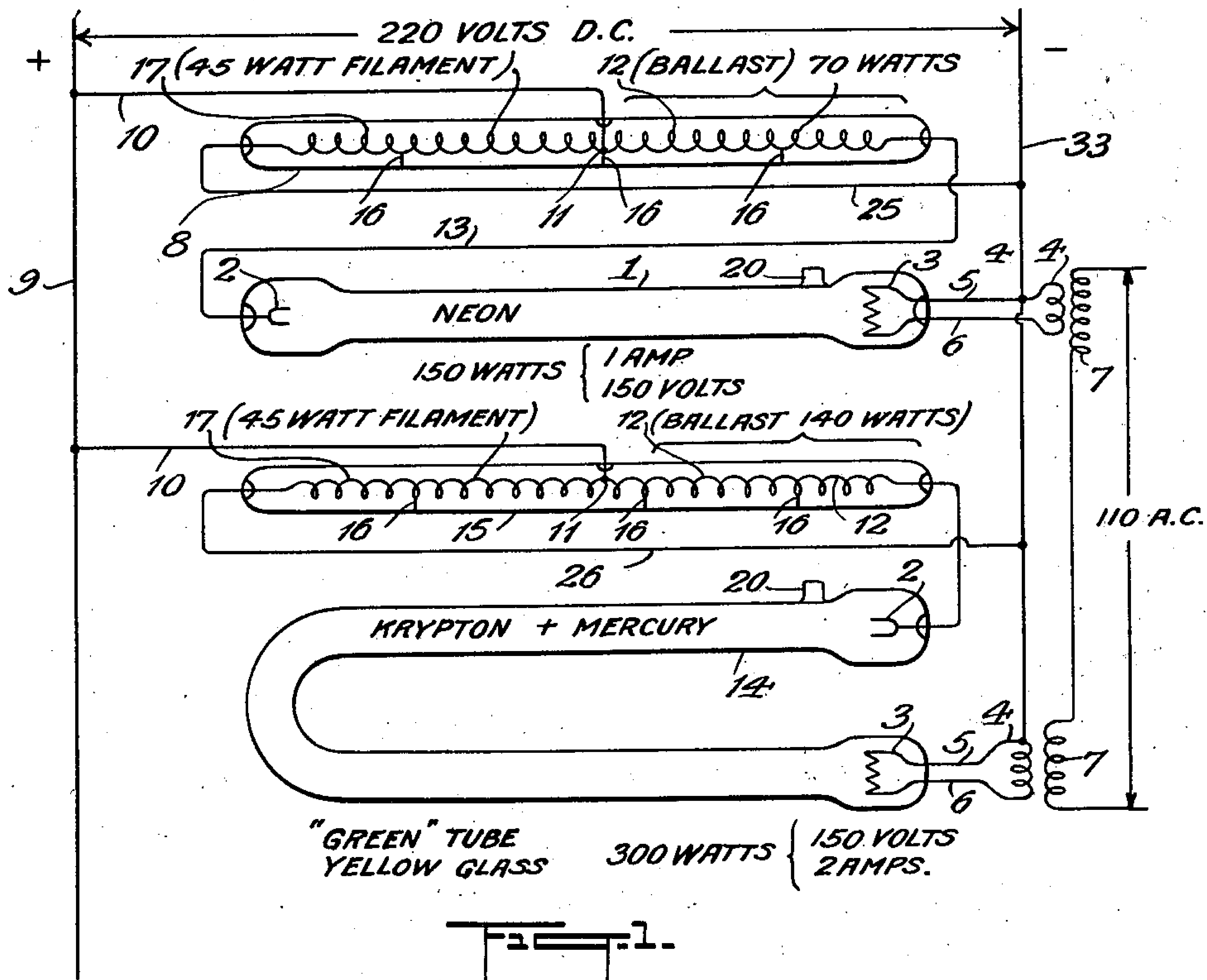

FIG. 1.

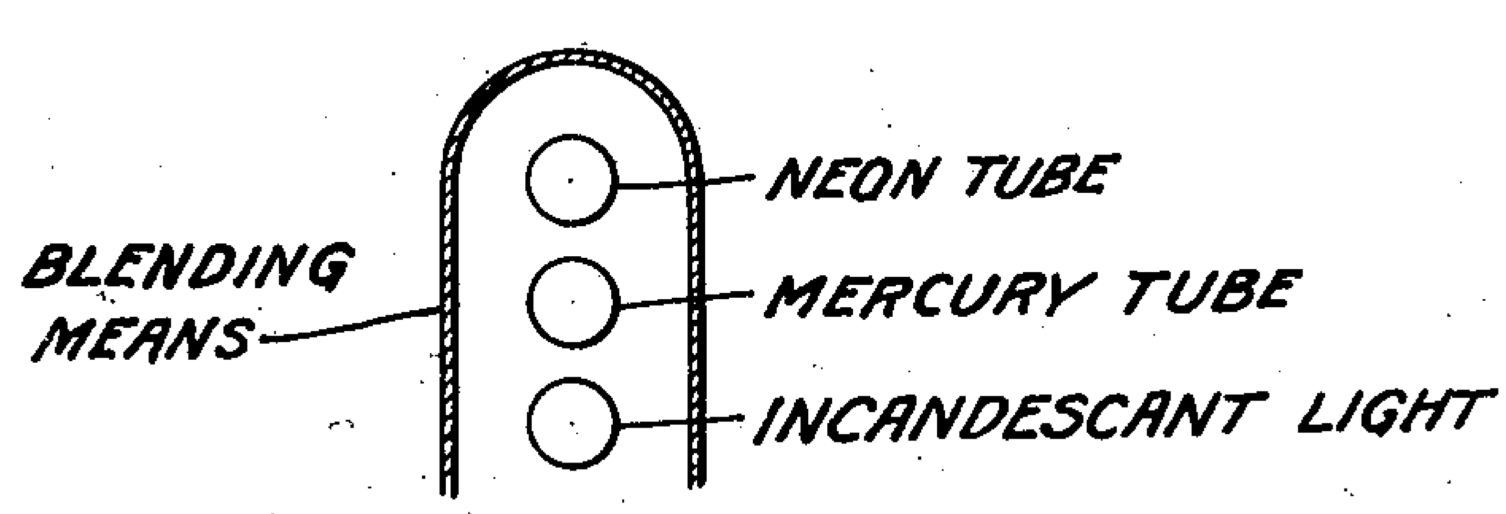

FIG. 3.

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LUMINOUS TUBE

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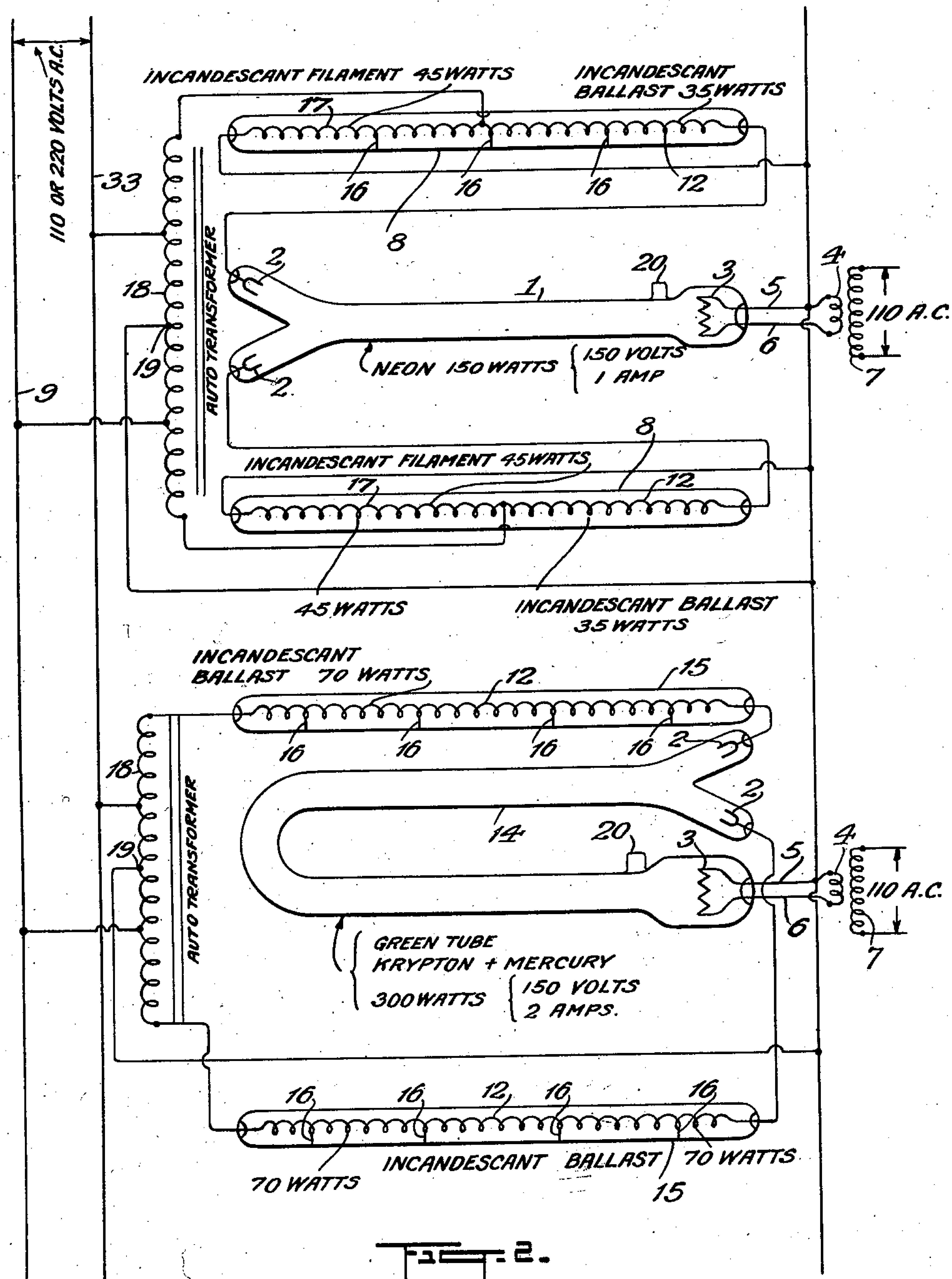

FIG. 2.

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LUMINOUS TUBE

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Application March 6, 1933, Serial No. 659,800

6 Claims. (Cl. 176—9)

This invention relates to and includes the art of gas and vapor electric lamps of the positive column type, frequently referred to as luminous tubes or luminescent tubes. This art is also referred to as the neon lamp art or luminescent tube art. It is exemplified by the now well known neon luminescent tubes commonly used for advertising and display purposes.

The progress of the illumination art and corresponding industry has been marked by well defined epochs and corresponding inventions. The oil lamp used as long ago as the dawn of the Christian era continued to be used until the discovery of illuminating gas. This was superseded by the Edison carbon filament incandescent lamp. This was followed by the now widely used tungsten filament lamp in which a filament of tungsten was substituted for the Edison carbon filament. Toward the end of the nineteenth century and in the early years of the present century, attempts were made to utilize the light emitted when a discharge of electricity is passed through a column of gas at low pressure, e. g. air, nitrogen, carbon dioxide, etc. contained in elongated tubes known as Moore tubes. These were commercially unsuccessful, largely because the gas filling became depleted very rapidly. Somewhat more successful were the Cooper-Hewitt mercury vapor lamps in which a discharge of electricity occurs between electrodes in an atmosphere of mercury vapor. For special purposes these lamps find application, but they are substantially monochromatic or at least the spectrum of the light emitted is so predominantly in the blue region that the human skin assumes a ghastly appearance. These lamps are quite useless for general illuminating purposes.

When the rare gases of the atmosphere, e. g. neon became available in commercial quantities, the practically dead art of illumination by discharge of electricity between electrodes in an atmosphere of gas was in a sense born again, because means was discovered whereby a tube having a filling of neon and provided with suitable electrodes would have a period of useful commercial life. But, like the Cooper-Hewitt mercury vapor lamp, the neon tube or lamp emits a substantially monochromatic light in the red end of the spectrum, and while such a light is of great value, for display purposes, it is useless as a general illuminant.

Throughout the history of the lamp art, the problem of securing a commercially satisfactory lamp having substantially the same effect as daylight has ever been present.

One of the objects of the present invention is the solution of that problem of long standing and it is believed that this invention marks a new epoch in illumination.

According to the present invention three kinds or species of light are utilized, combined and applied as described, viz: (1) light radiated by neon under the influence of an electric discharge (2) light radiated by mercury under the influence of an electrical discharge and filtered through a screen, e. g. a yellow or fluorescent screen which has the effect of intensifying the green radiations of the mercury spectrum and shifting the region of maximum intensity from the blue to the green portion of that spectrum; for the sake of simplicity of reference that modified mercury light will be herein referred to as the "green" light (3) light radiated by an incandescent body.

The term light as used in the present specification and claims means visible radiation. This may be measured and expressed in terms of lumens or other suitable units.

I have discovered that by blending one part of neon light (e. g. 1000 lumens) with approximately 3.5 to 4.5 parts (e. g. 3500 to 4500 lumens) of mercury light and about 3.5 to 4.5 parts (e. g. 3500 to 4500 lumens) of incandescent light, a composite light is obtained admirably suited to take the place of natural daylight for general illuminating purposes.

From this point of view my invention includes a method of producing a composite visible radiation adapted as a substitute for daylight which comprises discharging electricity through neon and through mercury vapor respectively, thereby generating neon light and mercury light, passing the mercury light through a screen to intensify the green radiations in the mercury light whereby said light is modified, passing an electric current through a solid body to raise the temperature thereof to incandescence, blending the neon light and mercury light in the proportion of one part of neon light to about 3.5 to 4.5 parts of mercury light and incorporating in this mixture an amount of incandescent light approximately equal to the amount of mercury light.

However, my invention goes further than this and provides a novel combination of sources of illumination adapted to produce a satisfactory daylight effect characterized by a high degree of luminous efficiency and mechanical simplicity.

I may employ luminous neon and mercury tubes of the arc-discharge type which operate at ordinary predetermined line potentials of the order of 100 to 230 volts. Such tubes have a negative can be used. For example, the ballast for each discharge tube may comprise all the filament in the tubes 8 and 15 and a separate elongated tube having an elongated filament may be used to consume the extra 90 watts (approximately) needed to get the extra incandescent light needed.

It will be observed that, with one exception, substantially all parts of the circuit which consume electrical energy are at the same time light emitters. That exception is the hot cathode 3 in each tube and the means to heat it. However, I have succeeded in eliminating or at least greatly reducing this source of loss by employing a particular form of cathode which I have devised and which is the subject of a separate application Ser. No. 659,801 filed on even date herewith, which application is incorporated by reference herein and made a part hereof. This application is entitled Cathode.

Turning now to Fig. 2, the differences between this and Fig. 1 are primarily those which I have found desirable or necessary for the operation of the tubes on alternating instead of direct current. The circuits of Fig. 2 are clearly shown therein. The chief difference between the circuits of Figs. 1 and 2 is the use of gas-discharge tubes of the double anode type. The autotransformers 18 step up the 110 or 220 volt supply current to 440 volts which is reduced back to 220 volts in each leg of the double anode circuit because the hot cathode 3 is connected to the neutral point 19 of the transformer 18. The wattage ratios in the neon tube 1, the "green" tube 14, the ballasts 12 and the filaments 17 is about the same as for Fig. 1. Ballast of about 70 watts for the neon tube 1 (Fig. 2) is divided accurately into two equal portions of 35 watts for each leg of the double anode circuit so as to get proper balancing of the discharge in each leg. In like manner, the ballast of about 140 watts for the 300 watt green tube 14 is accurately divided into two equal portions of 70 watts each. The proportion of light from an incandescent filament necessary to supply the extra incandescent light not radiated by ballasts 12 is in Fig. 2 indicated as shunts 17.

Instead of double anode tubes, it would be possible to use tubes having a single bidirectional hot cathode at each end, but double anode tubes are preferred partly at least because the use thereof is not attended with stroboscopic effects.

The tubes may be bent into any desired shape and grouped so that the respective radiations properly blend to produce the desired composite light. Preferably the neon light should traverse the green light as by having the green light between the neon light and the subject or article illuminated, as shown in Fig. 3.

Instead of using an elongated coil or filament in an elongated tube as a source of incandescent light, I may use an incandescent bulb light. But the elongated tube possesses advantages. For example, the elongated filament may be tapped off at various positions along the same to get any desired energy consumption in the sections corresponding to the taps; and the light from the elongated tube is sometimes much more easily blended with the light from the gas discharge tubes than would be the case with an incandescent bulb lamp.

The voltage drop through the tubes 1 and 14 of Figs. 1 and 2 is that occurring during operation. About one third more than this voltage is necessary to cause an initial discharge ("striking" or "lighting" are names commonly used to describe the initiation of discharge). This extra voltage would be wasted if the tubes were designed to "strike" instead of operate at the voltages necessary for operation. According to the present invention, therefore, some form of applying energy to "start" the gas discharge tubes is used and this is indicated broadly by the numeral 20 representing generally means for ionizing the gas filling. The broad notion of doing this as by high frequency, high inductive "kick", using the gas column as the dielectric between condenser plates, etc. is old, but in the copending application of Hrant Eknayen, Ser. No. 659,803 entitled Luminous tube starting device, there is disclosed a novel apparatus and method of starting gas discharge tubes. The disclosure of said application is incorporated herein by reference and made a part hereof, and I preferably use the starting means described therein.

The operation of the circuit shown in Fig. 1 will now be described. The operation of that shown in Fig. 2 is generally similar, with the differences necessary owing to the use of alternating current.

First, the filaments 3 are "lighted" i. e. current is sent through them from the transformers (4, 7) thus heating said filaments to an emissive temperature. Thereafter, discharge potential is applied across the tubes from the mains 9 and 33 by means of a suitable switch (not shown). No arc discharge occurs until additional "starting" energy is applied at 20, in the form, for example, of a high frequency, high voltage discharge to cause initial ionization of the gas. Thereupon, the tubes "strike" and an arc discharge occurs between anodes 2 and the cathodes 3 respectively. During operation of the apparatus, heating of the cathodes 3 by the transformers (4, 7) may or may not be continued.

Numerous modifications of the circuits diagrammatically shown in Figs. 1 and 2 and of the structure, properties and characteristics of the tubes may be effected within the scope of my invention. Upon measuring the relative amount of light emitted by the luminous tubes 1 and 14 respectively, it will be found that the green tube 14 radiates about four times as much light as neon tube 1 and about the same amount of light as the incandescent filaments in tubes 8 and 15. To attain this approximate ratio numerous other circuit connections, tube structure and other changes could be made. For example, the green tube could have the same overall length as the neon tube and have a smaller diameter, employing the same current (2 amperes). It could have the same length and the same diameter employing a larger discharge current value. In general, the amount of light (L) emitted by a source of illumination such as a luminous tube is proportional to the power (W) consumed thereby, so that $L=KW$ where K is a constant. Furthermore since $W=RI^2$ where R=resistance and I=current, then $L=K.RI^2$.

For a luminous tube having any given gas and/or vapor content it is therefore possible to vary the tube dimensions, the pressure of the gas, the current density, and the power input, in order to get any desired quantity of visible radiation. The luminous efficiency may vary considerably with changes in the several variables mentioned.

One of the objects of the present invention is a light having a high luminous efficiency and in proportioning the amounts of light radiated by the respective sources of incandescent light, neon light and "green" light as hereinabove described, the variables above set forth are preferably selected so as to maintain a high efficiency.

Furthermore according to the present invention it has been found that the composition of the gases in the green tube has a profound influence on the luminous efficiency of the mercury radiation and of the composite light. In the 750 watt combination hereinabove described, the green tube consumes about 300 watts but emits about four times as much light as the neon tube, which consumes about 150 watts. It would be expected that the green tube would emit only about twice as much light but actually it radiates about four times the amount of light radiated by the neon tube. This I ascribe to the krypton. The fact that the rare gas content of the green tube exerts a profound influence on the luminous efficiency is shown by the fact that if neon is substituted for the krypton, the efficiency of the resulting neon-mercury mixture is much less. Among the rare gases I prefer to employ in the green tube one or more selected from the group consisting of argon, krypton and xenon. These gases, jointly and severally, are highly efficient, the relative efficiency being in the order: xenon, krypton, argon. I prefer xenon, but it is not now economically available in commercial quantities.

It is to be observed that the invention comprises both method and apparatus (or manufacture) and both will be claimed.

What I claim is:

1. The method of producing a composite visible radiation adapted as a substitute for daylight which comprises discharging electricity through neon and through mercury vapor, respectively, thereby generating neon light and mercury light, passing the mercury light through a screen to intensify the green radiations in the mercury light whereby said mercury light is modified, passing an electric current through a solid body to raise the temperature of the body to incandescence, blending the visible neon light and the mercury light in the proportion of one part of neon light to approximately 3.5 to 4.5 parts of mercury light and incorporating in this mixture an amount of visible incandescent radiation approximately equal to the visible radiation from the mercury.

2. A unitary lamp having associated lighting units in combination comprising a neon tube for emitting light predominately in the red portion of the spectrum, said tube requiring a predetermined ballast resistance for limiting the current through said tube, a luminous mercury-containing tube for emitting light predominately in the green and blue portion of the spectrum, said tube requiring a second predetermined ballast resistance for limiting the current through said mercury-containing tube, said tubes being so proportioned for operation that the light emitted from said mercury-containing tube is from 3.5 to 4.5 times that emitted from the said neon tube, and incandescent light means for providing incandescent illumination, said light means consuming electrical energy substantially equivalent to the summation of the energy requirements of the first named and second named ballast resistance.

3. A unitary lamp having associated lighting units in combination comprising a neon tube for emitting light predominately in the red portion of the spectrum, said tube requiring a predetermined ballast resistance for limiting the current through said tube, a luminous mercury-containing tube for emitting light predominately in the green and blue portion of the spectrum, said tube requiring a second predetermined ballast resistance for limiting the current through said mercury-containing tube, said tubes being so proportioned for operation that the light emitted from said mercury-containing tube is from 3.5 to 4.5 times that emitted from the said neon tube, and incandescent light means for providing incandescent illumination, said light means consuming electrical energy substantially equivalent to the total energy requirements of said ballast resistances, at least a part of said incandescent illumination being furnished by ballast resistance.

4. A unitary lamp having associated lighting units in combination, comprising a luminous gaseous tube adapted to emit light predominately in the red portion of the spectrum, a ballast resistance for said tube, said ballast resistance functioning during operation of said tube as a source of incandescent light, a luminous vapor element containing tube adapted to emit light predominately in the green and blue area of the spectrum, a ballast resistance for said vapor element containing tube, said last-named ballast resistance functioning during operation of said vapor element containing tube as a source of incandescent light, said tubes being so proportioned for operation that the light emitted from the said mercury-containing tube is at least about 3.5 times that emitted by the first named tube, additional incandescent means for supplementing the incandescent illumination provided by the said ballast resistances to produce a balanced illumination having substantially the effect of daylight and means for passing electric current through said tubes, and said resistances.

5. A unitary lamp having associated lighting units in combination, comprising a luminous gaseous tube adapted to emit light predominately in the red portion of the spectrum, a ballast resistance for said tube, said ballast resistance functioning during operation of said tube as a source of incandescent light, a luminous mercury-containing tube adapted to emit light predominately in the green and blue portion of the spectrum, a ballast resistance for said mercury-containing tube, said ballast resistance functioning during operation of said mercury-containing tube as a source of incandescent light, said tubes being so proportioned for operation that the light emitted from the said mercury-containing tube is at least 3.5 times greater than that emitted by the first named tube, and additional incandescent means for supplementing the incandescent illumination provided by said ballast resistances to produce a balanced illumination having substantially the effect of daylight and means for passing electric current through said tubes and said resistances.

6. A unitary lamp having associated lighting units in combination, comprising a neon tube adapted to emit light predominately in the red portion of the spectrum, a ballast resistance for said tube, at least a part of said ballast resistance functioning during operation of said tube as a source of incandescent light, a luminous mercury-containing tube adapted to emit light predominately in the green, blue portion of the spectrum, means for intensifying the green radiations of said mercury-containing tube, a ballast resistance for said mercury-containing tube,

at least a part of said ballast resistance functioning during operation of said mercury-containing tube as a source of incandescent light, said tubes being so proportioned for operation that the light emitted from said mercury-containing tube is from about 3.5 to 4.5 times that emitted by the first named tube, additional incandescent means for supplementing the illumination provided by said ballast resistances to produce a balanced illumination in which the amount of light from the incandescent illumination is substantially equal to that from the said mercury-containing tube to provide substantially the effect of daylight, and means for passing electric current through said tubes and said resistances.

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CATHODE

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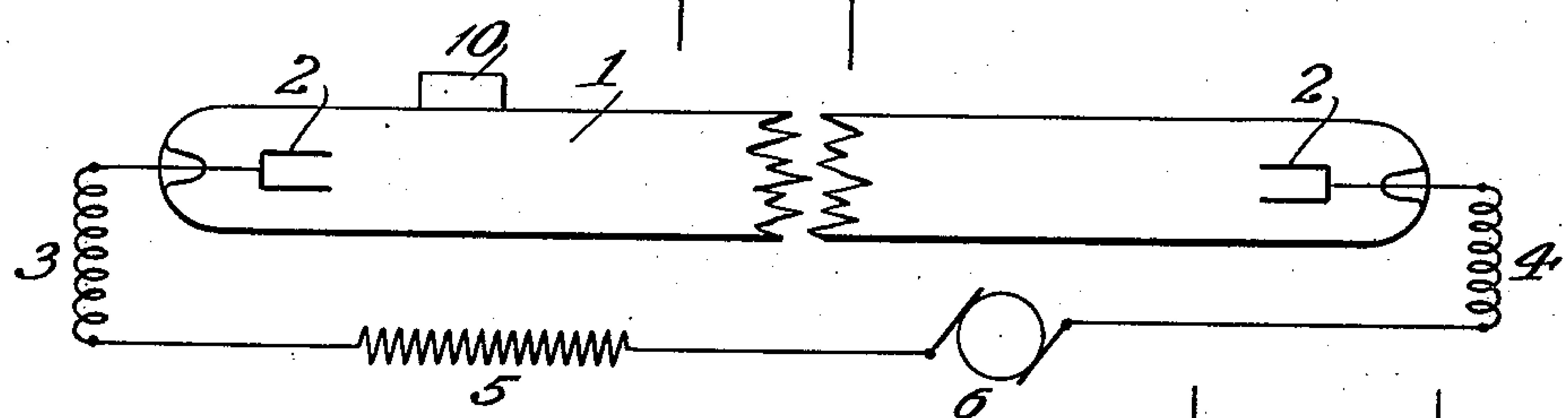
FIG. 1.



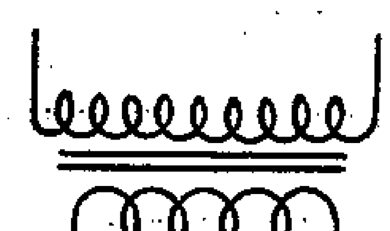


FIG. 4.

FIG. 2.

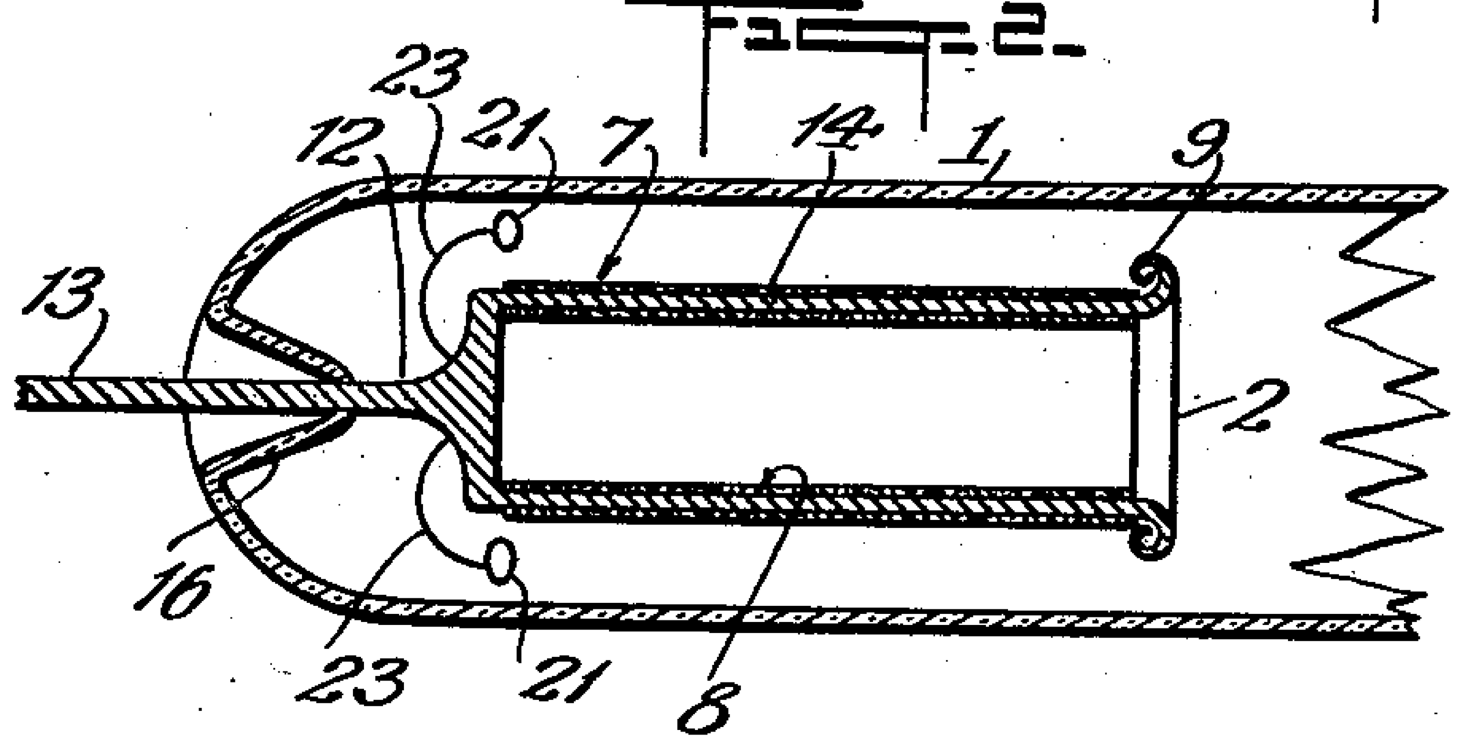


FIG. 3.

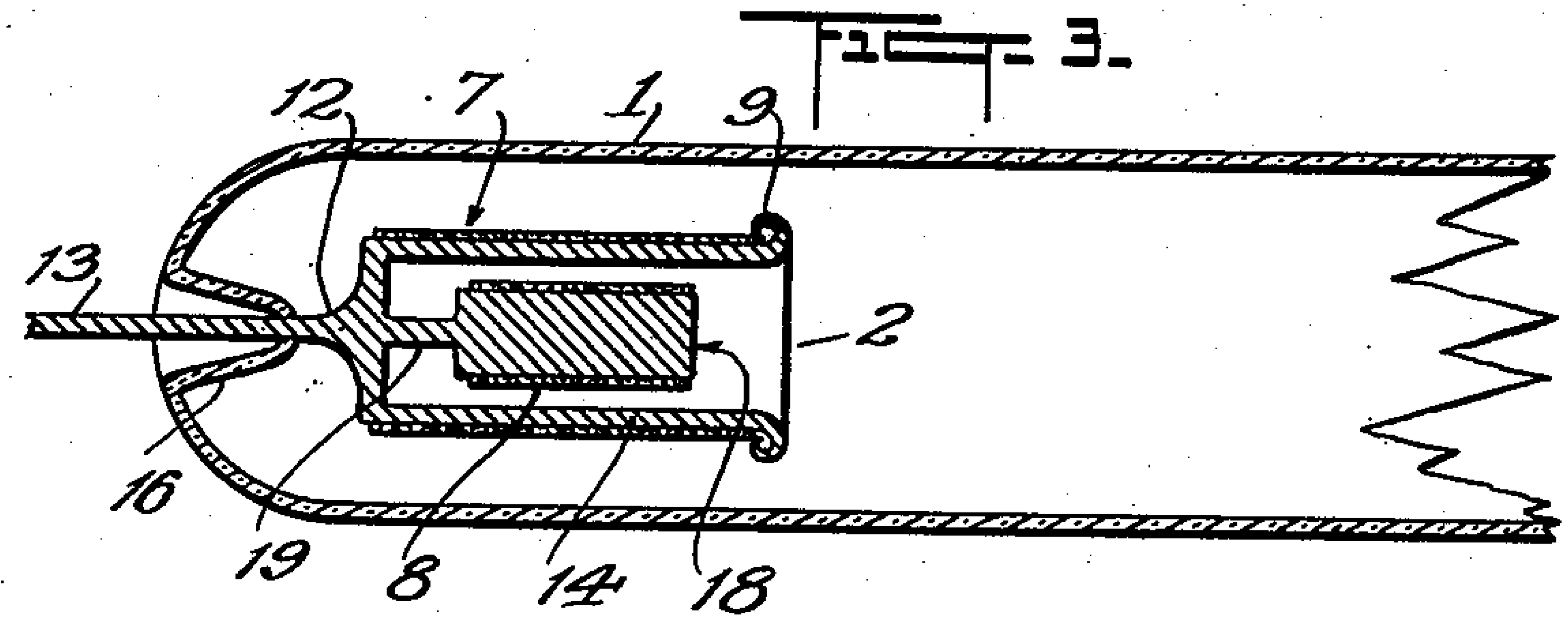
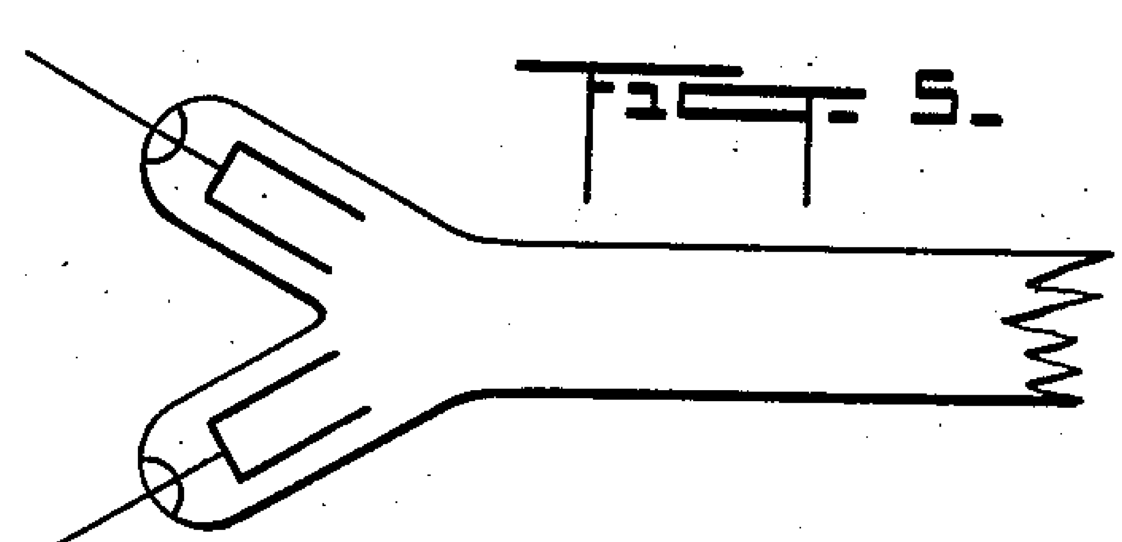


FIG. 5.



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