Nov. 21, 1933. Z. BAY 1,936,005

METHOD OF AND DEVICE FOR OPERATING LUMINOUS TUBES

Filed Oct. 23, 1929

FIG. 1

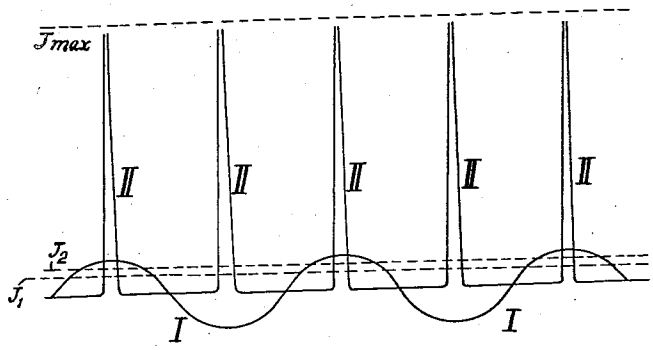


FIG. 2



FIG. 3

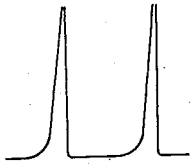


FIG. 4

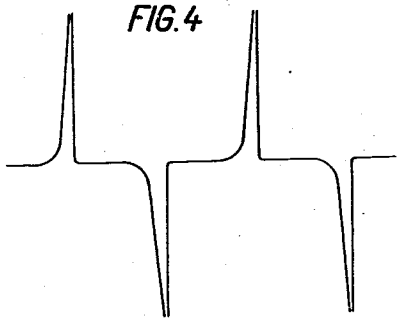


FIG. 5

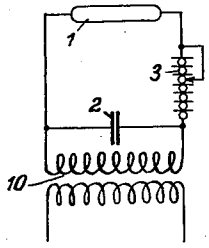


FIG. 6

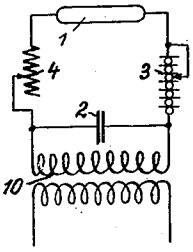


FIG. 7

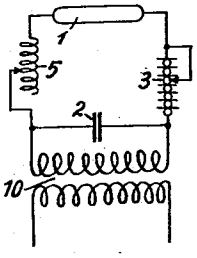


FIG. 8

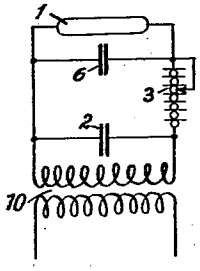


FIG. 9

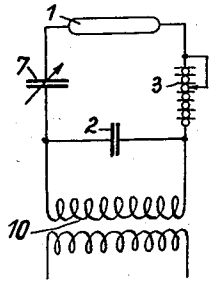


FIG. 10

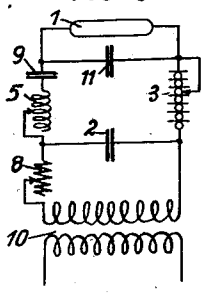
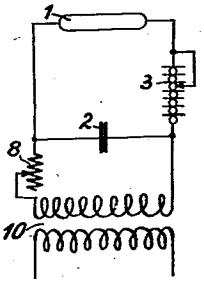


FIG. 11



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METHOD OF AND DEVICE FOR OPERATING LUMINOUS TUBES

Zoltan Bay, Berlin, Germany

Application October 23, 1929, Serial No. 401,866, and in Hungary October 26, 1928

9 Claims. (Cl. 176—124)

This invention relates, firstly, to a method of operating luminous tubes, and secondly, to means for use in connection with that method. Electric discharges in attenuated gases are, as is known, accompanied by luminous effects, the color of which is determined by the pressure and the kind of the respective gas. Luminous tubes of this kind require a certain minimum strength of the electric current in order to be able to produce a practically useful luminous effect. The radiation arising at this minimum of current will hereinafter be termed "fundamental radiation" and the corresponding color will be termed "fundamental color."

The object of the present invention is to act upon the fundamental colors of luminous tubes having a certain distinct or definite gas filling, and for this object, i. e. for the purpose of varying or changing the respective fundamental color, the respective tube is subjected to the action of current impulses which are separated from one another by distinct time intervals, the duration of each of which is a multiple of that of each individual impulse, the intensity or strength of the impulses being several times the effective strength of the respective current.

The manner of action, and the effect of this operation, can be explained and understood with the aid of the following considerations:

The molecules or the atoms of the attenuated gas filling, when being excited by the electric charge, produce a large number of different intermediate products. Thus, for instance, a tube filled with hydrogen, when being excited, besides the normal biatomic neutral hydrogen molecules, also generates hydrogen molecules with positive charge, neutral atoms, excited atoms, and even triatomic molecules, and the like. These different intermediate products can be rendered luminous by electronic impacts. The colors of the luminosities emitted by the various intermediate products are different.

The effect attained by, and according to, this invention, is based upon the feature that at will one or another or any one of the intermediate products is rendered luminous. It appears that the frequency of the electronic impacts is the determining factor, an assertion, which can be substantiated as follows:

The intermediate products generated by the excitation of the tube have a certain definite finite lifetime; they are, thus, continually generated and continually annihilated, and their constant concentration is determined by the fact that the generation process and the annihilation process are in equilibrium with one another.

In order to excite the spectrum of an intermediate transitory substance it is necessary that its corpuscles be excited by electronic impacts immediately after they have been produced, and within their lifetime. In this case the intensity of the spectrum of an intermediate product reveals itself in a twofold dependency upon the strength of the current, as follows:

(1) The concentration of the intermediate product in the gas space, that is to say, the percentage of the amount of the intermediate product in proportion to the entire amount of the gas, is a function of the strength of the current, and the concentration, in general, increases with the strength of the current.

(2) The probability of the excitation of the corpuscles of an intermediate product to radiation is a function of the frequency of the electronic impacts. This frequency also rises with the strength of the current.

It follows therefrom that the proportion of the intensities of the various spectra generated in a tube and, thus, the color of the emitted light, is, with a given gas or vapor content, determined by the strength of the current. Therefore, the color of the emitted light can be varied during operation by varying the strength of the current. The luminous tube requires, as has already been mentioned, a certain minimum strength of current to produce a useful luminous effect. The radiation arising at this minimum strength of current had been termed "fundamental radiation" in the introductory part of this specification, and the radiation attained by an increase of the strength of current will now be termed "forced" radiation.

Now, in order to change perceptibly the color of the radiated light at said minimum current strength, this latter must be increased to several times the original value. By way of example I mention that a certain luminous tube containing a neon-mercury filling emits a blue light at the normal load of about 100 milliamperes. To attain the first forced radiation at which the tube emits a red-yellow light, the strength of the current would have to be increased, to about 10 amperes, thus to about the hundredfold of the normal strength. The bluish-pink color emitted at normal load by a tube filled with hydrogen can be changed to a deep-red color by increasing the strength of the current about a hundredfold.

The load of a tube cannot, however, be increased materially beyond the normal load without heating the tube to a detrimental or destructive degree, but as, according to this invention, the tube is fed with a series of current impulses, the maximum strength of which is several times that of the effective strength of the current, the high strengths of current requisite for the excitation of the forced radiation can be attained without overloading the luminous tube. With a sinusoidal alternating current the maximum strength of the current is the $\sqrt{2}$-fold of the effective strength of the current, whereas,

according to this invention, for the excitation of the luminous tube, strengths of current must be used, the maximum strength of which is many times, preferably a hundredfold, the effective strength. In general, currents which are less than the tenfold of the effective strength will scarcely ever be used.

For carrying out the invention I make use of such arrangements and combinations of parts as are illustrated diagrammatically and by way of example in Figs. 5–10 of the accompanying drawing on which Figs. 1–4 are diagrams added in order to make the invention clearer. In Figure 1 I denotes the sinusoidal curve of the strength of an alternating current which is to have the effective strength J_1 in order to be able to produce a practically useful luminous effect in a tube of given size without exceeding the admissible load, it being assumed that the tube emits the fundamental radiation.

If, in order to produce the forced radiation, current impulses II, II, II are employed, a maximum strength of current *Jmax* can be attained which is manyfold, about the tenfold up to several hundredfold, of the effective strength of current J_2 which corresponds to the proper load of the luminous tube.

It is immaterial whether or not this effective strength of current J_2 is equal to J_1. The strength of current J_2 may be greater, but not by so much that the tube is overloaded, or it may be smaller, but not by so much that the intensity of the light is impaired.

Although it is satisfactory for the purpose in view to have the impulses II II follow one another at regular intervals, still, this is not indispensably requisite, provided, the frequency of the impulses be sufficient to prevent apparent flicker or scintillation of the light. This requirement being observed, the frequency of the current impulses employed to produce the impressed radiation may be any desired one without influencing perceptibly the color of the light. Also the temporal course of the current curve may be as desired, as shown in the examples Figs. 2–4, provided, the requirements stated be fulfilled.

With the impulses of the current serving to feed the luminous tubes the point to be observed is, therefore that their duration is only a small fraction, normally less than a tenth, of the time in which the impulses follow one another, so that after every impulse an interruption takes place, the duration of which is about tenfold of the preceding impulse. Inasmuch as the maximum strength of current is the determining factor for the generation of the light, whereas for the load of the tube the effective or the mean strength is the determining one, the possibility is afforded of producing the excitation of the gas or vapor therein by a current of any desired instantaneous value without an inadmissible increase of the load of the tube. In other words: the energy integral of the current impulses per unit of time must be approximately equal to the watt consumption in normal service with continuous current or with commercial alternating current.

By suitably choosing the ratio between the maximum and the effective strength of the current it is, in view of the large number of radiations rendered possible by the various intermediate transitory products, also made possible to cause the gas or vapor to radiate in just the desired color, viz. either solely with the fundamental radiation or with a forced radiation of a higher or a lower order. The invention presents, thus, a means for influencing the color of the emitted light, but besides making it possible to produce in luminous tubes, colors which heretofore have not been produced therein, it also affords the possibility of changing or varying the color during operation, by varying the ratio between the maximum strength and the effective strength of the current feeding the tube, or the shape of the current impulse curve respectively, during operation. That can be effected either in steps or gradually, so that the changes in, or variations of, the colors also take place either in steps or gradually.

The succession of current impulses can be produced in very different manners. Chiefly three methods are used for the purpose in view, viz. firstly, production of the current impulses by discharging a condenser, secondly, producing said impulses electrodynamically, and thirdly, producing them with the aid of electronic tubes.

In the first of these methods a condenser is charged up to the disruptive voltage of a spark gap, and is then caused to discharge instantaneously through the luminous tube. This method can be carried out with various arrangements and combinations of parts, as shown in Figs. 5–11. In Fig. 5 the charging voltage of a condenser 2 connected in parallel with the tube 1 is varied by varying the disruptive voltage of a quenched spark gap inserted in series with the tube, this variation entailing a corresponding variation of the maximum intensity of the current impulse.

In Fig. 6 a variable resistance 4 is inserted into the discharge circuit of the condenser 2 connected in parallel with the tube 1, as in Fig. 5, the effect being that the duration of the current impulse is varied. In Fig. 7 a regulable self-induction coil 5 is inserted into the condenser discharge circuit of Fig. 5, said coil constituting an impedance which is variable while the current impulse proceeds through its path, in that the quickly variable curve parts are choked by said coil more than are the less rapidly variable curve parts. In Fig. 8 another condenser 6 is connected in parallel with the tube 1 of Fig. 5, the effect of this arrangement being that the quick variations of the intensity of the current are short-circuited or passed by said condenser. In Fig. 9 a variable condenser 7 is inserted into the discharge circuit shown in Fig. 5 and is connected in series with the tube 1, the effect being that the slower variations of the current impulse are suppressed.

Concerning Fig. 6 I may add that instead of a variable ohmic resistance 4 a capacitive resistance or an inductive resistance or a combination of such resistances may be used.

In Figure 10 the essential elements of the arrangements and combinations of parts shown in Figs. 5–9 are combined and united in one wiring diagram in which 5 denotes the variable self-induction coil, 9 a capacity in the discharge circuit of the condenser 2, and 11 a second condenser connected in parallel with the tube. In all figures (5–10) 10 denotes the charging transformer.

When feeding tubes with the various current impulses mentioned care must be taken that the average watt consumption of the tube remains normal. With current impulses of different energy that requirement is fulfilled by varying the number of the impulses in the unit of time.

For this purpose the charging time of the condenser serving for the production of the impulses is altered by the insertion of a variable resistance 8 in the charging circuit, as shown in

Figure 11 whereby the individual impulses follow one another in different intervals of time. That resistance is shown also in Fig. 10.

The second method mentioned can be carried out by means of rotatory electromagnetic current generators, for instance homopolar machines, which may be designed similar to those used for the production of the igniting sparks in internal combustion motors. The current impulses obtained by generators of these designs are approximately of the kinds shown in Figs. 1–4.

The third method mentioned can be carried out with the aid of an electronic tube, into the anode circuit of which the luminous tube is inserted, and the grid voltage of which is so controlled that the anode current attains the desired form in which it appears as a succession of current impulses.

I claim:

1. The method of producing in a luminous tube during operation thereof colors, tinges or hues other than the fundamental color of the same, said method consisting in subjecting the tube to the action of current impulses separated from one another by intervals, the lengths of which are much greater than of the duration of every impulse, the intensity of the impulses being many times the effective strength of the current.

2. The method of producing in a luminous tube during operation thereof colors, tinges or hues, said method consisting in subjecting the tube to the action of current impulses separated from one another by intervals, the lengths of which are much greater than the duration of every impulse, the intensity of the impulses being many times the effective strength of the current, and the maximum intensity of the impulses being varied during operation.

3. The method of producing in a luminous tube during operation colors, tinges or hues other than the fundamental color of the same, said method consisting in subjecting the tube to the action of current impulses separated from one another by intervals, the lengths of which are much greater than the duration of every impulse, the intensity of the impulses being many times the effective strength of the current, and the current impulse curve being varied during operation.

4. The method of producing in a luminous tube during operation colors, tinges or hues other than the fundamental color of the same, said method consisting in subjecting the tube to the action of current impulses separated from one another by intervals, the lengths of which are much greater than the duration of every impulse, the intensity of the impulses being many times the effective strength of the current, the watt consumption being approximately the same during the operation of the tube in different colors with an alternating current of sine wave type in the fundamental color or with current impulses of different maximum intensity and curve form for the modified colors.

5. The method of producing in a luminous tube during operation colors, tinges or hues other than the fundamental color of the same, said method consisting in subjecting the tube to the action of current impulses separated from one another by intervals, the lengths of which are much greater than the duration of every impulse, the intensity of the impulses being many times the effective strength of the current, the current impulses being generated electromagnetically.

6. The method of producing in luminous tubes during operation colors, tinges or hues other than the fundamental color of the same, said method consisting in subjecting the tube to the action of current impulses separated from one another by intervals, the lengths of which are much greater than the duration of every impulse, the intensity of the impulses being many times the effective strength of the current, the current impulses being generated electromagnetically in the manner used in high tension magnetos for the production of the igniting sparks in internal combustion motors.

7. An arrangement and combination of parts for producing in a luminous tube during operation colors, tinges or hues other than the fundamental color of the tube, said arrangement and combination comprising, in connection with the luminous tube, a condenser charged in known manner; a discharge circuit pertaining to said condenser and having said tube inserted into it, and a quenched spark gap, the disruptive voltage of which is variable and which is also inserted into said circuit, and which is adapted to permit feeding the said tube with successive current impulses, the intensity of which is variable.

8. An arrangement and combination of parts for producing in a luminous tube during operation colors, tinges or hues other than the fundamental color of the tube, said arrangement and combination comprising, in connection with the luminous tube, a condenser charged in known manner; a discharge circuit pertaining to said condenser and having said tube inserted into it; a quenched spark gap, the disruptive voltage of which is variable and which is also inserted into said circuit, and which is adapted to permit feeding the said tube with successive current impulses, the intensity of which is variable, and a resistance likewise inserted into the said circuit.

9. An arrangement and combination of parts for producing in a luminous tube during operation colors, tinges or hues other than the fundamental color of the tube, said arrangement and combination comprising, in connection with the luminous tube, a condenser, charged in known manner; a discharge circuit pertaining to said condenser and having said tube inserted into it; a quenched spark gap, the disruptive voltage of which is variable and which is also inserted into said circuit, and which is adapted to permit feeding the said tube with successive current impulses, the intensity of which is variable, and a resistance likewise inserted into the said circuit, and another condenser connected in parallel with the said tube.

ZOLTAN BAY.