

Jan. 21, 1936.

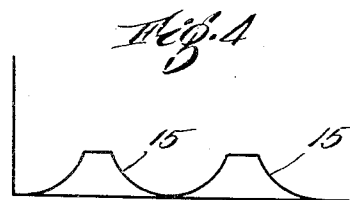
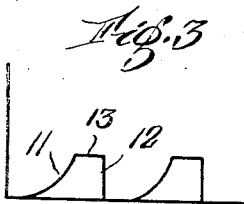
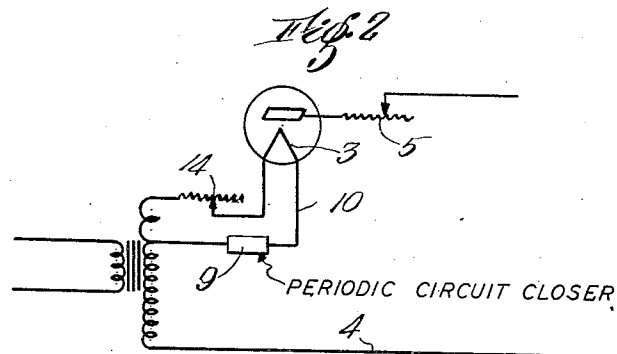
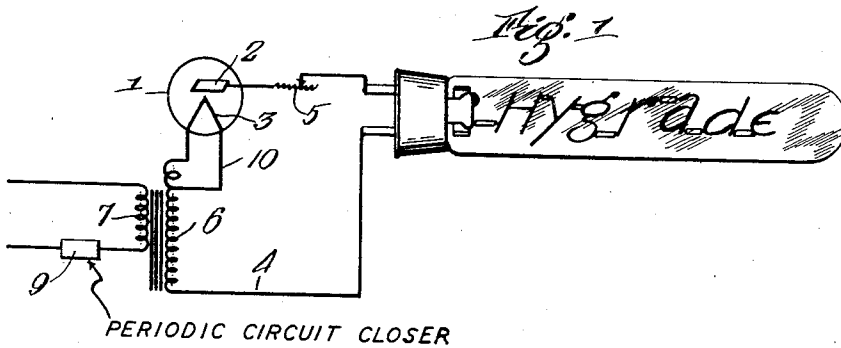
C. J. LE BEL

2,028,338

ELECTRICAL APPARATUS

Filed Oct. 30, 1931

2 Sheets-Sheet 1



Travertor
Clarence J. LeBel
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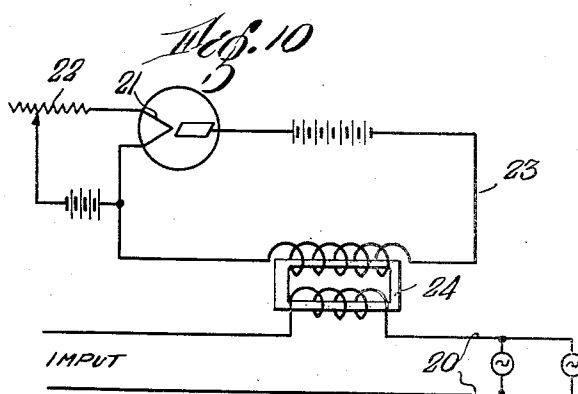
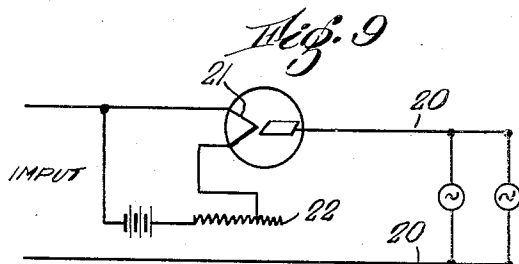
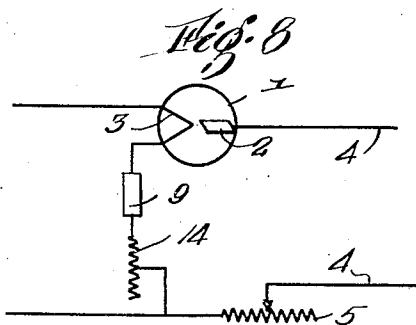
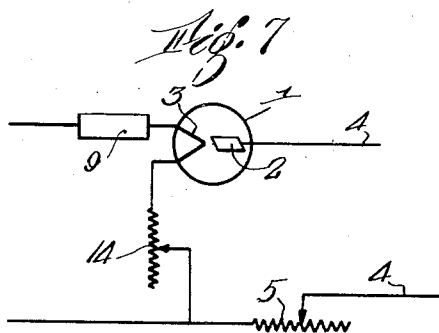
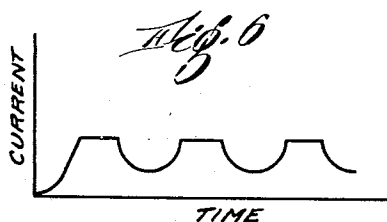
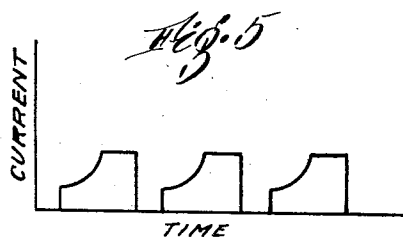
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ELECTRICAL APPARATUS

Filed Oct. 30, 1931

2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,028,338

ELECTRICAL APPARATUS

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Application October 30, 1931, Serial No. 572,090

9 Claims. (Cl. 176—124)

For many uses it has been found desirable to provide apparatus for periodically supplying to a circuit current waves having a gradual slope on one or both sides, usually with a gap between the waves. A typical use for such waves is disclosed in Patent No. 2,004,995, filed on even date herewith, viz., periodically to supply a gradually increasing current to a glow discharge sign in which successive portions of the cathode are caused to glow progressively as the current is increased.

To produce such waves heretofore it has been necessary to provide complicated mechanism involving moving parts such as motor driven rheostats and switches. Objects of the present invention are to produce said waves without such mechanism and without any moving parts other than a simple circuit closer such as a thermostatic switch which automatically opens and closes circuit (or otherwise effects resistance or potential changes) in response to current or potential changes effected thereby, to afford ready means for regulating the slope and/or periodicity of the waves, to produce such waves with either direct or alternating current, and to provide apparatus of the character referred to which is simple and economical to manufacture, which is reliable and durable in use and which involves little if any maintenance expense.

The present invention involves a device whose resistance to the passage of current changes slowly in response to a change in the potential impressed upon the device together with means connected with the device for automatically changing the potential impressed upon the device at intervals corresponding to the desired periodicity of the resulting waves. The most suitable device for this purpose comprises an ordinary heated-cathode space-current tube in which the cathode-anode current increases slowly as the temperature of the cathode increases even though full potential be impressed on the anode from the beginning of the heating period. Thus if the potential impressed on the device to heat the cathode be abruptly changed by opening or closing the heating circuit the space current between cathode and anode changes slowly whether the cathode-anode potential be changed correspondingly or remains unchanged. If the cathode-anode potential be maintained continuously the space current gradually increases after the auxiliary heater circuit is closed and then gradually decreases when the auxiliary circuit is opened, whereas if the two potentials be applied simultaneously and discontinued simultaneously each space current wave will have a gradual slope only

on the leading side, the trailing side being abrupt.

For the purpose of illustrating the genus of the invention typical concrete embodiments are shown in the accompanying drawings in which;

Figs. 1 and 2 are diagrams of circuit arrangements for alternating current, Fig. 1 showing one of the aforesaid glow-discharge signs in the working circuit;

Figs. 3, 4, 5 and 6 are diagrams showing various wave formations which may be produced according to this invention; and

Figs. 7 to 10 are diagrams of other typical circuit arrangements.

The particular embodiment of the invention illustrated in Fig. 1 comprises a space-current tube 1 having a plate anode 2 and a hot wire cathode 3, a working or output circuit 4 containing a fixed resistance 5 and a secondary 6 of a transformer for supplying current to the tube 1, the primary 7 of the transformer being connected to a suitable source of current and the working circuit 4 including a glow-discharge sign such as described and claimed in the aforesaid application. The primary circuit includes a periodic circuit closer 9 which, while it may be operated by any suitable means such as a clock, preferably comprises a thermostat which closes the circuit when its temperature decreases to a predetermined point and opens circuit when its temperature increases to a predetermined point in response to current flowing therethrough. Of course it will be understood that instead of completely opening the circuit this circuit closer may merely open a circuit across a suitable impedance device or otherwise change the potential impressed upon the primary 7 in any well-known manner. As shown in Fig. 1 the auxiliary heating circuit 10 for the cathode 3 is connected across a portion of the transformer.

When the primary circuit is connected to a suitable source of current, such as 110 volts alternating current, full potential is immediately impressed on both the working circuit 4 and also on the auxiliary circuit 10. While current immediately begins to flow through cathode 3 the current in the main circuit 4 increases slowly as the cathode gradually heats to normal temperature. When the circuit closer 9 opens the currents in circuits 4 and 10 are abruptly discontinued. After the switch 9 opens it begins to cool and after cooling to a predetermined temperature it again closes circuit to produce another wave of current. Thus the working circuit is supplied with a series of current waves of the general formation shown in Fig. 3, the leading

side 11 of each wave being sloping and the trailing side 12 being approximately vertical. If the periodic circuit closer 9 is adjusted to maintain its circuit closed for a time after the space current in the main circuit 4 attains its maximum each current wave will have a flat top 13. Obviously the slope of the leading side, the length of the flat top, and other characteristics of the current waves may be readily regulated and adjusted by varying the adjustment of the resistance 5, the circuit closer 9, etc.

The circuit arrangement shown in Fig. 2 is like that shown in Fig. 1 except in that the circuit closer 9 is located in the auxiliary cathode circuit 10 and this circuit also contains a variable resistance 14 to afford further adjustment of the resulting current waves. With this arrangement the potential impressed across the main or output circuit 4 is maintained continuously while periodically opening and closing the auxiliary circuit 10. In this way the current waves may be made sloping on their trailing sides as well as on their leading sides, as shown at 15 in Fig. 4, the trailing slope resulting from the gradual cooling of the cathode while full potential is impressed across the main circuit 4.

When using direct current the circuits of Figs. 1 and 2 may be modified as shown in Figs. 7 and 8 where corresponding parts are correspondingly designated.

From the foregoing it will be evident that successive current waves may be separated by gaps as shown in Fig. 3 or joined together as shown in Fig. 4. It will also be understood that when using an alternating current source the wave diagrams of Figs. 3 and 4 represent the average magnitude of successive pulsations of current in the main circuit.

The slope of the leading side of the wave is in part dependent on the thermal inertia of the filament of the tube; for example, using a rectifier tube with a filament rated at 5 volts and 2 amperes the space current will take one to two seconds to rise from zero to forty milliamperes; using one rated at 7.5 volts and 1.25 amperes it will take perhaps $\frac{1}{4}$ to $\frac{3}{4}$ second; and with one rated at 1.5 volts and 1.05 amperes it will take about $\frac{1}{16}$ to $\frac{1}{2}$ second. The slope is also affected by the voltage applied to the filament. The usual operating voltage is between a half and three quarters of the rating. For a given timing this must be changed as the amount of output current is changed and as the tube ages. The amount of rounding off where the slope joins the flat top may be increased by increasing the amount of series resistance 5. The length of the flat top is altered by changing the adjustment of the circuit closer 9. The minimum length of the gap between waves is in part determined by the time required for the filament to cool down sufficiently. This may be about 2 seconds for a 2 ampere filament, 1 second for a $1\frac{1}{4}$ ampere filament, and $\frac{3}{4}$ second for a 1 ampere filament. If the circuit closer is adjusted to allow less time than this, current waves of the forms shown in Figs. 5 and 6 are produced with systems such as shown in Figs. 1 and 2 respectively. If it is desired to reduce the magnitude of the cyclic pulsations, when operating on alternating current, a condenser may be connected across the output terminals. One or two microfarads usually produces enough effect. It also changes the wave form, reducing the steepness of the slope at the bottom.

When using the circuit arrangement of Figs.

1 and 7 to operate a glow-discharge sign of the type referred to, the letters of the sign are illuminated progressively but the illumination of all the letters is discontinued simultaneously, as described in the aforesaid patent; whereas with the circuit arrangements shown in Figs. 2 and 8, the glow-discharge not only spreads gradually along the letters but also gradually retreats as the space current in the working circuit gradually decreases.

By using the aforesaid current supply means for operating a glow-discharge sign of the type herein disclosed, a unique regulation is obtained automatically because of a novel functional relationship between the supply means and glow device. As the latter warms up it requires more current to afford the same degree of illumination; and as a regulator, such as the space current device 1, warms up it supplies more current. Consequently when using the two together as herein disclosed the temperature responsive changes in the current supplied to the sign tend to compensate the temperature responsive changes in the requirements of the sign. Thus the degree of sign illumination is more uniform throughout changes in temperature. This is particularly advantageous for example in the case of a sign operating in a show window where the temperature varies widely; also when a sign is put into operation after a considerable period of inoperativeness irrespective of the surrounding temperature.

Heretofore certain authorities have thought that full potential applied between cathode and anode with the cathode below normal temperature results in rapid erosion of the cathode filament, but I have found little if any such tendency with systems such as herein disclosed. While the voltages across the main circuit 4 and the auxiliary circuit 10 will of course vary widely depending upon the intended uses, suitable voltages for operating a sign flasher of the type referred to comprise 400 volts for the main circuit and 5 volts for the auxiliary circuit.

From the foregoing it will be evident that in one aspect the invention involves the control of current in a working circuit by varying the temperature of a filament such as 3, irrespective of the other features of the illustrative embodiments, and that this affords a unique method of effecting gradual changes in the working current in response to abrupt changes in the control element. In stage illumination, for example, lights in a cathode-anode circuit may be gradually brightened or shaded in response to an abrupt change of resistance in the heating circuit of the cathode. Typical ways of thus controlling light circuits are shown in Figs. 9 and 10 where 20 is the light circuit, 21 the control filament, and 22 the control rheostat. As shown in Fig. 10 the cathode-anode current in circuit 23 may be used to vary the saturation of an iron core reactor 24, thereby to control the magnitude of a current (in circuit 20) higher than the thermionic tube can carry. It will also be evident that in each of the foregoing embodiments the main or work circuit includes the output circuit of the space discharge tube, while the space conductive characteristics of this tube are controlled from an input circuit independently of the output current. For example, in Figs. 1 and 2 the lamp or other load device is connected in the output circuit and is adapted to be energized by the gradually sloped anode current waves, whereas the control device 9 is connected

in one of the input circuits 7-9-10. Thus the rate at which the current builds up in the load circuit, that is, the slope of the waves applied to the load device is directly adjustable by means of the resistances 5 and 14 without involving an adjustment of frequency of the device 9.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. Apparatus of the character referred to comprising a main circuit containing a cathode having a pre-determined heat-lag characteristic and an anode, an auxiliary circuit for supplying heating current to the cathode, and means operated by the cathode heating current for automatically varying the current in said auxiliary circuit at regularly recurrent intervals, thereby to vary the current in said main circuit at a corresponding frequency, the heat-lag of said cathode being correlated to the operation of said means so that said main circuit current consists of regularly recurrent waves having similar slowly rising wave fronts.

2. Apparatus of the character referred to comprising an output circuit containing a cathode having a pre-determined heat-lag characteristic and an anode, an input circuit for supplying heating current to the cathode, automatic means operated by the cathode heating current for recurrently increasing and decreasing the cathode current in the input auxiliary circuit, means for impressing a potential across the space between cathode and anode during each increase of current in the input circuit, whereby the current in the output circuit gradually increases in response to the gradual increase in the temperature of the cathode, the heat-lag of said cathode being correlated to the operation of said automatic means so that said output circuit current consists of regularly recurrent waves having similar slowly rising wave fronts.

3. In combination, a source of currents having regularly recurrent steep wave fronts, a gaseous conductive device arranged to be energized by currents having wave fronts with a predetermined gradual slope, and a space discharge tube having a thermionic cathode and an anode between said source and said gaseous device said cathode having a filament with a thermionic lag correlated to said predetermined slope said lag determining the shape of said wave fronts.

4. Apparatus of the character described comprising a circuit containing a heatable cathode having a predetermined thermal lag, an anode for said cathode, and means for producing in said circuit current waves of a predetermined frequency and predetermined wave shape having a gradual upward slope without a correspondingly gradual application of potential to the circuit, the last-mentioned means including automatic means energized by the cathode heating current and whose frequency of operation is definitely correlated to the thermal lag of the cathode to determine said wave shape and for gradually heating the cathode at periodic intervals substantially independently of the anode current.

5. Apparatus of the character described comprising an auxiliary circuit, a main circuit con-

taining a heatable cathode having a predetermined thermal lag and an anode for said cathode, means for slowly increasing the current in the main circuit without a correspondingly slow variation in the potential applied to either circuit, the last-mentioned means including automatic means operated by the cathode heating current and whose frequency of operation is definitely correlated to the thermal lag of the cathode for periodically making abrupt changes in the potential applied to the auxiliary circuit substantially independently of the anode current to determine the frequency and wave shape of the currents in said main circuit.

6. Apparatus for producing current waves of predetermined frequency and wave shape, comprising a main circuit containing a heatable cathode having a predetermined thermal lag, an anode for said cathode, an auxiliary circuit for heating said cathode, means for alternately increasing and decreasing the current in the auxiliary circuit substantially independently of the anode current, means for impressing a potential across the space between cathode and anode during each increase and decrease of current in the auxiliary circuit, whereby the current in the main circuit slowly increases and slowly decreases in accordance with the thermal lag of said cathode, said first means being definitely correlated to the thermal lag of the cathode and operating automatically at a frequency determined by the cathode heating current.

7. Apparatus of the character described comprising an output circuit containing a cathode having a predetermined thermal lag, an anode for said cathode, an input circuit for supplying heating current to the cathode at a frequency definitely correlated to the thermal lag of said cathode, and means automatically operated at a frequency determined by the cathode heating current for periodically modifying said current to thereby determine the wave shape of the current in the output circuit.

8. In a system of the character described, a source of operating current, means for sharply interrupting said current at regularly recurring intervals, a space current device having an anode and a cathode with a predetermined thermal lag definitely correlated to the frequency of said interruptions, means to energize said cathode and said interrupting means by said interrupted current substantially independently of said space current to produce space current waves having a wave shaped determined by the thermal lag of the cathode, and a load device energized by said waves.

9. In a system of the character described, the combination of a space discharge lamp, an electron discharge tube having a thermionic cathode and an anode, means for energizing said lamp by the space current of said discharge tube, means for supplying heating current to said cathode, automatic means responsive to the cathode current for controlling the application of heating current to the cathode substantially independently of the space current of said tube, said cathode having a thermal lag definitely related to the operation of said automatic means and determining the wave shape of the currents applied to said lamp.

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