April 17, 1951 G. C. IZENOUR 2,548,887

FILTERED THYRATRON CONTROL CIRCUITS

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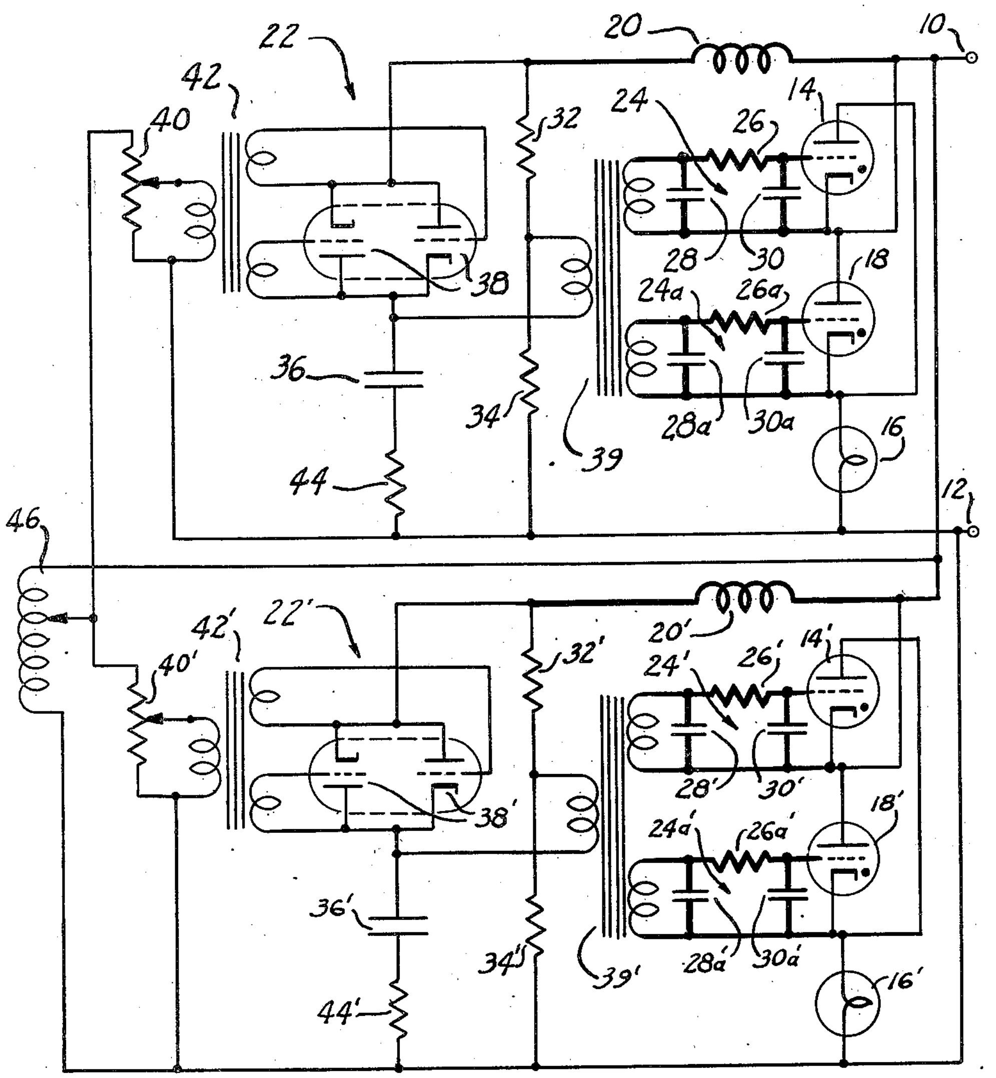

FIG. 1

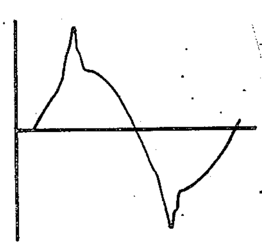

FIG. 2

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FILTERED THYRATRON CONTROL CIRCUITS

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5 Claims. (Cl. 315—291)

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The present invention relates to alternating-current lighting circuits including phase-responsive grid-controlled gaseous electron-discharge tubes, or thyratrons, as in my Patent 2,463,463 issued March 1, 1949.

This invention is more particularly concerned with a multiplicity of lighting circuits that may be operated at different intensities. In lighting circuits, thyratrons are commonly used to control the saturation of an iron-core reactance that is in series with a lamp or lamp bank; or in another circuit the thyratron is connected in series with the lamp or lamp bank. In both types of lamp circuits an adjustable control circuit is provided for the thyratron grid, for firing the thyratron at a time in each successive cycle that depends on the desired lamp intensity. Early firing produces bright illumination, whereas tardy firing results in lamp dimming.

A plurality of circuits for differently controlled lamps are commonly required in theatre lighting. The early firing of thyratrons in one lighting circuit erratically tends to trip other thyratrons set for later firing. This premature, sporadic discharge results from transient pulses produced by the abrupt current-change in early-fired thyratrons, from non-conducting to conducting state. The effect is found in both types of lighting circuit, although it is more prominent in the direct series connection of thyratron and lamp than in the indirect control circuit that utilizes a saturable reactor.

In an effort to meet the transient-flicker problem of such systems, filtering devices have been considered to suppress the transients, such as low-resistance chokes in series with the lamps. This has various disadvantages, including the high cost, and the great weight and bulk of such devices which must pass the heavy current of the lamps. Furthermore, a lamp of only one power level is suitable to any given transient filter, smaller lamps being inadequately filtered and larger lamps causing excessive voltage drop in the filter.

Rather than to attempt the suppression of the transients, the present invention achieves stability of control by preventing transients from affecting the control circuits. A low-pass filter is interposed, in the illustrative embodiment of the invention described in detail below, in each control circuit to attenute high-frequency transients produced in the power line by earlier-fired thyratrons of other lighting circuits; and the filter is subdivided to include a choke in series with the A.-C. leads of the phase-control circuit, and

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a broad-band low-pass resistance-capacitance filter at the output of the phase-control circuit. The choke is of such inductance as not to shift the phase of the control-circuit supply excessively relative to the lamp-circuit supply, but because of the low power requirements of the control circuit, its impedance can nevertheless be substantial. A broad-band, low-pass filter of the resistance-capacitance type is interposed between the control circuit and the thyratron grids to increase the filtering effect, the subdivision of filters achieving the desired result without appreciably restricting the range of the control circuit. Both forms of filter are in the low current-level part of the system, rather than in the high current part, and hence are of much smaller size and greater efficiency, and can be of more elaborate, effective design without excessive cost. Both forms of filter are connected in that circuit which is energized by the power line but is connected between the load circuit and the control electrode of the thyratron. And by using an inductance as the filtering impedance in the A.-C. supply leads of the adjustable phase-shifter of the resistance-capacitance type having a resistive voltage divider, the necessary broad latitude of control is preserved for varying the lighting from full brilliance to extinction.

The invention will be more fully appreciated from the following detailed description of an illustrative embodiment in which reference is made to accompanying drawings.

Fig. 1 is the wiring diagram of an illustrative two-lamp system embodying features of the invention, and

Fig. 2 is a diagram of an alternating-current wave-form of line voltage, including a typical transient.

In Fig. 1, a pair of terminals **10**, **12** represent an alternating current source that may include transmission lines, transformers, etc., typical of commercial power mains. To this a series circuit is connected including thyratron **14** and lamp load **16**. The term "thyratron" is here used generically to include gaseous electron-discharge tubes having control electrodes, which electrodes are herein termed "grids." A second thyratron **18** is reversely connected in parallel with thyratron **14** for potentially full-cycle conductivity, the cathode of each thyratron to the plate of the other in an arrangement conveniently termed "back-to-back" connection.

An alternating-current voltage is impressed between the thyratron grids and cathode, having a controlled, adjustable phase in relation to the phase of the thyratron-lamp circuit, to adjust the light intensity. Any instability of this circuit may cause flickering or even unintentional sustained lighting. Transient spikes (Fig. 2) resulting in the power line from the abrupt firing of the thyratrons in an associated lighting circuit of the system, tend to produce such effects.

Rather than to insert bulky and costly chokes in series with the lamp loads where they must necessarily lose power, and where they are limited to lighting loads of a certain rating, I have isolated the thyratron input electrodes from the effects of the transients by a filter of such character as not to limit the range of the adjustable phase-shifter. Choke **20** is interposed between the input of the adjustable phase-control circuit **22** and the connections of the thyratron-lamp circuit to the supply line. The choke should not be so large as to limit the necessary range of the phase-shifter, but it can nevertheless be quite large. Additionally low-pass filter **24** is interposed between the output of the phase-control circuit **22** and the thyratron input electrodes. This filter is of special importance because of the unfiltered input that controls the phase-shift circuit, as will be seen. This filter is of the pi resistance-capacitance type, including resistor **26** and capacitors **28** and **30** for tube **14**. The resistor serves the further purpose of limiting the thyratron grid current in the intervals when the grid of tube **14** is positive in respect to its cathode. Tube **18** similarly has a pi-type low-pass filter **24***a*, including resistor **26***a* and condensers **28***a* and **30***a*.

The particular phase-shifter shown is that disclosed in greater detail and claimed in my issued patent mentioned above. It includes a resistive voltage divider **32**, **34** in one circuit and a condenser **36** and a grid-controlled back-to-back pair of vacuum tubes **38** in a second circuit paralleling the voltage divider. An output transformer **39** has its primary winding connected between intermediate points of these two circuits and has a separate secondary winding for each thyratron. An adjustable alternating-current source of grid-control voltage is provided for the back-to-back vacuum tubes, including potentiometer **40** and transformer **42** that has a separate secondary winding for each vacuum-tube grid. Varied input voltage from potentiometer **40** to the vacuum tube grids changes the plate resistances, and shifts the phase of the voltage to transformer **39**. The vacuum tubes have their grids driven negative during half-cycles when the respective plates are positive, by proper phasing of the secondary windings of transformer **42**.

The order of magnitude of the components in relation to each other is given in the following example: Choke **30**, 7 henries; resistors **32** and **34**, 5,000 ohms; resistors **26** and **26***a*, 50,000 ohms; condensers **28** and **28***a*, .004 mfd; condenser **30** and **30***a*, .002 mfd; tube **38**, 6SL7 or 5691; condenser **36**, 0.25 mfd; resistor **44**, 50,000. The latter is a trimmer, to adjust the range of the phase-shift network.

A second lighting and control circuit, the duplicate of that described, is shown in Fig. 1. This circuit has parts with primed numerals corresponding to the parts in the circuit described, and is connected to the same line terminals **10**, **12**. The two lighting circuits will normally be adjusted differently (for different intensities of the two lamps **16** and **16'**) as may be required to light a set on a theatre stage. Transients produced by one lighting circuit are not suppressed, but are permitted to reach the line. The transients are not allowed to affect the ultimate control because of the filters described that isolate the thyraton grid circuits from the thyratron load circuits. I have discovered that transients of this nature are damped in comparatively short feeder lines so that they do not noticeably affect equipment outside the immediate lighting installation.

The two phase-shift networks are controlled separately by "individual" potentiometers **40** and **40'**. These are to be pre-set in uses as described in my aforementioned patent, and are proportionally dimmed by a common potentiometer **46** designated "master." It is notable that the master is energized directly by the power line where transients are to be expected to be troublesome; but such transients are attenuated in the phase-shift network, and whatever the extent that they may be transmitted through the phase-shift network, they are suppressed by the pi resistance-capacitance filters **24** and **24***a*.

What is claimed is:

1. An alternating-current lighting circuit including a lamp, a thyratron connected in control relation to said lamp and to power lines, a wide-range phase-shift circuit connected to said lines, said phase-shift network including a tapped resistive voltage divider, an adjustable series resistive-capacitive phase-shift circuit in parallel with said voltage divider, and a transformer having its primary winding connected between said resistive voltage divider and said phase-shift circuit, and a secondary winding connected to the control grid of said thyratron, a choke in the connection between said power line and said phase-shift network, and a resistor-capacitor low-pass filter in the connections between said secondary winding and said thyratron grid.

2. An alternating-current lighting system including two lamps to be separately controlled, a thyratron connected in control relation to each said lamp and to a power line, separate wide-range phase-shift circuits connected to said power line and connected in control relation to said thyratrons, respectively, whereby transients resulting from the early firing of one thyratron appear in the power line, and a low-pass filter in the connection of each phase-shift network to said power line, and an additional low-pass filter in the connection of each said thyratron to said phase-shift network, for preventing transmission of the transients to the thyratron that is set for later firing.

3. An alternating-current lighting circuit having a lamp, a thyratron connected in control relation to said lamp, said circuit being energized by a power line, a grid-controlled vacuum tube and a condenser connected as a resistance-capacitance circuit in control relation to the thyratron grid and having energizing connections to said power line, an adjustable-amplitude input circuit for the grid of said vacuum tube energized directly by said power line, and separate low-pass filters in the connection of the power line to said phase-shift circuit and in the connection of said phase-shift circuit to said thyratron, respectively, whereby transients in the power line are prevented from reaching the phase-shift network from the power line, and are prevented from reaching the thyratron input electrodes through the phase-shift circuit.

4. An alternating-current lighting system including separate lighting circuits and lighting-control networks connected to a common power line, each lighting circuit including a thyratron connected in control relation to a lamp, whereby early firing of one thyratron produces transients in the power line to disturb the waveform available to the control network of the other thyratron, and low-pass filters between each control network and the power line and between each thyratron and its related control network, respectively.

5. An alternating-current lighting system including separate thyratron-controlled lighting circuits and lighting-control networks each including a resistive voltage-divider and an adjustable resistance-capacitance phase-shift circuit, said lighting circuits and said phase-shift networks having energizing connections to a common power line, whereby early firing of a thyratron in one lighting circuit produces transients in the power line, an input-filtering choke and an output-filtering resistance-capacitance network connected to each phase-shift network for preventing transients in the power line produced by one lighting circuit from tripping the thyratron in the other lighting circuit prematurely.

GEORGE C. IZENOUR.

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