

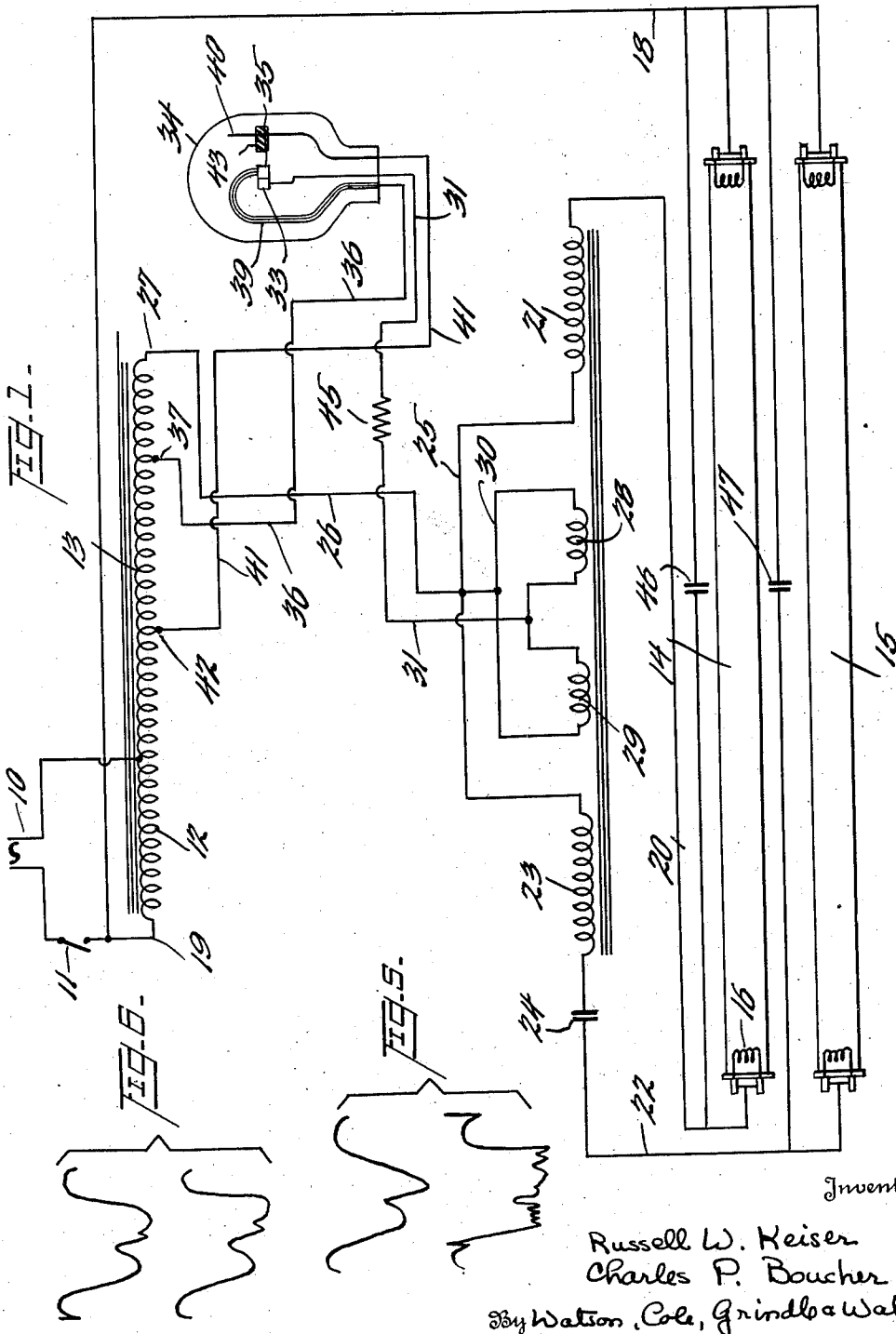
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R. W. KEISER ET AL
FLUORESCENT LAMP CIRCUIT

2,439,976

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2 Sheets-Sheet 1



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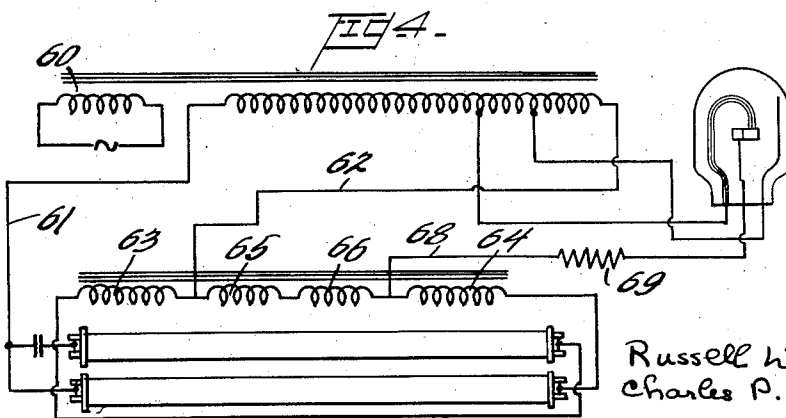
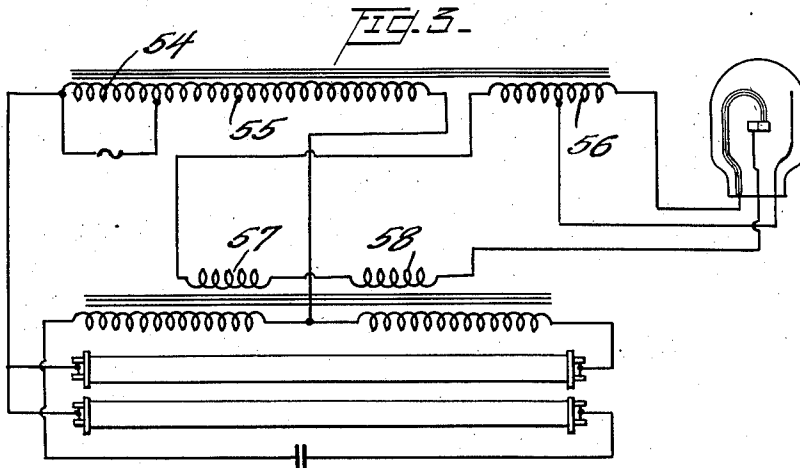
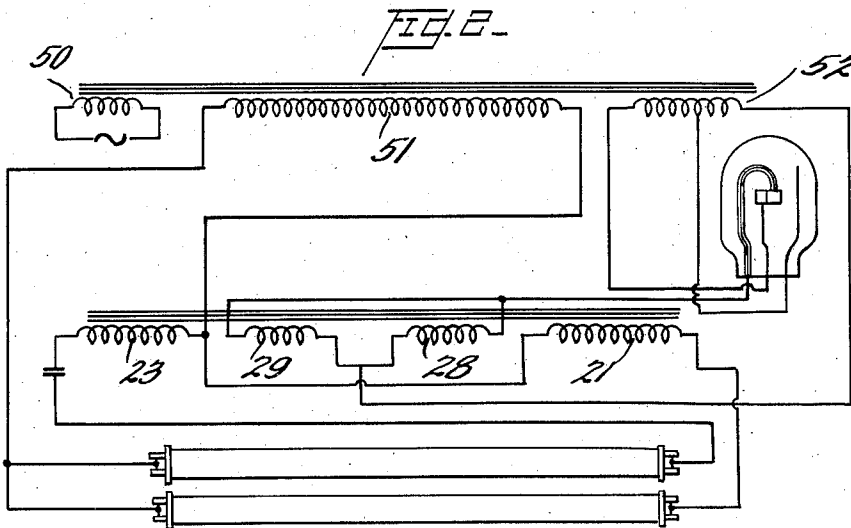
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UNITED STATES PATENT OFFICE

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FLUORESCENT LAMP CIRCUIT

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2 Claims. (Cl. 315—280)

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This invention relates to fluorescent lamps and, more particularly, to starting and operating circuits for such lamps.

It is the general object of the present invention to provide novel and improved starting circuits and associated apparatus for use in conjunction with one or more fluorescent lamps.

More particularly it is an object of the invention to provide circuits which operate automatically on closing of the line switch to first provide a potential for striking an arc in each of the lamps, associated with the circuit, by the cold cathode starting method and to subsequently reduce the voltage applied to the lamps to that most desirable for their continued operation and long life.

It is an important object of the invention to provide circuits for fluorescent lamps which provide substantially instantaneous lighting of the same upon the closing of the line switch and which automatically provide both the necessary striking potential for igniting the lamps and the reduced operating potential for delivering maximum life and light intensity.

A further object of the invention consists in the provision of accessories for incorporation into the starting and lighting circuits for fluorescent lamps, which use a minimum amount of copper and magnetic material commensurate with the supplied operating voltage and current.

A still further object of the invention consists in the provision of starting and operating circuits and accessories which provide not only a superior current wave form whereby maximum light is obtained from the lamps but which give substantially identical wave form to the current flowing to both the leading and lagging lamps of a pair.

One of the important features of the invention resides in the construction and operation of the switch which automatically changes the higher starting voltage to the lower operating voltage following the striking of the arcs in the lamps, and which, subsequent to the extinguishing of the lamps by the opening of the line switch, conditions the circuit for instantaneous starting of the lamps when the line switch is reclosed.

Other and further objects and features of the invention will be more apparent to those skilled in the art upon a consideration of the accompanying drawings and following specification wherein are disclosed several exemplary embodiments of the invention with the understanding that such changes therein, modifications thereof, and combinations of the same may be made as fall within the scope of the appended claims without departing from the spirit of the invention.

In said drawing:

Figure 1 is a schematic and diagrammatic showing of the circuit and accessories arranged be-

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tween a source of alternating current and a pair of fluorescent lamps requiring a different operating voltage than the source;

Figure 2 is a view similar to Figure 1 but showing a circuit providing less radio interference;

Figure 3 is a showing of another circuit modification;

Figure 4 shows a further circuit modification;

Figure 5 illustrates current curve wave forms in two lamps operated from prior art devices; and

Figure 6 is a view similar to Figure 5 but showing curves taken when using circuits and apparatus of the present invention.

There are commercially available at the present time two general systems for the starting of fluorescent lamps. The first of these systems, known as the hot cathode method, is the one most commonly used. It requires lamps having filaments at each end and some circuit arrangement which first supplies current to heat the filaments and then provides a shock voltage to break down the ionized gas between the filaments and strike and maintain the arc. The apparatus includes, in addition to a transformer if required, a ballast or reactance for each lamp and a so-called starter switch for each lamp which serves to connect the filaments thereof to the power source and to disconnect them after they have been heated. This system has a number of disadvantages, not the least among which is the slowness of the starting, from ten to forty-five seconds elapsing after the closing of the line switch before the lamps are properly burning. Furthermore, if a number of lamps are controlled by a single line switch they do not all light simultaneously.

A system of instantaneous starting is the second known form and actuates the lamps on the so-called cold cathode principle. Because lamps with filaments acting as the main electrodes are the only types readily available, these are used in this system also but the two terminals of each filament are connected together to increase the life of the same.

For starting, a relatively high potential must be applied between the electrodes of each lamp to break down the resistance of the gas column therein, but this high potential is not needed for operation and is, in fact, detrimental to the lamp life. If the actuating transformer is designed to supply the high striking voltage and relies on poor regulation to reduce this voltage to that approximating the desirable operating voltage, then high copper losses obtain and poor wave form results. This system also builds up an unnecessarily high voltage across the terminals of the main condenser used with one lamp of a pair to improve the power factor and lessen the stroboscopic effect. This, in connection with the necessary

high leakage reactance in the transformers and ballasts, creates high I²R losses.

A preferred form of circuit and accessory apparatus for carrying out the instantaneous system of lighting fluorescent lamps in accordance with the present invention, is illustrated in Figure 1, wherein the source of alternating current is indicated at 10, connected through a line switch 11 to the primary 12 of a transformer 13, shown in this embodiment as of the auto-transformer type although this form is not necessary and may not be desirable under certain conditions as will be later pointed out. The circuit is shown for the usual arrangement of lighting two lamps 14 and 15 from one set of accessories. The filamentary electrodes 16 of each of these lamps are short-circuited as shown to provide for a single connection at each end of each lamp. The right hand ends of the two lamps are connected by the conductor 18 to the left hand end 19 of the primary 12. The left hand end of lamp 14 is connected by conductor 20 to one end of the reactor 21 while the left hand end of lamp 15 is connected by the conductor 22 to one end of reactor 23, the condenser 24 being interposed in this circuit in the usual manner to improve the power factor. The remaining ends of the two reactors 21 and 23 are connected together by wire 25 and thence by wire 26 to right hand end 27 of the secondary of the transformer.

The connections just described provide the normal operating circuit for the lamps whereby the desired operating potential is applied to each lamp by reason of the turns ratio of the two windings of the transformer and the current limited by the predetermined reactances of the reactors 21 and 23 and the condenser 24.

In order to provide the higher voltage necessary for starting the lamps, each reactor has associated therewith and wound on the same core a coil 28, 29, respectively. These coils may be connected either in series or, as shown, in parallel and energized from a portion of the secondary winding of the auto transformer. The size of this portion is selected in accordance with the turns ratio between the reactor and its boosting coil to provide the desired starting potential.

In this connection it may be noted that each reactor and its booster coil can be considered as a transformer in which the booster coil as primary induces a superimposed voltage on that already existing in the secondary. The conductor 30 associating one end of each of the two booster coils, is connected to conductor 26. The other ends of the booster coils are connected together and to conductor 31 which leads to the stationary contact 33 in an automatic switch shown inclosed in the evacuated and gas-filled envelope 34. A second contact 35 is under "no current" conditions in engagement with contact 33 to close the circuit through wire 36 to tap 37 on the auto transformer. The condition just described is that for starting for now the booster coils are energized from the section between 27 and 37 on the transformer and increase the voltage in each of the reactor circuits to cause the striking of the arcs in the lamps.

It is not desired to maintain the striking voltage except momentarily, so delay acting means are provided, actuated by current flow, to open the contacts of the automatic switch.

Contact 35 is mounted on a bimetallic arm 39 so arranged that, upon heating of this arm, the contacts will be disengaged. The envelope 34 has an appreciable content of an ionizable medium,

such as argon, neon or the like. A glow electrode 40 is arranged within the switch envelope and connected by conductor 41 to some point such as 42 on the transformer which has a different potential than that to which the bimetallic strip 39 is connected. This difference in potential between 39 and 40 causes a glow in the ionizable medium, assisted by a suitable deposit of emissive material on the bimetallic arm 39 if necessary, which heats the bimetallic element causing it to move contact 35 out of engagement with contact 33 and open the circuit to the booster coils thereby conditioning the system for normal operation. The glow discharge, which consumes a very small amount of current, continues during the normal operation of the lamps to insure de-energization of the booster coils.

In order to limit the movement of the bimetallic arm 39 under the continuous heating of the "glow," to thus prevent it from becoming permanently distorted and unable to return the contacts to closed circuit position, the electrode 40 is made sufficiently rigid and provided with an insulating stop 43 as shown. This limits the movement of contact 35 to just slightly more than necessary to open circuit with 33.

If desired, a resistor 45 may be inserted in conductor 31 to control the starting current. This is in circuit for such a short time that losses therefrom are negligible.

The reactors 21 and 23 and their associated booster coils 28 and 29 are illustrated as all mounted on a single core but it will be evident that the parts constituting the equipment for each lamp may be arranged on separate cores. Furthermore, an additional number of reactors and booster coils might be used where it is desirable to control more than two lamps at one time. The reactors will preferably be constructed in accordance with the disclosure in the co-pending application of Russell W. Keiser, Serial No. 421,700, filed December 4, 1941, for "Reactances," which issued August 14, 1945, as United States Patent Number 2,382,012. Here are shown multiple current dividing reactors intended to be used with or without transformers, for increasing the potential of the available current. The booster coils may be applied to the device of that application in an obvious manner.

In Figure 1 the condensers 46 and 47 shown respectively as shunting the two lamps 14 and 15 are of small capacity and are intended solely to prevent interference with adjacent radio receiving equipment. They do not need to be used if found unnecessary and their use can be obviated even in the presence of radio receiving equipment by resorting to a circuit such as illustrated in Figure 2. The major portion of this circuit, particularly as regards the reactor, booster coils and automatic switch is identical with that in Figure 1 and will not be further described. The transformer, however, is modified by separating the windings into three parts. The primary 50 is an entirely independent winding and is connected only to the source of power supply through the line switch. The secondary 51 is directly connected with only the lamps and the reactor coils 21 and 23 while the tertiary winding 52 on the transformer provides the necessary voltage for the booster coils 28 and 29, its voltage being applied thereto through the medium of an automatic switch as previously described. The complete electrical separation of the three coils avoids any radio interference.

In Figure 3 is illustrated a further modifica-

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tion in which the primary 54 of the transformer is associated in the manner of an auto transformer with the secondary 55. The connections from these parts to the reactors and lamps being as shown in Figure 1. The tertiary winding 56 is arranged to be connected to the booster coils 57 and 58 in the manner already described except that these coils instead of being connected in parallel with each other are arranged for a series connection.

In Figure 4 a separate primary coil 60 is illustrated while the secondary is divided into several parts. The whole of the potential thereof is applied to the lamps by the leads 61 and 62. The reactors and their booster coils are arranged in a complete series relationship, the reactors 63 and 64 being at the ends and the booster coils 65 and 66 in the center. The leading lamp is operated from 61 and 62 through only the reactor 63 while the lagging lamp derives its operating potential between 61 and 62 and the three windings 64, 65 and 66, the total reactance of which is proper to provide the desired operating potential and current limitation.

For starting purposes an automatic switch connects an additional potential from the taps on the secondary of the transformer by way of the conductors 62 and 68 through the booster windings in series. A resistor 69 is interposed in this circuit to limit the starting current. It will be noted that in this embodiment only, the reactor-booster coil combination is of the auto transformer type as distinguished from the arrangement within other embodiments. This embodiment makes the maximum use of the copper and iron in the accessories since all the coils are always in use.

It has been ascertained that a greater quantity of light can be obtained from the fluorescent material which is activated by the arc burning in the lamp tube as the current curve thereof approaches a sine wave. The type of wave illustrated in the two views of Figure 5 represents one of the better forms obtained by oscillograph records from ballast equipment for fluorescent lamps now available on the market. The top view in that figure represents the curve of current flow in the lamp column of the lagging lamp of a pair, whereas the lower figure illustrates the current in the leading lamp. The upper curve is not too bad and will produce very good light but the lower curve is such as to reduce the total illumination per ampere from the lamp whereby low efficiency is obtained. Because of the symmetry of applicant's equipment, the superior form of curves illustrated in Figure 6 are obtainable. It will be noted that there is but little difference in the curves for the lagging and the leading lamps. There is also a minimum of third harmonic which is recognized as a serious disturbing factor in producing good illumination. It also has detrimental effect on adjacent radio equipment.

Any of the circuits shown with independent transformer primaries may be used without the small lamp shunting condensers, since the separation of primary and hence power line from any irregularities in the secondary eliminates any chance of radio interference.

It will be obvious to those skilled in the art that the transformers of any of the above cir-

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cuits can be designed or connected for use with various line potentials both higher or lower than those needed by the lamps. In fact the transformers can be entirely eliminated where the line voltage supplies the correct potential for normal lamp operation. Under these conditions the booster coils are merely energized direct from the line.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A starting and operating circuit for a fluorescent lamp comprising a current source, a voltage step-up transformer at least a portion of the winding of which is connected in series with said lamp across the said source, a switch to temporarily connect the primary of said transformer across said source to impress a high voltage across said lamp during the starting period, at least a portion of the transformer winding serving as a ballast for the lamp during operation thereof, said switch comprising a pair of contacts supported in normal engagement, a bimetallic support for one of said contacts, and means to heat said support to cause it to separate said contacts, said heating means being energized continuously from said current source only during the operation of the lamp.

2. An instantaneous lighting circuit for fluorescent lamps including in combination a source of alternating current, a step-up transformer connected to the source through a line switch, a lamp and reactor in series continuously so connected to said transformer as to supply appropriate potential and current for normal lamp operation, a booster coil inductively related to the said reactor, a normally closed switch through which said booster coil is connected to said transformer so as to increase the potential in the lamp circuit to that necessary for instantaneous starting of the lamp by the cold cathode method, said normally closed switch including a contact supported by a bimetallic element, and current actuated means to continuously heat said element upon the closure of the line switch.

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