Feb. 2, 1960 D. L. GREENE ET AL 2,923,856

HIGH FREQUENCY BALLAST UNIT

Filed Oct. 2, 1958 2 Sheets-Sheet 1

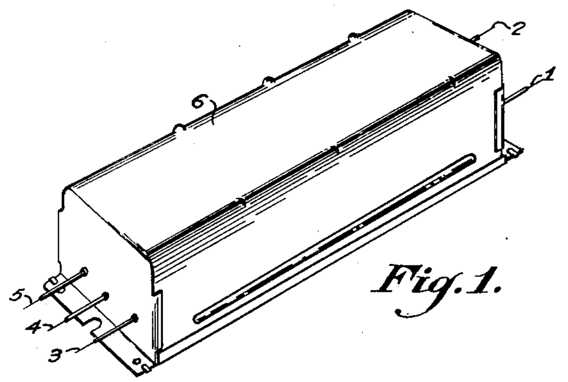

Fig. 1.

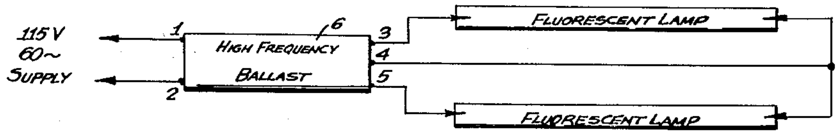

Fig. 2.

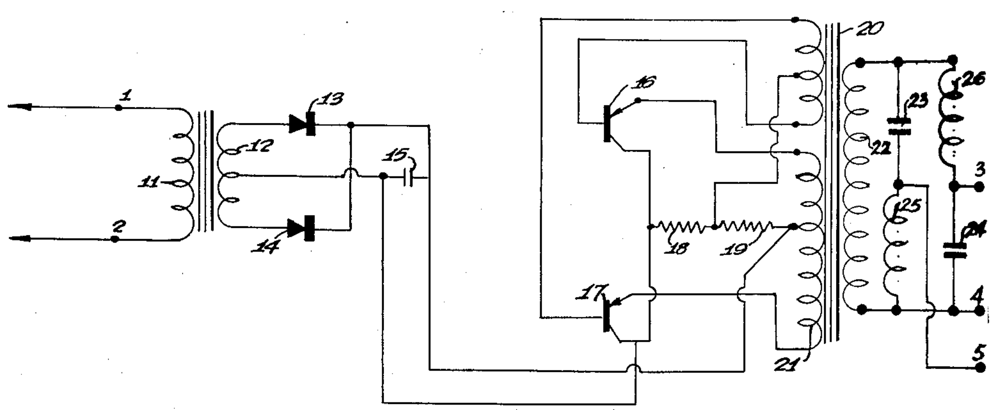

Fig. 3.

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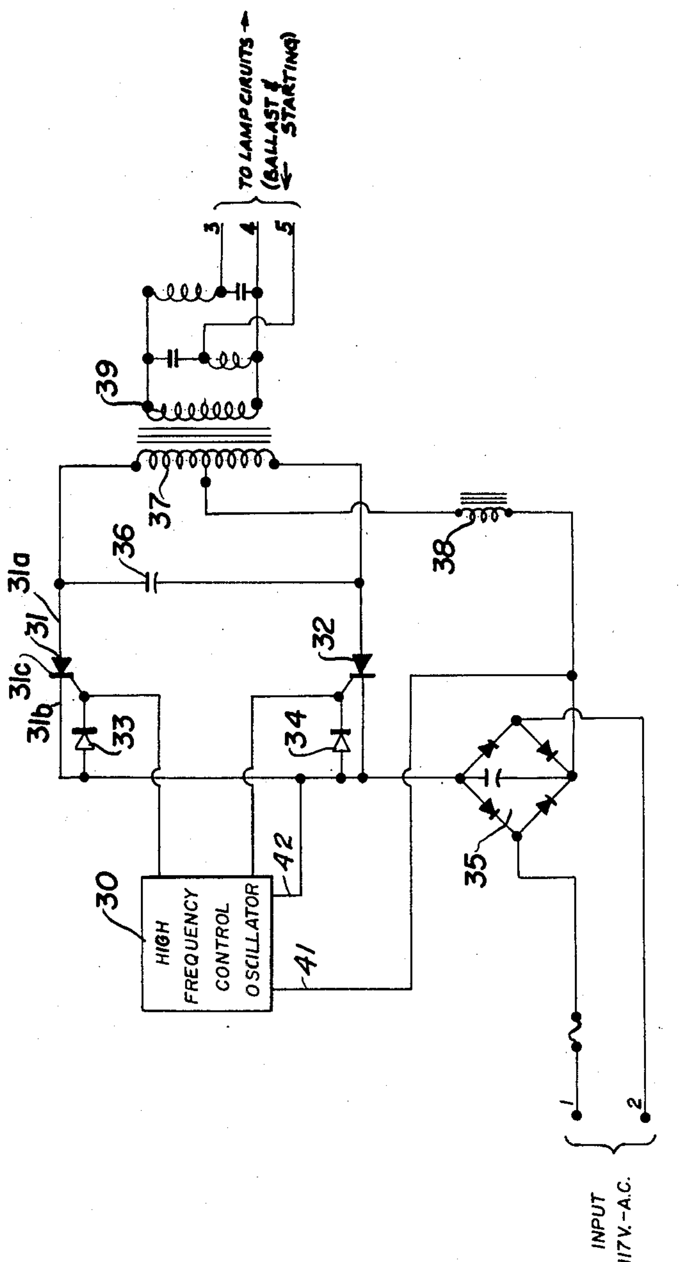

Fig. 4

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HIGH FREQUENCY BALLAST UNIT

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4 Claims. (Cl. 315—138)

This invention relates to a ballast unit for use in fluorescent lighting fixtures and, more particularly, it relates to a self-contained ballast unit for converting from the 60-cycle lighting source to a considerably higher frequency with inherent instantaneous starting.

An outstanding disadvantage of conventional types of high-frequency lighting systems recently developed is that various means of frequency conversion are used at the main source of supply for the building involved. Such means may be large power packs which convert from the lighting frequency to a higher frequency, either by rotating equipment or by electronic tubes or transistorized units, which high-frequency is then transmitted through the entire lighting system to the fixtures. In addition, each of the individual lighting fixtures must be equipped with a small starting ballast to complete the system.

Moreover, most conventional power pack supplies, which are at the power source of the building, must necessarily operate at a frequency of 400 to 1000 cycles. Any attempt to go to higher frequencies results in derating of switching equipment and undue losses in the transmission through the normal lighting circuits. It also results in annoying radio interference in the audio zone due to the possible exposure of the lighting circuits.

An object of the present invention is to provide a unitary high-frequency starting unit for fluorescent lights which is devoid of the above-named disadvantages and which will eliminate the necessity of providing a frequency conversion unit at the main source of supply of the building.

A more specific object of the present invention is to provide a high frequency, instantaneous starting unit for use in fluorescent lighting fixtures which is in the form of a single ballast unit which will replace the normally used ballast in lighting fixtures and which is essentially the same size and shape as the conventional ballast unit. This unit includes the necessary resonant circuits to initiate starting of the fluorescent tubes as a self-contained part, one component of which ballasts a tube in each case. No other external equipment or power packs are required.

Another object of the invention is to provide a high frequency ballast unit for starting fluorescent lights, in which unit all of the frequency conversion and high frequency elements are self-contained in the metallically shielded ballast unit, and in which the high frequency wiring between the ballast unit and the lamp tubes is also essentially in a shielded metal unit, so as to minimize or actually prevent any interference due to the use of higher frequencies—also which eliminates any increased line losses and switch derating since all of the normal lighting, wiring, and switching installation will be operating with the conventional 60 cycle supply source.

A further object of the invention is to provide a ballast unit which provides increased output from the fluorescent tube by reason of higher efficiency and the elimination, to a large extent, of any perceptible stroboscopic effect, which elimination is not possible by known means since it is not practical to transmit this high a frequency from a central source.

A still further object is to greatly reduce the size and weight of a fluorescent unit for a given lighting requirement and for greatly reducing heat dissipation, and branch circuit wiring costs, as well as to increase lighting efficiency, quietness in operation and the life of the unit.

Another object of the invention is to provide a fluorescent lighting circuit including silicon controlled rectifiers which eliminates the necessity for an input power transformer and which results in a unit having relatively few, simple and inexpensive parts.

Another object is to provide a ballast arrangement which inherently has much lower heat losses than the conventional or the high powered ballasts designed expressly for high output tubes, which allows the use of the higher output tubes in locations where there is a high temperature or ventilation problem and which is also an important factor where air conditioning is involved.

A further object of the invention is to provide a ballast unit having no moving parts and for starting fluorescent lamps, which unit eliminates any necessity for starting units as required in conventional fluorescent fixtures due to the inherent design of the internal ballast arrangement—and which unit, by controlled resonance and sufficiently high voltage, is available at start to cause the tubes to strike or light instantaneously, instead of with the usual delay, and the instant the tube is lighted, the voltage being restored to that required for normal operation.

A still further object of the invention is to provide a replacement ballast unit that can be used to replace any existing ballast in order to get more and better light from the same fixture, that is, which eliminates the necessity of rewiring existing lighting systems and enables one, merely by change of the ballast in the fixture, to obtain greater output of light and far superior quality—also which unit is readily interchangeable with, and has the same type of mounting design as conventional ballast units.

Other objects and advantages of the invention will become apparent from the study of the following description taken with the accompanying drawings wherein;

Fig. 1 is a perspective view of the high frequency ballast unit involving the principles of the present invention;

Fig. 2 is a circuit diagram showing how the high frequency ballast unit is connected to fluorescent lamps,

Fig. 3 is a complete circuit diagram showing the internal wiring of the ballast unit shown in Figs. 1 and 2, and Fig. 4 shows a modification.

Referring more particularly to the drawings, numerals **1** and **2** denote input terminals of the high frequency ballast unit **6** embodying the present invention, which terminals are connected to a 60 cycle lighting source of supply, that is, a conventional household potential source. Numerals **3**, **4**, and **5** denote the output terminals of the unit which are connected to the fluorescent lamps as shown in Fig. 2. The unit **6** is contained in a metallic casing and is of substantially the same size and shape, and has the same terminals, as the ordinary ballast unit used in the conventional fluorescent starting circuits. The cartridge or container of unit **6** is of metal so as to effectively shield all the internal wiring and parts of the ballast. Furthermore, the high frequency wiring between the ballast unit and lamp tubes is also essentially shielded, thus minimizing or actually preventing interference due to the use of such higher frequencies.

In Fig. 2 the high-frequency ballast unit is shown as being substituted for the conventional ballast. There are no separate starting elements, as shown, since this feature is inherent in the present unit **6**.

Referring more particularly to the circuit diagram shown in Fig. 3 of the unit **6**, the terminals **1** and **2** are connected to the normal 60 cycle lighting supply source to energize the primary **11** of the transformer. By means of dry type rectifiers **13** and **14**, such as copper oxide rectifiers, in circuit relationship with the secondary **12** of the transformer, A.C. current is rectified and converted into direct current.

This direct current is then fed into a transistorized amplifier comprising transistor elements **16** and **17** in circuit relationship with resistors **18** and **19**, as shown. Such amplifier can produce any selected frequency for the output terminals **3**, **4**, and **5**. Inductance coils **25** and **26** with capacitors **23** and **24** forming part of the starting resonance circuit, are shown connected to terminals **3** and **5**. This arrangement can be expanded readily to fixtures containing more than two tubes. In other words, a four tube fixture would have twice as many inductance coils and capacitors.

Essentially, therefore, the unit comprises three functional parts. The portion to the left of condenser **15** of Fig. 3 is a rectifier for converting 60 cycles to D.C. The intermediate portion up to the secondary coil **22** is a transistorized amplifier and converter for converting D.C. to high frequency A.C. The secondary winding **22**, inductance coils **25**, **26** and capacitors **23** and **24** form the starting resonance circuit.

The convertor amplifier operates in the following manner:

Direct current is supplied to two transistors **16** and **17** through the center tapped winding **21** of the output transformer. One of the transistors, as a natural phenomena, will conduct earlier than the other. The current in one-half of the primary of the output transformer will produce flux in the transformer core which will cut the conductors forming the second primary winding. This flux produces a voltage in the second primary winding which is fed back to the input of the same transistor, producing an increase in its conduction. This effect continues until the voltage drop across one-half of the primary **21** winding is equal to the supply voltage. At that moment, current in the winding increases no further, and no more flux is produced, so the flux starts to fall. This generates an opposite voltage in the second primary winding, which drives the second transistor into conduction. This process repeats itself continuously, producing a square wave output on winding **22**.

A simpler but less desirable starting resonance circuit would be simply to eliminate inductance coils **25** and **26**, thus leaving only capacitor **23** between terminal **5** and one terminal of coil **22**, and leaving only capacitor **24** between terminal **3** and the other terminal of coil **22**, terminal **3** being connected directly to the mid-point of coil **22**.

This invention allows the use of frequencies as high at 20,000 cycles per second or higher, but, for practical reasons, a reasonably high plateau of efficiency for fluorescent tubes is reached with frequencies of the order of 8,000 to 10,000 cycles per second. It is, therefore, evident this unit is capable and practical for the supply of frequencies in this range without system losses and without involving system radiation to cause radio interference.

The benefit obtained from the use of this unit at these higher frequencies is increased output from the fluorescent tubes by reason of higher efficiency and the elimination, to a large extent, of any perceptible stroboscopic effect. This is not obtainable by any other means since it is not practical to transmit this high a frequency from a central source. The invention eliminates any necessity for starting units as used in conventional fluorescent fixtures due to the inherent design of the internal ballast arrangement. In essence, by controlled resonance, sufficiently high voltage is available at start to cause the tube to strike or light immediately, and the instant the tube is lighted, by characteristics of the circuits, the voltage is restored to that required for normal operation. This controlled resonance starting feature has no moving parts and is merely inherent in the electrical design. The effective results are that the lighting tubes have no apparent delay in starting as is the case with most present day fluorescent fixtures and this ballast can, therefore, be classified as truly "instant starting." There is also a notable increase in the life of the tubes when operating at the higher frequencies. There is an additional benefit relating to the power supply due to the inherent high power factor (essentially 100%), created by this device. This results in less supply line losses with corresponding better voltage delivered to the lighting units and, of course, correspondingly less heat dissipation from the supply wires.

Fig. 4 shows an alternate circuit arrangement for the high frequency ballast unit. In principle, this circuit accomplishes the same end results and has been made possible by the recently developed higher voltage silicon controlled rectifiers.

In the basic diagram shown in Fig. 3, the transistors were inherently low voltage equipment, and it was, therefore, necessary to utilize an input power transformer to step down the voltage to the safe operating level. By the circuit shown in Fig. 4 utilizing silicon rectifiers, it is possible to eliminate the power transformer, and this, of course, means less heat dissipation as well as less space requirements. In effect, this does not change the overall concept of the invention of conversion to a very high frequency at the fixture but merely represents a more desirable means of accomplishing this result.

Fig. 4 shows a modification of the invention which involves the use of silicon controlled rectifiers **31** and **32** and control transistors **33** and **34** in circuit relationship with a commutating capacitor **36**, silicon-type rectifier **35** and choke **38**. A silicon controlled rectifier **31**, for example, comprises anode **31*a***, cathode **31*b*** and gate **31*c***. Rectifier **32**, in construction, is the same. A small high frequency oscillator **30** of any conventional type is provided for control and is energized by D.C. supply current fed across terminals **41** and **42**.

The inverter represented in Fig. 4 is a thyratron inverter, but the switching elements embody a new semi-conductor development, silicon controlled rectifiers. The rectifiers will prevent the flow of current in either direction unless a gate effect or driving signal initiates conduction. After conduction starts, it will continue until the anode voltage is reduced to zero, which is a typical thyratron characteristic. This switch-like characteristic allows any load characteristic to be chosen, since the internal dissipation of the controlled rectifier depends only on current drawn through it, as contrasted to transistors where the internal dissipation is dependent upon the phase difference of the voltage across the transistor and the current through it. For example, it is possible to have an elliptical load line for the thyratron and very low dissipation in the thyratron, whereas the same load characteristic with transistors would show a very high internal dissipation during the transition from cut-off to saturation.

The transistor inverter also requires that the output waveform be square for maximum efficiency. The thyratron inverter has no such requirement. The high frequency control oscillator provides the gate-effect signal which alternately switches the controlled rectifiers. Thus a fixed output frequency is assured which makes practical a resonant starting circuit. These controlled rectifiers are available with high peak inverse ratings which eliminates the necessity for an input power transformer.

The switching ability of the controlled rectifier makes practical very high frequencies, above the audio range, so that the most efficient frequency for the lamp can be chosen, also so that a quiet unit is possible. An additional advantage for very high frequencies is that the transformer, reactor and ballasts are all very small and correspondingly very inexpensive.

This alternate means has been proven by laboratory test to be highly satisfactory and provides for the elimination of the input power transformer which is required in the embodiment of Fig. 3 to step down the voltage to the permissible limit of the transistors involved.

The ballast unit can be used to replace any existing ballast in order to get more and better light from the same fixture. In other words, it is not necessary to do anything to the existing lighting system but merely change the ballast in the fixture by replacing the existing ballast with this unit to obtain a considerably greater output of light of a far superior quality. The mounting hole design is identical to the conventional ballast unit on the present market so that it is, therefore, readily interchangeable.

Thus it will be seen that we have provided a highly efficient, high frequency ballast unit which may be used to replace the conventional ballast for fluorescent lamps, which may be used as a substitute for such ballast and which will eliminate the necessity of providing a frequency converting unit at the building source or main supply source as generally required; furthermore, we have provided a high-frequency ballast unit which is truly instantaneous in starting instead of having the usual lag or delay of conventional ballasts; furthermore, we have provided a high-frequency ballast unit which is relatively inexpensive in construction and is of the same shape and configuration as the normal starting ballast, therefore which can be readily substituted therefor; furthermore we have provided a frequency converter and ballast combination having very low heat loss and involving a minimum number of inexpensive parts that occupy a relatively small space.

While we have illustrated and described several specific embodiments of our invention, it will be understood that these are by way of illustration only, and that various changes and modifications may be made within the contemplation of our invention and within the scope of the following claims.

We claim:

1. A high frequency, unitary ballast unit for replacing a standard fluorescent lamp ballast unit, comprising a transformer having a primary winding for connection to a 110 volt, 60 cycle supply source and a secondary winding, a dry-type rectifier connected to said secondary winding, a transistorized amplifier and converter energized

by the direct current output of said rectifier and including a plurality of transistors and an output transformer, said last mentioned transformer including primary windings connected to the output of said amplifier and converter and including a secondary winding and resonant circuits connected to the output terminals of said last mentioned secondary winding, said resonant circuits being connected to the terminals of fluorescent lamp means, and a metallic casing for housing and shielding all of the aforementioned elements exclusive of said fluorescent lamp means and being in the form of a single cartridge of substantially the same shape, and having the same type of terminals as a standard ballast unit so as to be usable interchangeably therewith, whereby high frequency instantaneous starting voltage pulses are generated across the lamp terminals.

2. A high frequency ballast unit as recited in claim 1 wherein said resonant circuits include two parallel circuits, each including a capacitor in series with an inductance coil, said parallel circuits being connected across the terminals of said last mentioned secondary winding, the terminals of the lamp means comprising one of the terminals of said last mentioned secondary winding and the two intermediate points between said capacitors and inductance coils in said parallel circuits.

3. A high frequency, unitary ballast unit for connection directly to fluorescent lamps, comprising a dry type rectifier connected to a 60 cycle, household power source, a frequency converter comprising a pair of silicon controlled rectifiers and a pair of control transistors in circuit relationship therewith, said rectifiers and transistors together with a high frequency control oscillator being energized by the direct current output of said rectifier and being connected to control said transistors, and an output transformer including a secondary winding having output terminals for connection to said fluorescent lamps.

4. A ballast unit as recited in claim 3 together with a metallic shield for enclosing said unit and the connections between the unit and said lamps.

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