

[54] POWER SUPPLY ARRANGEMENT FOR
FLUORESCENT TUBES, THERMIONIC
DEVICES AND THE LIKE

[76] Inventor: **Taras Avenir Kolomyjec, 15
Camelot Ct., Carlingford, N. S. W.,
Australia**

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315/105, 315/221, 315/DIG. 7

[51] **Int. Cl.**..... **H03k 3/28, H05b 41/29**

[58] **Field of Search** 315/94, 95, 96, 97, 101,
315/105, 221, 278, 200, 202, DIG. 2, DIG. 7;
331/112

[56] **References Cited**

UNITED STATES PATENTS

3,463,964	8/1969	Privett et al.	315/97 X
3,629,648	12/1971	Brown et al.	315/98

Primary Examiner—Rudolph V. Rolinec

Assistant Examiner—E. R. LaRoche

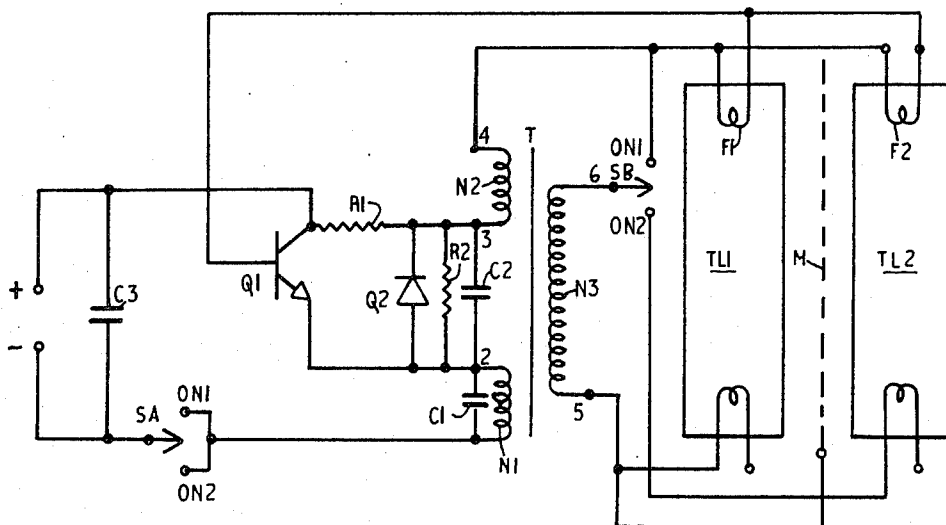
Attorney, Agent, or Firm—Ladas, Parry, Von Gehr,
Goldsmith & Deschamps

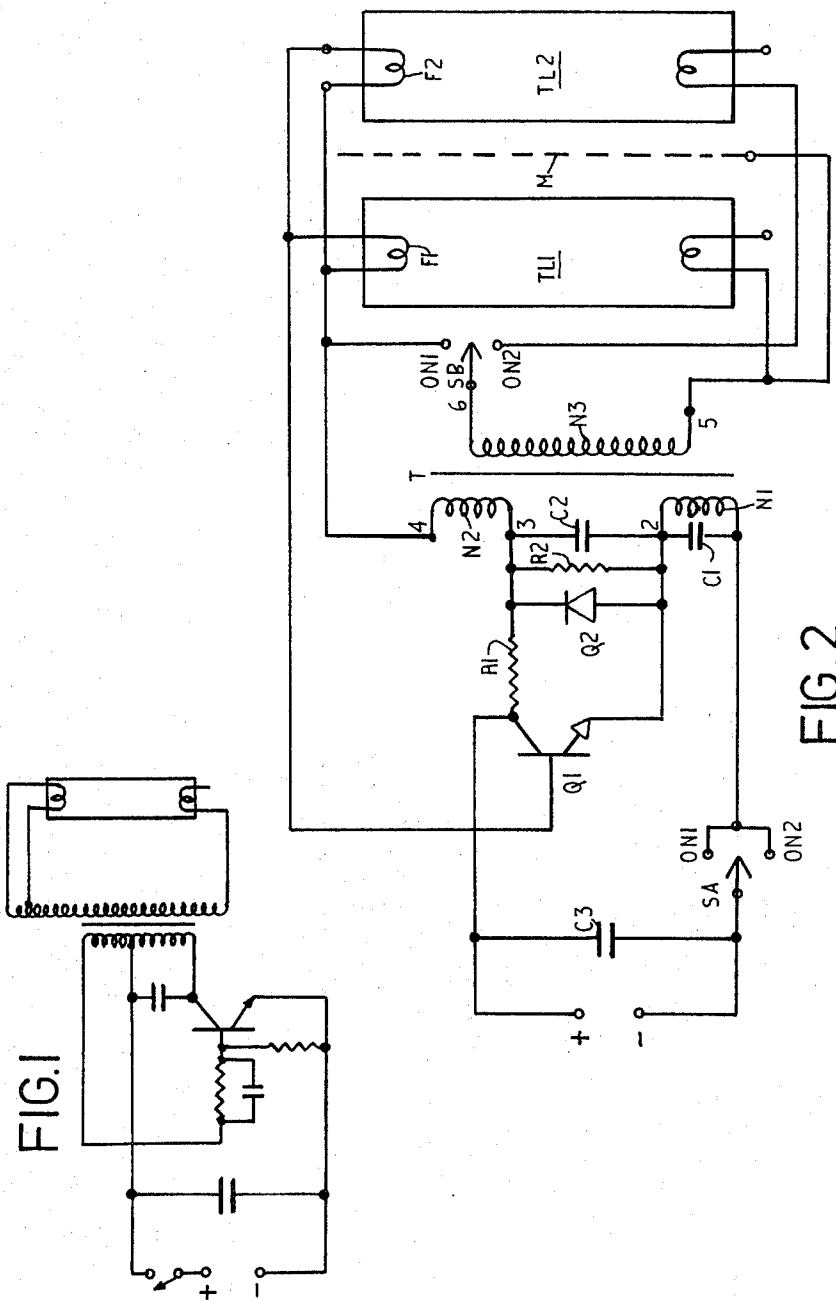
[57] ABSTRACT

A portable fluorescent lamp arrangement operated from a low voltage source by a D.C. to A.C. blocking oscillator inverter has switching means by which either one low-voltage tube, or two low-voltage tubes, can be used to give different levels of illumination. Difficulties in using a blocking oscillator inverter have been overcome by connecting one filament of one tube in series with the feedback winding of the oscillator whereby this filament is preheated by the collector current, and arranging the switching means so that

1. when one tube only is to be energised the secondary winding is connected across the said preheated filament and the other filament of that tube, and
2. when both tubes are to be energised the ends of the secondary winding are connected one to the non-preheated filament of the said one tube, and the other end of the winding to one filament of the second tube, there being a series path for the lighting current through both tubes.

10 Claims, 11 Drawing Figures





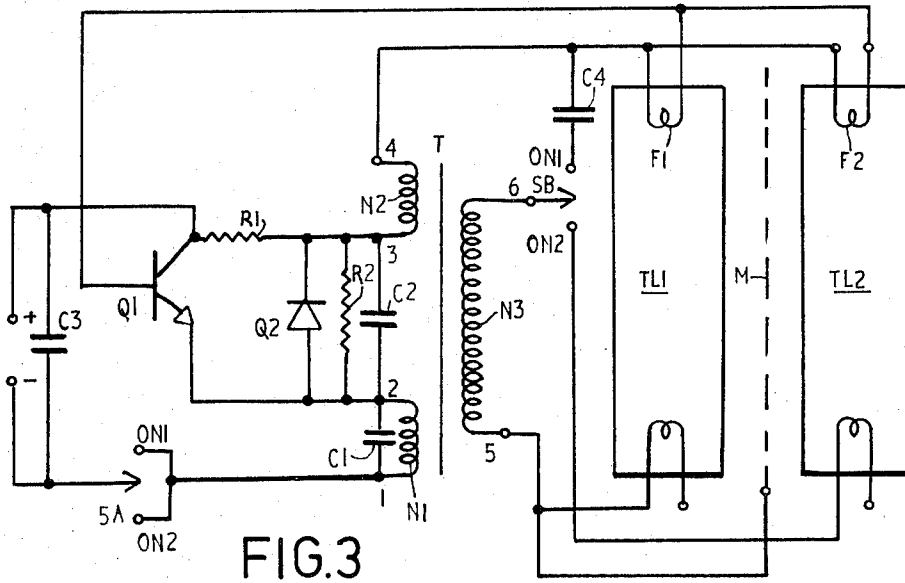


FIG. 3

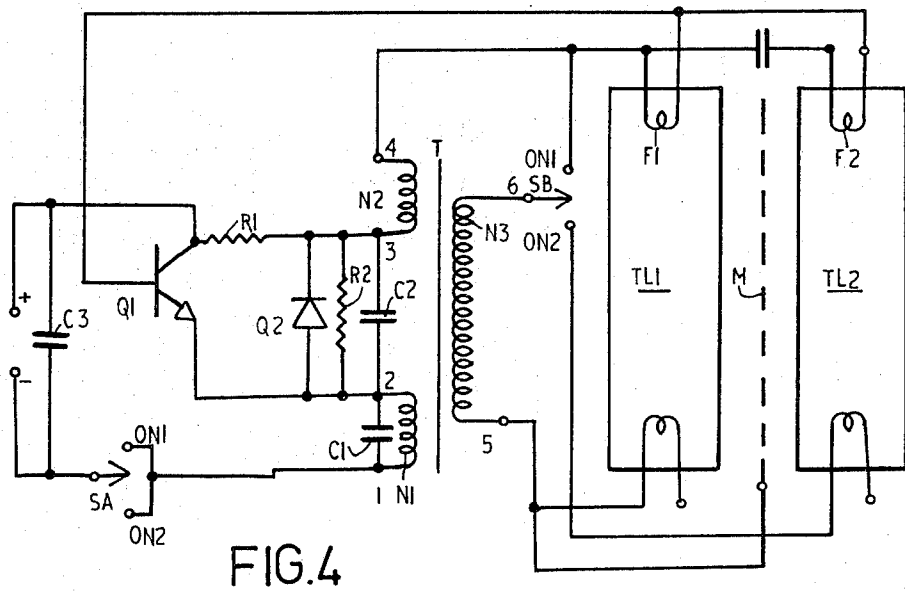
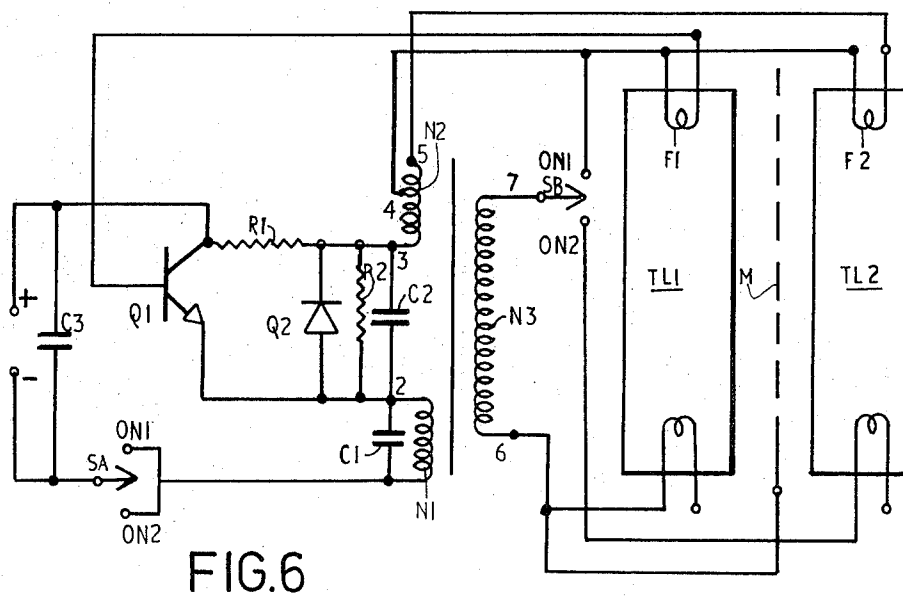
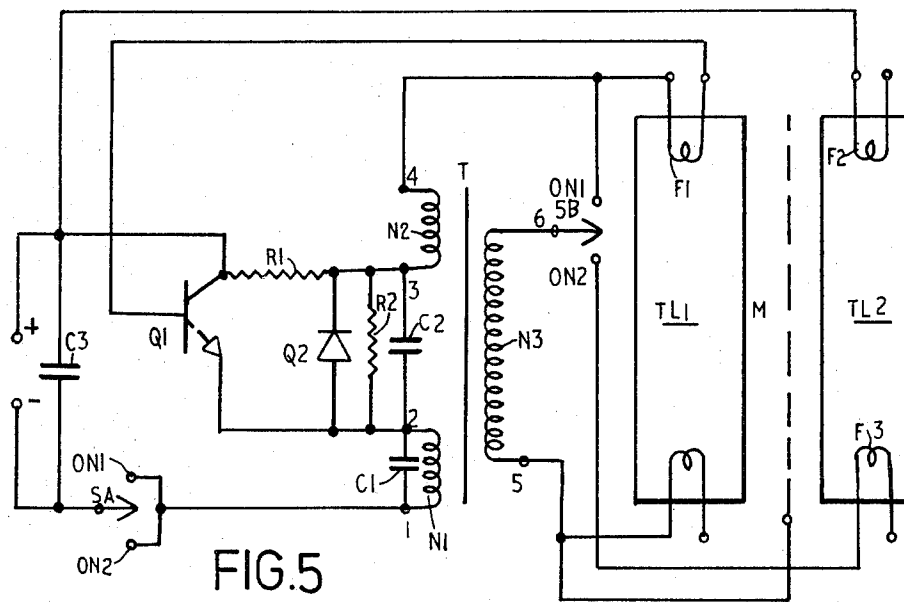


FIG. 4



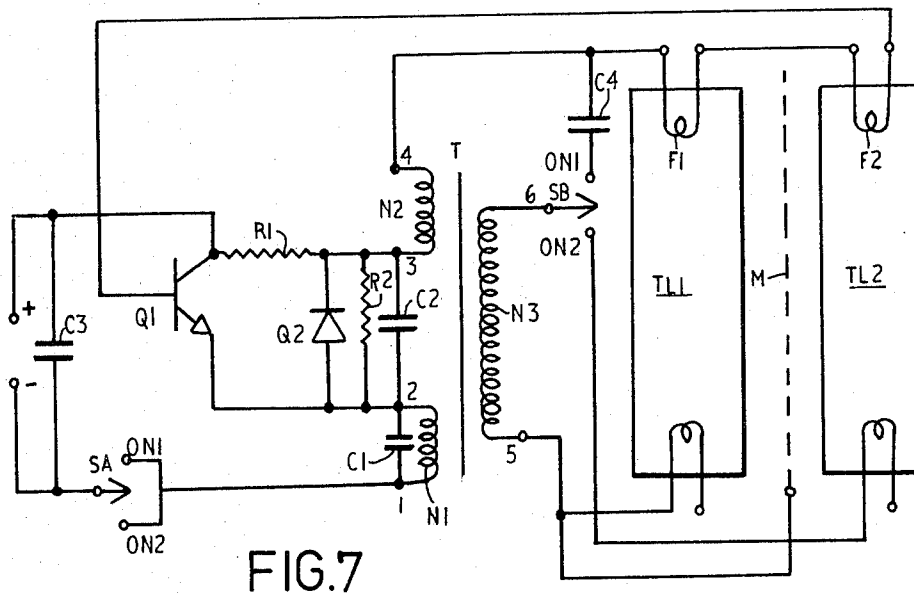


FIG. 7

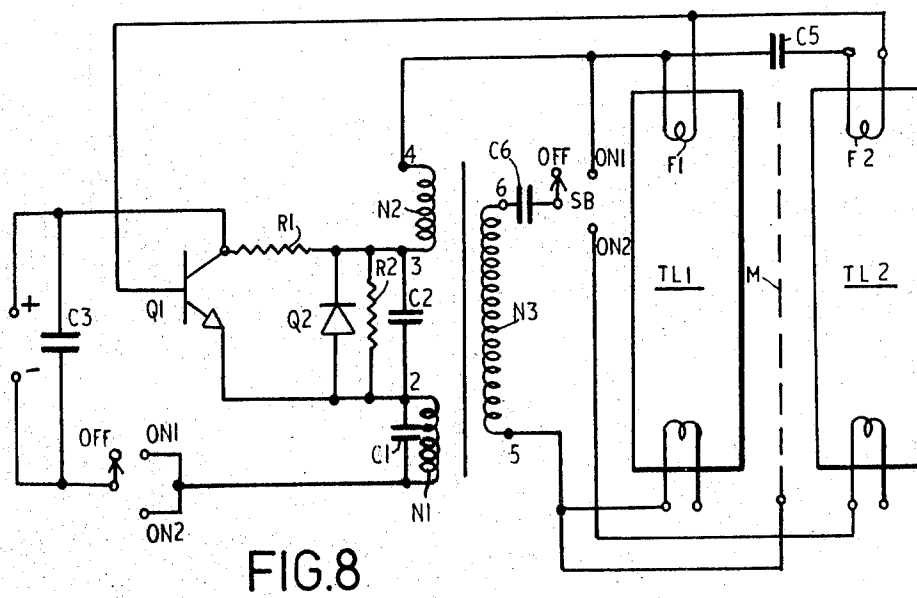
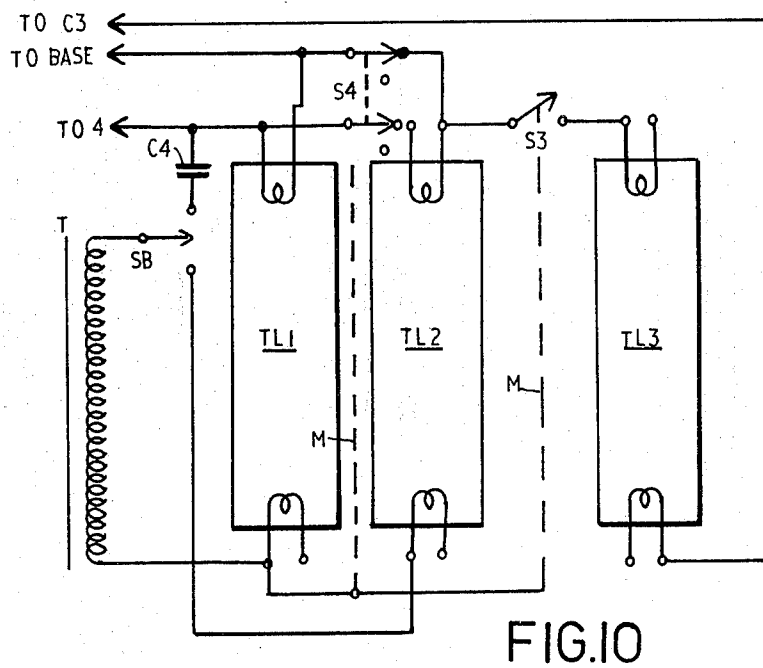
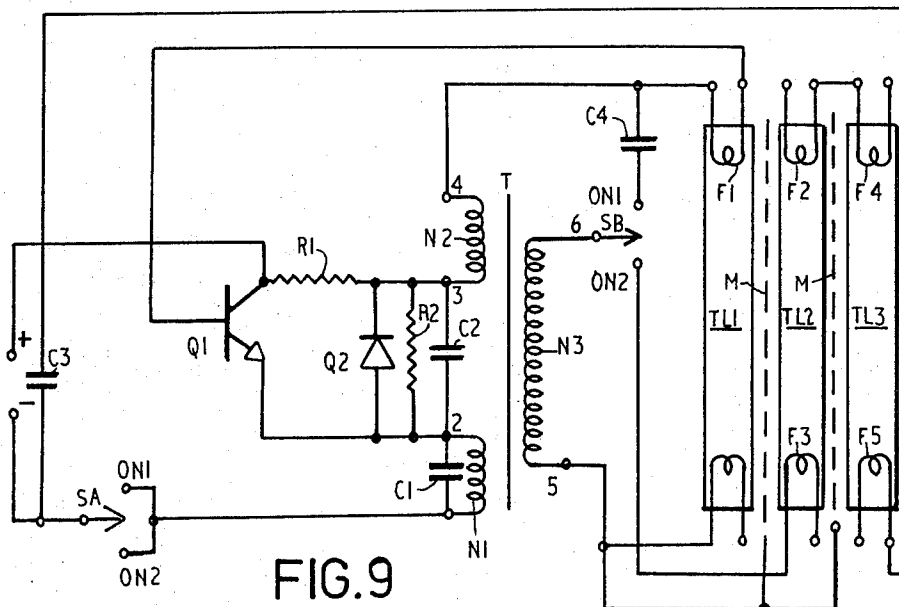


FIG. 8



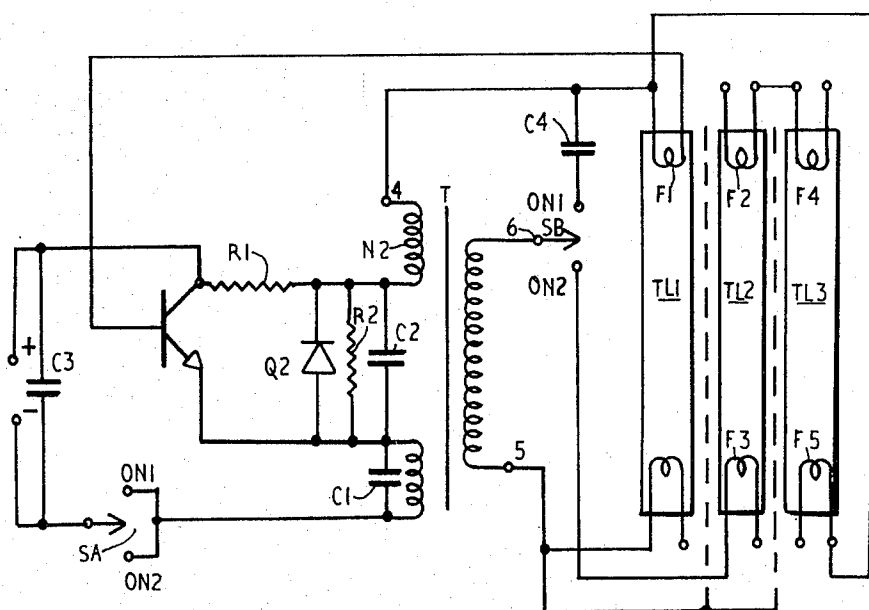


FIG. II

POWER SUPPLY ARRANGEMENT FOR FLUORESCENT TUBES, THERMIONIC DEVICES AND THE LIKE

This invention relates to a power supply arrangement for fluorescent lamps, thermionic devices and the like, the power being derived from a low voltage D.C. source.

It is at present known to operate a fluorescent lamp from a low voltage D.C. source by interposing a D.C. to A.C. inverter between the D.C. source and the fluorescent lamp, the voltage across the lamp being stepped up, in a typical case, to 175 volts. A typical circuit using a blocking oscillator type inverter is shown in FIG. 1, and it will be noted that it uses but one transistor and one transformer. The D.C. source is typically 12 to 13.5 volts and the fluorescent tube has typically a 4 or 6 watt electrical power rating. The inverter has an electrical power conversion efficiency in the range of 65% to 85%. It compensates for its 35% to 15% power loss by producing relatively high illumination from the fluorescent tubes. Fluorescent tubes that are driven by inverter circuits give off brighter illumination than mains driven fluorescent tubes because of the very high frequency of the induced alternating voltage produced by inverters that use ferroxcube core transformers.

There is a need for a portable light source operable from a low voltage D.C. source, such as a 12 volt battery, and which has two 6 watt fluorescent tubes, with switching arrangements such that either one only of the tubes, or both tubes together, can be used. If an attempt is made to connect a second fluorescent tube in parallel with the first tube shown in FIG. 1, the oscillator will not operate. This is because known circuit design leads to the construction of blocking oscillator type inverters that oscillate within a fixed narrow range, and this places a significant limitation on their use in powering and lighting two fluorescent lamps or one fluorescent lamp at will.

I have found out that blocking oscillator inverters have to operate at a significantly higher frequency when two fluorescent tubes are to be powered than when one tube only is to be powered. This requirement is very significant in inverter circuits designed for relatively low power outputs such as 6 to 12 watts where substantial power losses may occur during power conversion from D.C. to A.C. due to unstable circuit oscillation.

The object of this invention is to provide a blocking oscillator inverter which may power either one or two fluorescent tubes and in which the frequency of oscillation is automatically increased substantially when the second fluorescent tube is switched in. Further objects are to provide such an oscillator which doubles its power output and power input when the second tube is switched in without having to switch on or off any current limiting resistors in the converter circuit; in which the collector to emitter voltage is increased when the second tube is switched in without having to switch on or off any voltage regulating components connected to the transistor; and which increases the induced alternating secondary voltage in the secondary winding when the second tube is switched in without having to use extra inductance windings in the secondary coil of the transformer. In a modification a third similar fluorescent tube may be switched in if desired.

According to this invention a fluorescent lamp arrangement comprises a blocking oscillator transistor inverter having a primary winding, a feedback winding, and a secondary winding, there being a substantial step up ratio between primary and secondary windings, two fluorescent tubes, means connecting a filament of at least one tube in series with the feedback winding whereby the filament is preheated by the collector current of the transistor, and switching arrangements whereby

1. when one tube only is to be energised the secondary winding is connected across the said preheated filament and the other filament of that tube, and
2. when both tubes are to be energised the ends of the secondary winding are connected one to the non-preheated filament of the said one tube, and the other end of the winding to one filament of the second tube, there being a series path for the lighting current through both tubes.

Reference will now be made to the accompanying drawings in which

FIG. 1 is a circuit diagram of a typical blocking oscillator fluorescent lamp operating circuit,

FIG. 2 is a circuit diagram of a fluorescent lamp arrangement in accordance with this invention having two fluorescent tubes TL1 and TL2,

FIG. 3 is a circuit diagram of a modification of FIG. 2,

FIG. 4 is a circuit diagram of a further modification of FIG. 2,

FIG. 5 is a circuit diagram of a still further modification of FIG. 2,

FIG. 6 is a circuit diagram of yet another modification of FIG. 2,

FIG. 7 is a circuit diagram of yet another modification of FIG. 3,

FIG. 8 is a circuit diagram of a further modification of FIG. 4,

FIG. 9 is a circuit diagram of another modification including three fluorescent tubes,

FIG. 10 is a circuit diagram of part only of FIG. 8 showing a modification thereof,

FIG. 11 is a circuit diagram of a further modification of FIG. 9.

Referring first to FIG. 2 of the drawings, a D.C. voltage source, say a 12 volt battery is connected in a one transformer-one transistor blocking oscillator in which Q1 is the active component in the circuit which controls the oscillation of the converter circuit. Primary winding N1 is connected between the emitter and the negative terminal of the D.C. source. N2 is the feedback winding wound to facilitate positive feedback from the collector to the base of the transistor.

Diode Q2, resistor R2 and capacitor C2 function as a transistor anti-saturation device. The diode Q2 functions to discharge electricity from the emitter to neutralize the stored charge in the collector and shortens the storage time for collector saturation. Similarly capacitor C2 and resistor R2 function to discharge electricity from the emitter to neutralize the stored charge in the collector and thereby minimizes the storage time for positive charging of collector. The significance of having diode Q2 in parallel with capacitor C2 and resistor R2 is that the anti-saturation efficiency of C2 and R2 in parallel ceases to be effective when collector to emitter voltage frequency reaches some figure, typically 4 kilohertz. This voltage frequency is satisfactory

for efficient lighting of only one 6 WATT fluorescent tube. However, in order to light up two 6 WATT fluorescent tubes the collector to emitter voltage frequency must be substantially greater than, and preferably at least double, that required to light one 6 WATT fluorescent tube. The insertion of diode Q2 in parallel to the capacitor C2 and resistor R2 facilitates the production of higher frequency voltage between the collector and emitter. When two 6 WATT fluorescent tubes are lighted diode Q2 efficiently switches on and increases the collector to emitter voltage frequency to 10 kilohertz. This permits the circuit to light up two 6 WATT fluorescent light tubes.

Primary winding N1 functions as a voltage reservoir which supplies negative voltage to the diode Q2, capacitor C2 and resistor R2 to carry out their transistor anti-saturation functions.

Electrolytic capacitor C3 functions to stabilize the oscillation frequencies in the inverter circuit.

Capacitor C1 functions to regulate the oscillating frequency in N1 to prevent the production of higher harmonics in the transformer T which may cause radio interference.

Feedback winding N2 is connected in series with one parallel set F1, F2 of the filaments of fluorescent tubes TL1 and TL2. This facilitates the heating of the electrodes in the two fluorescent tubes and also dissipates excess electrical heat energy that may be generated between the collector and the base of the transistor. This contributes to preventing the transistor and resistor R1 from generating unwanted heat during circuit operations.

Resistor R1 controls the current flow from the collector to the base of the transistor and limits the current drain from the direct current power supply.

Secondary transformer winding N3 functions to raise the collector voltage to approximately its peak value and to provide alternating current electricity for lighting the fluorescent light tubes TL1 and TL2.

The switch S, having the two parts SA, SB in the circuit, when in position "ON1" functions to (i) connect the oscillator circuit to the direct current power supply and (ii) switch the secondary coil to connect the ends of the secondary coil N3 to the ends of fluorescent tube TL1.

When the switch is in this position, where one end of the secondary coil N3 (lead 6) is connected to that lead 4 of feedback winding N2 which is connected to the heated filament terminal in TL1, and secondary coil lead 5 is connected to the cold terminal end of TL1, the fluorescent tube TL1 regulates and sets the oscillating frequency of the circuit at comparatively low frequency, typically 3, 4 kilohertz.

When the switch is moved into position "ON2" the secondary lead 6 is connected to the cold terminal end of TL2 and the other end 5 remains connected to the cold terminal end of TL1.

The results of this switching where leads 5 and 6 of N3 become connected to the cold terminals of TL1 and TL2 are:

- i. Both TL1 and TL2 light up simultaneously.
- ii. The collector to emitter voltage across the transistor increases, typically from 30 to 40 volts.
- iii. The collector to emitter voltage frequency increases, typically from 3.4 kilohertz to 10 kilohertz.

iv. The induced voltage in the secondary winding of the transformer N3 increases typically from 124 volts A.C. to 250 volts A.C.

v. The frequency of the induced A.C. voltage in the secondary winding of the transformer N3 increases typically from 3.4 kilohertz to 10 kilohertz.

The connection of lead 5 of the secondary to the metal ionization (ignition strip) M increases the ionization field strength inside the two fluorescent tubes TL1 and TL2 and enables the fluorescent tubes to ignite (strike) immediately the circuit commences to oscillate. However, this strip need not be connected to lead 5 if the strip is disposed within half an inch of the tube. Typically this strip is a metal sheet light reflector on which the tubes are mounted.

The most significant functional feature of this circuit is the method used to control circuit operation for lighting either TL1 or TL2. The circuit is characterized by the complete absence of switching in or switching out of circuit components connected to the transistor to increase or decrease its operating characteristics to enable the circuit to cope with a 100% load variation requirement. The loads TL1 and TL2 are connected into the secondary winding N3 by means of switch S in such a way that the loads TL1 and TL2 control the transistor functions to fulfil the requirements of fluorescent tubes TL1 and TL2 to facilitate their efficient lighting.

The way the fluorescent tubes TL1 and TL2 behave in this circuit has not yet been clearly established for the operating period when two 6 WATT fluorescent light tubes TL1 and TL2 are alight. It is postulated that the ionization process inside the two tubes is achieved by the heating of the tube filaments with electrical current flowing from the collector through the feedback coil then through the tube filaments on one end of each of the two fluorescent tubes TL1 and TL2 into the base of the transistor.

The voltage in the heater electrodes of the two tubes TL1 and TL2 was measured in a typical case to be 7 to 7.5 volts and the current to be 0.05 amp when the two tubes are alight. Thus the electrodes dissipate 0.35 WATT electrical power from their filaments in each of the tubes TL1 and TL2. The heating of the tube filaments results in two things:

- i. Electrons are released into the inside of the fluorescent tubes by thermal emission into a vacuum.
- ii. Facilitates the vapourization of mercury near the electrodes.

When the switch S is switched to position ON2, leads 5 and 6 of the secondary coil of the transformer are connected to the cold electrodes of fluorescent tubes TL1 and TL2 respectively. These cold electrodes of TL1 and TL2 change their electrical charge polarity at a frequency of 10 kilohertz which is the frequency of the induced A.C. voltage in the secondary N3. The heated electrodes function as a cathode by emitting electrons into the fluorescent tubes. The metal strip M, which runs parallel and close to the lamps TL1 and TL2 and may be connected to lead 5 of secondary N3, facilitates the increase of ionization inside the fluorescent tubes TL1 and TL2 by increasing the electrical field strength inside the tubes.

The resultant movement of electrons inside the tubes TL1 and TL2 would bring the tubes into a "conductive" state which would result in the electrons colliding with mercury vapour inside the tubes. These collisions

between electrons and mercury vapour would lead to the production of ultra violet light radiation. This ultra violet radiation in turn would lead to the excitation of phosphorescent powder which is coated on the inside of the tubes TL1 and TL2, which would produce visible light radiation.

In the lighting of one 6 WATT fluorescent tube, TL1, the heater filament causes partial ionization inside the tube. Once the electrons emitted by the hot filament commence colliding with mercury vapour inside TL1 the tube reaches its conductive state and the circuit is completed between the two ends 5 and 6 of the secondary coil N3 through the movement of electrons between the two filaments of TL1. Visible light production TL1 is achieved by the collision of electrons with mercury vapour inside the tube with resultant ultra violet light production which causes the phosphorescent powder coating the inside of TL1 to emit light radiation.

In a particular arrangement Q1 was a silicon NPN power transistor and Q2 was a silicon low power diode. Transformer T is typically constructed as a 2-E core from type 3EI ferroxcube core material. N1 consisted of 25 turns, N2 of 13 to 25 turns, and N3 of 250 turns. A core gap of 0.95 mm to 1.0 mm was provided in each of the three legs of the E cores. Winding N1 and N2 are wound side by side on a former with a gap between them of 0.5 mm. N3 is wound over the top of N1 and N2.

The circuit of FIG. 3 differs from that of FIG. 2 by the inclusion of capacitor C4 between the switch position ON1 of switch SB and the connection of terminal 4 of secondary N2 to filament F1. Capacitor C4 has an influence on the frequency of the induced A.C. current between the two filaments of tube TL1 when switch SB is in position ON1. It also prevents undesirable R.F. wave generation in filament F2 in instances where poor quality core materials are encountered in the transformer. Values which have been used successfully for this capacitor are 0.0025 to 0.003 mfd.

FIG. 4 differs from FIG. 2 in providing a capacitor C5 between the filaments F1 and F2 so that only filament F1 is preheated by the collector-base current. The capacitor C4 of FIG. 3 can also be included in this arrangement.

FIG. 5 also shows an arrangement in which only the filament F1 of the tube TL1 is preheated, the filament F2 of tube TL2 being connected directly to the D.C. source, capacitor C3, and collector of Q1.

It is postulated that when both TL1 and TL2 are lit up the collector of transistor Q1 and the electrolytic capacitor C3, by being charged, will have an affinity for electrons. When switch S is in position ON2, so that lead 6 of secondary N3 is connected to the filament F3 of tube TL2 which is some 22 cms from the positively charged filament F2, it is feasible to expect the electrons will jump from the filament F3 to the positive filament F2. Since the filament electrode F3 is a reverse charge electrode, reciprocal movement of electrons between F1 and F2 will result. This will lead to collisions between electrons and mercury vapour inside the tube TL2 to produce fluorescent light in the usual way. The H.F. circuit is thought to be: Terminal 5, cold filament of TL1, F1, base of Q1, collector of Q1, F2, F3, ON2, terminal 6. Alternatively the H.F. circuit may be terminal 5, cold filament of TL1, F1, feedback winding N2, R1, F2, F3, ON2, terminal 6. As before the capacitor

C4 of FIG. 2 can be included between terminal ON1 of switch SB and the junction of lead 4 and filament F1.

FIG. 6 shows a modification of FIG. 2 in which feedback winding N2 is centre-tapped with filament F1 connected to the centre-tap 4 and filament F2 across the upper half of the secondary. The purpose of the centre-tapping is to reduce the feedback electrical current going into filament F1 when tube TL1 only is lit up. When both TL1 and TL2 are lit up it is postulated that the passage of feedback electrical current from N2 takes the path of a series circuit between lead 5 of N2 and the base of Q1 through filaments F1 and F2 in series. The capacitor C4 of FIG. 2 may be included.

Instead of the filaments F1 and F2 being connected in parallel as in FIG. 2 they may be connected in series, and this is shown in FIG. 7. The capacitor C4 of FIG. 2 has been shown in this FIG. 7, but it may be omitted.

FIG. 8 is the presently preferred form of the invention. It differs from FIG. 4 by including a capacitor C6 between the lead 6 of secondary N3 and the switch SB. The capacitor C5 may have a value of 0.002 μ F.

FIG. 9 shows a modification of FIG. 5 where either one tube can be lit when switch S is in the ON1 position, or three tubes TL1, TL2, TL3 when the switch S is in the ON2 position. In effect two tubes TL2, TL3 are connected in series in place of the single tube TL2 of FIG. 5. FIG. 11 shows a variant of FIG. 10 in which the filament F5, that is the filament of TL3 not connected to the filament F2 of TL2, is connected to the preheated filament F1 of tube TL1 instead of to the capacitor C3 and collector of Q2. The capacitor C4 can be omitted as in FIG. 2.

FIG. 10 shows portion of the circuit of FIG. 9 modified to permit either one, two, or three tubes to be lit. When one or two tubes are to be lit switch S3 is open, as shown, and switch S4 is closed giving the circuit of FIG. 3. When all three lamps are to be lit switch SB is left in the ON2 position, switch S4 is opened, and simultaneously switch S3 is closed, giving the circuit of FIG. 9. All three switches can be combined so as to be operable by a single control.

What I claim is:

1. A fluorescent lamp arrangement comprising a blocking oscillator transistor inverter having a primary winding, a feedback winding, and a secondary winding, there being a substantial step up ratio between primary and secondary windings, two fluorescent tubes, means connecting a filament of at least one tube in series with the feedback winding whereby the filament is preheated by the collector current of the transistor, a conductive connection between the preheated filament of the said one tube and one filament of the second tube, a connection between one end of the secondary winding and the other filament of said one tube, and a switch connected to the other end of the secondary winding, said switch in one position connecting the said other end to the said preheated filament of said one tube and in another position connecting the said other end of the secondary winding to the other filament of said second tube, whereby

1. when one tube only is to be energized the secondary winding is connected across the said preheated filament and the other filament of that tube, and
2. when both tubes are to be energized the ends of the secondary winding are connected one to the nonpreheated filament of the said one tube, and

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the other end of the winding to the other filament of the second tube, there being a series path for the lighting current through both tubes.

2. A fluorescent lamp arrangement as claimed in claim 1 wherein the one filament of the second tube is connected in parallel with the preheated filament of the said one tube.

3. A fluorescent lamp arrangement as claimed in claim 1 wherein the one filament of the second tube is connected in series with the preheated filament of the said one tube.

4. A fluorescent lamp arrangement as claimed in claim 1 comprising a capacitor connected between the one filament of the second tube and the preheated filament of the said one tube.

5. A fluorescent lamp arrangement as claimed in claim 1 wherein the feedback winding is centre-tapped, the preheated filament of said one tube is connected across one half of the feedback winding, and the one filament of the other tube is connected across the other half of the feedback winding.

6. A fluorescent lamp arrangement as claimed in

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claim 1 wherein the one filament of the second tube is connected to the collector of the transistor, and to a capacitor connected to the collector and to the emitter circuit.

7. A fluorescent lamp arrangement as claimed in claim 1 including a capacitor, said capacitor being connected between the other end of the secondary winding and said switch.

8. A fluorescent lamp arrangement as claimed in claim 1 including a capacitor connected between the one filament of the second tube and the preheated filament of the said one tube.

9. A fluorescent lamp arrangement as claimed in claim 1 including a capacitor connected to said switch so as to be in series between the secondary winding and the said one tube when said one tube only is energised.

10. A fluorescent lamp arrangement as claimed in claim 9 wherein the one filament of the second tube is connected in series with the preheated filament of the said one tube.

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