An inverter suitable for use as a fluorescent light ballast is disclosed. The inverter has a constant output regardless of load. Good efficiency at high frequency is provided by minimizing the transistor switching losses by means of a resonant storage means and a unique feedback and magnetic structure.
FIG. 1
INVERTER CIRCUIT AND SWITCHING MEANS

BACKGROUND OF INVENTION

Almost since the invention of the transistor, those skilled in the art have used it as a switching means in inverter systems to effect AC power from a DC source. It is well recognized by those skilled in the art that the switching loss of the transistor becomes a critical limiting factor, particularly as the operating frequency is raised. The ideal solution to the switching loss problem is well recognized as some circuit means to reduce the level of current that must be switched to as low a value as possible prior to the time that actual switching occurs. This is true since switching loss is represented by the instantaneous product of the voltage across the switch and the current through it. Therefore, minimum switching loss will be realized when zero current switching can be made practical. Further, the high instantaneous power represented by the product of voltage and current during switching can cause the transistor to lose its voltage blocking capability (secondary breakdown) and, thereby, be destroyed. So, in addition to operating efficiency, zero current switching makes possible higher system reliability through the elimination of the secondary breakdown phenomena.

High frequency power has many applications, one of which is the operation of fluorescent lamps. Here the high frequency provides about 10 to 15 percent more lumens per lamp watt as compared to 60 Hz operation. Also, by setting the operating frequency higher than 20,000 Hz, the audible noise common to lower frequency is eliminated. Also, in application where size and weight is important such as transportation vehicle lighting, the high frequency makes possible impressive gains. For the above described advantages of high frequency operation to be realized, the solution of the transistor switching loss must be effected.

Also, the fluorescent lamp, being of a gas ionization type, requires a high voltage to start the lamp and a much lower operating voltage. The lamp current must be limited to the safe design value for good lamp life and to prevent over loading of the inverter. Combining this current limiting characteristic into the inverter would make possible an inverter ballast suitable for the direct operation of fluorescent lamps from DC voltage sources. The fluorescent lamp life is sensitive to the form factor of the current through the lamp. For this reason, a suitable inverter ballast should have a minimum of harmonic content in its output.

GENERAL DESCRIPTION OF THE INVENTION

A circuit arrangement has been demonstrated that uses feedback means to always maintain the operating frequency at resonance. The magnetic-semiconductor combination, more completely described later, utilizes the energy stored in the system resonance to reduce the input current through the switching elements to near zero during switching. Since feedback is utilized to maintain the resonant frequency, good operating stability results for all conditions. Minor variations of component values with temperature and time is automatically compensated for by a corresponding minor change in the operating frequency. The use of ferrite core material and the above low loss switching make practical very high operating efficiency at frequencies in the 20 to 30 KHZ range. Efficiencies of 88 percent have been demonstrated on units delivering 80 watts of output power. The output current, at a given input operating voltage, is set by the frequency of operation and the value of capacitor used in the resonant circuit. Because of the resonant operation, the harmonics in the output current are maintained at a low value.

OBJECTS OF THE INVENTION

It is an object of the invention to provide an improved inverter circuit.

Another object of the invention is to provide an improved inverter circuit suitable for use as a fluorescent light ballast.

Another object of the invention is to provide an inverter circuit that is simple in construction, economical to manufacture, and simple and efficient to use.

With the above and other objects in view, the present invention consists of the combination and arrangement of parts hereinafter more fully described, illustrated in the accompanying drawings and more particularly pointed out in the appended claims, it being understood that changes may be made in the form, size, proportions, and minor details of construction without departing from the spirit or sacrificing any of the advantages of the invention.

GENERAL DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of one embodiment of the invention.

FIG. 2A shows wave forms of the primary voltage which occurs when the output load of the circuit is short-circuited.

FIG. 2B shows a wave form of the current into the inverter when the output load is short-circuited.

FIG. 2C shows a wave form of the voltage and current into the center leg of the circuit when the output load is short-circuited.

FIG. 3A shows the primary voltage wave form for the operating condition with the inverter ballast providing current to fluorescent lamps.

FIG. 3B shows the primary current when the inverter ballast is supplying two fluorescent lamps.

FIG. 3C shows a wave form of the voltage and current in the center leg of the magnetic winding 13-14 when the inverter ballast is supplying current to two fluorescent lamps.

FIG. 4 is the wave form which occurs with normal load as in FIG. 3A, in an actual test.

FIG. 5 is a wave form by the voltage 13-14 as in FIG. 3B during an actual test.

FIG. 6 is an actual wave form of the voltage and current into the center leg of the circuit.

FIG. 7 is an actual wave form similar to FIGS. 2B and 2C.

FIG. 8 is a schematic view of the magnetic member used in the embodiment of FIG. 1.

FIG. 9A is a schematic diagram of another embodiment of the invention.

FIG. 9B is a schematic view of the magnetic member used in the embodiment of FIG. 9A.

FIG. 10 is a block diagram of the circuits according to the invention.

FIG. 11 is an isometric bottom view of the chassis with the switch parts exploded for better understanding.

FIG. 12 is a bottom view of the switch.
DETAILED DESCRIPTION OF THE DRAWINGS

A description of the system operation will be made with reference to FIG. 1, which shows schematically one such system operating two 40 watt rapid start fluorescent lamps from a DC voltage source. FIG. 8 shows the magnetic structure and the location and relative directions of the windings shown schematically in FIG. 1. Rectifier diode RD6 is simply used to prevent damage in the event that reverse voltage is applied to the system. Capacitor C1 provides input voltage filtering to prevent any damaging voltage transient from affecting the system. Capacitor C2, which is a much smaller value, provides an energy storage arrangement capable of accepting energy returned from the system. This phenomenon will be more completely described later.

Resistor R2 provides a small turn-on current for both transistor T1 and T2 to assure reliable starting of the inverter.

This particular inverter ballast was designed to operate under a voltage range of 25 volts to 45 volts and for that reason, transistor T3, Resistor R1, rectifying diode RD1 and RD7, and resistor R3 comprise a constant current regulating means to assure an adequate feedback signal for transistor T1 and T2 at the 25 volt operating point, while preventing an excessive feedback current for the 45 volt operating point. If the inverter ballast design were to operate at a single nominal voltage, then this regulating circuit could be replaced by a single limiting resistor. Capacitor C4 provides a lead function in the feedback, thereby compensating for the delay and storage times that are inherent in all transistors. Feedback current is provided alternately by winding 5-6 for transistor T1 and then winding 7-8 for transistor T2. Capacitor C3 and the very small inductor L1 serve to limit induced voltage transients in the primary winding due to the leakage reactance of the primary windings.

Winding 11-12 is connected in series aiding to winding 13-14 and these windings are closed through a capacitor C6 to form a loop circuit. It is this loop circuit that is maintained in resonance and provides the desirable low-loss switching previously described. Note that the primary windings 1-2 and 3-4 are wound on the outer leg P of the E-Core in FIG. 8. Also, that winding 13-14 and the feedback windings 5-6 and 7-8 are wound on the center leg (C) while the winding 11-12 is wound on the outer other leg (S). Further, that an air gap G is provided in series with the center leg. Windings A-A, B-B, and C-C are filament heater windings to heat the fluorescent lamp filaments. These windings are also wound on the secondary leg S. Certain inherent advantages of having these filament heater windings located as shown will be later described.

Capacitor C5 is selected relatively large for the operating frequency being used so that it will prevent negligible A-C impedance. Its function, however, is very important when the fluorescent lamps comprise the inverter load. The reason for this is as follows:

The fluorescent lamp conducts current by the emission of electrons from the respective cathodes at the lamp ends. If for some reason the active material becomes depleted on one of the lamp ends, the lamp will continue to conduct current in one direction, but will not conduct in the other; and, in effect, will impose a half-wave rectified load on the inverter. The inverter operation is adversely affected by such operation and hence, capacitor C5 prevents such operation by preventing any DC component of current from flowing through the inverter load. Capacitor C8 provides a limit of output voltage which otherwise could reach a damaging value when either the lamp loads are disconnected or the lamps are so damaged as to present an open circuit to the inverter.

Consider a single half-cycle of inverter operation as the inverter is operating. Certain early-cycle transients occur during inverter start-up that are not important to the system operation; and, for that reason, the explanation will assume that the inverter is already operating.

Transistor T1 is turned on by the feedback voltage on winding 5-6 causing current to flow through the base of transistor T1 out of its emitter through the previously described current limiting circuit through rectifier diode RD3 and back to the feedback winding. The transistor T1 is now completely turned-on and current flow is from the voltage source through rectifying diode RD6 and into the primary winding 1-2 through the collector to emitter of transistor T1 and back to the negative of the voltage source. The winding convention utilized is such that all of the dotted winding ends will experience a positive induced voltage at the same instant.

Therefore, the terminal 13 of winding 13-14 will be positive and the terminal 11 of winding 11-12 will be positive and a current will flow to charge capacitor C6 around the loop comprising winding 13-14, 11-12 and the capacitor C6 and current will also flow to charge capacitor C8 and to provide the load current through lamp No. 2, lamp No. 1 and capacitor C5. Note that the feedback windings 5-6 and 7-8, being wound on the center leg, experience the same rate of change of flux or induced voltage per turn that is experienced by winding 13-14. Then, that by circuit design, transistor T1 will be switched off and T2 will be switched on when a reversal in the induced voltage of winding 13-14 is experienced. The induced voltage in winding 13-14 will be zero when the rate of change of flux through the center leg is zero and that occurs when the flux density in the center leg is at its maximum value and when the current through winding 13-14 reaches a peak value. Current flowing in winding 13-14 leads the voltage induced in 13-14 by 90° and reaches a peak value when the transistors T1 and T2 are switched. If the previously described desirable operation of transistor switching at minimum or zero current are to be realized, the primary windings must be rendered as non-current receptive at this time due to the operation of some energy storing means in the system. Referring to the wave shapes of FIGS. 2A, 2B and 2C, which occur for the special case of a short-circuit on the output load, the primary voltage is shown in FIG. 2A, the current supplied to the inverter in FIG. 2B, and the wave shapes of the center leg winding 13-14 and its associated capacitor C6 are shown in FIG. 2C. For the time period A-B of FIG. 2B current is flowing into the inverter and for the period B-C is flowing out of the inverter. The difference in these two values of current is simply the short circuit loss of the inverter. That is, since the load is short-circuited, it cannot absorb any power; hence, during each half cycle, energy accepted by the inverter during the beginning of the half cycle will be returned to the source during the end of the half cycle less any system loss.

Referring to FIG. 2C, for the time period A-B, current is flowing out of winding 13-14 and for the period
B-C current is actually flowing in the opposite direction or into winding 13-14. By transformer action, the current into winding 13-14 makes the induced voltage in the primary winding 1-2 go positive, with respect to 2 transferring this energy back into the source.

Previously the function of C2 was described. It is the type of circuit operation which requires C2 so that the current flowing out of the inverter will experience a reuctive source. Similar operation is repeated in the following half-cycle, except with the complimentary portions of the circuit. The reason for studying the special case of the shorted output condition now becomes clear. We have shown that this system arrangement makes possible energy storage during the first portion of each half cycle which can then be either returned to the source if the load is non-receptive or used to satisfy load and system loss requirements during normal operation (output not shorted, hence, receptive load) during the latter or switching portion of the cycle, thus rendering the current to be switched to a low or zero or negative value.

With reference to the schematic circuit of FIG. 1, the wave shapes shown in FIGS. 3A, 3B, and 3C illustrate the operating condition where the inverter ballast is working into the two fluorescent lamps as shown. The primary voltage wave form is shown in FIG. 3A. It looks much like the case where the inverter was operating into a short circuit. Notice, however, that the input current into the inverter shown in FIG. 3B changes from the large value negative of 3A to very near zero at the time that the inverter switches. This is desirable near zero current switching that makes the high frequency and efficiency operation possible. To further develop a physical picture of this operating phenomena, refer to FIG. 3C which shows the voltage induced in winding 13-14, the voltage experienced by capacitor C6 and the current through the combination of winding 13-14 and C6. Again we see that the current is leading the voltage of winding 13-14 and in that portion of the cycle just prior to switching this current reverse polarity, and in effect is flowing into winding terminal 13 of schematic FIG. 1. Unlike the short circuit operation previously described and demonstrated in FIG. 2A, 2B and 2C, a load voltage is actually impressed on winding 11-12. The instantaneous polarity of the 11-12 winding and 13-14 winding as shown in FIG. 1A is such that when current is flowing into the dotted winding terminal 13 it is also flowing into the dotted winding terminal 11, thereby reflecting by transformer action an increase in the induced voltage of primary 1-2 in such a manner that it becomes less receptive for current from the source thereby causing the input current to reduce toward zero. Compare the input current wave shapes shown in FIGS. 2B and 3B. Remember that the input current wave shape of FIG. 2B was for the case when the output was shorted, thereby no power was transmitted to the load, hence all input power not consumed in inverter losses had been transformed back to the source during the latter portion of each cycle. For the wave shape of FIG. 3B on the other hand, when the load now constitutes 80 watts of fluorescent lamp, now that no current is being transformed back to the source. One should intuitively deduce, then, that for every design the ideal of zero current switching will occur at a given output load and for all load less than this value, current will be transformed back to the source and conversely for all loads greater than this value the actual switching will occur at a positive value of current. This, in fact, is the demonstrated characteristic of the inverter circuitry.

FIG. 6 shows an actual curve that corresponds to FIG. 2C, and FIG. 7 shows an actual curve for FIGS. 2A and 2B with the voltage wave forms V13-14 of FIG. 2B all superimposed. The curve of FIG. 4 corresponds to FIG. 3C, and the curve of FIG. 5 corresponds to FIGS. 3A, 3B and the voltage wave form V13-14 of FIG. 3C all super-imposed. The difference in these curves should be noted: Where FIGS. 2B and 3B show the input current for the entire cycle, the curves were taken from actual wave shapes and were taken with the input current of only a half current, however, that current simply repeats itself in the following half cycle.

A schematic diagram of another embodiment of the invention combined with unique switching arrangements and dual function battery chargers is shown in FIG. 9A. A storage battery is used to power an inverter circuit used in a portable lighting means. FIG. 9A shows transformer X1 with rectifying diodes RD1 and RD2 with suitable switching means so that the storage battery can be charged when S1 is connected to S2. By alternately connecting a 12 volt DC source between terminals marked 7 and 2, and disconnecting the AC supply to transformer X1; the battery can be charged through an 8 ohm ballast resistor, and the previously mentioned switch arrangement. If desired, an AC supply external battery can be used rather than consuming energy from the 8 volt internal battery made possible by the following switching arrangements: S1 may be connected to S2, S2 may be connected to S3, and the appropriate either AC supply or external battery connection may be made. Capacitor C3' corresponds to capacitor C6 of FIG. 1 and can be paralleled by capacitor C4' through switching arrangement S8 to S9. With S8 connected to S9 the inverter ballast will deliver increased power to the fluorescent tube. Therefore, this arrangement provides for a dim or bright operation of the fluorescent lantern making possible two light levels and also longer portable lighting for the dim position. While the arrangement of FIG. 1 uses the rapid start lamp wherein the filament windings are continuously energized, for battery power conservation reasons the electric lantern uses only a momentary pre-heat of the fluorescent tube filament. This is accomplished by the connection of points S6 and S7 and points S4 and S5, therefore the fluorescent lighting system schematic depicted in FIG. 9A requires a multitude of switching function combined with both DC and AC charging means to effect an efficient portable lighting means capable of either external DC operation, external AC operation, DC voltage source re-charging, AC voltage source re-charging, dim operation, bright operation, and lamp pre-heat capability. By suitable printed circuit structuring combined with a rotary index switch all of the aforesaid switching functions are performed directly on the printed circuit board, therefore allowing an economical solution of the problem. The peculiar combination of the inverter ballast, the internal battery source, the AC charging means, the DC charging means, and the integral switching means constitute a novel solution to this problem.

In FIG. 10, a block diagram shows how the components of the circuit cooperate. The source is indicated as a battery which is electrically connected through the transistors T1 and T2 which are referred to as electric
valves. These valves are electrically connected to the first excitation means, referred to as winding 1-2. The winding 1-2 is magnetically connected through the magnetic core H' to the magnetic load means referred to as windings 11-12, A-A, B-B and C-C.

The electric load means which is lamps L1 and L2 in FIG. 1, and lamp FL in FIG. 9A, are electrically connected to the resonant storage capacitor C2 in the embodiment of FIG. 1 and is capacitors C3' and C4' in the embodiment of FIG. 9A.

The resonant energy storage capacitor is electrically connected to the second excitation means which is the winding 13-14, as shown. The second excitation means is magnetically connected through the air gap G to the magnetic load means, winding 11-12. The feedback means is made up of winding 5-6 and is electrically connected to the transistors T1 and T2 and magnetically connected through the magnetic member H to the winding 13-14.

It will be noted in FIG. 8 that the windings 1-2 and 3-4 are wound in the same direction around the leg P. The windings 5-6, 7-8, and 13-14 are wound in the same direction around the central leg C of the core H. The windings A-A, B-B, C-C and 11-12 are wound in the same direction around the leg S. The air gap indicated at G is of a critical magnitude and for purposes of this application, a proper gap has been found to be approximately 0.020 inches.

The magnetic core H has the bar B which closes the outer legs P, S and forms a magnetic circuit through the bar B and through the legs. Central leg C is integral with the core H and has the air gap G between the central leg C and the bar B.

In the embodiment of the invention shown in FIG. 9B, the gap G' and the E-frame H' is generally similar to the corresponding numbers in FIG. 8. The windings have corresponding numbers as shown on both the magnetic member and in the circuit.

The switches S2 and S3 in FIG. 9A are for the purpose of connecting the battery to the lighting circuit. The switch S1 is for the purpose of connecting the AC supply to the tap 51 to supply a suitable power line through the terminals 1-3. The battery K is indicated as an automobile battery or other auxiliary source of battery and it may be used instead of the internal battery J in FIG. 45. 9A. Thus there may be three alternate sources of power for the embodiment shown in FIGS. 9A-9B; namely, the internal battery J, the external battery K, or the AC source X1.

The tube L-1' is started by closing switches 6-7 and 8-9 and switch 2-3 with the internal battery J connected. This will connect a voltage through the heaters of tube L-1' and heat them. When the switches 6-7 and 4-5 are opened, the power will flow through from the battery J to the tube in the manner described above.

The following table shows the several parts of the block diagram FIG. 10:

<table>
<thead>
<tr>
<th>BLOCKS OF DIAGRAM</th>
<th>FIG. 1 &amp; 8</th>
<th>FIG. 9A &amp; 9B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical load means</td>
<td>L1-L2</td>
<td>L1-L2</td>
</tr>
<tr>
<td>Magnetic load</td>
<td>Windings 11-12, A-A, B-B, C-C</td>
<td>11'-12'</td>
</tr>
<tr>
<td>First excitation means</td>
<td>Winding 1-2</td>
<td>Winding 1'-2'</td>
</tr>
<tr>
<td>Second excitation means</td>
<td>Winding 13-14</td>
<td>Winding 13'-14'</td>
</tr>
<tr>
<td>Feedback means</td>
<td>Winding 5-6</td>
<td>Winding 5'-6'</td>
</tr>
<tr>
<td>Electric valve</td>
<td>T1, T2</td>
<td>T1', T2'</td>
</tr>
<tr>
<td>Resonant energy storage capacitor</td>
<td>C6</td>
<td>C3', C4'</td>
</tr>
<tr>
<td>Source of power</td>
<td>Battery J</td>
<td>Battery J</td>
</tr>
</tbody>
</table>

FIG. 11 shows a printed circuit board with the circuit according to the invention built on it, together with an integral switch. The board 39 supports the circuit components; for example, transformer, transistors, rectifiers, and capacitor, and the other electronic components of the circuit. The end of the board remote from the switch body 40 may have the terminals best shown in FIG. 11. The switch body or disk 40 has a boss 41 which is received in the hole 42 in the board and the switch disk has the wiper brushes 31, 32 and 33 which are in the form of leaf springs having wiper contacts on the ends which connect between the arcuate contacts that surround the opening 42 and are connected to the various conductors on the bottom of the board 39. A handle 50 is connected to the switch to move the switch to its normal positions.

The outer periphery of the body disk 40 has notches 44 which receive the curved ends of springs 45 and 46. The springs 45 and 46 stop the disk at any one of several selected positions so that the switch brushes 31, 32 and 33 engage the proper conductors 47 thereby forming the connections at S1, S2, S3, S4, S5, S6, S7, S8, and S9. When the members S1 and S2 on handle 50 engage in the slots 38, 43, and 48, the switch disk can be rotated to the proper position to close circuits at the respective positions S1-S9; when the switch handle is in the desired position, the ends 55 of springs 45 and 46 are resiliently received in slots 57 in board 39.

The switch may be moved to the following positions to carry out the several functions of the circuit: (1) charge, (2) off, (3) start, (4) dim, (5) bright. The position of the contacts on the switch when the switch is moved to positions 1 through 5, is as outlined below:

1. “Charge” position; S1 to S2 & S2 to S3 are closed, S4 through S9 are open.
2. “Off” position; S1 through S9 are all open.
3. “Start” position; S2 to S3, S4 to S5 & S6 to S7 are closed; S1, S8 and S9 are open.
4. “Dim” position; move S1 to S2 and S2 to S3 are closed, S4 through S9 are open.
5. “Bright” position; S1 to S2, S2 to S3 & S8 to S9 are closed; S4 through S7 are open.

The above contact positions of the switches are accomplished by simply rotating the switch disk 40 through the positions numbered 1 to 5 above.

I claim:

1. An inverter circuit comprising magnetic load means, electrical load means, first excitation means, second excitation means, feedback means, electrical valve means, resonant energy storage capacitor means, a source of direct current voltage, first electrical means connecting said source of direct current voltage through said electrical valve means to said first excitation means, a magnetic member having first magnetic means, second magnetic means, and third magnetic means, said first magnetic means connecting said first excitation means to said magnetic load means, second electrical means connecting said magnetic load means to said electrical load means,
said second magnetic coupling means having an air gap coupling said first excitation means to said second excitation means,
third electrical means connecting said second excitation means to said resonant energy storage capacitor means,
fourth electrical means connecting said resonant energy storage capacitor to said magnetic load means,
fifth electrical means connecting said feedback means to said electrical load means,
said third magnetic means connecting said second excitation means to said magnetic load means,
said feedback means being so coupled to said energy storage means that said resonant frequency will be maintained for all values of said electrical load means.

2. The circuit recited in claim 1 wherein said first, second, third, and said fourth magnetic means comprise a transformer having a first leg, a second leg, and a third leg,
magnetic means connecting said second leg and said third leg together,
said first leg having a first end and a second end, said first end of said first leg being connected to said magnetic means,
said second end of said first leg being separated from said magnetic means by an air gap,
said second excitation means and said feedback means comprising windings wound on said first leg, said first excitation means and said load means comprising windings wound on said second leg and said third leg respectively.

3. The circuit recited in claim 1 wherein said first leg is disposed between said second leg and said third leg.

4. The circuit recited in claim 1 wherein said magnetic load means includes a single winding around said third leg.

5. An inverter comprising,
a source of direct current voltage,
a transformer,
said transformer having a plurality of windings comprising a magnetic load winding, a first excitation winding, a second excitation winding, and a feedback winding,
an electric valve having a control element,
said source of direct current voltage being connected to said first excitation winding through said valve,
said feedback winding being connected to said control element on said valve for controlling said valve whereby the energy to said first excitation winding is controlled,
said transformer having a continuous magnetic path, a first leg having a first end and a second end, said first end of said first leg being connected to said continuous magnetic path and an air gap between the said second end of said first leg and said magnetic path,
said first excitation winding and said magnetic load winding being wound around said continuous magnetic path,
said second excitation winding and said feedback winding being wound on said first leg.

6. An inverter comprising

an electrical load,
a source of direct current,
a transformer having a closed magnetic circuit and a leg connected to said magnetic circuit at one end, and its other end spaced from said closed magnetic circuit forming an air gap between the second end of said leg and said closed magnetic circuit,
means for connecting said electrical load to said transformer,
valve means for connecting said source of direct current to said transformer,
feedback means comprising said leg for controlling the flow of said current through said valve,
said feedback means adapted to switch said valve means when current through said valve means reaches substantially a minimum value, and resonant means connected to said transformer for controlling the output of said transformer to said electrical load.

7. An inverter comprising
an electrical load,
a source of direct current,
a transformer having a closed magnetic circuit and a leg connected to said magnetic circuit at one end, and its other end spaced from said closed magnetic circuit forming an air gap between the second end of said leg and said closed magnetic circuit,
means for connecting said electrical load to said transformer,
valve means for connecting said source of direct current to said transformer,
feedback means comprising said leg for controlling the flow of said current through said valve,
said feedback means adapted to switch said valve means when current through said valve means reaches substantially a minimum value, and resonant means connected to said transformer for controlling the output of said transformer to said electrical load,
said transformer having a first, a second, and a third leg comprising a continuous magnetic path, and a primary winding on said continuous path, said primary winding being connected to said electrical valve,
said means connecting said electrical load to said transformer comprising a winding on said third leg.

8. The inverter recited in claim 7 wherein said magnetic load comprises a plurality of load winding on said magnetic circuit.

9. The inverter recited in claim 8 wherein said electrical load comprises fluorescent lamps having heaters, and said load windings are connected in series with said heaters.

10. The inverter recited in claim 5 wherein a second valve is provided in said circuit, and a second feedback means controls said second valve, controlling the flow of current through said lamps.

11. The inverter recited in claim 5 wherein a second valve is provided in said circuit, and a second transformer winding connected in series with said valve for controlling current through said circuit on half-cycles other than those controlled by said first mentioned valve means.

12. In combination, a switch and an electrical circuit comprising
a chassis having a flat surface having a printed circuit board,
a switch body having a relatively flat surface,
a plurality of conductor elements,
said conductor elements being supported on a first side of said board,
a plurality of circuit members supported on said board on a second side of said board,
means movably supporting said switch body on said first side of said board,
brushes on the side of said switch body adjacent said chassis and adapted to engage said circuit members to selectively connect predetermined members together at predetermined positions of said switch body whereby predetermined circuits are established among said circuit members when said switch body is moved to a predetermined position,
said means movably supporting said switch body on said chassis comprises a hole formed in said chassis,
a boss on said switch body extending into said hole, at least one elongated wire spring means having a first end and a second end fixed to said chassis at said first end and selectively engaging notches in said switch body at its said second end whereby said body is stopped at said predetermined positions relative to said conductor members.
13. The combination recited in claim 12 wherein said circuit members are arranged in concentric patterns around said hole in said chassis.
14. An inverter circuit for lamps having filaments and requiring starting voltage and running voltage comprising,
a magnetic means comprising a magnetic circuit having a plurality of magnetic paths therein, one of said paths including an air gap,
feedback winding means on said magnetic path having said air gap,
said magnetic means having a first load winding means and a second load winding means,
a lamp having a filament,
said second load winding means being connected to said filaments for supplying heating voltage thereto,
said first load winding means being connected to said lamp to supply starting and running voltage thereto,
said running voltage being lower than said starting voltage,
said circuit having means adapted to control said voltages so that said filament voltage is reduced when said load winding is supplying running voltage,
said filament voltage is reduced by the ratio of said starting voltage to said running voltage.
15. An inverter circuit for lamps having filaments and requiring starting voltage and running voltage comprising,
a magnetic means,
said magnetic means having a first magnetic load winding means and a second magnetic load winding means,
a lamp having a filament,
said second magnetic load winding means being connected to said filaments for supplying heating voltage thereto,
said first magnetic load winding means being connected to said lamp to supply starting and running voltage thereto,
movable member is moved to said charge position.
22. The combination recited in claim 20 wherein said movable member is movable to an on position and an off position, said movable member being adapted to connect predetermined of said conductor members together in said on position and connecting said source of power to said inverter circuit.

23. The combination recited in claim 20 wherein said movable member is adapted to connect predetermined of said conductors together to short-out said magnetic load means and to connect heaters on said lamp in series with each other when said switch is in said start position.