The foregoing and other objects, advantages and features of the invention will be apparent from the following description taken in conjunction with the attached drawings which illustrate an exemplary embodiment of the invention.

In the drawing:

FIG. 1 is a schematic wiring diagram of an apparatus for starting and operating a compact arc lamp in accordance with the present invention; and

FIG. 2 is a diagrammatic illustration of the core and coil assembly of the transformer of FIG. 1.

Referring to the drawing and more particularly to FIG. 1, input terminals 10A and 12A adapted to be connected to an A.C. power source are connected by lines 10 and 12 to the primary 14 of a high leakage reactance transformer 16. A thermal disconnect 18 is connected in series with the line 10 to prevent over-heating of the apparatus in the event of continuous failure of any part of the circuit. The primary 14 is wound on a core 20 having a plurality of air gaps or magnetic shunts or the like 22 and 24. A coil or winding 26 is wound on the core 20 between the shunts 22 and 24 and is shunted by two parallel connected capacitors 28 and 30 to provide a ferro-resonant circuit generally indicated by the reference numeral 32. An output winding 34 is wound on the portion of the core 20 beneath the shunt 24 and is connected at points 36 and 38 with output lines 40 and 42 leading to a lamp load 43. A lead 44 connects one end 56 of winding 26 with a tap 46 on winding 34. Connected with a tap 48 on the winding 26 is a conductor 50 leading to a pulse switch starting circuit indicated generally by the dashed lines 52. The other side of the pulse switch starting circuit 52 is connected by a conductor 54 to the point 38 of output winding 34. The pulse switch circuit 52 may be of any desired type adapted to furnish pulses to winding 34 but is illustrated in FIG. 1 as comprising a SCR switching circuit to be hereinafter described.

The operation of the apparatus as thus far described is as follows. Assuming a lamp-out condition and an A.C. voltage applied to the terminals 10A and 12A and leads 10 and 12, the pulse switch starting circuit supplies relatively high voltage pulses taken across the portion 54 of resonant winding 26 between the points 48 and 56 to the portion 58 of output winding 34 between the points 38 and 46 via conductors 50, 54 and 44. The portions 58 and 60 of the output winding 34 then act as an autotransformer to step up the voltage pulses and apply them to the lamp load through leads 40 and 42. The relative turn ratio of the several windings is such that the voltage pulses supplied to the lamp load are sufficient to cause ignition of the lamp or lamps, and the starting switch means is so synchronized with the input sine wave as to provide a pulse to the winding portion 58 once every half cycle at or near the peaks of the input sine wave. After ignition of lamp 43, the windings 26 and 34 on core 20 serve to limit the current to the lamp load and provide a constant output voltage for the load in the manner of known high leakage reactance constant voltage transformers. The ferro-resonant circuit 32 provides a squarish type wave through output winding 34 which provides for improved lamp operation characteristics.
As shown in FIG. 2, the transformer 16 may comprise a shell type core 62 having a center leg 64 on which the windings 14, 26 and 34 are mounted. The windings may be enclosed within a layer or coating of insulating mate-
rial 66, and winding 26 has a tap 46 while winding 34 has a tap 48 for the connections shown in FIG. 1. Air gaps or magnetic shunts 22 and 24 are positioned be-
tween the coils 14 and 26 and the coils 26 and 34 respectively.

Further to provide for safety in the operation of the inverter circuit, a timing circuit is provided for the lamp starter. Referring again to FIG. 1, a relay timing circuit 70 is connected by leads 72 and 74 to the input lines 10 and 12. The timing circuit 70 comprises a capacitor 76, a rectifier 78 and a resistor 80 connected in series across the leads 72 and 74, and a relay operating coil 82. Relay circuit 90 is connected to a bus 102 and capacitor 76 is charged up at a predetermined rate depend-
ing upon the charging RC time constant of capacitor 76 and resistor 80. When capacitor 76 has been charged to a sufficiently high voltage, after say 5 seconds, for example, the relay coil 82 operates to effect disconnection of the starter circuit through a contactor 84 connected in the lead 54 of the starter circuit. The first 5 seconds after energizing the ballast are sufficient to start the lamp. Capacitor 76 will stay charged all the time while the ballast is energized and thus keeps relay contacts 84 open after this first 5 seconds. This will eliminate unnecessary pulsing after lamp is started or discontinued to operate.

As above set forth, the pulse switch starting circuit 52 may be of any desired type but is shown in FIG. 1 as comprising a SCR switching circuit. Referring now to the portion of FIG. 1 contained within the dashed lines 52, it will be noted that the conductor 50 leading from point 48 on the winding 26 of ferro-resonant circuit 32 is con-
ected to a pulse-forming circuit or network 90 comprising a capacitor 92 connected in series with a capacitor 94 and resistor 96 arranged in parallel. The other side of the pulse-forming circuit 90 is connected to bus 102, forming one side of the SCR pulse switch circuit. A bus 102 providing a continuation of conductor 54 forms the other side of the SCR circuit.

Connected in series between the buses 100 and 102 are a resistor 104, a capacitor 106, and a resistor 108. Also connected between or across the buses 100 and 102 are a pulse switch 110 and 112 so oriented as to provide full wave switching (one pulse each half cycle of the applied input A.C. sine wave). The gate of SCR 110 is connected at point 114 to a conductor 116 con-
ected at one end to the bus 102 through a resistor 118. The other end of conductor 116 connects to a switching diode 120 having its other side connected between the resistor 104 and capacitor 106 at point 122. The gate of SCR 112 is connected at point 124 to a conductor 126 connected at one end to the bus 100 through a resistor 128. The other end of conductor 126 connects through a capacitor 130 to a point 132 between the capacitor 106 and resistor 108. While the circuit thus described provides for full wave switching, it will be apparent that additional circuitry is needed for half wave switching, i.e., one pulse each full cycle of input voltage.

The operation of the above described SCR pulse switching circuits is as follows. The components between bus lines 100 and 102 form an A.C. electronic switch, prin-
ciples of which are well known to those familiar with the art. The triggering circuit of the switch is so adjusted that for proper operation approximately in middle of each half cycle one of the SCR's (110 or 112) is turned on when proper voltage is applied to leads 50 and 54, which in turn happens when an A.C. source is connected to the transformer input lines 10 and 12 thus energizing transformer 16.

As soon as one of the SCR's is turned on, the follow-

ing circuit path is closed: winding 54—capacitor 92—
capacitor 94 parallel with resistor 96—SCR (110 or 112) —closed contacts 84 and winding 58. This is an oscillatory circuit in which winding 54 is the dominating volt-
age source. Initially a high current pulse flows through this circuit. The current then starts from zero, reaches a certain maximum and reverses, going again through zero level. At this moment, the SCR in action is turned off. As a result a high voltage pulse is created in winding 58, stepped up in winding 60 and applied to the lamp load 43. This process repeats once every half cycle until ca-
pacitor 76 is charged to a certain level causing relay coil 82 to open contacts 84, thus interrupting operation of the starter 52. During this time interval lamp 43 is ignited and no pulse is required for further lamp operation.

Relay contacts 84 will return to closed condition as soon as the A.C. source is removed from the ballast input lines 10 and 12 thus setting the ballast for a new start of the lamp.

While an exemplary embodiment of the invention has been shown and described, it will be evident that modifica-
tions, changes and alterations may be made therein without departing from the spirit of the invention, and it is intended to be limited only by the scope of the ap-
ended claims.

What is claimed is:
1. A circuit for a starting and operation of lamps of the compact metallic vapor type, the combination which includes means for connecting in series a source of A.C. power; a high leakage reactance transformer hav-
ing an input winding, a ferro-resonant winding, and an output winding; means for connecting said input winding to said input means; capacitor means connected across said ferro-resonant winding to provide a resonant circuit; conductor means for connecting a portion of said ferro-resonant winding with a pulse switch starting means; means for connecting said pulse switch starting means to one end of said output winding; conductor means for connecting an intermediate point of said output winding to a terminal point of said ferro-resonant winding, and conductor means for connecting said output winding to a lamp load.
2. A circuit as defined in claim 1 in which said wind-
ings are mounted on a core having magnetic shunts be-
tween said input and resonant circuit windings and said resonant circuit and output windings, respectively.
3. A circuit as defined in claim 9 in which said pulse switch starting means includes a SCR switching means connected across a portion of said resonant winding and a portion of said output winding.
4. A circuit as defined in claim 3 in which means in-
cluding a voltage taken from said resonant winding pro-
vides gating pulses for said SCR switching means.
5. A circuit as defined in claim 9 in which when delay switching means connected to said input power means provides for discontinuing operation of said pulse switch starting means after a predetermined period of time.
6. A circuit as defined in claim 5 in which said time delay switching means includes a capacitor—resistor charging circuit and a switch operating means connected across said capacitor.
7. A circuit as defined in claim 3 in which a pulse forming network is connected between said resonant wind-
ing and said SCR switching means.
8. A circuit as defined in claim 7 in which said pulse forming network includes a first capacitor connected in series with a second capacitor and resistor connected in parallel.
9. In a circuit for the starting and operation of lamps of the compact metallic vapor type, the combination com-
prising core means having an input winding, a resonant winding, and an output winding; means for connecting said input winding to a source of A.C. power; means for
connecting said output winding to a load; capacitance means connected across said resonant winding to provide a resonant circuit; a pulse switch starting means; and circuit means for connecting a portion of said resonant winding to a portion of said output winding through said pulse switch starting means thereby to provide said output winding with high voltage ignition pulses by autotransformer action.

10. A circuit as defined in claim 9 wherein said input winding, said resonant winding, and said output winding are loosely coupled on said core means.

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