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(54) **Fluorescent tube converter and protection circuit**

(57) To permit direct adaptation of a pre-existing light fittings supporting T8 or T12 technologies into a T5 compliant arrangement, a current limiting and control circuit is inserted across electrical terminals (502, 515) in a T5 end-cap adaptor (10). Current limiting devices (PTC1, PTC2), such as a positive temperature coefficient (PTC) thermistor, restrict current flow under conditions where current passed through the electrical terminals exceeds

a maximum input current of an electronic ballast (510), such as a T5 fluorescent tube (406). To further accommodate physical sizing of a molded T5 end-cap adaptor (10) and to produce an increase in creepage distance, electrical contact pins (22) extending rearwardly from end-cap adaptor (10) are separated from a peripheral edge of the molded end-cap by an isolating channel (26) formed generally about outermost edges of each electrical contact pin (22).

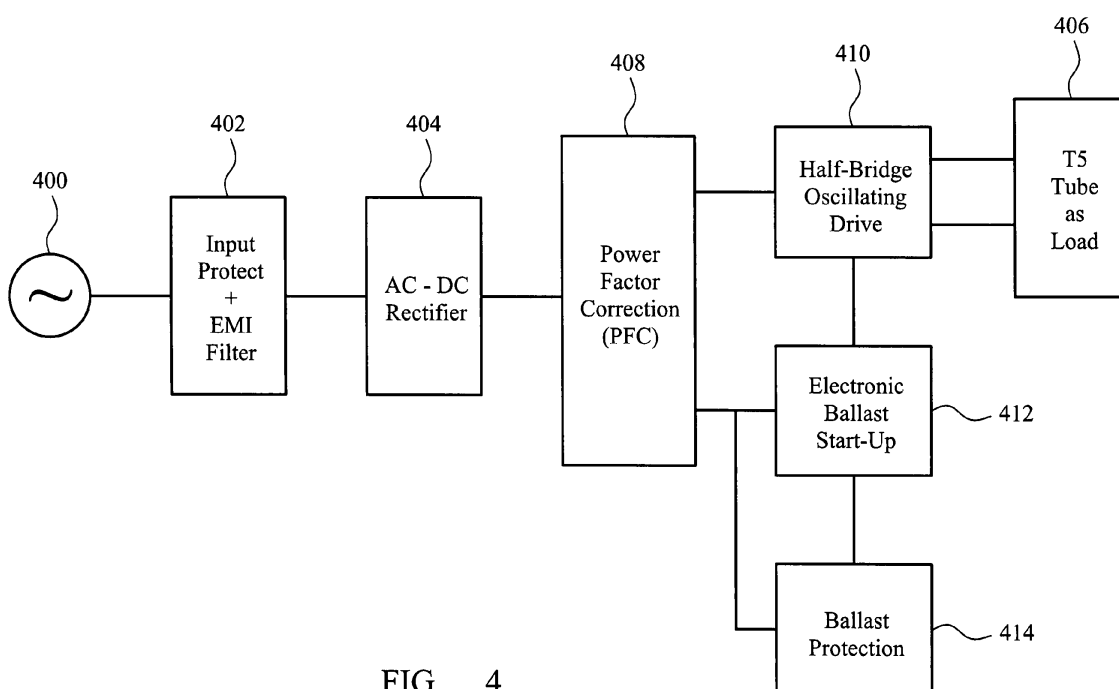


FIG. 4

Description

Field of the Invention

[0001] This invention relates, in general, to fluorescent light fittings and is particularly, but not exclusively, applicable to the conversion of existing T8 (and T12) fittings to accommodate T5 tubes having greater energy efficiencies.

Summary of the Prior Art

[0002] Standard fluorescent light fittings (often referred to as "luminaires") are used extensively in Europe and throughout the world and have conventionally accepted either "T8" or "T12" tubes. Indeed, there has been massive investment in conventional electromagnetically ballasted luminaires over the past thirty (and more) years. The expense and disruption of ditching that existing investment and installing a whole new generation of energy-efficient luminaires is the greatest single barrier to achieving the cost and environmental advantages now sought.

[0003] Particularly, more energy efficient fluorescent tubes are now available; these new tubes are known as "T5" tubes. Indeed, comparison of T5 technology against the older electromagnetic ballast technology in T8 and T12 fittings suggests potential energy savings of up to 50%. In addition, T5 tubes offer improved lighting effects arising from light output from a T5 fittings being about 85% that of natural sunlight, with this effect produced at lower output wattages. Furthermore, T5 tubes are more environmentally friendly through lower mercury content and a reduced CO₂ footprint. From maintenance and replacement perspectives, T5 tubes can last for about 20,000 hours while their built-in ballast can last for 50,000 hours, with this life expectancy surpassing older T8/T12 technologies.

[0004] By way of further explanation and contrast, the magnetic ballast in old T8 and T12 adds a large power loss to the already relatively high wattage required by those tubes. The older generation tubes are often also susceptible to undesirable light flicker where light output intensity varies at about the ac input frequency.

[0005] The entire replacement of a pre-existing T8 fitting is one option, although this is wasteful of material.

[0006] Retro-fit adaptors or conversion kits have also been proposed because T5 fluorescent tubes are not directly exchangeable into existing light fittings since T5 tubes are shorter in overall length, smaller in diameter and require the use of a high frequency (ballast) electronic power supply.

[0007] Conversion kits from T8/T12 to T5 technology generally fall into two categories:

1. Tube end kits which have their own starter and two end-pieces that fit over the end of the T5 tube so that it slots into existing T8/T12 fittings; and

2. Baton type fittings that contain a one piece kit that slots into existing T8/T12 light fittings, with the new T5 tube inserted between the ends of the one piece adapter.

[0008] One known converter incorporates an electric ballast with a pre-heat function on it that works in combination with the existing magnetic ballast.

[0009] Save-It-Easy[®] adaptors are known retrofit conversion kits that plug into existing switch start and quick-start luminaires, transforming them electronically from conventional fittings to high frequency ballast fittings of correct type and size to accept high efficiency T5 and T8 lamps.

[0010] Existing adaptors, however, require the installer to remember to remove the existing starter from the T8/T12 fitting. In the event of failing to remove the starter, a risk of fire or electric shock can arise within the now modified hybrid circuit containing the T5 adaptor.

[0011] GB 2,454,400 relates to a push-fit end-cap mains power connector for use on T8 to T5 fluorescent tube retro-fit adaptors. A 230V socket/plug in an end-cap fitting allows mains power to be provided to the retro-fit T5 light unit and allows the device to be operated by entirely by-passing existing and previously used electrical or electronic control gear or components inside the existing T8/T12 fitting. The incoming mains power socket/plug allows for a 2-wire (live and neutral) connection.

Summary of the Invention

[0012] According to a first aspect of the invention there is provided a fluorescent tube T5 converter circuit comprising: at least one current limiting protection device connectable in series with a pre-existing electromagnetic ballast for an electronic ballast, the current limiting protection device connectable to a first input of a fluorescent tube and coupled directly across contact terminals in an end-cap converter.

[0013] In a preferred embodiment, the circuit is configured or arranged such that: an open circuit condition in the current limiting device (such as a positive temperature coefficient (PTC) thermistor) creates a voltage spike from a back EMF associated with the electromagnetic ballast, the voltage spike applied to inputs of the electronic ballast producing a current spike through the fluorescent tube; wherein the current limiting device functions to detect the current spike and to shut down operation of the electronic ballast, thereby protecting the fluorescent tube and the electronic ballast; and wherein operation of the electronic ballast only resumes after resetting of the current limiting device, resetting preferably occurring automatically.

[0014] In a second aspect of the invention there is provided a fluorescent tube T5 converter including opposing end-caps having electrical terminals for mounting and supplying power to a fluorescent tube located therein, the converter comprising: a half-bridge oscillating driver

operationally responsive to a ballast protection circuit operable to detect, in use, over-voltage or over-current conditions in a fluorescent tube, the ballast protection circuit comprising at least one current limiting device arranged to restrict current flow under conditions where current passed through the electrical terminals exceeds a maximum input current of the fluorescent tube.

[0015] In a further aspect of the invention there is provided an end-cap adaptor for accommodating a fluorescent tube, the adaptor comprising: a body portion containing a pair of electrical contacts for routing power, the electrical contacts extending rearwardly and externally from an outer surface; and a pair of isolating channels formed generally about outermost edges of each electrical contact, each channel thereby separating each respective electrical contact from a peripheral edge of the outer surface of the body portion.

[0016] Advantageously, the present invention permits the adaptation of existing fluorescent light technologies, e.g. T8 luminaires, without having to undertake extensive re-wiring of those luminaires or for the installer to remember to remove existing electromagnetic ballasts and starters. In this way, the embodiments of the present invention encourages migration to more energy efficient technologies, whilst also protecting existing electrical circuits from damage arising from incorrect installation. Beneficially, the present invention readily permits an untrained individual to adapt existing T8 and T12 luminaires with a simple plug-and-go adaptor that compensates for potentially dangerous risks (associated with catastrophic tube or circuit failures) that would otherwise arise from over-current and/or over-voltage situations.

[0017] Additionally, the present invention addresses space constraints and electrical isolation requirements that arise with the use of smaller fluorescent tubes through the re-design on the end-cap. Improved electrical isolation is therefore acquired through implementation of preferred embodiments of the present invention.

Brief Description of the Drawings

[0018] Exemplary embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIGs. 1 and 2 are perspective views of a T5 end-cap adaptor according to a preferred embodiment of the present invention;

FIG. 3 is a preferred lighting control and conversion circuit used, preferably, in combination with the T5 end-cap adaptor of FIGs. 1 and 2;

FIG. 4 is a block diagram of the core circuit elements of FIG. 3;

FIG. 5 is a schematic representation of a prior art T5 fluorescent light conversion circuit from the perspective of current flow; and

FIGs. 6 and 7 together show modified current flow arising from use of the circuit configurations of FIG.

3 and FIG.4.

Detailed Description of a Preferred Embodiment

[0019] FIGs. 1 and 2 show different perspective views of T5 end-cap converter 10 that, preferably, is of modular design. In essence, the end-cap converter 10 is preferably produced as a molded plastic part and resembles a cradle 12 having a lower u-shaped base portion 14 (which, in use, fits flush against a downwardly facing surface of an existing T8 fluorescent light fitting) and a hood 16 that surrounds the end connection to a T5 fluorescent tube. Projecting rearwardly from the hood 12 is a wedge-shaped coupler 18 that is configured and arranged to engage into an existing T8 (or T12) fitting, thereby converting the existing luminaire to accept a T5 fluorescent tube.

[0020] The wedge-shaped coupler 18 includes a rear surface 20 through which are formed bores 21 that accept electrical contact pins 22 (shown in FIG. 2 only) that align into electrical connectors (not shown) of an existing T8 luminaire. Typically, as will be understood, the electrical contact pins 22 are themselves generally housed within a molded insert that engages into the hood 16 of the end-cap 10.

[0021] To meet the safety requirements of "creepage distance" under IEC60598-1, the spacing between electrical contact pins 22 and the edge 25 of the end-cap 10 that can be touched by a user must be at least 5mm. Creepage distance is actually defined as the shortest path between two conductive parts (or between a conductive part and the bounding surface of the equipment) measured along the surface of the insulation. As will be understood, adequate creepage distance protects against tracking, i.e. a process that produces a partially conducting path of localized deterioration on the surface of an insulating material as a result of the electric discharges on or close to an insulation surface. In a preferred embodiment, creepage distance is increased through the inclusion of isolating channel 26 formed generally about outermost edges of each electrical contact pin 22. In a preferred embodiment, the isolating channel 26 is substantially semi-spherical in shape, although the fullness and shape of the isolating channel 26 is open to some design freedom given the actual shape and external edge profile of the wedge-shaped coupler 18.

[0022] To further reduce the risk of electrical tracking, a preferred embodiment of the end-cap makes use of a material having a comparative or proof tracking index ("CTI" or "PTI") equal to or greater than about 600. [The CTI provides a numerical value of the voltage that will cause failure from electrical tracking under standard test conditions of IEC60598-1 Section 11]. The combination of the isolating channel 26 and the breakdown (CTI) properties of the material permit the end-cap 10 to be physically minimized and thus to facilitate the insertion of the T5 converter into existing T8 (or T12) fittings.

[0023] The general shape and dimensions of the end-

cap 10 ensure that it can fit within an existing T8 or T12 luminaire (i.e. fitting), with the hood 16 providing a degree of electrical insulation about the metal end plate of the fluorescent tube, as will be understood.

[0024] The base portion 14 typically includes a molded slide coupler 28 that permits the end-cap 10 to be positively engaged into a (typically) metal base plate (not shown) that separates two opposing end-caps by a fixed distance. The slide coupler 28 may comprise runner sections 30 at its top and bottom, which runner sections 30 operate to engage the base plate to permit formation of fixed-length luminaires. In one embodiment, the slide coupler 28 engages into a tunnel-shaped connector that, in turn, engages onto rails formed in, on or along an end region of the base plate.

[0025] The base plate may further incorporate a recess and associated cover plate, which recess is designed to accommodate preferred lighting control circuitry (shown in FIG. 3) and which is preferably inaccessible once the luminaire is fitted to a ceiling or the fluorescent tube is engaged between opposing end-caps 10. Alternatively, the lighting control circuitry may be located within the end-cap 10, such as a beneath a false floor in the u-shaped base portion 14. For example, a generally flat, snap-fit cover plate (not shown) may be arranged to engage with runners 30 to enclose and electrically isolate any electrical connections within the end cap 10. When installed, the T5 fitting therefore lies above the cover plate. The use and construction of cover plates in fluorescent fittings are well known. As such, the plastic cover engages onto the top of base portion 14 to provide insulation between the end cap of the fluorescent tube and the metal base structure which holds the electronic ballast and the fluorescent tube. For reasons of safety and compliance, the cover provides a minimum of 5mm clearance or creepage between the edge of the metal ring of the fluorescent tube and the edge of the metal base structure.

[0026] The base plate is generally configured to provide a secure, electrically isolated routing conduit for electrical wiring between the end-caps 10.

[0027] Turning to the circuit diagram of FIG. 3, a preferred lighting control and conversion circuit 100 is shown.

[0028] In overview, to simplify conversion of a T8 (or T12) luminaire to support T5 technology, the lighting control and conversion circuit 100 provides for temperature compensation for the pre-existing electromagnetic ballasts (in the T8 luminaire), thereby avoiding overheating of both the starter and ballast. The installer can therefore ignore re-wiring of the existing luminaire circuit and is further now unconcerned as to whether they remember to remove the pre-existing electromagnetic ballast. This simplifies installation and improves safety.

[0029] Contrastingly, with prior T5 converters where the installer omits to remove the starter, the current (I_{in}) passing through the T8/T10 magnetic ballast is equal to the sum of the starter current (I_{str}) and electromagnetic

ballast input current (I_{bal}). The resultant large current will not dissipate with time and eventually will result in overheating, burn-out and failure of the Magnetic Ballast (L).

[0030] Additionally, the lighting control and conversion circuit 100 of the preferred embodiment produces a modified high-frequency power supply suitable for T5 use. Particularly, the lighting control and conversion circuit 100 is configured to operate at a switching frequency of about (and preferably above) 41kHz or below 30kHz to avoid interference with remote control devices for TVs, DVD players, set-top boxes and the like having RC controller operating at around 36kHz. The increased power supply switching frequency addresses the discrepancy in power supply operating frequencies relative to existing T8 or T12 luminaires (that make use of ac line frequencies of typically either 50Hz or 60Hz). Also, the high operating frequency eliminates undesirable light flicker of experienced in existing T8 and T12 luminaires that operate at the line frequency, i.e. 50Hz or 60Hz.

[0031] Briefly referring to FIG. 4, a block diagram of the core circuit elements of FIG. 3 is shown.

[0032] An ac supply 400 is coupled through an input protection and electromagnetic interference (EMI) filter circuit 402, the output of which is then DC rectified in ac-to-dc bridge rectifier 404. In view of the non-linear nature of both the rectifier and final load 406 (i.e. the T5 fluorescent tube), a power factor correction circuit (PFC) 408 is coupled between the bridge rectifier 404 and a half-bridge oscillator driver circuit 410. The PFC circuit 408 operates to suppress current harmonics that affect power distribution, thereby increasing overall power efficiency. Typically, the PFC circuit 408 is arranged as a passive in either a low-pass or bandpass configuration. Operation of an electronic ballast start-up circuit 412 is modified by a ballast protection circuit 414, with the half-bridge oscillator driver circuit 410 and electronic ballast start-up circuit 412 therefore coupled to PFC circuit 408.

[0033] In an alternative arrangement (especially for longer tubes powered at 220V), the diode-capacitor passive PFC circuit 408 (described immediately above) may be replaced by an IC-controlled Power Factor Correction (PFC) circuit, i.e. an active PFC.

[0034] Before returning to the preferred circuit configuration of FIG. 3, reference is made to FIG. 5 that shows a schematic representation of a prior art T5 fluorescent light conversion circuit from the perspective of current flow. Further reference is made to FIGs. 6 and 7 that together show modified current flow arising from use of the circuit configurations of FIG. 3 and FIG. 4.

[0035] In FIG. 5 a first ac input 500 is coupled to a first electrical contact 502 (of a lamp fitting 501) via magnetic ballast 504. More particularly, the first electrical contact 502 is coupled to the magnetic ballast 504 through a first set of lamp holders (i.e. end-caps), with a first lamp holder 506 being located in a conventional T8 (or T12) fitting and a second lamp holder adaptor 508 fitting inside of and correspondingly engaging electrical contacts in the first lamp holder 506. The second lamp holder thereby

adapts the effective length of the lamp fitting 501 to accept at least one electronic ballast, i.e. a T5 tube 510. The first electrical contact 502 is coupled to a first terminal 511 of the T5 tube 510 and, furthermore, is also coupled to a second terminal 513 of the T5 tube 510 via a path that includes: i) a second electrical contact 515 in the first set of lamp holders; ii) a fluorescent tube starter 517; and a third electrical contact 519 in a second set of lamp holders at a distal end of the lamp fitting 501. A second ac input 521 is coupled to a fourth electrical contact 523 of the T5 fitting, the fourth electrical contact 523 located proximate to the third electrical contact 519 and coupled to second terminal 513 of the T5 tube 510. The fourth electrical contact 523 is thus also within a circuit that includes the third electrical contact 519.

[0036] In the arrangement, a T5 lamp holder 508 is thus fitted inside hood 16, with the wedge shaped coupler 25 (of the end cap 10) including contact pins 22 that engage into existing electrical contacts on the T8/T12 lamp holder that is subject to conversion..

[0037] In the configuration of FIG. 5 (where the fluorescent tube starter 517 of the T8/T12 tube has not been removed), the current (I_{in}) passing through the magnetic ballast 504 is equal to the sum of the current (I_{Strt}) through the starter 517 and input current (I_{bal}) to the electronic ballast 510. These summed currents will circulate inside the T8 lamp fitting and will eventually over-heat and burn-out the magnetic ballast 504.

[0038] Turning now to FIG. 6 and 7, the same basic lamp fitting configuration is shown, although (according to preferred embodiments of the present invention) one or more current limiting protective devices ("PTC1", "PTC2") are connected between the pins of the end-cap 508 (in the first set of lamp holders) to prevent the electromagnetic ballast 504 from over-temperature. The current limiting devices can take the form of a common fuse, but is preferably realized by positive temperature coefficient (PTC) thermistors, polymeric positive temperature coefficient devices (PPTC) or resettable fuses. Now, according to the modified circuit of FIG. 6 and 7, when the current passed through the electrical first 502 and second electrical contacts 502, 515 exceeds the maximum input current of the electronic ballast 510, the current limiting devices are triggered.

[0039] More specifically, with connection of the current limiting protective devices PTC1, PTC2 across the terminals, the current passing through the electromagnetic ballast 504 is the sum of starter current (I_{strt}) and the electronic ballast input current (I_{bal}), with this summed current appearing across the protective device PTC1, i.e. $I_{in} = I_{PTC}$. This high current will change the conduction state of current limiting protective device from a low resistive device to a high resistive device, thereby limiting and reducing the current passing through the electromagnetic ballast 504 and thus protect the electromagnetic ballast 504 from overheating. In the event that the starter 517 is removed, the current limiting protective device PTC(x) reverts to standard low resistance operation.

[0040] Re-wiring of an existing electromagnetically-ballasted fluorescent fitting is therefore avoided. The electromagnetic-ballast can be left in place without violating any safety requirement, but its presence will consume (i.e. waste) about 1 to 2 watts of electrical power. However the starter has to be removed.

[0041] Returning to the preferred circuit configuration of FIG. 3, the skilled addressee will understand that the input protection and EMI filter is coupled across the ac input 400 from an ac power source. A first ac line terminal 302 is coupled through a fuse 303 to a winding of a first iron-cored inductor 304. A second ac line input 306 is coupled to a winding of a second iron-cored inductor 308, with the first and second windings producing a first transformer 310. A parallel capacitor C_1 and resistor chain R_1 , R_2 is coupled from a circuit node between the fuse 303 and the second ac line input 306. Transformer 310 is made up of winding 304 and winding 308 formed as a common mode EMI filter.

[0042] The first inductor 304 is coupled in series to a third iron-cored inductor 312 of a second transformer 314. A fourth iron-cored inductor 316 is coupled in series to the second inductor 308. The third and fourth inductors realize the second transformer. A varistor 317 (typically a metal oxide varistor) is coupled across the inputs of the second transformer 314, with a parallel arrangement of capacitors C_2 , C_3 coupled across outputs of the second transformer 314. The varistor 317 protects against excessive transient voltages such that, when triggered, it shunts current created by the high voltage away from sensitive components within the circuit of FIG. 3, as will be understood. Particularly, when a large voltage is applied to the varistor 317 its diode junction breaks and a large current flows; this produces a highly nonlinear current-voltage characteristic in which the varistor has a high resistance at low voltages and a low resistance at high voltages.

[0043] Transformer 314 is made up of winding 312 and winding 316 formed as a differential mode EMI filter.

[0044] The bridge rectifier 404 is of conventional design and comprises a standard diode network and is coupled across the parallel arrangement of capacitors C_2 , C_3 . The PFC circuit 408 that reduces harmonics and optimizes actual power utilization is similarly of a conventional configuration of diodes, capacitors and polarized electrolytic capacitors, with the PFC circuit 408 coupled across the outputs of the bridge rectifier 404. A first output 330 from the PFC 408 is coupled to a first side of T5 tube 406.

[0045] A capacitor C_2 is located across the line outputs of the PFC circuit 404, with a first terminal of capacitor C_2 located at a first circuit node 340 and a second terminal of capacitor located at a second circuit node 342.

[0046] A chain comprising resistors R_3 and R_4 and capacitor C_3 is located between the first and second circuit nodes 340, 342. A series combination of a resistor and first diac 344 completes a circuit between a second circuit node 342 and a connection point 346 between resistor

R_4 and capacitor C_3 . Resistors R_3 , R_4 , capacitor C_3 and first diac 344 form electronic ballast start-up circuit 412.

[0047] Connection point 346 is coupled to a second side of T5 tube 406 through a series combination of second diode 350 (the anode of which is coupled to connection point 346) with fifth inductor 352, sixth inductor 354 and seventh inductor 356. Fifth inductor 352 is typically a fixed ferrite cored inductor, whereas sixth and seventh inductors are typically iron-cored. A fourth capacitor C_4 appears across the terminals of the T5 tube and is thus connected between first circuit node 340 and a third circuit node 360 between the second side of T5 tube 406 and the seventh inductor 356.

[0048] Resistors R_5 and R_6 are in parallel with capacitor C_5 and connect to cathode of second diode 350 and the first circuit node 340. The cathode of second diode 350 is further coupled through resistor R_7 to emitter junction of transistor 362, the collector of first TRANSISTOR 362 coupled to first circuit node 340. Base of TRANSISTOR 362 is coupled to the cathode second diode 350 via five circuit paths comprising: i) capacitor C_6 and resistor R_7 ; ii) capacitor C_6 and resistor R_8 ; resistor R_9 and eighth ferrite-cored inductor 366; iv) third diode 368 and resistor R_7 ; and v) third diode 368 and resistor R_8 . The cathode of third diode 368 is coupled to the base junction of first TRANSISTOR 362.

[0049] A second TRANSISTOR 370 has its collector coupled to both the cathode of second diode 350 and resistor R_7 . The emitter of second TRANSISTOR 370 is coupled through resistor R_9 to the second circuit node 342 and also via capacitor C_7 to its base. The emitter is further coupled to the second circuit node 342 via resistor R_{10} . The emitter is also coupled to the base of second TRANSISTOR 370 via a path that includes a fourth diode 378, with the cathode of the fourth diode connected to the base of second TRANSISTOR 370 and first diac 344. A ninth inductor 380 is coupled between the second circuit node 342 and both the anode of third diode 378 and base of second TRANSISTOR 370.

[0050] Windings (i.e. inductors) 366, 380 and 352 form a base-drive transformer that functions selectively and alternately to turn transistors 362 and 370 on and off.

[0051] The combination of resistors R_5 and R_{10} , fifth to ninth inductors, first and second TRANSISTORS, capacitors C_4 to C_7 and first, second and third diodes make up half-bridge oscillating driver 410.

[0052] With respect to the ballast protection circuit 414, an anode 382 of a silicon-controlled rectifier (SCR) 384 is coupled through resistor R_{11} to base of second TRANSISTOR 370. The gate of SCR 384 is coupled through a series combination of resistor R_{12} and second diac 386 to the second circuit node 342. Polarized capacitor C_8 is located the gate and cathode of SCR 384. The cathode of SCR 384 is further coupled to the second circuit node 342 via four parallel lines comprising: i) resistor R_{13} and the second diac 386; ii) ninth capacitor C_9 ; iii) resistor R_{14} ; and iv) a series combination of tenth inductor 390 and third fourth diode 392, the cathode of which is

coupled the second circuit node 342.

[0053] A current transformer made up of inductors 354 and 390 forms a current sensor. Current passing through sixth inductor 354 is coupled to tenth inductor 390 such that when the current exceeds the predetermined or desirable limit, the over-current will trigger diac 386 which in turn fires SCR 384 which in turn shorts the base-drive voltage for transistor 370 and thus stops oscillation of the device.

[0054] SCR 384, resistors R_{11} to R_{14} , capacitors C_8 and C_9 , second diac 386, fourth diode 392 and tenth inductor 390 form the ballast protection circuit 414.

[0055] From a functional perspective, ballast protection circuit 414 and particularly SCR 384 and tenth inductor 390 operate to protect against over-current and over-voltage. When ballast protection circuit 414 senses an abnormal condition (i.e. over-voltage or over-current condition) appearing across the T5 tube 406 (e.g. when the tube is broken or worn-out), the protection circuit 414 operates to stop the oscillation in the half bridge oscillating driver 410 with the effect that a zero voltage appears at both ends of the T5 tube. During operation, any existing electromagnetic ballast (if not removed from the original T8 fitting) will act as an additional "PFC filter" and will not act as a current limiting device as it was originally intended. Consequently, current passes through the pre-existing electromagnetic ballast 504 at levels of about 0.1A. The current limiting function is performed in the LLC Resonant Circuit.

[0056] In another embodiment shown in FIG. 7, two current limiting protection circuits combine to allow direct adaption of a T8 liminaire that retains both its starter and electromagnetic ballast. In this instance, a first protection circuit PTC1 (as described above) is coupled between the electromagnetic inductor 504 and a first terminal 511 connectable, in use, to the T5 tube. Additionally, a second current limiting protection circuit PTC2 is coupled from the first terminal 511 and via starter 517 to second terminal 513, the second terminal being connectable (in use) to the T5 tube. This V-shaped configuration of protection circuits to the first terminal of the T5 tubes protects both the electromagnetic ballast and the tube itself from over-heating brought about by over-current or over-voltage. More particularly, in the event the starter of the original T8 tube was left in place at adaption of the liminaire to T5 technology, a resettable over-current device that is connected from one end of the T8 end-cap pin to AC2 of the fluorescent ballast will activate and turn off the ac mains supply to the converter, with this operation causing no current to pass through the existing magnetic ballast.

[0057] The starter requires no specific protection since it essentially operates as a thermally controlled on/off switch (with associated thermal-based protection).

[0058] In operation, the brightness of the tube is governed by the current through the tube which is regulated by the LLC resonant circuit. When the current limiting devices (e.g. the PTCs) activate (i.e. goes open circuit), there will be a high voltage spike created by the back

EMF of the electromagnetic-ballast which will then be applied to the input of the electronic ballast. This in turn will introduce a high current spike through the tube. The over-current protection circuit 414 functions to pick it up and shut down the electronic ballast and in turn protects the tube and the electronic ballast. The electronic ballast will then only return to normal operation after the PTC resets itself.

[0059] It will, of course, be appreciated that the above description has been given by way of example only and that modifications in detail may be made within the scope of the present invention. For example, the over-current protective device does not have to be a Positive Temperature Coefficient (PTC) thermistor, but rather any current limiting device including common fuses, Polymeric Positive Temperature Coefficient devices (PPTC) or resettable fuses. The circuits of the preferred embodiments may be adapted to permit other forms of existing light fitting (other than T8) to be adapted to support T5 technology, with the foregoing provided to illustrate one particular application.

[0060] To provide a more robust solution for T5 end-cap adaptors and conversion kits (that include adaptors and base plates), the current limiting circuit protection and modified housing design (containing the isolating channels) can be implemented in concert or independently of each other. Indeed, the isolating channels that increase creepage distance can be employed in any instance where there are space constraints and electrical isolation requirements.

Claims

1. A fluorescent tube T5 converter circuit comprising:

at least one current limiting protection device connectable in series with a pre-existing electromagnetic ballast for an electronic ballast, the current limiting protection device connectable to a first input of a fluorescent tube and coupled directly across contact terminals in an end-cap converter.

2. The fluorescent tube T5 converter circuit according to claim 1, wherein the current limiting protection device is serially connectable through the end-cap converter to a starter of one of a T8 or T12 luminaire.

3. The fluorescent tube T5 converter circuit according to claim 1 or 2, wherein the current limiting protection device is selected from the group consisting of:

a positive temperature coefficient (PTC) thermistor
a polymeric positive temperature coefficient devices (PPTC);
a resettable fuse; and

a fuse.

4. The fluorescent tube T5 converter circuit according to claim 1 or 2, wherein the current limiting protection device limits current passing through the electromagnetic ballast (504), thereby protecting the electromagnetic ballast (504) from overheating.

5. The fluorescent tube T5 converter circuit according to any preceding claim, comprising first and second current limiting protection device, wherein:

the first protection device is connectable to a first input of a fluorescent tube and coupled directly across first and second contact terminals (502, 515) in an end-cap converter; and the second protection device is connectable to a first input of a fluorescent tube and coupled to both the second contact terminal and the first protection device, the second contact terminal separated from the electromagnetic ballast (504) by a series connection through the first protection circuit.

6. The fluorescent tube T5 converter circuit according to claim 5, wherein the second protection device is connectable in series with a starter of one of a T8 or T12 luminaire.

7. The fluorescent tube T5 converter circuit according to any preceding claim, the circuit configured or arranged such that:

an open circuit condition in the current limiting device creates a voltage spike from a back EMF associated with the electromagnetic ballast, the voltage spike applied to inputs of the electronic ballast producing a current spike through the fluorescent tube;

wherein the current limiting device functions to detect the current spike and to shut down operation of the electronic ballast, thereby protecting the fluorescent tube and the electronic ballast; and

wherein operation of the electronic ballast only resumes after resetting of the current limiting device, resetting preferably occurring automatically.

8. A fluorescent tube T5 converter including opposing end-caps having electrical terminals for mounting and supplying power to a fluorescent tube located therein, the converter comprising:

a half-bridge oscillating driver operationally responsive to a ballast protection circuit operable to detect, in use, over-voltage or over-current conditions in a fluorescent tube, the ballast pro-

tection circuit comprising at least one current limiting device arranged to restrict current flow under conditions where current passed through the electrical terminals exceeds a maximum input current of the fluorescent tube.

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9. The fluorescent tube T5 converter according to claim 8, further comprising the fluorescent tube T5 converter of any of claims 1 to 7.

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10. An end-cap adaptor for accommodating a fluorescent tube, the adaptor comprising:

a body portion containing a pair of electrical contacts for routing power, the electrical contacts extending rearwardly and externally from an outer surface; and

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a pair of isolating channels formed generally about outermost edges of each electrical contact, each channel thereby separating each respective electrical contact from a peripheral edge of the outer surface of the body portion.

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11. The end cap comprised from a material having a comparative tracking index that is equal to or greater than about 600.

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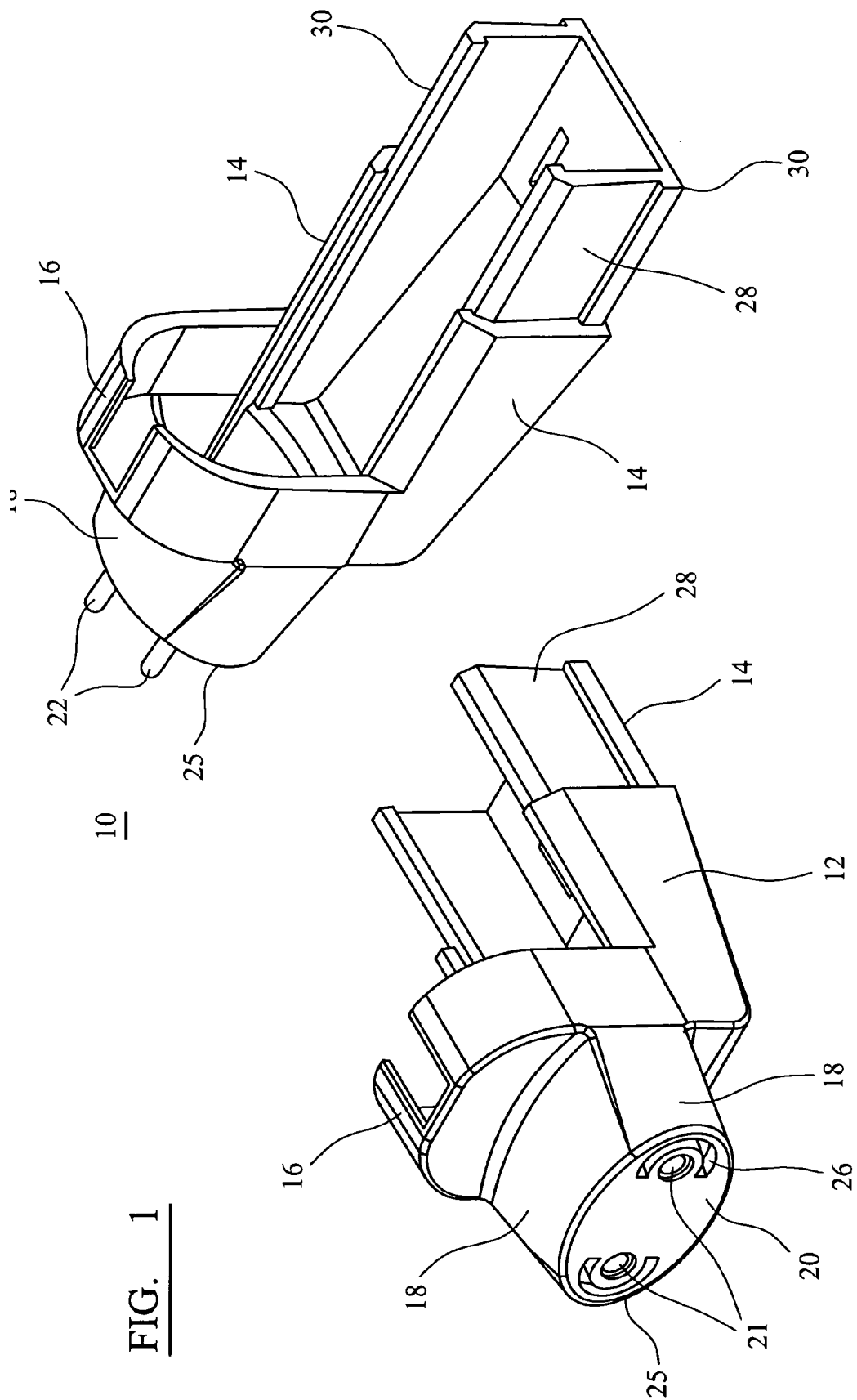
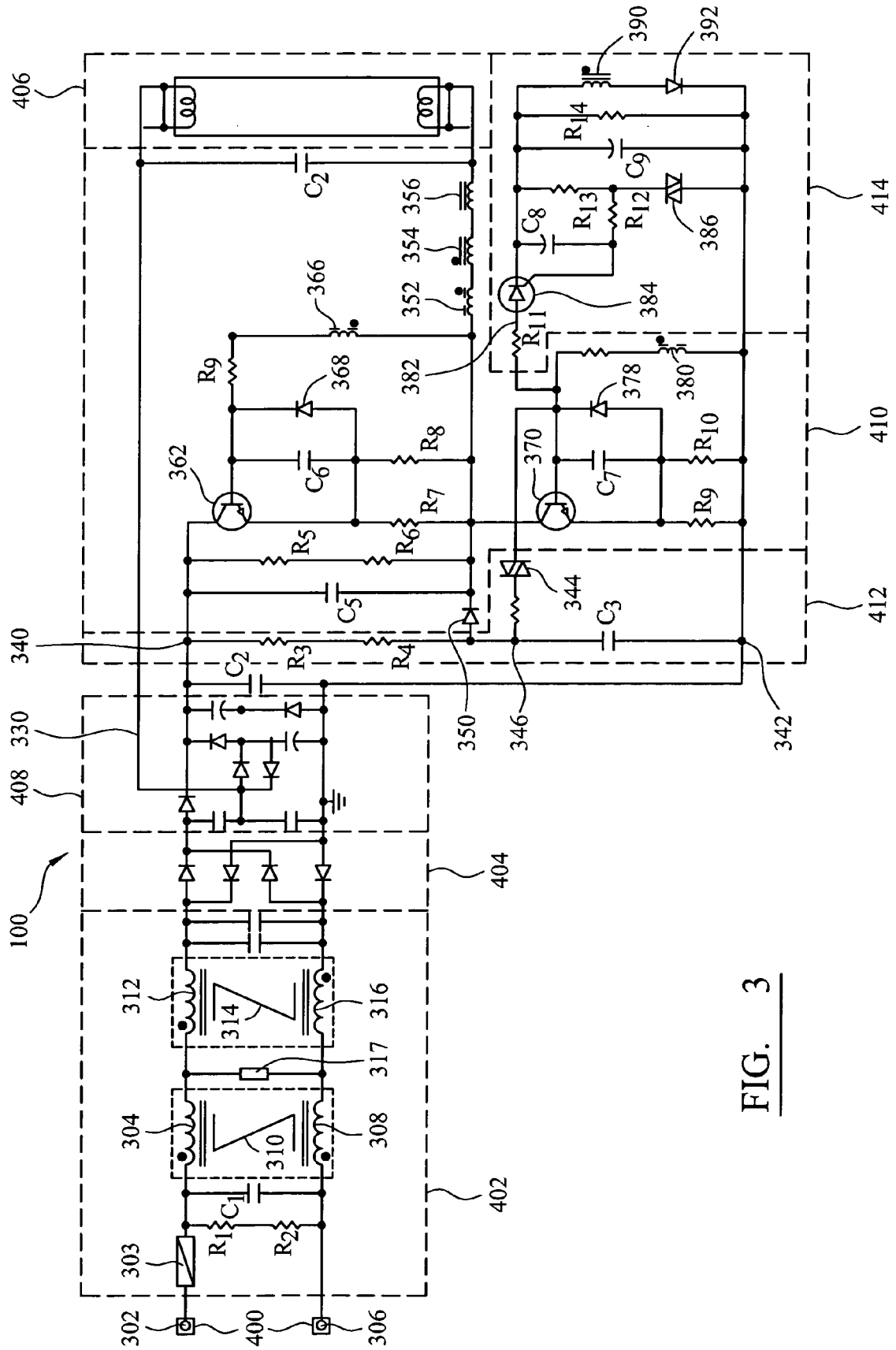


FIG. 1

FIG. 2



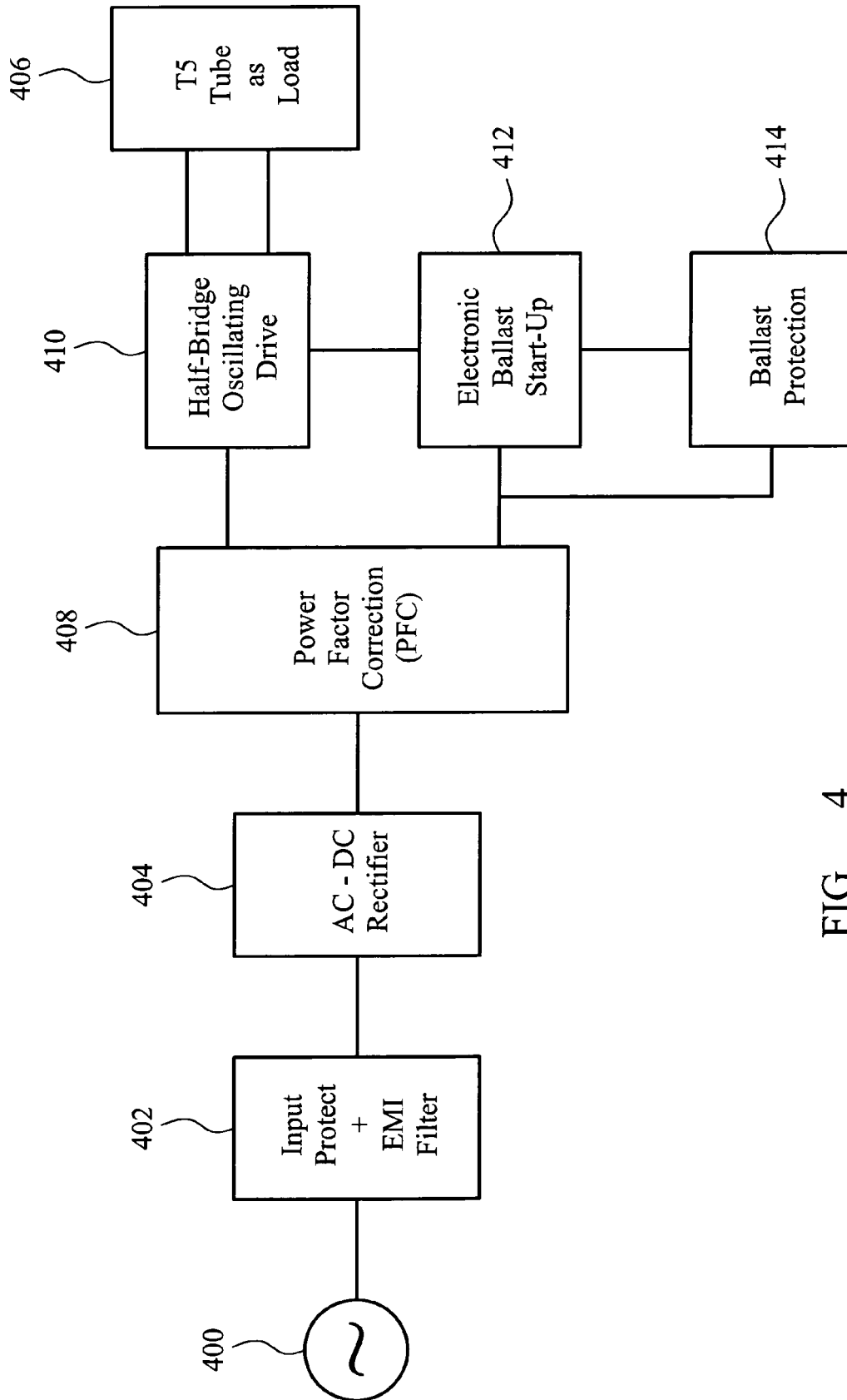


FIG. 4

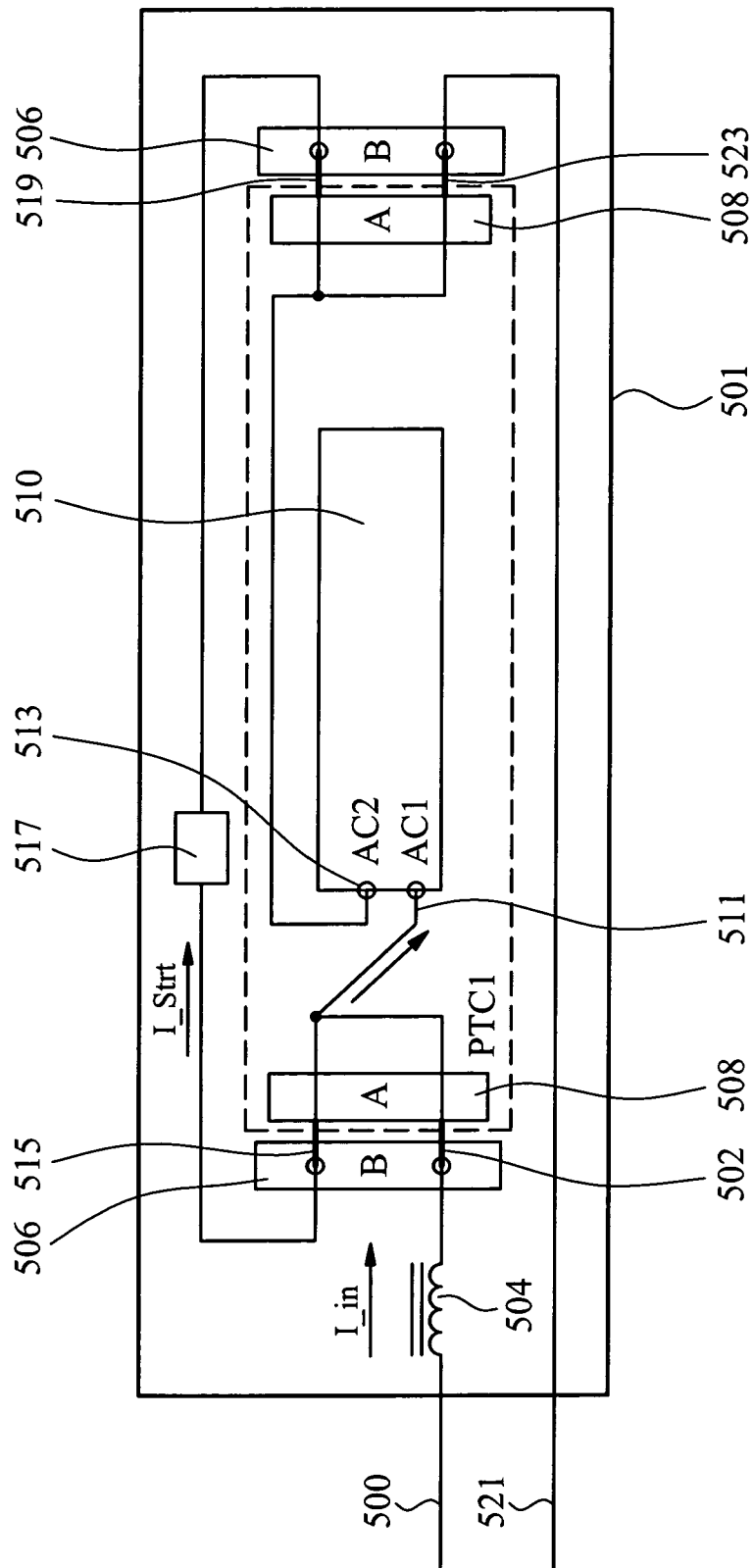


FIG. 5

PRIOR ART

FIG. 6

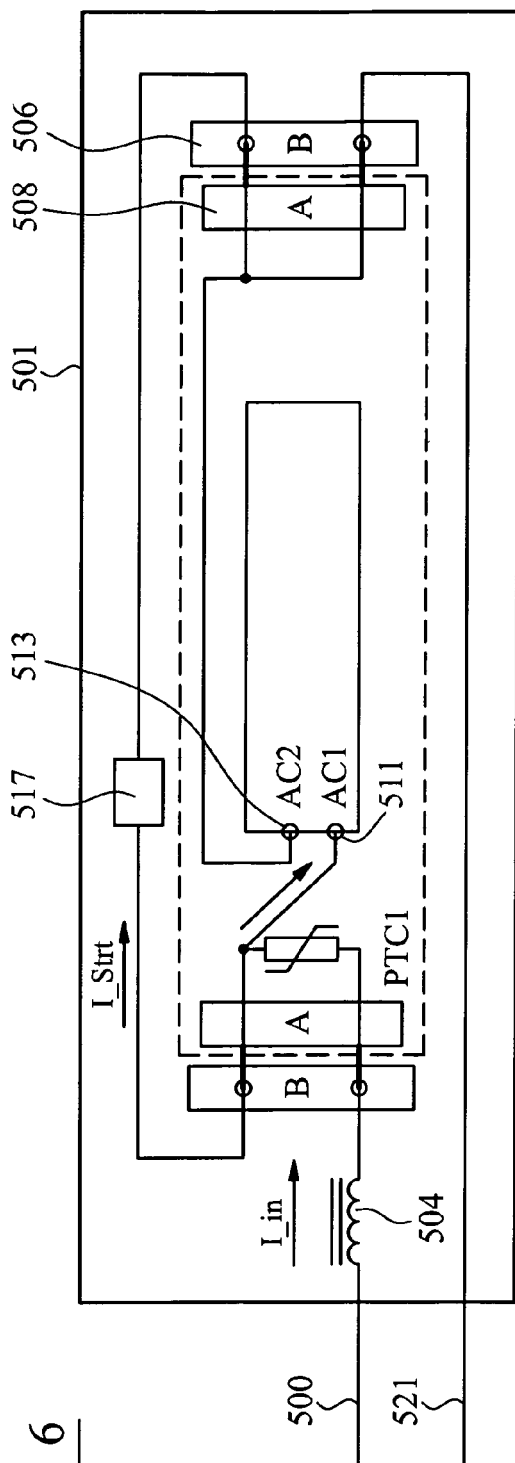
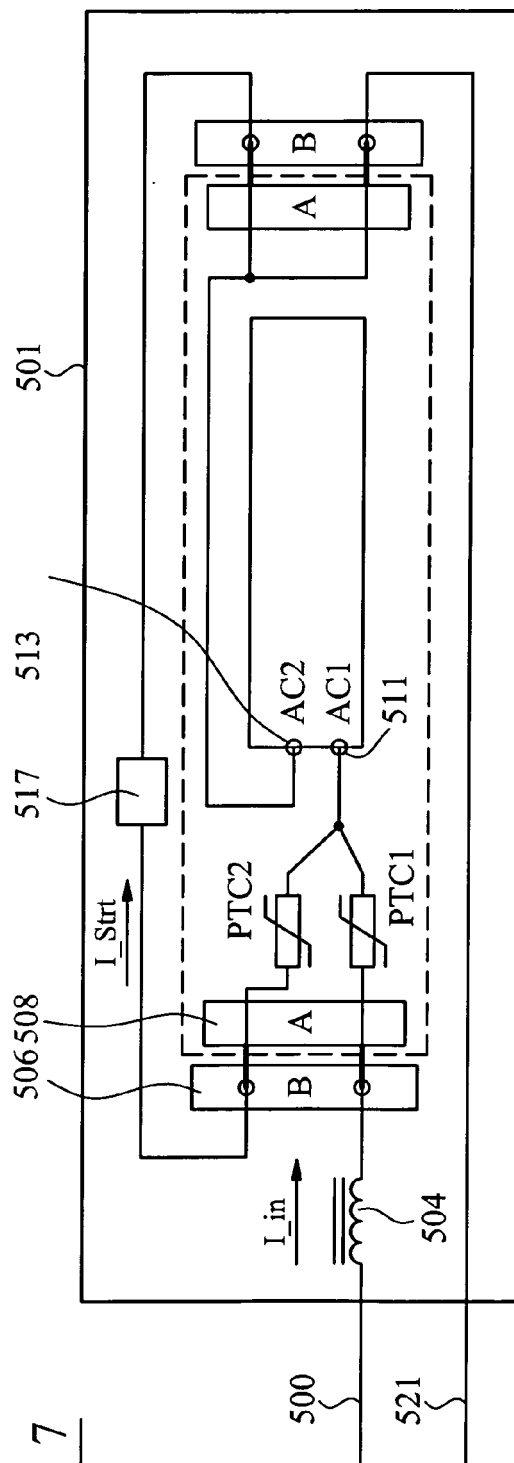


FIG. 7



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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