

An Electrical Distribution Assembly

In the United Kingdom (UK) mains electricity supplied at nominal voltage of 230V $\pm 10\%$ per European CE standard. In practice the nominal supply voltage is 242V in the UK and 220V in many other EU countries.

- 5 As standards testing of electrical equipment is carried out at 230V-230V there is evidence that some electrical equipment is inefficient or unsafe at supply voltages commonly found in the UK.

Because the Continental European market is far larger than the UK market, electrical
10 appliances are predominantly designed to operate most efficiently at 220V. Consequently, electrical appliances that are 'A' rated for efficiency, may only achieve that rating when laboratory tested at 220V-230V and be significantly less efficient when operated at 242V. Further, operating an electrical appliance at a voltage higher than it is designed for (overvoltage) often reduces its lifespan.

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A solution to these problems is to install a voltage optimisation system, commonly known as a voltage optimiser, into the mains electrical supply. The voltage optimiser is adapted to provide a controlled voltage reduction to nearer 220V for electrical equipment powered through the supply. Some voltage optimisers provide a fixed
20 voltage adjustment whereas others provide dynamic regulation to account for changes in the input voltage.

The use of voltage optimisation provides a solution to the above and additionally provides an energy saving.

Voltage optimisers have been installed in domestic dwellings for this purpose in the United Kingdom since at least 2004, though the use of voltage optimisers in
5 commercial premises predate this significantly.

Voltage optimisers used in domestic dwellings are housed in an exterior case having one or more outer dimensions that are comparable with modern consumer units (fuse boxes). The voltage optimiser will generally be installed where the main power feed enters the building and so are usually installed nearby the consumer unit.

10 Retrofitting a voltage optimiser to an existing domestic power supply is frequently problematic as there is often little or no room available to install the voltage optimiser unit.

Additionally, the existing consumer unit is often installed over the location through which the main feed passes into the building so that the feed can pass into the consumer
15 unit through its back panel. Where so, it is necessary either to reposition the consumer unit or extend the feeds out of the consumer unit to the voltage optimiser.

GB2591979 discloses a solution in which the voltage optimiser is positioned within the consumer unit behind the fuses and/or circuit.

The present inventions result from subsequent developments of this design.

According to a first aspect of the invention there is provided an electrical distribution assembly comprising:

a first enclosure having an interior cavity for housing circuitry for distributing electrical power from a supply to one or more sub-circuits; and

- 5 a second enclosure housing a voltage optimiser for reducing the voltage of the supply before it is distributed to the one or more sub-circuits;

wherein the first enclosure is configured to define an exterior recess and in which the first and second enclosures are arranged adjacent to one another with the second enclosure lying within the recess.

- 10 The invention still provides a degree of the space saving of GB2591979 but as a consequence of being in separate housings that lie adjacent to one another, greater thermal isolation is provided between the voltage optimiser and the circuitry within the first enclosure. The inventors have realised this is important because the voltage optimiser will often run at a temperature that exceeds the permitted maximum
- 15 temperature within the interior of a consumer unit housing. A further advantage is that it allows, if desired, the two housings to be mounted onto a supporting wall separately. As the voltage optimiser is significantly heavier than the first enclosure, this advantageously allows the assembly to be easily fitted by a single person. The second enclosure with voltage optimiser may be mounted first, and then the first enclosure
- 20 presented to the wall and cables to be fed into it, e.g. through its rear side, before being secured into place. Nevertheless, in certain embodiments, the first and second enclosures may be directly fastened together using one or more fasteners.

If required, the assembly may include a thermal insulating layer lying within the recess, directly between the first and second enclosures to further reduce heat transfer between the voltage optimiser and the internal cavity of the first enclosure.

The first enclosure may have an openable first side (e.g. front panel) to provide access
5 to the circuitry within the interior cavity.

A region of the interior cavity may lie directly between the first side and a portion of the second enclosure lying within the recess. As such, a portion of the internal cavity of the first enclosure may extend directly in front of the second enclosure. This region may be used to house the circuitry. Favourably the voltage optimiser at least partially
10 sits within the recess. Where so, the region of the interior cavity may lie directly between the first side and the voltage optimiser.

The first enclosure may house a supporting rail (e.g. DIN rail) for mechanically supporting the one or more electrical components of the circuitry, and a power
15 distribution bar (e.g. busbar), which may extend substantially parallel with the supporting rail, adapted for direct electrical connection with one or more of the components of the sub-circuits to distribute power to the sub-circuits; and wherein said supporting rail and/or power distribution bar extend within said region of the interior cavity. As such, when in use, said supporting rail and/or power distribution bar may lie
20 directly in front of the second enclosure. Further, one or more of the electrical components may sit within said region and thus directly in front of the second enclosure. The supporting rail and/or power distribution bar may be supported directly

onto a recessed wall of a second side of the first enclosure that lies opposite the first side and which faces into the region of the interior cavity.

The electrical components supported by the supporting rail may comprise one or more of an electrical switch, e.g. main switch, that controls power from the main feed to all
5 of the sub-circuits, and/or one or more electrical safety devices. The one or more electrical safety devices may comprise one or more: circuit breakers, e.g. fuses and/or miniature circuit breakers (MCBs); residual current devices (RCD); surge protection devices (SPD); arc fault detection devices (AFDD); and residual current breaker with over-current devices.

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The recess may take the form of a rebate. The rebate may extend to a second (rear) side of the first enclosure, that when in use, faces a supporting wall upon which the assembly is supported.

The second enclosure favourably lies partially within the recess such that a portion of
15 the second enclosure lies outside the recess. This allows for improved heat dissipation from the second enclosure away from the first enclosure. One or more walls of the second enclosure lying outside of the recess may define multiple, e.g. at least eighty, ventilation apertures to ventilate heat out of the interior of the second enclosure. In contrast, portions of the walls of the second enclosure lying within the recess and/or
20 directly facing the first enclosure may define fewer, or no ventilation apertures.

The electrical distribution assembly may comprise one or more electrical supply cables for electrically connecting the voltage optimiser into the circuitry within the first enclosure, said one or more electrical supply cables extending between the first and

second enclosures through a first aperture provided in a wall of the second enclosure lying within the recess, and through a corresponding aperture in a wall of the first enclosure directly facing the wall of the second enclosure. Favourably the walls are closely spaced or in contact and, where so, the apertures of the two enclosures are
5 aligned.

The second enclosure may comprise a detachable first side (e.g. front panel) to allow access to the voltage optimiser within the second enclosure.

The voltage optimiser may comprise an auto-transformer. The auto-transformer may comprise multiple electrical outputs each providing a different voltage fraction of the
10 voltage of the supply.

The electrical distribution assembly may comprise multiple electrical supply cables each connected to different one of the multiple electrical outputs of the voltage optimiser to selectively provide different fractional voltages of the supply voltage to
15 the sub circuits.

The first enclosure may house a multiple-pole electrical connector for receiving the multiple electrical supply cables and for selectively electrically connecting one of the voltage optimiser's multiple outputs into the circuitry. Each supply cable can be
20 connected to a first terminal of a different pole of the multiple-pole electrical connector. A supply cable feeding power to the sub-circuitry within the first enclosure may then be selectively connected to the terminal of the electrical connector providing the desired output voltage from the voltage optimiser.

In one embodiment the enclosure may house a main switch and a separate circuit breaker means associated with each sub circuit; the main switch having a first pole within input terminal adapted to be connected to the main electrical supply; a first
5 electrical connection extends between the first and second enclosures to electrically connect an output terminal of the first pole of the main switch to an input of the voltage optimiser; a second electrical connection extends between the first and second enclosures that carries the voltage transformed output supply from the voltage optimiser to the one or more sub circuits. The second connection may connect to an
10 input terminal of a second pole of the main switch, and in which an output terminal of the second pole is electrically connected to the sub circuits via the power distribution bar. The first enclosure may house a multiple-pole electrical connector for receiving the multiple electrical supply cables and for selectively connecting one of them to the sub circuits.

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The invention also relates to a novel circuit design and thus according to a second aspect of the invention there is provided an electrical distribution assembly for distributing power from a main electrical supply to one or more sub circuits; the electrical distribution assembly comprising: a first enclosure having an interior cavity
20 housing a main switch and a separate circuit breaker means associated with each sub circuit; the main switch having a first pole input terminal adapted to be connected to the main electrical supply; a second enclosure housing a voltage optimiser for providing a transformed supply to each of the sub circuits; said transformed supply having a voltage that is a fraction of the voltage of the main electrical supply; a first

electrical connection extending between the first and second enclosures to electrically connect an output of the main switch to an input of the voltage optimiser; a second electrical connection extending between the first and second enclosures that carries the output supply from the voltage optimiser to the one or more sub circuits.

- 5 In contrast to existing circuits known to the inventor, in which the main supply is fed directly to the voltage optimiser, the circuit of the present invention simplifies the installation process for the installer, particularly where the assembly is replacing an existing consumer unit, as the first enclosure can be located in the same position as the existing consumer unit meaning the existing meter tails can be connected with minimal
10 alteration.

The second connection may connect to an input terminal of a second pole of the main switch, and an output terminal of the second pole may be connected to the sub circuits. Where so the main switch may be a multi-pole single-throw switch.

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The voltage optimiser may comprise multiple electrical outputs each configured to provide a different fractional voltage of the main supply voltage, and the assembly includes multiple electrical supply cables that extend between the first and second enclosures, each connected to a different electrical output of the voltage optimiser.

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The first enclosure may house a multiple-pole electrical connector for receiving each of the multiple electrical supply cables and for selectively electrically connecting one of the multiple electrical supply cables to the sub circuits to supply the sub circuits with one of the fractional voltage outputs of the voltage optimiser.

The first electrical connection may comprise a circuit breaker means (optionally within the first enclosure), e.g. an MCB, between the main switch and the input of the voltage optimiser. The circuit breaker means may be carried on the supporting rail.

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A main electrical feed cable for supplying power from the main electrical supply may extend through an aperture through the first enclosure for connection to the main switch.

The voltage optimiser may comprise an auto-transformer.

- 10 The invention will now be described by way of example with reference to the following figures in which:

Figure 1 is a perspective view of an electrical distribution assembly from a front left side;

Figure 2 is a perspective view of the assembly from the rear right hand side;

- 15 **Figure 3** is a perspective view of the enclosure assembly from a front right side;

Figure 4 is a front elevation of the assembly;

Figure 5 is a rear elevation of the assembly;

Figure 6 is a top elevation of the assembly;

- 20 **Figure 7** is a front right side perspective view with the front wall removed to reveal the interior cavity and some circuitry components without wiring;

Figure 8 is a front elevation of the assembly with front wall of both first and second enclosure removed to expose the interior of both enclosures;

Figure 9 is a perspective rear downward view of the main enclosure;

Figure 10 is a perspective front right side view of the secondary enclosure;

- 5 **Figure 11** is the same view as Fig 10 with the front panel of the secondary enclosure removed to expose the auto-transformer;

Figure 12 is a front elevation of the secondary enclosure with front panel removed;

Figure 13 is a schematic of the circuitry of the electrical distribution assembly; and

Figure 14 is a perspective view of the exterior of an auto-transformer.

- 10 With reference to the figures there is shown an electrical distribution assembly 1 suitable for use with a domestic electrical supply, comprising a main enclosure 100 and a secondary enclosure 200.

The main enclosure 100, which may also be referred to as a consumer unit or fuse box, defines an interior cavity 101 (see Figs 7 & 8) that houses circuitry for dividing power
15 from an electrical power feed 300 to subsidiary circuits 310 (e.g. ring main circuits and/or radial circuits). The secondary enclosure 200 houses a voltage optimiser, in this example implemented by an autotransformer 250 (see Figs 8, 10, 11 & 12).

The main and secondary enclosures 100, 200 are arranged side-by-side. The main enclosure 100 defines a rearward external rebate 102 (best seen in Fig 9) in which the
20 secondary enclosure 200 and voltage optimiser 250 partially sit. This configuration

reduces the overall wall space ‘footprint’ required by the electrical distribution assembly 1.

The main enclosure 100 has a front side 110, rear side 120, left side 130, right side 140, top side 150, and bottom side 160. Each side is provided by one or more walls provided
5 by sheet metal panels, e.g. of steel. One or more of the walls are provided with knockout portions 103 to facilitate cable entry from the top 150, bottom 160, right 140 and rear sides 120.

The relative terms: front, rear, left, right, top and bottom are used to improve readability. They reflect the relative orientation of the assembly 1 as usually viewed
10 when in use mounted on a wall, and as seen in Figs 1, 3, 4, 7 & 8.

A front side panel 111 is releasably attachable (e.g. by fasteners) to the rest of the main enclosure 100 to allow it to be temporarily removed when access is required to the internal cavity 101, e.g. for an electrician to install or check the electrical circuitry. The front side panel 111 is provided with a hinged door member 112 that covers an aperture
15 (not shown) through the front side panel 111 to provide access to switches (e.g. toggle switches and/or push button) of the electrical circuitry without the need to remove the front panel 111.

Each of the rear side 120 and left side 130 of the main enclosure comprise a first panel 121, 131 and a second panel 122 132. The first panels 121, 131 of the rear and left sides
20 120, 130 being recessed with respect to their second panels 122 132 to provide the rebate 102 at the rear left hand corner of the main enclosure 100.

Provided through the recessed left panel 132 is a first aperture 133 (see Figs 7 & 9) through which extend electrical tap connectors 320 (see Fig 8) electrically for connecting the auto-transformer 250 into the circuitry within the cavity 101.

As best seen in Fig 7, a portion 101A of the internal cavity 101 lies directly in front of the recess 102, i.e. directly between the recessed rear side panel 121 and the front side panel 111. As a consequence, the portion 101A is shallower than the remained of the internal cavity 101.

The second panel 122 of the rear side 120 is provides with fixing indents mounting bosses 122A (or equivalent – e.g. mounting bosses) about which the main enclosure 100 can be supported, onto a vertical surface, e.g. interior wall of a building using suitable fasteners.

The secondary enclosure has a front side 201, rear side 202, left side 203, right side 204, top side 205, and bottom side 206. Each side is provided by a sheet metal panel. Defined between these sides in an internal cavity 210 in which the autotransformer 250 sits. The panel providing the front side 201 is releasably detachable from the rest of the secondary enclosure 201 to provide access to the voltage optimiser 250.

The depth of the secondary enclosure, i.e. dimension from front to back, substantially match the depth of the rebate 102 (front side to back side) such that when the secondary enclosure 200 lies in the rebate 102 with front side 201 directly facing and against recessed rear panel 121 (see Fig 6), the exterior face of the rear side panel 202 lies substantially flush with exterior face of the second panel 122 of the rear side 120 of the main enclosure 100.

The rear side panel 202 also comprises fixing indents 202A about which the secondary enclosure 200 can be supported, onto the vertical surface using suitable fasteners, immediately adjacent the second panel 122 of the rear side 120 of the main enclosure 100.

- 5 The lateral dimension of the rebate 102, that being the dimension between the right and left sides, is less than the width of the secondary enclosure 200 (i.e. dimension between its right and left sides) such that a portion of the secondary enclosure 200 lies outside of the recess 102 with a portion 201A of the first side 202 extending laterally beyond the first enclosure 100. This arrangement increases the surface area of the secondary
- 10 enclosure 200 that is not directly facing the main enclosure 100 to allow for improved heat transfer out of the secondary enclosure 200 in a direction away from the main enclosure 100.

- Each of the left side panel 203, top panel 205, rear panel 202, bottom panel 206 and portion 201A of the front panel are provided with multiple vent holes 220 to convection
- 15 of heat out of the second unit 202. In contrast, the faces of the second enclosure 200 that directly face the main enclosure 100, namely those provided by the right panel 204 and portion 201A front panel 201 have no vent holes to minimise heat transfer from the second enclosure 200 towards the first enclosure 100.

- To further minimise heat transfer, a non-combustible thermal insulating layer (not
- 20 shown), may be positioned between the main and secondary enclosures 100, 200, or within either the main and/or second enclosures 100, 200. Examples of suitable thermal insulating layers include a flexible or rigid ceramic heat shield material such as supplied under the brand ZircoFlex(RTM), or a heat resistant rubber shield material.

An aperture 204A (see Figs 10 & 11) is provided in the right side 204 of the secondary enclosure 200 which aligns with aperture 133 in the recessed left side panel 131 to provide a passageway between the main and secondary enclosures 100, 200.

With reference particularly to Figures 10-12 & 14, the autotransformer 250 comprises
5 a winding (not shown), with a first tap connector 320A providing an electrical input, a second tap connector 320B to provide a neutral connection, and multiple, in this example three, further taps connectors 320C providing three electrical outputs each providing a different fractional voltage value of the voltage supply based on their position along the winding. One or more of the tap connectors 320 may be
10 implemented by multiple parallel extending cables that are electrically connected together at each end. Using multiple cables that can each have a smaller gauge compared with a single larger gauge cable, facilitates bending of the tap connector out of the autotransformer and secondary housing 200.

The construction and manner of function of autotransformers is well known and so will
15 not be described here further.

Each electrical tap connector 320 extends out through the secondary enclosure 200 into the main enclosure 100 through the apertures 133, 204A.

With reference to Figures 7 and 8, mounted within the internal cavity 101 is a supporting rail (typically a DIN rail) 401 for mechanically supporting a main switch
20 402 (through which all power to the circuitry first passes) and one or more electrical safety devices 403 of the circuitry. The supporting rail 401 extends laterally across the unit 100 such that a portion lies directly in front of the recessed rear wall 121 and rebate

102. The supporting rail 401 may be mechanically supported directly to the recessed rear face 121.

The one or more electrical safety devices may comprise one or more residual current devices (RCD); one or more circuit breakers, e.g. miniature circuit breakers (MCB); a
5 combination e.g. in the form of a Residual Current Overload device (RCBO); and a surge protector.

Also housed within the internal cavity 101 are one or more busbars 404 (in this example two, 404A, 404B) and corresponding neutral and earth bars 405 for distributing power from the main switch 402 to circuit breakers 408 of the sub circuits, in this example
10 through RCDs 409. One or more of the bus bars 404 and/or one or more of the neutral and earth bars 405 also extend within the cavity region 101A, directly in front of the recessed rear wall 121.

Additionally housed within the internal cavity 101 is an electrical terminal block 406. The terminal block 406 is mounted onto the inward facing side of the rear panel 122
15 adjacent aperture 133, though an alternative position could be selected. The terminal block 406 has multiple, in this example, five poles. Each tap 320 is connected to a different pole on one side of the block 406 for connection into the circuitry as described below.

Figure 13 illustrates a possible circuit arrangement within the main enclosure 100. The
20 main switch 402 has a triple-pole single-throw configuration. A first terminal of each of the first two poles 402A 402B are reserved for direct connection (live and neutral) to the incoming power supply 300 to the property (e.g. from the electricity meter). The

third pole 402C is connected (Lout) to a selected one of the outputs of the auto-transformer 250 via the connection block 406, in this example V_3 OUT.

The second terminal of the first pole 402A connects (Lin) the live feed of the incoming power supply, through a circuit breaker 407, to the input terminal of the auto-transformer 250 via the terminal block 406.

The output terminal of the third pole 402C of the main switch 402 distributes power from the selected output of the auto-transformer 250 to MCBs 408 of each sub-circuit 310, via RCDs 409 and bus bars 404 in a conventional manner.

To install the assembly 1, the secondary enclosure, with voltage optimiser, is mounted onto the wall using fastenings that pass through indents 202A. If not already done so, the installer then pulls through the meter tails and sub-circuit 310 cables into the interior cavity 101 of the main enclosure, knocking out the knock outs 103 as required. Each of the cables 320 of the auto-transformer 250 are also pulled through cavity 133. The main unit 100 is then mounted onto the wall, using fasteners passing through indents 122A, over the secondary enclosure 200.

The sub circuitry 310 wiring is installed. Each of the cables 320 are connected to different poles of the connector block 406. The wiring that feeds power from the main switch 402 to the auto-transformer 250 is installed by connection to the relevant poles of the connector block 406. The main switch 402 is connected to the main power feed 300.

The voltage output (specifically the root mean square of the voltage) provided from each of the three outputs of the auto transformer 250 is measured (e.g. using a voltage

meter). The output that provides the voltage closest to the preferred voltage is connected to the third pole of the main switch 402 to supply the sub-circuits with the selected voltage. In the United Kingdom, that will typically be the output with voltage closest to, but above, 220V. This is done by connecting the appropriate pole of the
5 connector block 406 to the third pole of the main switch 402 with an electrical cable.

In a variant design, the rebate 102 could be provided elsewhere, including, for example, on the rear right hand side of the main unit.

It will be appreciated that other electrical terminal means may be used in place of the electrical terminal block 406.

10 The voltage optimiser may be implemented by means other than an auto-transformer.

Claims

1. An electrical distribution assembly comprising:
a first enclosure having an interior cavity for housing circuitry for distributing electrical power from a supply to one or more sub-circuits; and
5 a second enclosure housing a voltage optimiser for reducing the voltage of the supply before it is distributed to the one or more sub-circuits;
wherein the first enclosure is configured to define an exterior recess and in which the first and second enclosures are arranged adjacent to one another with the second enclosure lying within the recess.
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2. An electrical distribution assembly according to claim 1 wherein the second enclosure lies partially within the recess.
3. An electrical distribution assembly according to claim 1 or 2 wherein the first
15 enclosure has an openable first side to provide access to the circuitry within the interior cavity; and wherein a region of the interior cavity lies directly between the first side and a portion of the second enclosure lying within the recess.
4. An electrical distribution assembly according to claim 3 wherein the first
20 enclosure houses a supporting rail for carrying one or more electrical components of the circuitry, and a power distribution bar adapted for direct electrical connection with one or more of the components; and wherein said supporting rail and/or power distribution bar lie within said region of the interior cavity.

5. An electrical distribution assembly according to any previous claim comprising one or more electrical supply cables for electrically connecting the voltage optimiser into the circuitry within the first enclosure; wherein said one or more electrical supply cables extend between the first and second enclosures through a first aperture provided in a wall of the second enclosure lying within the recess and a corresponding second aperture in a wall of the first enclosure directly facing the first aperture.
6. An electrical distribution assembly according to claim 5 including at least two electrical supply cables connected to different electrical outputs of the voltage optimiser to selectively provide different fractional voltages of the supply voltage to the sub circuits.
7. An electrical distribution assembly according to claim 6 wherein the first enclosure houses a multiple-pole electrical connector for receiving the two electrical supply cables and for selectively electrically connecting one into the circuitry.
8. An electrical distribution assembly according to any previous claim wherein the voltage optimiser comprises an auto-transformer.
9. An electrical distribution assembly according to any previous claim wherein the exterior recess is a rebate, and when in use, in which the assembly is supported to an upwardly extending supporting surface, a portion of the second enclosure

within the recess lies directly between the first enclosure and the supporting surface.

10. An electrical distribution assembly for distributing power from a main electrical supply to one or more sub circuits; the electrical distribution assembly comprising:
- 5 a first enclosure having an interior cavity housing a main switch and a separate circuit breaker means associated with each sub circuit; the main switch having a first pole input adapted to be connected to the main electrical supply;
- 10 a second enclosure housing a voltage optimiser for providing a transformed supply to each of the sub circuits; said transformed supply having a voltage that is a fraction of the voltage of the main electrical supply;
- 15 a first electrical connection extending between the first and second enclosures to electrically connect an output of the main switch to an input of the voltage optimiser;
- a second electrical connection extending between the first and second enclosures that carries the output supply from the voltage optimiser to the one
- 20 or more sub circuits.

11. An assembly according to claim 10 wherein the second connection connects to an input of a second pole of the main switch, and in which an output of the second pole is connected to the sub circuits.

12. An assembly according to claim 10 or 11 wherein the voltage optimiser comprises multiple electrical outputs each configured to provide a different fractional voltage of the main supply voltage, and the assembly includes
5 multiple electrical supply cables that extend between the first and second enclosures, each connected to a different electrical output of the voltage optimiser.

13. An assembly according to any claim 10-12 wherein the first electrical
10 connection comprises a circuit breaker means between the main switch and the input of the voltage optimiser.

14. An electrical distribution assembly according to claim 13 wherein a main electrical feed cable for supplying power from the main electrical supply
15 extends through an aperture through the first enclosure for connection to the main switch.

15. An electrical distribution assembly according to any claim 10-14 wherein the voltage optimiser comprises an auto-transformer.