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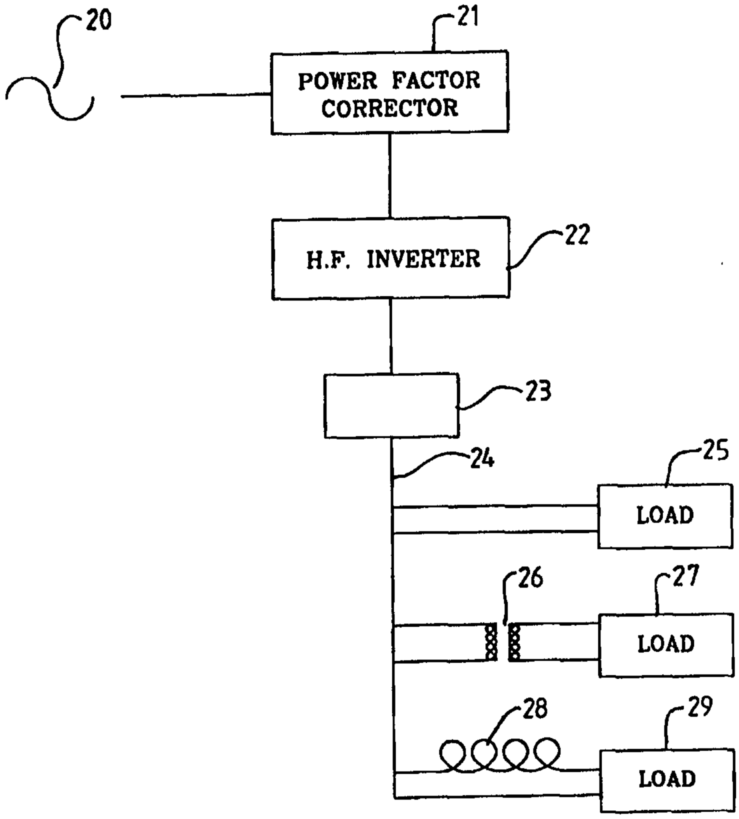
(57) Abstract

An electric power distribution comprises a source (20) alternating current having a frequency of 10 kHz or greater, and a distribution line (24) connected to the source. The distribution line comprises two conductors (1, 2), each of a substantially flat configuration. The conductors are located in spaced parallelism and are located a short distance apart, being separated by an insulator (3). At least one load (25, 27, 29) is connected to the conductors to receive electric power therefrom.



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"A POWER DISTRIBUTION SYSTEM"

THE PRESENT INVENTION relates to a power distribution system, and more particularly relates to a power distribution system adapted to distribute electric power from a power source to at least one load.

Various power distribution systems have been used to distribute power from a power source to a load.

The power may be distributed at a typical "mains" voltage of 240 volts (or, in some countries 110 volts) and at a typical "mains" frequency of 50 cycles per second (in some countries, 60 cycles per second). A disadvantage of this type of distribution system is that since a relatively low voltage is used, for a moderate power supply, a substantial current flows, meaning that the conductors must be capable of carrying a substantial current. Consequently, the cables typically include conductors formed of copper, the conductors having a relatively large cross-section.

If a distribution system of this type is utilised with a discharge lamp, for example, a step-up transformer has to be utilised. Since the frequency of the alternating current is relatively low, the transformer must be relatively bulky.

There is a desire to be able to utilise, in connection with dichroic lamps and discharge lamps, an electronic ballast. An electronic ballast is small and light and also, in connection with a discharge lamp, provides high efficiency and a light that is substantially flicker-free. However, to be able to utilise an electronic ballast, there is a need for a high frequency alternating current. In many states, local legislation insists that where an electronic ballast is utilised, a power factor corrector must be provided to ensure that the power factor is "seen" at the main supply is appropriate.

A problem exists in connection with a high frequency power distribution system in that substantial H field "interference" can be generated.

The present invention seeks to provide an improved power distribution system.

According to this invention there is provided an electric power distribution arrangement comprising a source of alternating current having a frequency of 10 kHz or greater, a distribution line connected to said source, the distribution line comprising two conductors, each of substantially flat configuration, the conductors being located in spaced parallelism and being located a short distance apart, being separated by an insulator, and at least one load connected to said conductors to receive electric power therefrom. In one embodiment the load is connected directly to the two conductors. In another embodiment the load is connected to the conductors by means of a transformer, the transformer having a primary winding connected to the two conductors, and having a secondary winding connected to the load. It is conceivable that the load comprises a low voltage incandescent lamp, but preferably the load comprises a discharge lamp, an impedance being provided which is connected in circuit with the secondary winding and the discharge lamp.

In another embodiment the or each load comprises a discharge lamp connected to one conductor of the distribution line by means of an inductance and connected directly to the other conductor of the distribution line.

Preferably the source of alternating current comprises a power factor corrector which receives supply from a mains electricity supply, and an inverter which receives power from the power factor corrector.

Conveniently the power factor corrector comprises a rectifier producing a DC output, the DC output of the power factor corrector being provided as an input to the inverter.

Advantageously a transformer is provided located between the source of high frequency current and the distribution line.

Preferably at least one of the conductors of the transmission line is associated with a further element formed of a material of high relative permeability.

Advantageously a second element of high permeability is provided associated with the other conductor.

Conveniently the or each element of high relative permeability extends laterally beyond the associated flat conductor.

Preferably the or each element of high permeability is formed of a amorphous or nano-crystalline metal.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a view of a power transmission line suitable for use in a power distribution system in accordance with the invention, with parts thereof cut away for the sake of clarity of illustration,

FIGURE 2 is a view corresponding to Figure 1 illustrating a second power line for use in the invention, and

FIGURE 3 is a block diagram illustrating a power distribution arrangement in accordance with the invention, and

FIGURE 5 is a view illustrating the transmission line and a connecting clip.

Referring initially to Figure 1 of the accompanying drawings, a power transmission line is illustrated which is suitable for use in transmitting power of a voltage between, for example, 150 volts and 1 kv, at an operating frequency of greater than 10 kHz, most preferably at a frequency of 60 kHz. The power transmission line comprises two principal conductors 1,2. Each of the conductors is of substantially flat or rectangular cross-section, with two opposed parallel flat faces. The conductors may be formed of copper or copper alloy and may have a thickness of between 0.025 and 0.25 mm, and a width of up to 30 mm, depending upon the current to be carried.

The two conductors are separated by a sheet of insulating material 3. The insulating material may be an appropriate plastic such as a polyester, polypropylene or polyphenylene sulphide. The thickness of the insulating sheet 3 depends upon the voltage to be carried by the conductors 1 and 2 and may typically be of the order of 0.1 millimetres.

It is to be observed that the insulating sheet 3, in the embodiment illustrated in Figure 1, has such a width that it extends beyond the conductors 1 and 2.

Although a suitable transmission line may comprise simply the three layers described above, in this embodiment a foil 4 is associated with the conductor 2. The foil 4 is made of a material having a high relative permeability. Typically the relative permeability of the foil may be of the order of 10^5. The foil 4 is secured to the face of the conductive element 2 which is remote from the insulating layer 3. The foil 4 has a width which is greater than the width of the conductive element 2, so that parts of the foil project beyond the conductive element 2 on each side thereof.

The foil 4 may be formed from an amorphous or nano-crystalline metal, such as steel or a cobalt/steel alloy. Such a metal has a high resistivity.

Typically, a foil of high permeability of this type may be created by quenching cooling molten metal at a very high speed, for example, at a speed of 10^6 degrees celsius per second. The molten metal may be sprayed to a cooled, rapidly rotating drum. The metal cools on the drum and may be removed from the drum in the form of a strip.

It has been found that the foil 4 of high relative permeability constitutes a low reluctance path for magnetic field and, when a distribution line, as illustrated in Figure 1 is utilised, on the side of the transmission line where the foil is provided there is a 100 fold reduction in the flux that causes the radio frequency interference, (as compared with an equivalent transmission line without a foil of relatively high permeability) and on the other side of the transmission line there is a ten fold reduction in the flux.

The embodiment of Figure 1 may be altered by providing a second foil corresponding to the foil 4, the second foil being secured to the exposed face of conductor 1.

Figure 2 illustrates a second embodiment of the invention in which the conductors 1 and 2 are as described above, with the insulating layer 3 being of the same width as that of the conductors 1 and 2. In this embodiment, a foil 4 of high permeability material is provided in contact with the conductor 2, but has the same width as the width of the conductor 2. A second foil 5, of high permeability material, which corresponds directly with foil 4, is connected to the conductor 1.

It is found that by providing a foil of high relative permeability adjacent each of the conductors 1 and 2, the flux that generates the radio frequency interference signal is reduced, on each side of the distribution line, of a factor of approximately 1,000. In the embodiment of Figure 2 the foils have the same width as the width of the conductors. This provides a transmission line which is easy to handle, and which, if desired, may be easily provided with an insulating sheath. However, because the foils 4 and 5 do not extend beyond the conductors, the shielding effect provided by the foils 4 and 5 is not as great as it would be if the foils 4 and 5 were wider than the conductors 1,2.

Figure 3 illustrates a further embodiment of a transmission line. In this embodiment of the invention, the copper conductor 1 is provided with a central core region 10 which extends axially of the transmission line and, on either side thereof, two further spaced apart regions 11,12, which extend in parallelism with the core region 10. Similarly the conductor 3 comprises a central core region 13 and, on either side, two further spaced apart regions 14,15. The conductors 1 and 2 are separated by an insulating layer 3. The conductor 1 is separated from a foil 5 of high permeability by a thin insulating layer 16. Equally, the conductor 2 is separated from the foil 4 by means of a thin insulating layer 17. The spaces between the various parts of each conductor 1 and 2 may be filled with an adhesive such as an acrylic adhesive.

The entire arrangement, as so far described, is covered by an outer sleeve 18 of an appropriate insulating material, such as a plastic material.

It is to be appreciated that in the transmission line of Figure 3, the layers of foil of high permeability material are separated from the conductive layers with which they are associated by means of a respective thin layer of an insulating material.

It is to be appreciated that in the transmission line of Figure 3, each conductive layer is formed of a central core and further components which extend parallel with that core but spaced therefrom. The provision of an arrangement of this type has been found to reduce eddy-currents which might otherwise occur at the edge of a relatively large flat conductive core. The provision of an adhesive between the various components of the conductive element help ensure that the various layers that form the laminate that constitutes the distribution line illustrated in Figure 3, remain in a predetermined position relative to each other.

It has been found that distribution lines of the type described above provide very low inductance, low resistance and high capacitance. The capacitance provided by the distribution line can be incorporated into the circuit of the power generator which is utilised as a supply power through the distribution line, for example as part of a resonating circuit.

It is preferred to use an appropriate insulating material for the insulating sheet 3 between the conductors 1 and 2 so that the capacitance is of a high quality, that is to say with a low power loss. The polyester material mentioned above provides good characteristics and is suitable for use at a low to medium temperature. Polypropylene provides better characteristics, but is only suitable for use at low temperatures. Polyphenylene sulphide provides good properties, and is suitable for use at high to medium temperatures.

Referring now to Figure 4 of the accompanying drawings, a power distribution arrangement in accordance with the invention is illustrated.

Referring to Figure 4, a mains supply 20 is connected to a power factor corrector 21. The power factor corrector is intended to ensure that the power factor of the current drawn by the load is appropriate. In this embodiment of the invention the power factor corrector is a rectifier which produces a 340 volt DC output.

The output of the power factor corrector 21 is provided to a high frequency inverter 22. The output of the high frequency inverter 22 is typically 10 kHz or greater. The preferred frequency is 60 kHz. The output of the inverter 22 is connected to a transformer 23 which must be considered to be "optional". The transformer 23 may provide an isolating function, separating, electrically, the components now to be described from the components described above. The transformer may step the output voltage, provided by the inverter 22, either up or down, as is desired.

The output of the transformer 23 is connected to a transmission line 24. The transmission line 24 may have the form as illustrated, for example, in Figure 1, or Figure 2 or Figure 3 and as described above.

The two conductors 1,2 of the power distribution line 24 may be connected, as illustrated, directly to a load 25. The load 25 may comprise an appropriate incandescent lamp, or could comprise a heater or some other equivalent device.

A transformer 26 may have a primary winding connected to the two conductors of the distribution line 24. The secondary winding of the transformer may be connected to a load 27. Because the alternating current present on the distribution line 24 has a high frequency, in excess of 10 kHz, the transformer need physically only be very small. The load may comprise, for example, a 12 volt dichroic incandescent lamp or, alternatively, a discharge lamp. Of course, in the case of a discharge lamp, an appropriate impedance, such as an inductance, will need to be incorporated within the circuit to act as a ballast.

Alternatively, one conductor of the distribution line 24 may be connected by means of an inductor 28 to a load 29, the other conductor in the distribution line 24 being connected directly to the load. The load may comprise a discharge lamp. The inductor 28 provides an appropriate ballasting effect.

Whilst only one load connection of each of the three types discussed above is provided, it is to be understood that a power distribution arrangement in accordance with the invention may supply power to a large number of loads.

Figure 5 illustrates a transmission line 3 of the types shown in Figure 2. A clip 22 is provided which has two spaced apart blades 33,34, which engages the opposed faces of the transmission line. Although the high permeability foils 4 and 5 are amorphous and thus have a high resistance, nevertheless, since the blades 33,34 of the clip 25 engage a substantial area of the foils 4 and 5, the arms of the clip may provide an appropriate power-take-off. The arms of the clip may be connected to, for example, a housing 35 which contains an appropriate transformer to an item which is to be supplied with electrical power. Thus, a clip as shown may establish the content between a load and a distribution line.

In an arrangement as described, the electric power is distributed at a high frequency. Problems that might arise, in connection with the use of a high frequency distribution system, as a consequence of "interference", are overcome by the use of the specific transmission line which incorporates two substantially flat conductors which are located in spaced parallelism, very close to each other, and which are separated by an appropriate insulator. The problem of interference may be reduced further by providing the high permeability material mentioned above.

The power may be distributed at a moderate voltage, for example, 300-340 RMS, or 150-170 RMS or approximately 85 RMS. If the power is distributed at a moderate voltage and needs to be transformed to a lower or higher voltage at the point of utilisation only a physically small transformer need be utilised, because of the high frequency.

It has been found that in utilising a preferred embodiment of the invention, it is possible to connect a mains supply 20 through an appropriate power factor corrector 21 to a high frequency distribution system, with a plurality of lamps being connected to the distribution system, each lamp being associated with its own electronic ballast. Because the lamps are provided with high frequency alternating current, ballasts need only be small and light and if the lamps are discharge lamps, it is possible to obtain high efficiency and substantially flicker-free-light. The power factor corrector satisfies the appropriate legislation, and because a distribution line of the type described with reference to Figures 1, 2 or 3 is utilised, there is virtually no H-field interference.

If the voltage present on the two conductors of the distribution line is always equal and opposite, about earth, - that is to say if the two conductors of the distribution line are provided with an alternating voltage in anti-phase about earth - then only a very small electric field, E, is generated.

In the described embodiment, a main supply is connected through a power factor corrector to a high frequency inverter to generate the initial high frequency. However, in alternative embodiments of the invention, the high frequency may be generated directly from the mains using an appropriate frequency generator.

CLAIMS:

1. An electric power distribution arrangement comprising a source of alternating current having a frequency of 10 kHz or greater, a distribution line connected to said source, the distribution line comprising two conductors, each of substantially flat configuration, the conductors being located in spaced parallelism and being located a short distance apart, being separated by an insulator, and at least one load connected to said conductors to receive electric power therefrom.

2. An arrangement according to Claim 1 wherein the load is connected directly to the two conductors.

3. An arrangement according to Claim 1 wherein the load is connected to the conductors by means of a transformer, the transformer having a primary winding connected to the two conductors, and having a secondary winding connected to the load.

4. An arrangement according to Claim 3 wherein the load comprises a low voltage incandescent lamp.

5. An arrangement according to Claim 3 wherein the load comprises a discharge lamp, an impedance being provided which is connected in circuit with the secondary winding and the discharge lamp.

6. An arrangement according to Claim 1 wherein the or each load comprises a discharge lamp connected to one conductor of the distribution line by means of an

inductance and connected directly to the other conductor of the distribution line.

7. An arrangement according to any one of the preceding Claims wherein the source of alternating current comprises a power factor corrector which receives supply from a mains electricity supply, and an inverter which receives power from the power factor corrector.

8. An arrangement according to Claim 7 wherein the power factor corrector comprises a rectifier producing a DC output, the DC output of the power factor corrector being provided as an input to the inverter.

9. An arrangement according to any one of the preceding Claims wherein a transformer is provided located between the source of high frequency current and the distribution line.

10. An arrangement according to any one of the preceding Claims wherein at least one of the conductors of the transmission line is associated with a further element formed of a material of high relative permeability.

11. An arrangement according to Claim 10 where a second element of high permeability is provided associated with the other conductor.

12. An arrangement according to Claim 10 or 11 wherein the or each element of high relative permeability extends laterally beyond the associated flat conductor.

13. An arrangement according to Claim 10, 11 or 12 wherein the or each element of high permeability is formed of a amorphous or nano-crystalline metal.

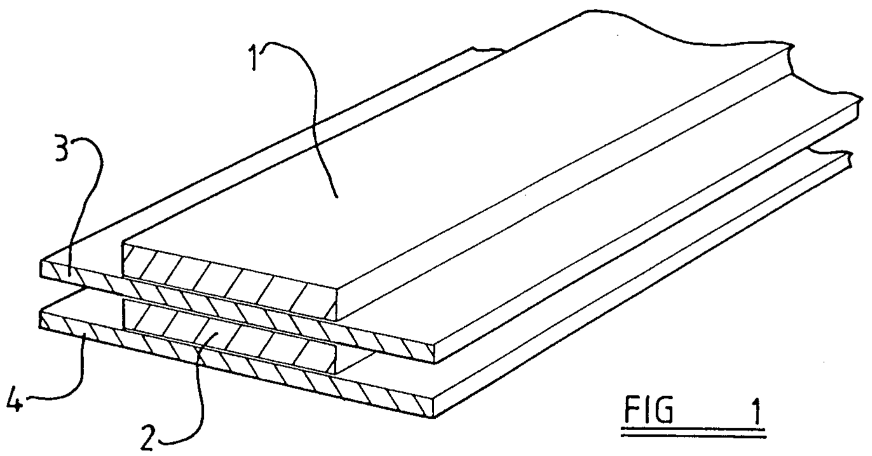


FIG 1

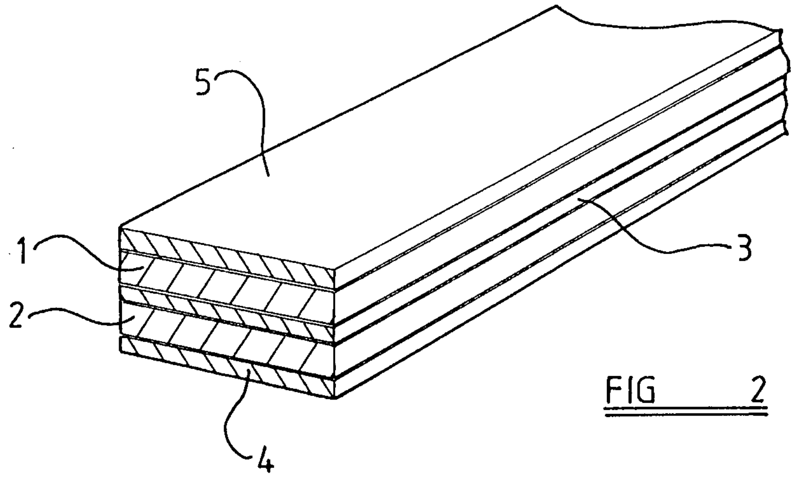


FIG 2

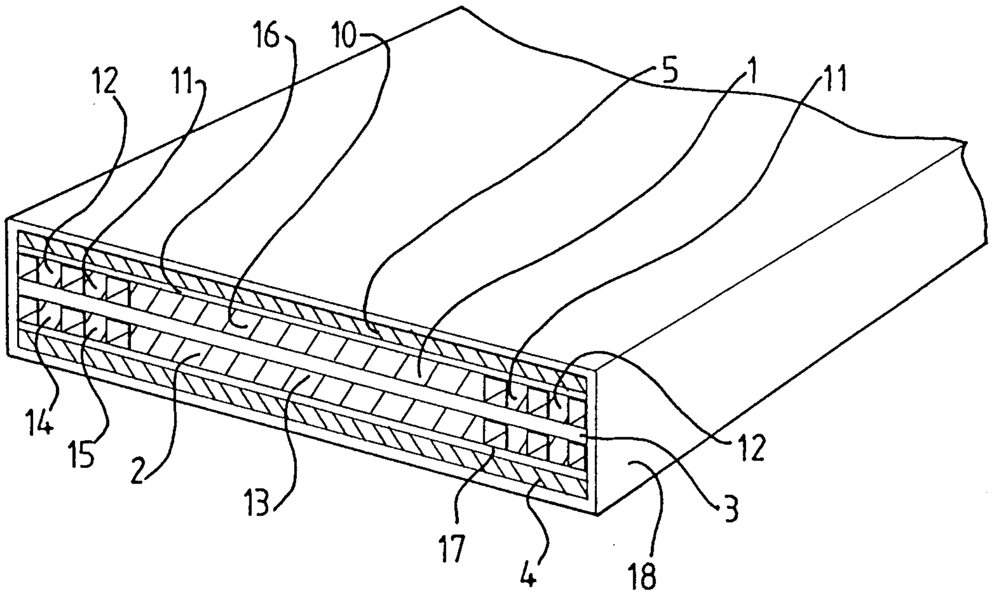


FIG 3

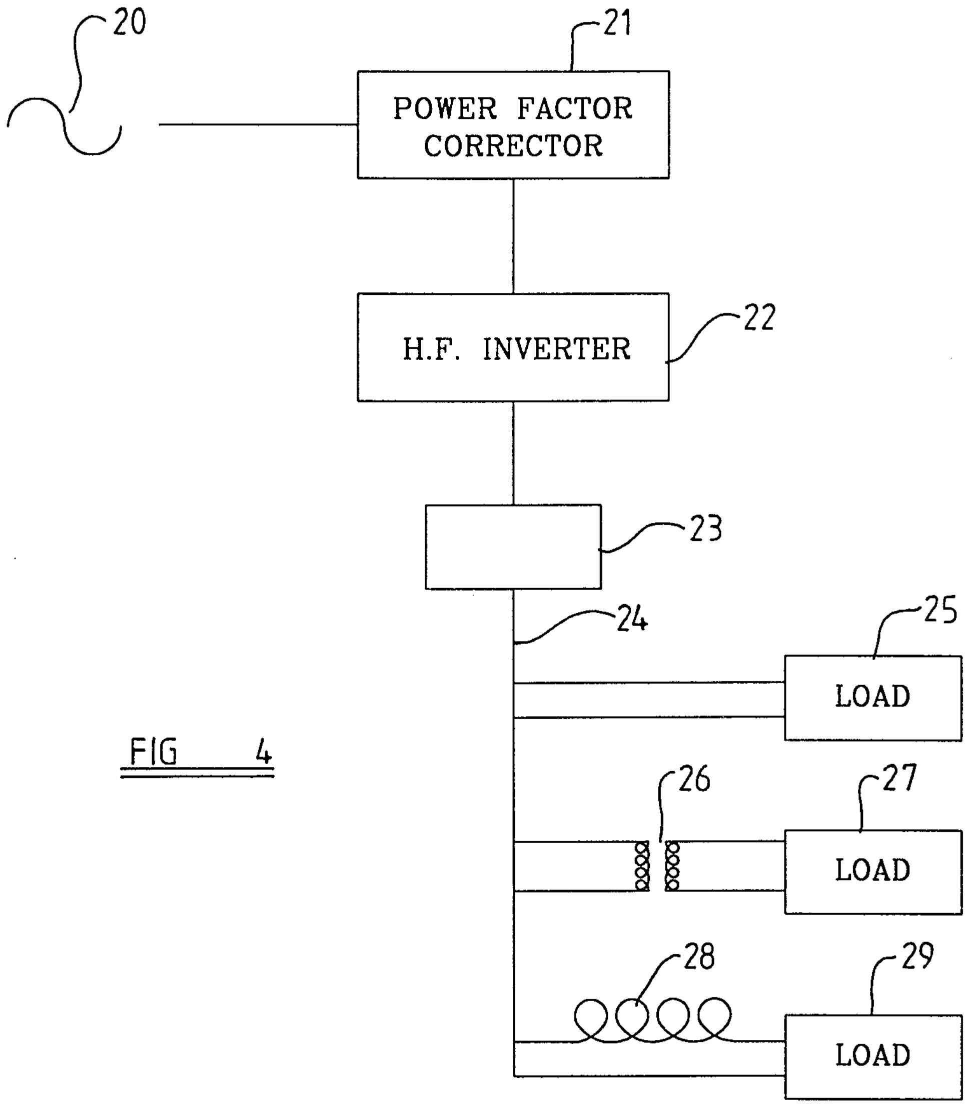
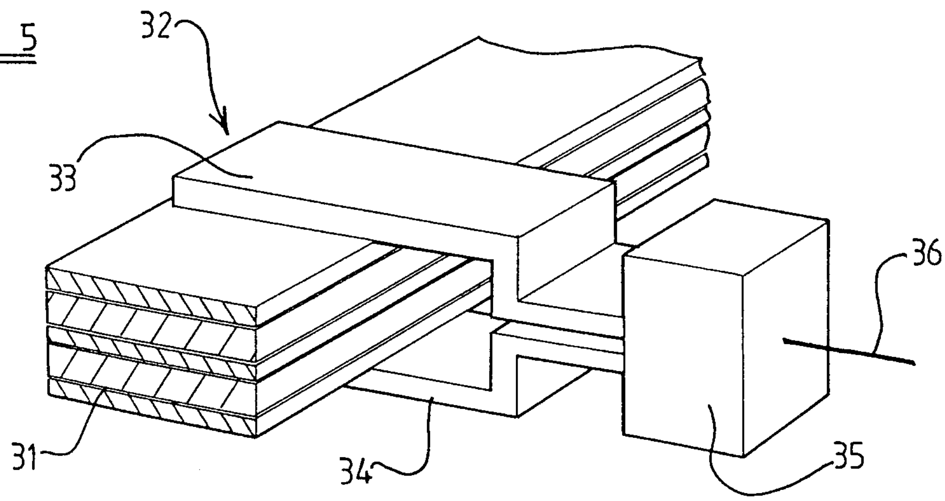

20
21
POWER FACTOR CORRECTOR
H.F. INVERTER
22
23
24
25
LOAD
26
27
LOAD
28
29
LOAD

FIG 4

FIG 5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INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05B41/24 H01B7/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05B H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	GB 2 012 097 A (MAYER F) 18 July 1979 see page 1, line 5 - page 2, line 28; figure 2 ---	1,3-5,9, 10,12,13
A	EP 0 397 080 A (FILOTEX SA) 14 November 1990 see column 2, line 13 - line 52; figures 1-3 --- -/--	2,6

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 December 1997	18/12/1997

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INTERNATIONAL SEARCH REPORT

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