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(71) Applicant *(for all designated States except US)*: **ENERGIA EUROPA S.R.L.** [IT/IT]; Via Villaraspa, 19, I-36061 Bassano Del Grappa (VI) (IT).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **D'ANTUONO, Ernesto** [IT/IT]; Via Spinà, 42, I-36033 Isola Vicentina (VI) (IT).

(74) Agent: **BONINI, Ercole**; Studio Bonini SRL, Corso Fogazzaro, 8, I-36100 Vicenza (IT).

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(54) **Title**: AN IMPROVED, HIGH-EFFICIENCY, ENERGY-SAVING DEVICE FOR INSERTING BETWEEN A POWER SOURCE AND A MOTIVE AND/OR LIGHTING POWER LOAD

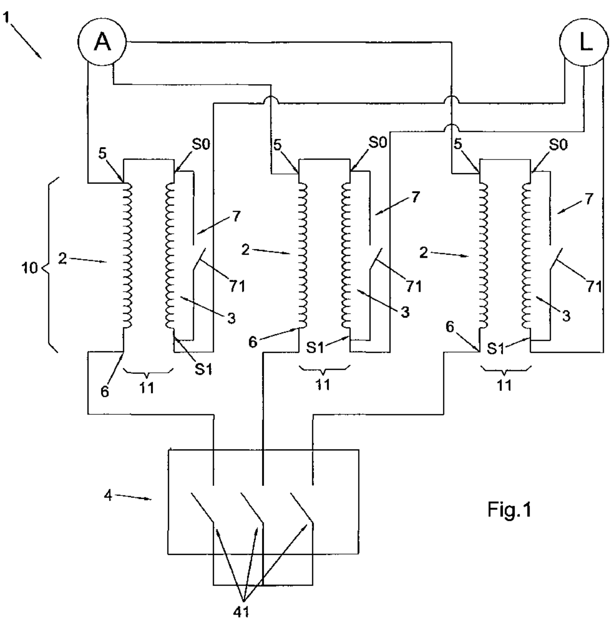

Fig.1

(57) **Abstract**: An energy-saving device (1) inserted between a three-phase power supply (A) and a three-phase load (L), comprising a three-phase electrical transformer (10), each phase of which includes a transformation assembly (1 1) with a primary winding (2) connected at a first end (5) to one phase of the power supply (A) and electromagnetically coupled to a secondary winding (3) connected at its second end (S1) to one phase of the load (L). The device (1) involves the primary winding (2) comprising two portions (21, 22), where a principal portion (21) extends between a first point (PO) and a second point (P1), and the second portion (22) extends from the second point (P1) to a third point (P2). The device also involves each of the transformation assemblies (11) being dimensioned so that the value of the voltage (Vpo-p2) established between the first point (P0) and the third point (P2) of the primary winding (2) is in the range defined by the voltage (Vkvp), applied to the principal portion (21) multiplied by the coefficients 1.2043 - 2% and 1.2043 + 2%; the value of the voltage (Vso-si) between the first end (SO) and the second end (S1) of the secondary winding (3) is in the range defined by the voltage (Vkvp), multiplied by the coefficient 0.1021 - 5% and 0.1021 + 5%; the value of the current (IPO-PI) flowing through the principal portion (21) is in the range defined by the current (Ikas) flowing through the secondary winding multiplied by the coefficients 0.1133 - 5% and 0.1133 + 5%; the value of the current (lPi.p2) flowing in the second portion (22) is in the range defined by the current (Ikas) multiplied by the coefficients 0.0940 - 5% and 0.0940 + 5%; the value of the magnetic induction relating to the configuration defined by the first point (P0) and the third point (P2) of the primary winding (2) and of the secondary winding (3) is in the range defined by the coefficient of magnetic induction (Ckim) for the configuration defined by the principal portion (21) of the primary winding (2) and of the secondary winding (3) multiplied by the coefficients 0.9965 - 0.03% and 0.9965 + 0.03%.

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AN IMPROVED, HIGH-EFFICIENCY, ENERGY-SAVING DEVICE FOR INSERTING BETWEEN A POWER SOURCE AND A MOTIVE AND/OR LIGHTING POWER LOAD

DESCRIPTION

This invention concerns an energy-saving device capable of reducing the energy consumption determined during the supply of electrical energy from a power source to a load.

It is common knowledge that it is necessary to transform the values of the electrical energy supplied by the mains power supply network in order to suitably power one or more loads consuming motive and/or lighting power.

To achieve said transformation it is consequently necessary to insert a static electrical machine between the power source and the loads to supply that is capable of converting the values of the input electrical quantities, i.e. the input voltage V_i and the input current I_i, into suitable output values V_o and I_o.

Such machine is known by the name of power transformer.

It is also common knowledge that a transformer generally incurs energy losses due to various factors, such as the loss in potential due to the Joule effect in the windings, or the losses due to dispersion of the flows.

These unwanted losses coincide with a high energy consumption during the operation of a transformer and a consequently reduced efficiency.

The above-mentioned disadvantages are greater, the higher the power of the electrical energy being controlled.

For this reason, energy-saving devices have been proposed on the market for inserting and enabling between a three-phase power source and one or more three-phase loads in order to attenuate the above-described drawbacks.

Even using such devices, however, it is still impossible to obtain the desirable optimal energy saving.

The present invention aims to overcome the aforesaid drawbacks.

In particular, the main object of the invention is to produce an energy-saving device that is more efficient than the devices according to the known state of the art.

Another object of the present invention is to produce an energy-saving device capable of attenuating the harmonics contained in the signals of the electrical quantities involved.

A further object of the present invention is to produce an energy-saving device capable of attenuating the distortions coming from the power supply network.

Another object of the invention is to produce an energy-saving device capable of attenuating the inrush current peaks when the transformer starts up, with a balancing of the energy transmission.

Another object of the invention is to produce an energy-saving device capable of attenuating the current peaks in the waveforms at the rated frequency.

A further, not necessarily last, object of the invention is to produce an energy-saving device capable of optimising the regulation of the energy transmission.

The aforesaid objects are achieved by the energy-saving device according to the invention, the characteristics of which are described in the main claim.

In particular, the energy-saving device according to the invention is designed to be inserted between a three-phase power source and a three-phase load, said energy-saving device comprising a three-phase power transformer, each phase of which involves a primary winding electromagnetically coupled to a secondary winding, wherein the primary winding comprises at least two adjacent portions of suitably dimensioned winding.

In particular, the various elements comprising each phase of the three-phase transformer (hereinafter, for the sake of simplicity, called the "transformation assembly") are dimensioned with reference to the rated voltages established on one of the aforesaid two portions (configured as the principal portion), the rated current identified on the secondary winding, and the value of the magnetic induction relating to the configuration defined by said principal portion of the primary winding and secondary winding.

Said reference values are multiplied by specific ratio coefficients, described in detail below, that enable the dimensioning of the various elements forming part of the energy-saving device according to the invention, thereby achieving a high level of efficiency.

Further characteristics of the energy-saving device according to the invention are described in the dependent claims.

The fact that the energy-saving device according to the invention, in the preferred embodiments described in detail below, advantageously involves first and second switching means, enables the passage from a configuration in which said device is enabled to another configuration in which it is disabled without giving rise to anomalous transient operating conditions that could damage the device.

The above-mentioned objects and advantages are further illustrated in a description of several preferred embodiments of the invention given below as non-limiting examples with reference to the attached drawings, wherein:

- fig. 1 schematically represents the electrical configuration of the energy-saving device according to the invention;
- fig. 2 schematically represents the feedback control that is established during the use of the energy-saving device according to the invention;
- fig. 3 schematically represents a first embodiment of a single transformation assembly belonging to the three-phase transformer of the energy-saving device according to the invention;
- fig. 4 schematically represents a second embodiment of a single transformation assembly belonging to the three-phase transformer of the energy-saving device according to the invention;
- fig. 5 schematically represents a third embodiment of a single transformation assembly belonging to the three-phase transformer of the energy-saving device according to the invention;
- fig. 6 schematically represents a fourth embodiment of a single transformation assembly belonging to the three-phase transformer of the energy-saving device according to the invention;
- fig. 7 schematically represents a fifth embodiment of a single transformation assembly belonging to the three-phase transformer of the energy-saving device according to the invention;
- fig. 8 schematically represents a sixth embodiment of a single transformation assembly belonging to the three-phase transformer of the energy-saving device according to the invention;
- fig. 9 schematically represents the insertion and usage of the energy-saving device according to the invention between a power source and a load being powered;
- fig. 10 shows two graphs enabling a comparison of the energy consumption at a commercial complex respectively using (in the "saving" configuration) or not using (in the bypass configuration) the energy-saving device according to the invention.

The energy-saving device according to the invention is globally illustrated in fig. 1, where it is indicated by the numeral **1**.

As shown in the diagram in fig. 9, the energy-saving device according to the invention is designed to be inserted between a three-phase power source **A** (such as a three-phase mains power supply) and one or more three-phase loads **L**, which may be of the motive and/or lighting power type.

In particular, the energy-saving device **1** according to the invention comprises a three-phase transformer **10**, wherein each phase - called the transformation assembly **11** - comprises a primary winding **2** electromagnetically coupled to a secondary winding **3**.

As shown in fig. 1, each transformation assembly **11** of the three-phase transformer **10** involves a first end **5** of the primary winding **2** being connected to one phase of the power source **A**, while the second end **S1** of the secondary winding **3** is connected to one of the phases of the three-phase load **L**.

According to the invention, the first end **5** of each primary winding **2** is short-circuited to the first end **S0** of the corresponding secondary winding **3** so as to define a common reference for said two windings **2** and **3**.

Again as shown in fig. 1, the second ends **6** of the primary windings **2** of each transformation assembly **11** have a common connection by means of first switching means **4**, which enable the enabling or disabling of the energy-saving device **1** inserted between the power source **A** and the load **L** to be powered.

The presence of said first switching means **4** thus enables the energy-saving device **1** according to the invention to be switched from a condition in which it is enabled (called the “saving” configuration in technical jargon) to a condition in which said energy-saving device **1** is disabled and bypassed, and consequently in the so-called “bypass” configuration.

Said first switching means **4** may preferably, but not necessarily, comprise a remote control switch **41** with three contacts, each of which is associated with a transformation assembly **11** of said three-phase transformer **10**.

To be able to switch safely from the saving configuration to the bypass configuration, and vice versa, without incurring in transient operating conditions of the energy-saving device **1** that could interfere with its performance or even cause damage, said device **1** according to the invention comprises second switching means **7** that are placed in parallel with each secondary winding **3** of each transformation assembly **11**, as shown in fig. 1.

Said second switching means **7** may preferably, but not necessarily, comprise an isolator **71** with three contacts, each of which is placed in parallel with a corresponding secondary winding **3** of each transformation assembly **11**.

It is consequently possible to switch from the saving configuration to the bypass configuration, and vice versa, in total safety and without giving rise to anomalous transient operating conditions of the energy-saving device **1** according to the invention.

In particular, when the energy-saving device **1** is operating in the saving configuration, the first switching means **4** are in the "on" condition, i.e. they close the contact between the second ends **6** of the three primary windings **2**, while the second switching means **7** are in the "off", i.e. open, condition and consequently all of the current induced by each primary winding **2** flows through the corresponding secondary winding **3**.

Thus, in order to switch to the bypass configuration of the energy-saving device **1** according to the invention, the first step to take is to switch the first switching means **4** to the "off" condition, and thereby open the contact, and only subsequently to switch the second switching means **7** to the "on" condition, thereby short-circuiting each secondary winding **3**.

Then to return from the bypass configuration to the saving configuration of the energy-saving device **1** according to the invention, it is necessary to proceed first to switch said second switching means **7** to the "off" condition, i.e. their contact is opened, and only subsequently to switch the first switching means **4** to the "on" condition, i.e. by restoring the common connection between the second ends **6** of the three primary windings **2**.

In a first embodiment of the energy-saving device **1** according to the invention as shown in fig. 3, the primary winding **2** of each transformation assembly **11** comprises two portions of winding **21** and **22** electrically connected in series.

In said embodiment in particular, there is a principal portion **21** extending between a first point **P0** (that in this case coincides with the first end **5**) and a second point **P1** of the primary winding **2**, while the second portion of winding **22** extends from said second point **P1** to a third point identified in fig. 3 as **P2**, which coincides with the second end **6**.

Again according to the invention, each pair comprising the primary **2** and secondary **3** windings of the energy-saving device **1** according to the invention is dimensioned so that the value of the voltage V_{P0-P2} established between the first point **P0** and the third point **P2** of the primary winding **2** - and therefore, in

this embodiment, the voltage value established on the whole primary winding **2** - is in the range defined by the voltage V_{kvp} applied to the principal portion **21** multiplied by the coefficients 1.2043 - 2% and 1.2043 + 2%.
In particular, the value established for the voltage V_{P0-P2} is preferably, but not necessarily, the result of V_{kvp} multiplied by the coefficient 1.2043.
According to the invention, moreover, the dimensioning of each transformation assembly **11** must be such that the value of the voltage V_{S0-S1} between the first end **S0** and the second end **S1** of the secondary winding **3** is in the range defined by said voltage V_{kvp} multiplied by the coefficients 0.1021 - 5% and 0.1021 + 5%.
Here again, the value of V_{S0-S1} is preferably, but not necessarily, obtained by multiplying the voltage V_{kvp} by the coefficient 0.1021.
To adequately dimension both the primary winding **2** and the secondary winding **3** of each transformation assembly **11** in the energy-saving device **1** according to the invention, the value of the current I_{P0-P1} that flows through the main portion **21** of the primary winding **2** must also be defined.
In particular, said current value I_{P0-P1} is in the range defined by the current I_{kas} flowing in the secondary winding **3** multiplied by the coefficients 0.1133 - 5% and 0.1133 + 5%.
The value of the current I_{P0-P1} is preferably, but not necessarily, the current I_{kas} multiplied by the coefficient 0.1133.
Likewise, the value of the current I_{P1-P2} flowing in the second portion **22** shall be in the range defined by said current I_{kas} multiplied by the coefficients 0.0940 - 5% and 0.0940 + 5%.
More precisely, the value of the current I_{P1-P2} is the current I_{kas} multiplied by the coefficient 0.0940.
Finally, each transformation assembly **11** forming part of the energy-saving device **1** according to the invention is dimensioned so that the value of the magnetic induction relating to the configuration defined by the primary winding **2**, delimited between the first point **P0** and the third point **P2**, and by the secondary winding **3** is in the range defined by the coefficient of magnetic induction C_{kim} relating to the configuration comprising the principal portion **21** of said primary winding **2** and secondary winding **3**, multiplied by the coefficients 0.9965 - 0.03% and 0.9965 + 0.03%.
Said value of the magnetic induction is preferably, but not necessarily, the

coefficient of magnetic induction C_{kim} multiplied by the coefficient 0.9965.

A second embodiment of the energy-saving device **1** according to the invention involves each transformation assembly **11** having a further portion **23** added to the primary winding **2**, as shown in fig. 4, by comparison with said first embodiment in fig. 3, extending from the third point **P2** up to a fourth point **P3**, that in this case coincides with the second end **6**.

Here again, said portion **23** is dimensioned so that the value of the voltage V_{P0-P3} established between the first point **P0** and the fourth point **P3** of the primary winding **2** is in the range defined by said voltage V_{kvp} multiplied by the coefficients 1.5149 - 2% and 1.5149 + 2%.

More precisely, said embodiment involves the voltage value V_{P0-P3} to obtain being the result of the voltage V_{kvp} multiplied by the coefficient 1.5149.

The value of the current I_{P2-P3} flowing through said third portion **23** is in the range defined by the current I_{kas} multiplied by the coefficients 0.0748 - 5% and 0.0748 + 5%.

Said current value I_{P2-P3} flowing through said third portion **23** is preferably, but not necessarily, I_{kas} multiplied by 0.0748.

A third embodiment of the energy-saving device **1** involves each transformation assembly **11** differing, as illustrated in fig. 5, from that of the above-described second embodiment in that a fourth portion **24** is added to the primary winding **2**, extending from the fourth point **P3** to a fifth point **P4**, that in this case coincides with the second end **6**.

Here again, said fourth portion **24** is dimensioned so that the value of the voltage V_{P0-P4} established between the first point **P0** and said fifth point **P4** of the primary winding **2** is in the range defined by the voltage V_{kvp} multiplied by the coefficients 2.0851 - 2% and 2.0851 + 2%.

More precisely, said voltage value V_{P0-P4} coincides with the voltage V_{kvp} multiplied by the coefficient 2.0851.

In addition, the dimensioning of said fourth portion **24** is such that the value of the current I_{P3-P4} flowing through said portion is in the range defined by the current I_{kas} multiplied by the coefficients 0.0543 - 5% and 0.0543 + 5%.

Here again, said current I_{P3-P4} is preferably, but not necessarily, the product of I_{kas} multiplied by 0.0543.

Figs. 6 to 8 respectively illustrate a fourth, fifth and sixth type of transformation assembly **11** belonging to further different embodiments of the energy-saving device **1** according to the invention.

Generally speaking, all these three further embodiments have a characteristic in common, i.e. the fact that the primary winding **2** comprises a so-called safety portion **25** extending from the first point **P0** up to a sixth point defined as **-P1**, that in this case coincides with the above-mentioned first end **5**.

In detail, as shown in fig. 6, the fourth embodiment is simply the first embodiment shown in fig. 3 with the addition of the safety portion **25**, and the fifth embodiment coincides with the second embodiment of the transformation assembly **11** according to the invention, shown in fig. 4, with the addition of said safety portion **25**, as shown in fig. 7.

Said safety portion **25** is what also distinguishes the sixth embodiment of each transformation assembly **11**, shown in fig. 8, forming part of the energy-saving device **1** according to the invention, from the type of transformation assembly **11** shown in fig. 5.

In all three cases of figs. 6, 7 and 8, said safety portion **25** is dimensioned so that the value of the voltage V_{-P1-P0} established between the sixth point **-P1** and the first point **P0** of the primary winding **2** is in the range defined by the voltage V_{kvp} multiplied by the coefficients 0.6383 - 2% and 0.6383 + 2%; in particular, said voltage V_{-P1-P0} acquires the voltage value of V_{kvp} multiplied by 0.6383.

Moreover, said dimensioning enables a current I_{-P1-P0} flowing through the safety portion **25** to be obtained in the range defined by said current I_{kas} multiplied by the coefficients 0.0691 - 5% and 0.0691 + 5%.

Here again, the current value I_{-P1-P0} flowing through the safety portion **25** is preferably, but not necessarily, the current I_{kas} multiplied by the coefficient 0.0691.

As for the methods with which the various elements of each transformation assembly **11** forming part of the various above-described energy-saving devices **1** according to the invention are dimensioned in order to obtain the voltage and current values required, these include choosing a suitable number of turns on the two windings **2** and **3** of each transformation assembly **11**, and/or choosing a suitable cross-section for the conductor used to make said primary and secondary windings **2** and **3**, and/or choosing the type and size of the ferromagnetic material on which said primary **2** and secondary **3** windings are wound.

As concerns the value of the voltage V_{kvp} taken as a reference for the dimensioning of the various elements in each transformation assembly **11** for the various embodiments of the energy-saving device **1** according to the invention, this may preferably, but not necessarily coincide with the rated voltage of the mains power supply network.

It is nonetheless possible, in different embodiments of the energy-saving device **1** according to the invention, to have a value of the voltage V_{kvp} differing from the voltage of the mains power supply network.

Likewise, for the coefficient of magnetic induction C_{kim}, this comes preferably, but not necessarily, in the range of 0.9 to 1.5 Tesla.

Here again, however, in different embodiments of the invention, the value C_{kim} may differ from said range of 0.9 to 1.5 Tesla.

As for the current I_{kas}, this obviously depends on the load connected to each secondary winding **3** on each transformation assembly **11** forming part of the energy-saving device **1** according to the invention.

It is important to note that the objects of the invention are achieved by all the previously-described configurations of the energy-saving device **1**, in that they advantageously enable a system of feedback control on the energy characteristics, and the harmonics in particular, contained in the signals, i.e. V_i and I_i, supplied as input to said device **1** according to the invention.

In particular, it is possible to obtain a deamplification system designed to attenuate the non-functional energy characteristics of the input energy quantities V_i and I_i that interfere with the efficiency of the energy-saving device **1** and of the load **L**.

In detail, from the functional standpoint, as shown in the diagram in fig. 2, the currents I_2 that flow in the secondary winding **3** of each transformation assembly **11**, induce a counter current on each primary winding **2** as a result of magnetic induction that contrasts and reduces the above-mentioned non-functional energy characteristics, and the harmonics in particular, of the input energy quantities V_i and I_i in the primary winding **2**.

It is therefore possible to achieve a system for the transformation and supply of electrical energy to a load **L** that enables output electrical quantities to be obtained with more limited non-functional electrical characteristics (harmonics) and that operates in a smoother and slower steady state both during the inrush phases and when operating at the rated frequency.

From experiments conducted by the applicant, as shown in the diagram in fig. 10, the use of the energy-saving device **1** according to the invention enables an energy saving of no less than 10% to be obtained by comparison with the use of the energy-saving devices according to the known state of the art.

In particular, these tests were conducted at a commercial complex covering approximately 6000 m² and lasted for six days, during three of which the energy-saving device **1** according to the invention was enabled, while for the other three days said device **1** was bypassed.

The loads at the above-mentioned commercial complex consisted of approximately 8% for electronic equipment, 77% for lighting, 5% for escalators, and 10% for lifts.

From the two graphs **200** and **300** shown in fig. 10, where the graph on the left (**200**) represents the outcome of the test with the energy-saving device **1** according to the invention enabled, while the one on the right (**300**) represents the outcome of the test with said device **1** bypassed, it is clear that in both cases the energy consumption has three peaks **201** and **301** during a 24-hour period coinciding with daytime hours and three troughs **202** and **302** relating to night-time hours, i.e. when the energy consumption is determined exclusively by electronic equipment operating around the clock.

Basically, from a comparison between the two graphs **200** and **300**, it is clear that the use of the three-phase transformer **10** according to the invention coincided with a total consumption **203** of 7,107.8 kWh and a mean power absorbed **204** of 98,743.05 W, while during the days of measurements without said energy-saving device **1** enabled the total consumption **303** was 7,919.6 kWh and the mean power absorbed **304** was 109,951.6 W.

It can consequently be claimed that using the energy-saving device **1** according to the invention achieved a saving **401** of 811.8 kWh altogether (270.6 kWh per day) with a consequent monetary saving **402** of approximately 81.18 Euro (27.06 Euro a day) based on the cost of energy in Italy.

Thus, as previously claimed, the percentage energy saving achieved **403**, in this particular case, was 10.25%.

Based on the above, it is clear that the energy-saving device **1** according to the invention achieves all the previously-stated objects.

In particular, the invention achieves the object of producing an energy-saving device that is more efficient than the devices according to the known state of the art.

More in detail, the invention achieves the object of producing an energy-saving device capable of attenuating the harmonics contained in the signals of the electrical quantities involved.

In addition, the invention achieves the object of producing an energy-saving device capable of attenuating the distortions coming from the mains power supply.

Another object achieved by the invention is that it produces an energy-saving device capable of attenuating the inrush current peaks during the start-up phase, with the balancing of the energy transmission.

Another object achieved by the invention is that it produces an energy-saving device capable of attenuating the current peaks in the waveforms at the rated frequency.

Another object achieved by the invention is that it produces an energy-saving device capable of optimizing the control of the energy transmission.

In the executive phase, variants of the energy-saving device according to the invention may be developed and, even though they are not described herein, if they come within the scope of the following claims, they shall be deemed to be covered by the present patent.

Where technical characteristics are indicated in the following claims by means of reference signs, these have been added merely for the purpose of facilitating the reading of the claims and said reference signs shall consequently have no limiting effect on the protected scope of each element identified thereby for explanatory purposes.

CLAIMS

1) An energy-saving device (1) designed to be inserted between a three-phase power source (A) and a three-phase load (L), of the type comprising a three-phase electrical transformer (10), each phase of which comprises a transformation assembly (11) involving a primary winding (2) designed to be connected at a first end (5) to one phase of said power source (A) and electromagnetically coupled to a secondary winding (3) connected at its second end (S1) to a phase of said load (L), **characterized in that** said primary winding (2) comprises at least two portions (21, 22), where a principal portion (21) extends between a first point (P0) and a second point (P1), and the second portion (22) extends from said second point (P1) to a third point (P2), **and in that** each of said transformation assemblies (11) is dimensioned so that:

- the value of the voltage (V_{P0-P2}) established between said first point (P0) and said third point (P2) of said primary winding (2) is in the range defined by the voltage (V_{kvp}), applied to the principal portion (21), multiplied by the coefficient 1.2043 - 2% and 1.2043 + 2%;
- the value of the voltage (V_{S0-S1}) between the first end (S0) and said second end (S1) of said secondary winding (3) is in the range defined by said voltage (V_{kvp}), multiplied by the coefficients 0.1021 - 5% and 0.1021 + 5%;
- the value of the current (I_{P0-P1}) flowing through said principal portion (21) is in the range defined by the current (I_{kas}) that flows through said secondary winding multiplied by the coefficients 0.1133 - 5% and 0.1133 + 5%;
- the value of the current (I_{P1-P2}) flowing in said second portion (22) is in the range defined by said current (I_{kas}) multiplied by the coefficients 0.0940 - 5% and 0.0940 + 5%;
- the value of the magnetic induction for the configuration defined by said first point (P0) and said third point (P2) of said primary winding (2) and said secondary winding (3) is in the range defined by the coefficient of magnetic induction (C_{kim}) for the configuration defined by said principal portion (21) of said primary winding (2) and said secondary winding (3) multiplied by the coefficients 0.9965 - 0.03% and 0.9965 + 0.03%.

2) A device (1) according to claim 1), **characterized in that** the second ends (6) of said primary windings (2) in each of said transformation assemblies (11) lying opposite said first ends (5) are electrically connected to

one another by first switching means (4), **and in that** each of said secondary windings (3) is connected in parallel to second switching means (7) for enabling or disabling the operation of said energy-saving device (1) between said power source (A) and said load (L).

3) A device (1) according to claim 2), **characterized in that** said first switching means (4) comprise a remote control switch (41) with three contacts, each of which is associated with one of said transformation assemblies (11).

4) A device (1) according to claims 2) or 3), **characterized in that** said second switching means (7) comprise an isolator (71) with three contacts, each of which is connected in parallel to a corresponding secondary winding (3) of each of said transformation assemblies (11).

5) A device (1) according to any of the previous claims, **characterized in that** said first end (5) of each of said primary windings (2) is connected to said first end (S0) of the corresponding secondary winding (3), so as to define a common reference between said primary winding (2) and said secondary winding (3).

6) A device (1) according to any of the previous claims, **characterized in that** said primary winding (2) comprises a third portion (23) extending from said third point (P2) to a fourth point (P3), said third portion (23) being dimensioned so that:

- the value of the voltage (V_{P0-P3}) established between said first point (P0) and said fourth point (P3) of said primary winding (2) is in the range defined by said voltage (V_{kvp}) multiplied by the coefficients 1.5149 - 2% and 1.5149 + 2%;
- the value of the current (I_{P2-P3}) flowing through said third portion (23) is in the range defined by said current (I_{kas}) multiplied by the coefficients 0.0748 - 5% and 0.0748 + 5%.

7) A device (1) according to claim 6), **characterized in that** said primary winding (2) comprises a fourth portion (24) extending from said fourth point (P3) to a fifth point (P4), said fourth portion (24) being dimensioned so that:

- the value of the voltage (V_{P0-P4}) established between said first point (P0) and said fifth point (P4) of said primary winding (2) is in the range defined by said voltage (V_{kvp}) multiplied by the coefficients 2.0851 - 2% and 2.0851 + 2%;

- the value of the current (I_{P3-P4}) flowing through said fourth portion (24) is in the range defined by said current (I_{kas}) multiplied by the coefficients 0.0543 - 5% and 0.0543 + 5%.

8) A device (1) according to any of the previous claims, **characterized in that** said primary winding (2) comprises a safety portion (25) extending from said first point (P0) to a sixth point (-P1), said safety portion (25) being dimensioned so that:

- the value of the voltage (V_{-P1-P0}) established between said sixth point (-P1) and said first point (P0) of said primary winding (2) is in the range defined by said voltage (V_{kvp}) multiplied by the coefficients 0.6383 - 2% and 0.6383 + 2%;
- the value of the current (I_{-P1-P0}) flowing through said safety portion (25) is in the range defined by said current (I_{kas}) multiplied by the coefficients 0.0691 - 5% and 0.0691 + 5%.

9) A device (1) according to any of the previous claims, **characterized in that** each of said transformation assemblies (11) in said three-phase transformer (10) is dimensioned by choosing the number of turns for said primary and secondary windings (2, 3), and/or the cross-section of the conductor used to prepare said primary and secondary windings (2, 3), and/or the type and dimension of the ferromagnetic material on which said primary and secondary windings (2, 3) are wound.

10) A device (1) according to any of the previous claims, **characterized in that** said voltage (V_{kvp}) is the rated voltage of the mains power supply.

11) A device (1) according to any of the previous claims, **characterized in that** said coefficient of magnetic induction is in the range of 0.9 to 1.5 Tesla.

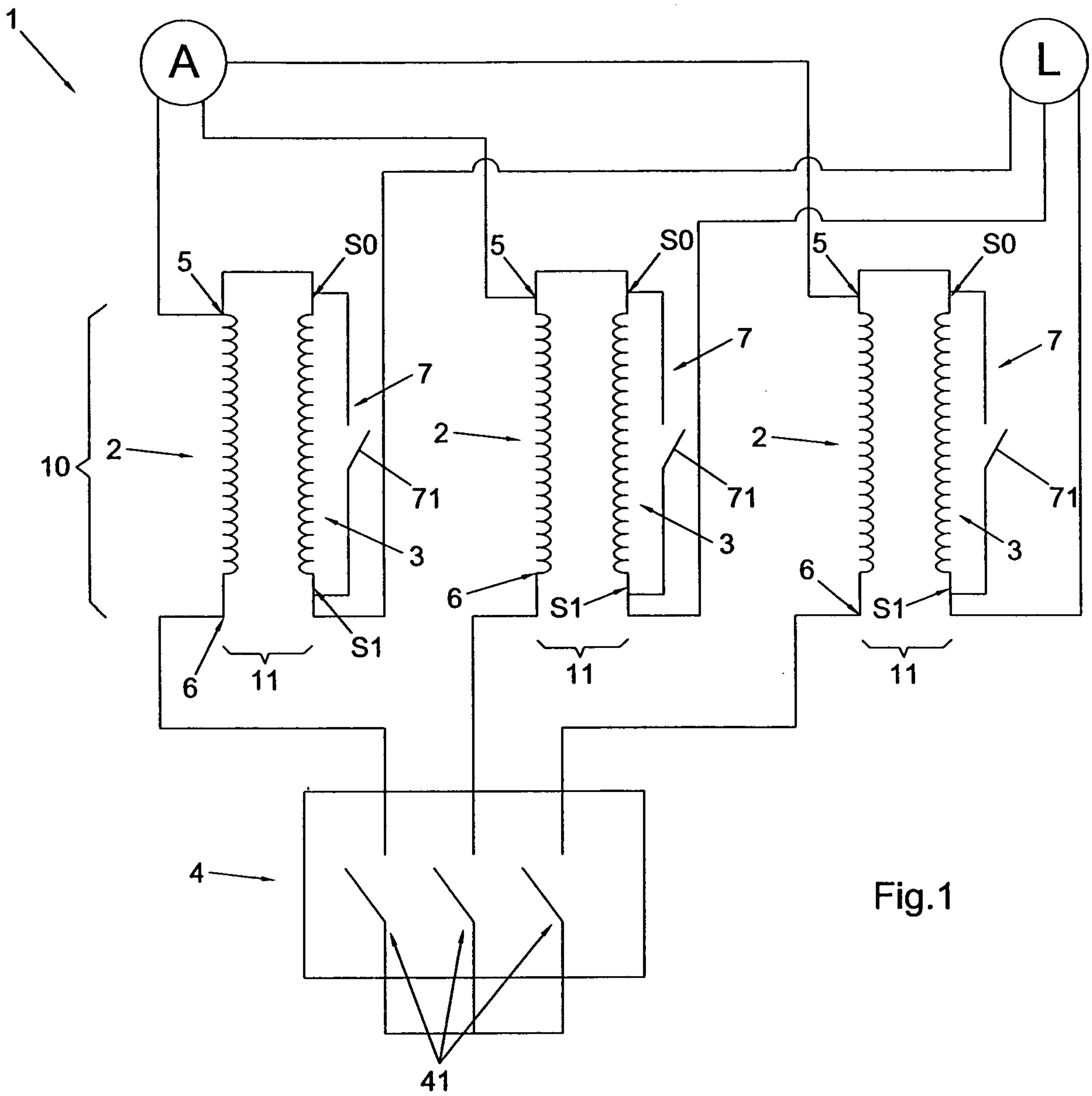

1
A
L
5
S0
7
71
3
2
10
6
11
S1
4
41

Fig.1

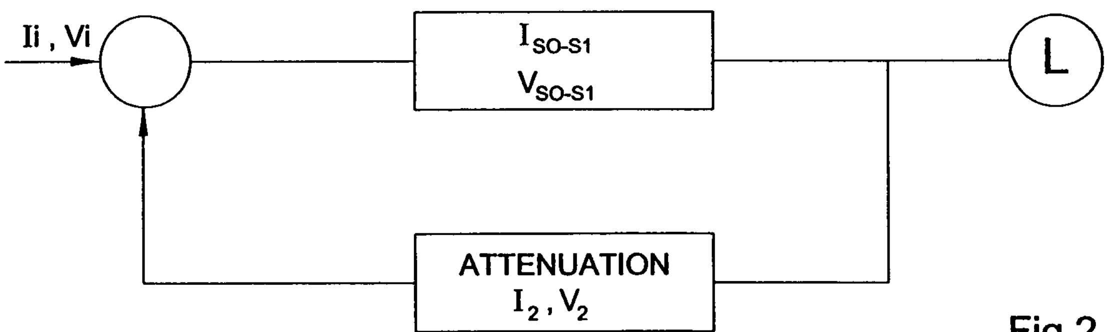

Ii , Vi
I SO-S1
V SO-S1
L
ATTENUATION
I 2 , V 2

Fig.2

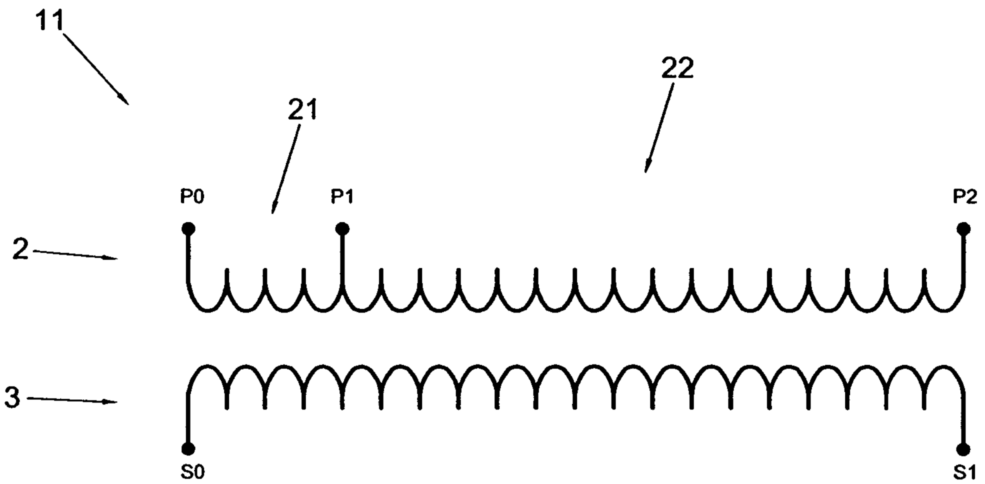


Fig.3

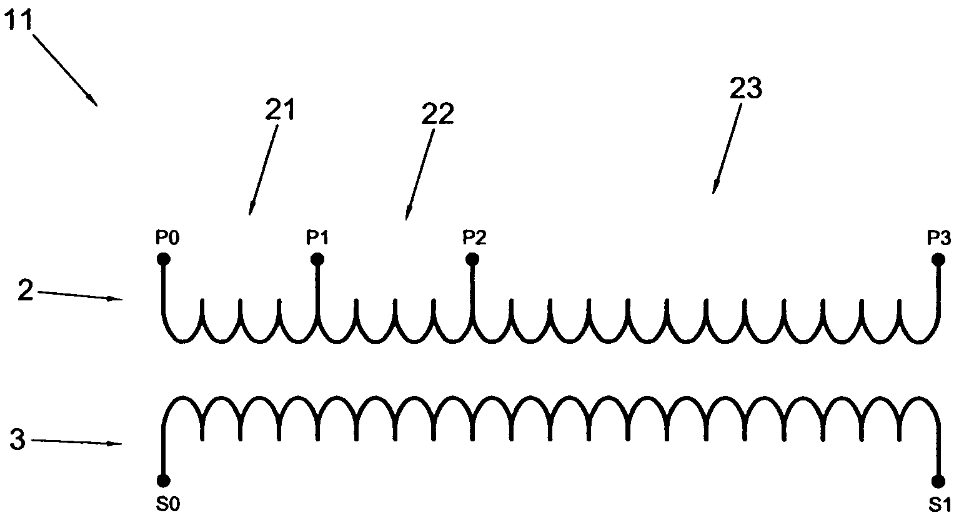


Fig.4

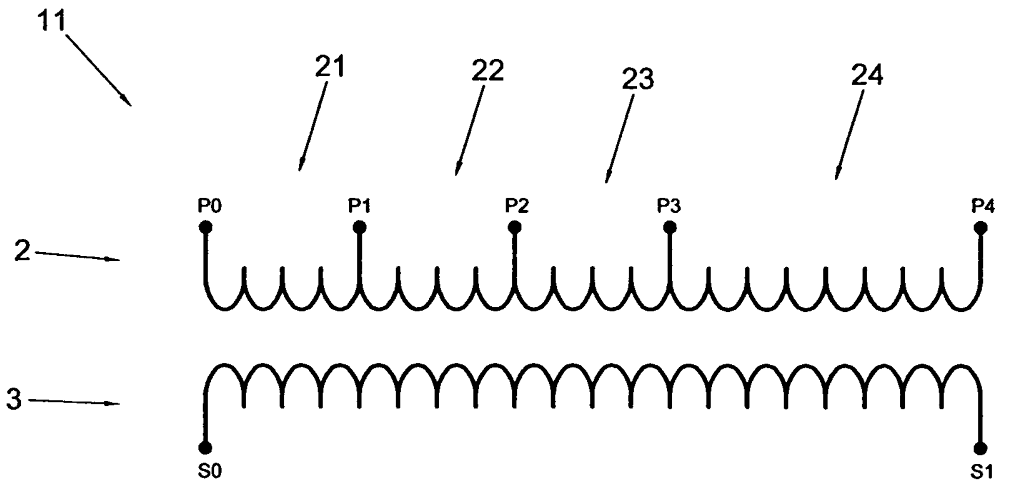


Fig.5

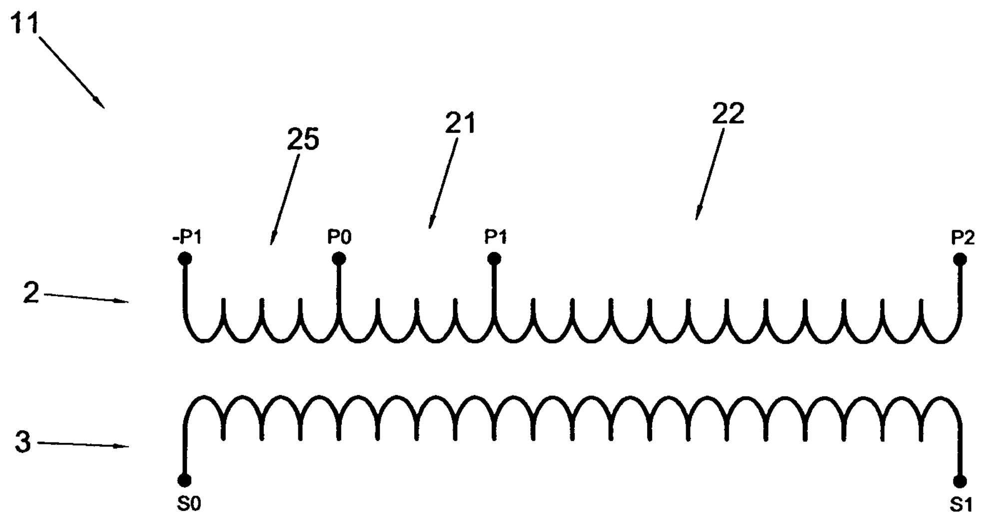


Fig.6

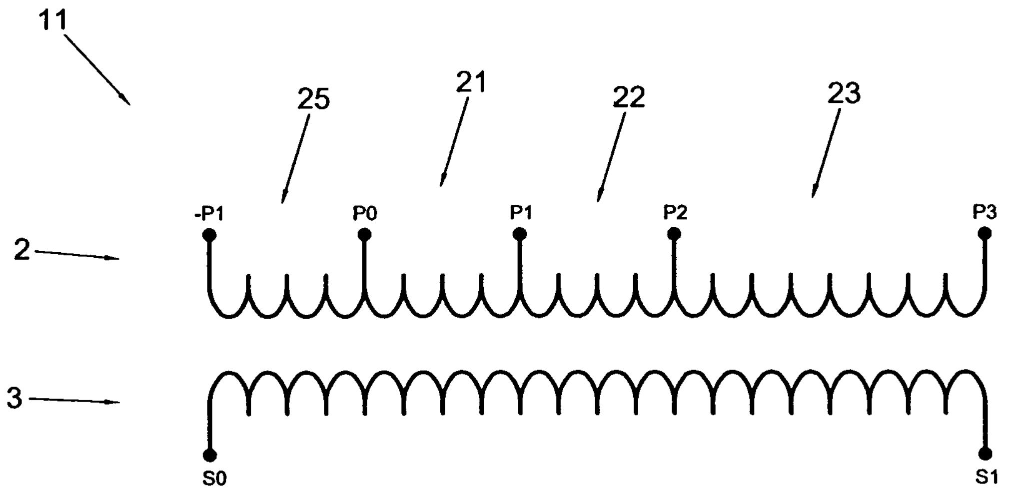

11
25
21
22
23
2
3
-P1
P0
P1
P2
P3
S0
S1

Fig.7

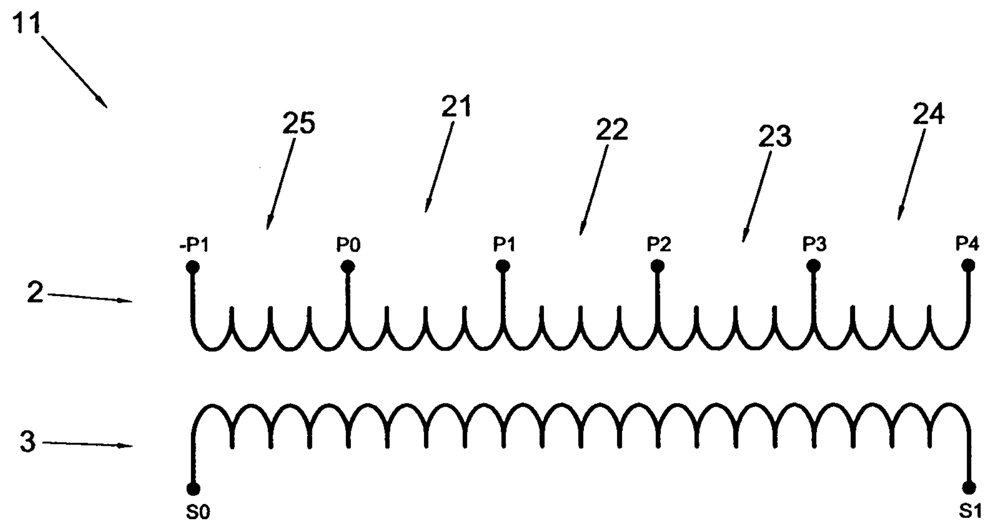

11
25
21
22
23
24
2
3
-P1
P0
P1
P2
P3
P4
S0
S1

Fig.8

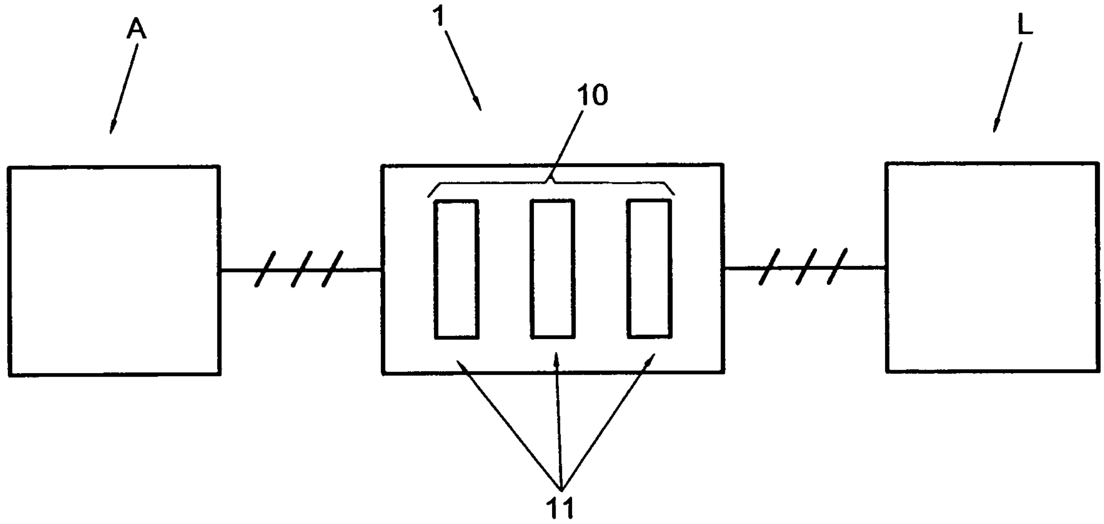
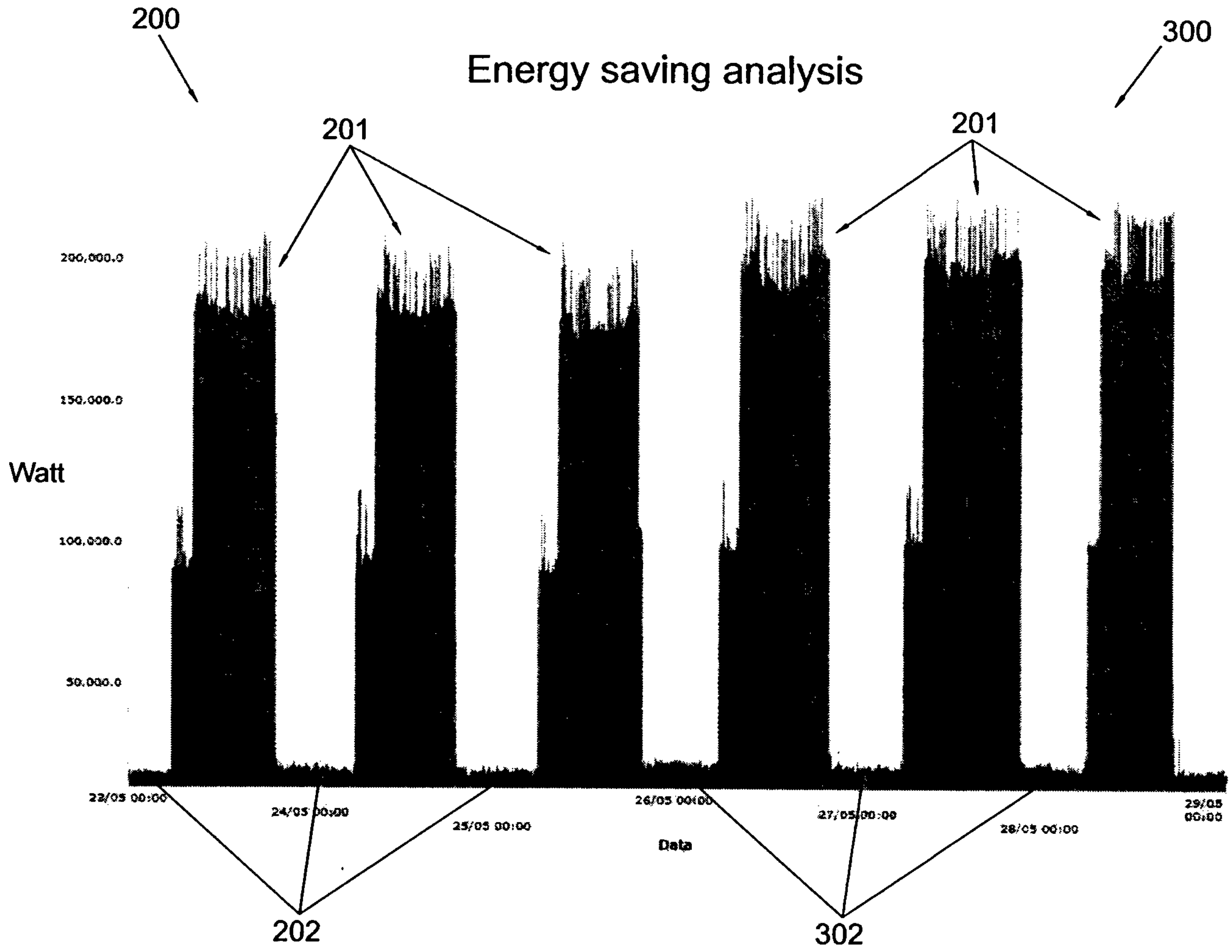


Fig.9



SAVING measurement

203 Total consumption: 7107 KWh
204 Average power: 98743,05 W

BYPASS measurement

303 Total consumption: 7919,6 KWh
304 Average power: 109951,6 W

401 Saved Energy: 811,8 KWh (270,6 per day)

402 Money saving: 81,18€ (27,06€ per day)

403 Energy saving: 10,25%

Fig.10

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2011/000275

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01F29/02 G05F1/14
ADD.

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)
H01F G05F

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)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 599 318 C (AEG) 29 July 1934 (1934-07-29) the whole document -----	1,5-11
X	WO 2007/037609 A1 (LIM JEONG-DO [KR]) 5 April 2007 (2007-04-05) abstract; figure 1 page 1, lines 24-30 page 3, line 29 - page 4, line 7 page 5, line 32 - page 6, line 16 -----	1,5-11
X	WO 97/05536 A1 (GEB ZUID HOLLAND WEST NV [NL]; ASSELMAN PAULUS GERARDUS JOHAN [NL]; GR) 13 February 1997 (1997-02-13) abstract; figure 1 page 2, line 13 - page 3, line 19 page 9, lines 1-24 -----	1,6-11

-/--

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

[X] See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 March 2012	22/03/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Reder, Michael

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JAWAD FAIZ ET AL: "New Solid-State Onload Tap-Changers Topology for Distribution Transformers", IEEE TRANSACTIONS ON POWER DELIVERY, IEEE SERVICE CENTER, NEW YORK, NY, US, vol. 18, no. 1, 1 January 2003 (2003-01-01), XP011078911, ISSN: 0885-8977 the whole document -----	1,6-11
A	JP 9 312223 A (KAWAMURA ELECTRIC INC) 2 December 1997 (1997-12-02) abstract; figure 1 -----	1-11
A	JP 10 079315 A (KAWAMURA ELECTRIC INC) 24 March 1998 (1998-03-24) abstract; figures 1,4 -----	1-11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IT2011/000275

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