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(54) **CURRENT TRANSFORMER**

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Description

Field of the Invention

[0001] The present invention relates to the field of current transformers.

Background of the Invention

[0002] Current transformers are used to scale down large primary AC electric currents to smaller electric currents which can be more easily and safely measured. Current transformers can be used to scale down single phase or multiple phase currents.

[0003] For example, a known three phase current transformer 10 is schematically illustrated in Figures 1A and 1B. In particular, Figure 1A is an external view of such a current transformer 10. The current transformer 10 comprises a casing 15 having three apertures 12a, 12b and 12c, each of which is able to receive a cable or busbar. More specifically, a cable or busbar received through each of the apertures 12a, 12b, 12c is intended to correspond to a respective phase of a three phase power supply. It will be appreciated that each cable is able to pass completely through the current transformer casing 15, emerging to continue on to its destination. Also visible in Figure 1A are six terminals arranged in three pairs, each pair corresponding to a respective phase of the three phase current transformer 10. The six terminals are protected by a cover 16.

[0004] Figure 1B is an internal cross-section of the three phase current transformer 10 of Figure 1A. Visible are three magnetic cores 18a, 18b, 18c which each surround a respective one of the apertures 12a, 12b, 12c. It will be appreciated that this arrangement puts each of the magnetic cores in proximity to a primary cable or busbar passing through one of the apertures 12a, 12b, 12c and carrying a particular phase of an electric power supply. Each of the magnetic cores 18a, 18b, 18c is provided with a secondary winding 20a, 20b, 20c wrapped around at least a portion of the respective magnetic core 18a, 18b, 18c. With this configuration, an electric current passing through the primary cable or busbar within one of the apertures 12a, 12b, 12c will produce a magnetic field in the respective magnetic core 18a, 18b, 18c which in turn induces a much smaller current in the respective secondary winding 20a, 20b, 20c. The ends of the secondary windings are connected to one of the pairs of terminals 14a, 14b, 14c. A separate measurement device (not shown) can be wired up to the terminals 14a, 14b, 14c to measure the amount of current passing through the secondary windings. The measurement device is able to estimate the amount of current passing through the primary cable or busbar based on the amount of current measured at the secondary windings and based on a known primary/secondary current ratio of the current transformer 10. This works because the amount of current induced in the secondary windings is proportional to the amount of current flowing through the primary cable or busbar.

[0005] One major disadvantage with the design of the current transformer 10 of Figures 1A and 1B is the amount of labour involved in connecting the secondary circuit (secondary windings and terminals) to a multi-function meter or the like. To achieve this, typically 12 terminals need to be loosened (6 on the transformer, 6 on the multi-function meter), 6 cables need routing, 12 cable ends need stripping, 12 crimp terminals need fitting to the exposed conductors, 12 heat shrink markers may need fitting and shrinking, 12 terminals need tightening and terminal covers need to be secured to protect contact with exposed terminals.

[0006] A common problem associated with the existing device is the relatively high probability of wiring errors, for example crossed wires, during connection of the devices. This can cause damage to the device or injury to a user.

[0007] Another major problem with current transformers in general is safety. In particular, if the secondary circuit is left open-circuit with no load across the terminals, a potentially lethal high voltage can be induced due to flux saturation if a current is caused to flow through the primary cable or busbar. This may cause arcing, and if the terminals are touched in this condition has the potential to cause severe injury or even death.

[0008] A three phase current transformer having a fly lead built (potted) into the case, and having an RJ11 type connector on the end of the fly lead, has previously been proposed.

[0009] GB 658297 A describes a transformer unit in which the primary winding consists of a single conductor extending through a closed magnetic core, upon which a secondary winding is wound, a grounded split metallic shield being interposed between the secondary winding and the said conductor, wherein the secondary winding is in the form of a coil which is wound upon only one side of the core. The ends of the secondary winding lead to a connector plug mounted to the transformer housing.

[0010] CN 201319314 Y describes a current transformer with a resistor connected with two ends of the secondary winding.

[0011] GB 2183049 A describes a diac and triac connected in parallel with the secondary of a metering current transformer to render the transformer non-hazardous under open-circuit conditions.

[0012] CN 2771996 Y describes a secondary loop open circuit prevention device for a current transformer, which is a false load circuit connected in parallel to a secondary loop together with a load.

[0013] GB 1321806 A describes a three phase transformer.

[0014] JP 2006 344620 A describes a current transformer.

Summary of the Invention

[0015] According to one aspect, the present invention provides a three phase current transformer according to present claim 1.

[0016] In this way, the labour costs incurred during installation of the current transformer can be substantially reduced due to the 'plug and play' nature of the connector socket. Rather than wires being individually connected to the correct exposed terminals, a connector plug is simply inserted into the connector socket to provide a connection to a measurement device. Furthermore, the risk of wiring errors is eliminated, because the only connection to be made is to plug in a single cable.

[0017] In addition, the risk of electrocution from secondary terminals being left open-circuit is removed due to (a) the lack of exposed terminals, and (b) the secondary windings having shunts across them at all times. This means that the secondary circuit (windings) will remain loaded regardless of whether the data lead is connected to the current transformer. Moreover, the data cable itself will generally only be carrying very low power signals. Finally, the 'plug and play' nature of this arrangement makes it possible to provide great flexibility in terms of cable length. In particular, different lengths (and types) of cable can be provided to suit the particular application and environment in which the current transformer is being used.

[0018] The shunt circuitry and the connector socket may be mounted to a circuit board located within the housing.

[0019] While a current will be generated in the secondary windings as long as the magnetic core is in proximity to the primary cable or busbar, preferably each magnetic core substantially surrounds the respective aperture, resulting in improved electromagnetic coupling between the primary cable and the magnetic core.

[0020] Rather than the current transformer being provided with open apertures for receiving a cable, the current transformer may be provided with busbars fixed within respective ones of the apertures. In this case primary cables may be connected to the fixed busbar in order for the amount of current flowing through the primary cables to be measured.

[0021] The shunt circuitry may comprise a first shunt resistor connected across a first of the three secondary windings, a second shunt resistor connected across a second of the three secondary windings, and a third shunt resistor connected across a third of the three secondary windings. The first, second and third shunt resistors may be connected together at one end at a common ground, the voltage drop between the common ground and the other end of each of the first, second and third shunt resistors providing voltage signals for the respective phases. Alternatively, the shunt circuitry may comprise a first shunt resistor group connected in parallel across a first of the three secondary windings, a second shunt resistor group connected in parallel across a second of the three secondary windings, and a third shunt resistor group connected in parallel across a third of the three secondary windings. Again, the use of multiple resistors in parallel enables greater flexibility in setting an equivalent resistance value for the shunt circuitry. The first, second and third shunt resistor groups are connected together at one end at a common ground, the voltage drop between the common ground and the other end of each of the first, second and third shunt resistor groups providing voltage signals for the respective phases.

[0022] It will be appreciated that any suitable connector and data cable configuration could be used. In one example, the socket is an RJ45 connector.

[0023] In one example, the full scale output of the secondary windings is 1A. However, a full scale output of 5A could instead be used, or any other suitable current rating, depending on the particular application. It will be appreciated that the full scale output is in practice dependent upon the full scale input current of the primary cable. A particular current transformer will have a specified primary to secondary current ratio, largely dependent on the number of secondary windings provided in the current transformer. It will therefore be understood that a specific current transformer configuration will be selected in dependence on the maximum primary current to be measured, and the desired output voltage signal. It is also possible to vary the number of primary turns (in practice to pass the primary cable through an aperture more than once) to alter the primary to secondary current ratio of a particular current transformer.

[0024] Similarly, any required output voltage rating for the shunt circuitry could be used, depending on the effective resistance of the shunt circuitry, and the current value of the secondary windings. In one example, the maximum output voltage of the shunt circuitry is 333 mV.

[0025] According to another aspect, the present invention provides a system for measuring electric current in a primary cable or busbar according to claim 10, comprising:

> a current transformer as described above; and
> a measurement device for receiving the one or more voltage signals output from the current transformer and estimating the amount of current carried by the primary cable or busbar in dependence on the received voltage signals.

[0026] The current transformer may further comprise protection circuitry enclosed within the housing and being connected across the secondary windings to limit the accessible voltage at the connector socket imposed by the secondary windings. Such a structure could be used as a backup form of protection in the event that the shunt circuitry should fail. For example, a single resistor across a secondary winding could form the shunt circuitry, with the protection circuitry being provided in parallel with the resistor circuitry to clamp the accessible voltage in the event that the resistor should fail. In one example, the protection circuitry comprises a first diode connected across the secondary winding and a second diode connected in parallel with the first diode across the secondary winding, the first and second diodes being connected across the secondary winding in opposite directions. Either instead of or in addition to the first and second diodes, a Transil diode may be connected across the secondary winding.

[0027] According to another aspect, the present invention provides a three phase current transformer according to claim 14.

[0028] In this alternative arrangement, shunt circuitry is not provided within the current transformer itself. Instead, the current transformer relies on an external shunt, in the form of measurement circuitry within a multi-meter for connection to the current transformer, for example.

[0029] The protection circuitry and the connector socket may be mounted to a circuit board located within the housing. Each magnetic core may substantially surround the respective aperture. One or more busbars may be fixed within respective ones of the apertures. The socket may be an RJ45 connector. The maximum output current of the secondary windings may be one of 1A and 5A.

[0030] The protection circuitry may comprise a first set of diodes connected across a first of the three secondary windings, a second set of diodes connected across a second of the three secondary windings, and a third set of diodes connected across a third of the three secondary windings. Each set of diodes may comprise a first diode connected across a respective secondary winding and a second diode connected across the respective secondary winding in parallel with the first diode, the first and second diodes being connected across the secondary winding in opposite directions. Each set of diodes may comprise a Transil diode connected across a respective secondary winding. It will be appreciated that some degree of protection would be provided by using either the first and second opposed diodes or the Transil diode, but preferably both the first and second opposed diodes and the Transil diode are present.

[0031] According to another aspect, the present invention provides a system for measuring electric current in a primary cable or busbar according to claim 15, comprising a current transformer having protection circuitry as described above, and a measurement device having shunt circuitry.

[0032] It will be appreciated that the use of diodes connected across the secondary windings results in a current signal being output at the connector socket. A current (rather than voltage) signal may be advantageous in alleviating possible pickup problems due to frequencies and general noise which may be present within the industrial environment within which current transformers may be installed.

Brief Description of the Drawing

[0033] The above, and other preferable objects, features and advantages of this invention will be apparent from the following detailed description of illustrative embodiments which is to be read in connection with the accompanying drawings, in which:

Figures 1A and 1B schematically illustrate a known current transformer;
Figures 2A and 2B schematically illustrate a current transformer according to an embodiment of the invention;
Figure 3 presents another view of the current transformer of Figures 2A and 2B;
Figure 4 schematically illustrates shunt circuitry according to an embodiment of the present invention;
Figure 5 schematically illustrates a current measurement system according to an embodiment of the present invention;
Figure 6 schematically illustrates protection circuitry according to an alternative embodiment of the present invention; and
Figure 7 schematically illustrates a single phase of protection circuitry of the alternative embodiment coupled to an integral shunt of a multi-function meter.

Description of the Example Embodiments

[0034] Figure 2A is an external schematic view of a current transformer 100 according to one embodiment. The current transformer comprises a casing 105 having three apertures 110a, 110b and 110c, each of which is able to receive a cable or busbar. More specifically, a cable or busbar received through each of the apertures 110a, 110b, 110c is intended to correspond to a respective phase of a three phase power supply. It will be appreciated that each cable is able to pass completely through the current transformer casing 105, emerging to continue on to its destination. Notably, in comparison with Figure 1A (prior art), the current transformer 100 of Figure 2A lacks terminals for connecting the current transformer 100 to an external measurement device. Instead, the current transformer 100 of Figure 2A comprises a connector socket 120, in the present case an RJ45 socket. An RJ45 plug (not shown) of a data cable can be inserted into the RJ45 socket of the current transformer 100 to connect the current transformer 100 to an external measurement device.

[0035] Figure 2B is an internal cross-section of the three phase current transformer 100 of Figure 2A. Visible are three magnetic cores 130a, 130b, 130c which each surround a respective one of the apertures 110a, 110b, 110c. It will be appreciated that this arrangement puts each of the magnetic cores in proximity to a primary cable or busbar passing through one of the apertures 110a, 110b, 110c and carrying a particular phase of an electric power supply. Each of the magnetic cores 130a, 130b, 130c is provided with a secondary winding 140a, 140b, 140c wrapped around at least a portion of the respective magnetic core 130a, 130b, 130c. With this configuration, an electric current passing through the primary cable or busbar within one of the apertures 110a, 110b, 110c will produce a magnetic field in the respective magnetic core 130a, 130b, 130c which in turn induces a much smaller current in the respective secondary winding 140a, 140b, 140c. The ends of the secondary windings are connected to a circuit board 150, which comprises shunt circuitry 152 which forms resistive connections across the ends of the secondary windings. The voltage drop across the resistive connection of a given secondary winding provides a voltage signal related to and indicative of the amount of current being driven through that secondary winding. In addition, the resistive connection provides a permanent load which avoids open-circuit safety problems.

[0036] The connector socket 120 is mounted on the circuit board 150 and is electrically connected to the shunt circuitry 152 to receive the voltage signals related to each of the secondary windings. In this way, the voltage signals can be safely and conveniently output to a measurement device external to the current transformer 100.

[0037] In Figure 3, a disassembled view of the current transformer 100 of Figures 2A and 2B is schematically illustrated. The same elements of Figures 2A and 2B are identified in Figure 3 using the same reference numerals. As can be seen, the casing 105 is provided in two halves, which can be closed around the internal components of the current transformer 100 to enclose all elements except for an exposed portion of the connector socket 120 (to permit a plug to be inserted). Each half of the casing 100 comprises the three apertures 110a, 110b, 110c which are in line with corresponding apertures in the ring-shaped magnetic cores 130a, 130b, 130c. For clarity only the magnetic core 130a is identified in Figure 3. At the top portion of the magnetic core 130a the secondary winding 140a can be seen, with ends of the windings being connected to the back of the circuit board 150 located above the magnetic cores 130a, 130b, 130c. A similar configuration is provided for the secondary windings 140b and 140c corresponding to the magnetic cores 130b and 130c. Circuit elements of the shunt circuitry 152 can be seen mounted to the top surface of the circuit board 150. Also mounted to the top surface of the circuit board 150 is the connector socket 120. An aperture 125 is provided in one half of the casing 105 to expose a portion of the connector 120 to the external of the current transformer 100.

[0038] Figure 4 schematically illustrates the shunt circuitry 152 according to an embodiment of the invention. Visible at the bottom of Figure 4 are the top portions of each of the magnetic cores, bearing the windings 140a, 140b and 140c. The winding 140a has ends 142a and 142b which are connected to the shunt circuitry 152. The winding 140b has ends 144a and 144b which are connected to the shunt circuitry 152. The winding 140c has ends 146a and 146b which are connected to the shunt circuitry 152. Visible at the top of Figure 4 is the connector socket 120, mounted to the circuit board 150. The connector socket 120 is connected to various points of the shunt circuitry 152.

[0039] The shunt circuitry 152 can be considered to comprise three (related) portions. A first portion comprises a first group of resistors 162a, 162b and 162c which are connected in parallel across the ends 142a and 142b of the winding 140a. This group of resistors forms a load across the secondary winding 140a. The side of the load connected to the winding end 142b is connected to ground terminal T_g of the connector socket 120. The other side of the load, connected to the winding end 142a is connected to a first voltage signal terminal T_1. The potential difference between T_1 and T_g, corresponding to a voltage drop over the load provided by the group of resistors 162a, 162b and 162c, provides a voltage signal indicative of the amount of current being driven through the secondary winding 140a, and thus the amount of current being driven through the corresponding primary cable or busbar.

[0040] Similarly, a second portion of the shunt circuitry 152 comprises a second group of resistors 164a, 164b and 164c which are connected in parallel across the ends 144a and 144b of the winding 140b. This group of resistors forms a load across the secondary winding 140b. The side of the load connected to the winding end 144b is connected to ground terminal T_g of the connector socket 120. The other side of the load, connected to the winding end 144a is connected to a second voltage signal terminal T_2. The potential difference between T_2 and T_g, corresponding to a voltage drop over the load provided by the group of resistors 164a, 164b and 164c, provides a voltage signal indicative of the amount of current being driven through the secondary winding 140b, and thus the amount of current being driven through the corresponding primary cable or busbar.

[0041] Similarly, a third portion of the shunt circuitry 152 comprises a third group of resistors 166a, 166b and 166c which are connected in parallel across the ends 146a and 146b of the winding 140c. This group of resistors forms a load across the secondary winding 140c. The side of the load connected to the winding end 146b is connected to ground terminal T_g of the connector socket 120. The other side of the load, connected to the winding end 146a is connected to a third voltage signal terminal T_3. The potential difference between T_3 and T_g, corresponding to a voltage drop over the load provided by the group of resistors 166a, 166b and 166c, provides a voltage signal indicative of the amount of current being driven through the secondary winding 140c, and thus the amount of current being driven through the corresponding primary cable or busbar.

[0042] The connector socket 120 therefore provides voltage signals derived from secondary windings 140a, 140b and 140c at terminals T_1, T_2 and T_3 respectively, as well as providing a grounded terminal Tg, for connection and output to a measurement device. The voltage signals will vary with respect to time in proportion to the amount of current being driven through the respective secondary windings, which in turn varies in proportion to the amount of current being driven through the respective primary cable or busbar. The voltage signals can therefore be used to infer the amount of current passing through the primary cable or busbar, based on a predictable current ratio between the primary cable and the secondary winding, and based on a predictable relationship between the current applied to the loads of the shunt circuitry and the voltage drop across those loads.

[0043] In Figure 4, the three groups of resistors are connected together to a common ground. It will be appreciated that this may not be necessary for some applications. Furthermore, in Figure 4, groups of resistors are used together in parallel. It would be appreciated that instead of this, a single resistor could be used as a load for each secondary winding.

[0044] For a single phase current transformer, only a single group, or a single resistor, will be required to form a load for the one secondary winding required for a single phase current transformer. For example, to adapt the circuit diagram of Figure 4 to a single phase design, the windings 140b and 140c would be dispensed with, as well as the resistors 164a, b, c and 166a, b, c.

[0045] Figure 5 schematically illustrates a current measurement system according to an embodiment of the present invention. The current measurement system comprises a current transformer as described above in relation to Figures 2, 3 and 4, as well as a measurement device 200. As described previously, the current transformer comprises a connector socket 120 mounted in the housing 100. This permits a data cable 300 to be used to connect the current transformer to the measurement device 100. The data cable 300 comprises a first plug 310a for insertion into the connector socket 120 of the current transformer. The data cable 300 also comprises a second plug 310b for insertion into a connector socket 220 of the measurement device 200. The measurement device 200 comprises a display 230 for displaying voltage and current measurements relating to the current transformer and the primary cable to which the current transformer is being applied. The measurement device 200 also comprises a user interface 240 (for example buttons and/or switches) permitting the user to interact with the measurement device. It will be appreciated that the measurement device 200 is exemplary, and other types of devices, such as general purpose computers, could be used if provided with appropriate interface circuitry for receiving the voltage signal via the data cable 300.

[0046] Figure 6 schematically illustrates shunt circuitry according to an alternative embodiment. In this embodiment, shunt circuitry is not provided within the current transformer itself. Instead, external shunt circuitry is used to measure the current through the secondary winding (and by inference the primary cable or busbar). It will therefore be appreciated that this type of current transformer is intended to support a current output signal at the connector socket. Without shunt circuitry being provided internally of the current transformer, the open-circuit safety concerns referred to above become an issue. To alleviate this, protection circuitry is provided in the place of the shunt circuitry. The purpose of the protection circuitry is to clamp the accessible voltage at the connector socket imposed by the secondary circuit (when it is not loaded with an external shunt) to an acceptable level.

[0047] Visible at the bottom of Figure 6 are the top portions of each of the magnetic cores, bearing the windings 240a, 240b and 240c. The winding 240a has ends 242a and 242b which are connected to the protection circuitry on a circuit board 250 (analogous to the circuit board 150 of Figure 4). The winding 240b has ends 244a and 244b which are connected to the protection circuitry on the circuit board 250. The winding 240c has ends 246a and 246b which are connected to the protection circuitry on the circuit board 250. Visible at the top of Figure 4 is a connector socket 220, mounted to the circuit board 250, and connected to the protection circuitry and both ends of the secondary windings.

[0048] The protection circuitry on the circuit board 250 can be considered to comprise three portions. A first portion comprises a first group of diodes 262a, 262b and 262c which are connected in parallel across the ends 242a and 242b of the winding 240a. This group of diodes serves as a voltage clamp across the secondary winding 240a when no external shunt (of for example a current measuring circuit) is connected across the secondary winding 240a. Each side of the voltage clamp (and thus each end of the secondary winding 240a) is connected to a terminal U_1 of the connector socket 220. When a current measuring device is connected across the terminals U_1, then the current running through the secondary winding 240a can be measured, and the voltage clamp will have no effect. The measured current through the secondary winding 240a is in turn indicative of the amount of current being driven through the corresponding primary cable or busbar.

[0049] Similarly, a second portion of the protection circuitry on the circuit board 250 comprises a second group of diodes 264a, 264b and 264c which are connected in parallel across the ends 244a and 244b of the winding 240b. This group of diodes serves as a voltage clamp across the secondary winding 240b when no external shunt is connected across the secondary winding 240b. Each side of the voltage clamp (and thus each end of the secondary winding 240b) is connected to a terminal U_2 of the connector socket 220. When a current measuring device is connected across the terminals U_2, then the current running through the secondary winding 240b can be measured, and the voltage clamp will have no effect. The measured current through the secondary winding 240b is in turn indicative of the amount of current being driven through the corresponding primary cable or busbar.

[0050] Similarly, a third portion of the shunt circuitry on the circuit board 250 comprises a second group of diodes 266a, 266b and 266c which are connected in parallel across the ends 246a and 246b of the winding 240c. This group of diodes serves as a voltage clamp across the secondary winding 240c when no current measuring circuit is connected across the secondary winding 240c. Each side of the voltage clamp (and thus each end of the secondary winding 240c) is connected to a terminal U_3 of the connector socket 220. When a current measuring device is connected across the terminals U_3, then the current running through the secondary winding 240c can be measured, and the voltage clamp will have no effect. The measured current through the secondary winding 240c is in turn indicative of the amount of current being driven through the corresponding primary cable or busbar.

[0051] The connector socket 220 therefore permits current signals derived from secondary windings 240a, 240b and 240c at terminal groups U_1, U_2 and U_3 respectively, to be drawn through a measurement device. The current signals represent the amount of current being driven through the respective secondary windings, which in turn varies in proportion to the amount of current being driven through the respective primary cable or busbar. The current signals can therefore be used to infer the amount of current passing through the primary cable or busbar, based on a predictable current ratio between the primary cable and the secondary winding.

[0052] For a single phase current transformer, only a single group of diodes will be required to act as a voltage clamp for the one secondary winding required for a single phase current transformer. For example, to adapt the circuit diagram of Figure 6 to a single phase design, the windings 240b and 240c would be dispensed with, as well as the corresponding groups of diodes.

[0053] The operation of the voltage clamp circuitry will now be explained with respect to Figure 7, which schematically illustrates the circuitry associated with a single phase. This could represent the only phase of a single phase current transformer, or one of the phases of a three phase current transformer.

[0054] Shown in Figure 7 is a secondary circuit 610 comprising a secondary winding 612, a first diode 614 connected across the secondary winding 612 in a first direction, a second diode 616 connected across the secondary winding 612 in a secondary direction opposite to the first direction, and a Transil diode 618. Also shown in Figure 6 is the integral shunt resistor 622 of a current measurement circuit 620 which is connected to the secondary circuit 610 of the current transformer. The current measurement circuit 620 may be part of a multi-function meter. The current measurement circuit 620 monitors the voltage drop across the integral shunt resistor 622, which is connected across the secondary winding 612 when the multi-function meter is plugged into the current transformer via the socket. As the current flowing through the integral shunt resistor 622 increases, so does the voltage drop across it. In this way, the current signal generated as an output from the secondary circuit 610 of the current transformer is converted into a voltage signal at the current measurement circuit 620 and handled within the multi-function meter. In particular, the microprocessor of the multi-meter may be provided with circuitry which measures the voltage drop across the integral shunt resistor 622 and converts the read value into a digital value which the microprocessor can understand, process and display. The voltage drop across the integral shunt resistor 622 maybe of order 100mV.

[0055] When in normal use as described above, the voltage drop seen by the diodes 614 and 616 will be well below the forward voltage required for the diodes to conduct, and therefore the diodes will not affect the signal. The voltage drop seen by the diodes 614, 616 in normal use may be for example around 100mV across the shunt resistor plus a negligible voltage drop of the cable connecting the current transformer to the multi-meter. This is lower than the 0.6V typical forward voltage for a diode.

[0056] When the measurement circuit 620 is disconnected from the secondary circuit 610 while current is running through the primary cable or busbar, then the voltage seen by the diodes will begin to rise to approximately 0.6V (for example), at which point the diode forward voltage of the diodes 614, 616 will be exceeded and the diodes 614, 616 will begin to conduct. This serves to clip the output waveform and clamp the voltage accessible at the connector socket of the current transformer to a safe level. The secondary current will be flowing through the diodes 614, 616 with approximately a 0.6V voltage drop when the current transformer is in an unplugged (open circuit) state with current running through the primary cable or busbar. It will be appreciated that the diode 614 serves to limit the current flowing in one direction through the secondary circuit 610 while the diode 616 serves to limit the current flowing in the other direction through the secondary circuit 612.

[0057] The diode 618 is a Transil diode, which is fitted as a secondary method of protection in case the diodes 614, 616 fail for any reason. If this happens then the Transil diode would serve to limit the accessible voltage at the output socket of the current transformer to the chosen Transil diode level.

[0058] It will be appreciated that in the case of the shunt circuitry of Figure 4, an integral shunt is not required in the measurement device 200, since the output from the shunt circuitry is a voltage signal which can be directly read and handled by a microprocessor of the measurement device 200. In contrast, in the case of the protection circuitry of Figures 6 and 7, a shunt will be required in the measurement device connecting to the current transformer, since the output from the shunt circuitry of the current transformer is a current signal which needs to be converted into a voltage signal which can be read and handled by the microprocessor of the measurement device 200.

[0059] The first described embodiment uses internal shunt circuitry to output a voltage signal at the connector socket of the current transformer. Safety results in part from the fact that a shunt is present across the secondary winding(s) at all times. The alternative embodiment does not use internal shunt circuitry, thus effectively outputting current signals. Safety in this case results from the protection circuitry, which forms a voltage clamp which would clamp the accessible voltage in the event that an external shunt is not connected (via the connector socket) to the secondary windings while current is running through the primary cable or busbar. It should be understood that the first and second embodiments can be combined, to result in a current transformer having both internal shunt circuitry (resistive shunt) resulting in a voltage output, and protection circuitry (for example coupled in parallel with the internal shunt circuitry across the secondary winding(s)) which would act as a back-up form of protection should the shunt circuitry (e.g. a resistor) fail.

[0060] Although illustrative embodiments of the invention have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications can be effected therein by one skilled in the art within the scope of the invention as defined by the appended claims.

Claims

1. A three phase current transformer (100), comprising:

    a housing (105) having three apertures (110a-110c), each for receiving a primary cable or busbar of a respective phase of a three phase power supply;
    three magnetic cores (130a-130c) enclosed within the housing and being positioned proximate to respective ones of the apertures so that a magnetic field is produced in the respective magnetic core when a primary current flows through a primary cable or busbar received through the respective aperture;
    three secondary windings (140a-140c) enclosed within the housing, each secondary winding being wrapped around at least a portion of a respective one of the magnetic cores so that a secondary current is induced in the secondary winding when a magnetic field is produced in the respective magnetic core;
    a shunt circuitry (152) enclosed within the housing and being connected across the secondary windings to generate a respective voltage signal for each secondary winding; and
    a connector socket (120) integrally mounted to the housing and electrically connected to the shunt circuitry for outputting the voltage signals;
    wherein the shunt circuitry (152) is configured to provide a load across the secondary windings regardless of whether a data lead is connected to the connector socket;
    wherein the shunt circuitry (152) generates a respective voltage signal for each of the three phases of the power supply; and wherein
    the connector socket (120) is configured to output the voltage signals for each of the three phases.

2. A current transformer according to claim 1, wherein the shunt circuitry and the connector socket are mounted to a circuit board located within the housing.

3. A current transformer according to any preceding claim, wherein each magnetic core substantially surrounds the respective aperture.

4. A current transformer according to claim 1, further comprising one or more busbars fixed within respective ones of the apertures.

5. A current transformer according to claim 1, wherein the shunt circuitry comprises a first shunt resistor connected across a first of the three secondary windings, a second shunt resistor connected across a second of the three secondary windings, and a third shunt resistor connected across a third of the three secondary windings.

6. A current transformer according to claim 5, wherein the first, second and third shunt resistors are connected together at one end at a common ground, the voltage drop between the common ground and the other end of each of the first, second and third shunt resistors providing voltage signals for the respective phases.

7. A current transformer according to claim 1, wherein the shunt circuitry comprises a first shunt resistor group connected in parallel across a first of the three secondary windings, a second shunt resistor group connected in parallel across a second of the three secondary windings, and a third shunt resistor group connected in parallel across a third of the three secondary windings.

8. A current transformer according to claim 7, wherein the first, second and third shunt resistor groups are connected together at one end at a common ground, the voltage drop between the common ground and the other end of each of the first, second and third shunt resistor groups providing voltage signals for the respective phases.

9. A current transformer according to any preceding claim, wherein the socket is an RJ45 connector.

10. A system for measuring electric current in a primary cable or busbar, comprising:

    a current transformer (100) according to any one of claims 1 to 9; and a measurement device (200) for receiving the voltage signals output from the current transformer and estimating the amount of current carried by the primary cable or busbar in dependence on the received voltage signals.

11. A current transformer according to any one of claims 1 to 9, further comprising protection circuitry enclosed within the housing and being connected across the secondary windings to limit the accessible voltage at the connector socket imposed by the secondary windings.

12. A current transformer according to claim 11, wherein the protection circuitry comprises a first diode connected across the secondary winding and a second diode connected in parallel with the first diode across the secondary winding, the first and second diodes being connected across the secondary winding in opposite directions.

13. A current transformer according to claim 11 or claim 12, wherein the protection circuitry comprises a Transil diode connected across the secondary winding.

14. A three phase current transformer, comprising:

a housing having three apertures, each for receiving a primary cable or busbar of a respective phase of a three phase power supply;
three magnetic cores enclosed within the housing and being positioned proximate to respective ones of the apertures so that a magnetic field is produced in the respective magnetic core when a primary current flows through a primary cable or busbar received through the respective aperture;
three secondary windings enclosed within the housing, each secondary winding being wrapped around at least a portion of a respective one of the magnetic cores so that a secondary current is induced in the secondary winding when a magnetic field is produced in the respective magnetic core;
a connector socket (220) integrally mounted to the housing for outputting the current generated by the secondary windings; and
a protection circuitry enclosed within the housing and being connected across the secondary windings to limit the accessible voltage at the connector socket imposed by the secondary windings;
wherein the connector socket is electrically connected to the protection circuitry and configured to output the current signals generated by each of the three secondary windings.

15. A system for measuring electric current in a primary cable or busbar, comprising:

a current transformer according to claim 14; and
a measurement device having a shunt circuitry which when connected across the secondary windings of the current transformer via the connector socket is operable to generate a respective voltage signal for each secondary winding, and operable to estimate the amount of current carried by the primary cable or busbar in dependence on the received voltage signals.

Patentansprüche

1. Dreiphasiger Stromwandler (100), umfassend:

ein Gehäuse (105) mit drei Öffnungen (110a-110c), wobei jede zum Aufnehmen eines Primärkabels oder einer Sammelschiene einer entsprechenden Phase einer dreiphasigen Stromversorgung ausgelegt ist,
drei Magnetkerne (130a-130c), die in dem Gehäuse enthalten und nahe an entsprechenden der Öffnungen positioniert sind, so dass ein Magnetfeld in dem entsprechenden Magnetkern erzeugt wird, wenn ein Primärstrom durch ein Primärkabel oder eine Sammelschiene fließt, die durch die entsprechende Öffnung aufgenommen wurde;
drei Sekundärwicklungen (140a-140c), die in dem Gehäuse enthalten sind, wobei jede Sekundärwicklung um mindestens einen Teil eines entsprechenden der Magnetkerne herumgewickelt ist, so dass ein Sekundärstrom in der Sekundärwicklung induziert wird,
wenn ein Magnetfeld in dem entsprechenden Magnetkern erzeugt wird;
eine Messschaltung (152), die in dem Gehäuse enthalten und über die Sekundärwicklungen geschaltet ist, um ein entsprechendes Spannungssignal für jede Sekundärwicklung zu erzeugen; und
eine Verbindungsbuchse (120), die in dem Gehäuse integriert eingebaut und elektrisch mit der Messschaltung verbunden ist, um die Spannungssignale auszugeben;
wobei die Messschaltung (152) dafür ausgelegt ist, unabhängig davon, ob eine Datenleitung mit der Verbindungsbuchse verbunden ist, eine Last über den Sekundärwicklungen bereitzustellen;
wobei die Messschaltung (152) ein entsprechendes Spannungssignal für jede der drei Phasen der Stromversorgung erzeugt, und wobei
die Verbindungsbuchse (120) dafür ausgelegt ist, die Spannungssignale für jede der drei Pha-

sen auszugeben.

2. Stromwandler nach Anspruch 1, wobei die Messschaltung und die Verbindungsbuchse auf einer Leiterplatte angebracht sind, die sich in dem Gehäuse befindet.

3. Stromwandler nach einem der vorhergehenden Ansprüche, wobei jeder Magnetkern im Wesentlichen die entsprechende Öffnung umgibt.

4. Stromwandler nach Anspruch 1, ferner eine oder mehrere Sammelschienen umfassend, die in entsprechenden der Öffnungen befestigt sind.

5. Stromwandler nach Anspruch 1, wobei die Messschaltung einen ersten Messwiderstand, der über eine erste der drei Sekundärwicklungen geschaltet ist, einen zweiten Messwiderstand, der über eine zweite der drei Sekundärwicklungen geschaltet ist, und einen dritten Messwiderstand, der über eine dritte der drei Sekundärwicklungen geschaltet ist, umfasst.

6. Stromwandler nach Anspruch 5, wobei der erste, der zweite und der dritte Messwiderstand an jeweils einem Ende zusammen mit einer gemeinsamen Masse verbunden sind, wobei der Spannungsabfall zwischen der gemeinsamen Masse und dem jeweils anderen Ende jedes des ersten, des zweiten und des dritten Messwiderstands Spannungssignale für die entsprechenden Phasen bereitstellt.

7. Stromwandler nach Anspruch 1, wobei die Messschaltung eine erste Messwiderstandsgruppe, die parallel über eine erste der drei Sekundärwicklungen geschaltet ist, eine zweite Messwiderstandsgruppe, die parallel über eine zweite der drei Sekundärwicklungen geschaltet ist, und eine dritte Messwiderstandsgruppe, die parallel über eine dritte der drei Sekundärwicklungen geschaltet ist, umfasst.

8. Stromwandler nach Anspruch 7, wobei die erste, die zweite und die dritte Messwiderstandsgruppe an jeweils einem Ende zusammen mit einer gemeinsamen Masse verbunden sind, wobei der Spannungsabfall zwischen der gemeinsamen Masse und dem jeweils anderen Ende jeder der ersten, zweiten und der dritten Messwiderstandsgruppe Spannungssignale für die entsprechenden Phasen bereitstellt.

9. Stromwandler nach einem der vorhergehenden Ansprüche, wobei die Buchse ein RJ45-Verbinder ist.

10. System zum Messen elektrischen Stroms in einem Primärkabel oder einer Sammelschiene, umfassend:

einen Stromwandler (100) nach einem der Ansprüche 1 bis 9; und
eine Messvorrichtung (200) zum Aufnehmen der Spannungssignale, die von dem Stromwandler ausgegeben werden, und Schätzen der Stromstärke, die von dem Primärkabel oder der Sammelschiene geführt wird, in Abhängigkeit von den aufgenommenen Spannungssignalen.

11. Stromwandler nach einem der Ansprüche 1 bis 9, ferner eine Schutzschaltung umfassend, die in dem Gehäuse enthalten und über die Sekundärwicklungen geschaltet ist, um die von den Sekundärwicklungen aufgeprägte, an der Verbindungsbuchse abgreifbare Spannung zu begrenzen.

12. Stromwandler nach Anspruch 11, wobei die Schutzschaltung eine erste Diode, die über die Sekundärwicklung, und eine zweite Diode, die parallel zur ersten Diode über die Sekundärwicklung geschaltet ist, umfasst, wobei die erste und die zweite Diode in entgegengesetzten Richtungen über die Sekundärwicklung geschaltet sind.

13. Stromwandler nach Anspruch 11 oder Anspruch 12, wobei die Schutzschaltung eine Transil-Diode umfasst, die über die Sekundärwicklung geschaltet ist.

14. Dreiphasiger Stromwandler, umfassend:

ein Gehäuse mit drei Öffnungen, wobei jede zum Aufnehmen eines Primärkabels oder einer Sammelschiene einer entsprechenden Phase einer dreiphasigen Stromversorgung ausgelegt ist,
drei Magnetkerne, die in dem Gehäuse enthalten und nahe an entsprechenden der Öffnungen positioniert sind, so dass ein Magnetfeld in dem entsprechenden Magnetkern erzeugt wird, wenn ein Primärstrom durch ein Primärkabel oder eine Sammelschiene fließt, die durch die entsprechende Öffnung aufgenommen wurde;
drei Sekundärwicklungen, die in dem Gehäuse enthalten sind, wobei jede Sekundärwicklung um mindestens einen Teil eines entsprechenden der Magnetkerne herumgewickelt ist, so dass ein Sekundärstrom in der Sekundärwicklung induziert wird, wenn ein Magnetfeld in dem entsprechenden Magnetkern erzeugt wird;
eine Verbindungsbuchse (220), die in dem Gehäuse integriert eingebaut ist, zum Ausgeben des von den Sekundärwicklungen erzeugten Stroms; und
eine Schutzschaltung, die in dem Gehäuse enthalten und über die Sekundärwicklungen geschaltet ist, um die von den Sekundärwicklungen aufgeprägte, an der Verbindungsbuchse abgreifbare Spannung zu begrenzen;
wobei die Verbindungsbuchse mit der Schutz-

schaltung elektrisch verbunden und dafür ausgelegt ist, die Stromsignale auszugeben, die von jeder der drei Sekundärwicklungen erzeugt werden.

15. System zum Messen elektrischen Stroms in einem Primärkabel oder einer Sammelschiene, das umfasst:

einen Stromwandler nach Anspruch 14; und eine Messeinrichtung mit einer Messschaltung, die, wenn sie über die Sekundärwicklungen des Stromwandlers geschaltet ist, über die Verbindungsbuchse betrieben werden kann, um ein entsprechendes Spannungssignal für jede Sekundärwicklung zu erzeugen, und betrieben werden kann, die Stromstärke zu schätzen, die von dem Primärkabel oder der Sammelschiene geführt wird, in Abhängigkeit von den aufgenommenen Spannungssignalen.

Revendications

1. Transformateur de courant triphasé (100), comprenant :

une enveloppe (105) ayant trois ouvertures (110a-110c), chacune étant destinée à recevoir une barre omnibus ou câble primaire d'une phase respective d'une alimentation triphasée ;
trois noyaux magnétiques (130a-130c) enfermés à l'intérieur de l'enveloppe et étant positionnés à proximité immédiate des ouvertures respectives de manière à ce qu'un champ magnétique soit produit dans les noyaux magnétiques respectifs lorsqu'un courant primaire s'écoule à travers une barre omnibus ou câble primaire reçu à travers l'ouverture respective ;
trois enroulements secondaires (140a-140c) enfermés à l'intérieur de l'enveloppe, chaque enroulement secondaire étant enroulé autour d'au moins une partie d'un noyau respectif des noyaux magnétiques de manière à ce qu'un courant secondaire soit induit dans l'enroulement secondaire lorsqu'un champ magnétique est produit dans le noyau magnétique respectif ;
une circuiterie en dérivation (152) enfermée à l'intérieur de l'enveloppe et étant connectée aux bornes des enroulements secondaires pour générer un signal de tension respectif pour chaque enroulement secondaire ; et
une embase de connecteur (120) montée solidairement sur l'enveloppe et connectée électriquement à la circuiterie en dérivation pour fournir des signaux de tension ;
dans lequel la circuiterie en dérivation (152) est configurée de façon à fournir une charge aux bornes des enroulements secondaires, qu'un fil de données soit connecté ou pas à l'embase de connecteur ;
dans lequel la circuiterie en dérivation (152) génère un signal de tension respectif pour chacune des trois phases de l'alimentation ; et dans lequel
l'embase de connecteur (120) est configurée de façon à fournir les signaux de tension pour chacune des trois phases.

2. Transformateur de courant selon la revendication 1, dans lequel la circuiterie en dérivation et l'embase de connecteur sont montées sur une carte de circuits imprimés à l'intérieur de l'enveloppe.

3. Transformateur de courant selon l'une quelconque des revendications précédentes, dans lequel chaque noyau magnétique entoure essentiellement l'ouverture respective.

4. Transformateur de courant selon la revendication 1, comprenant en outre une ou plusieurs barres omnibus fixées à l'intérieur des ouvertures respectives.

5. Transformateur de courant selon la revendication 1, dans lequel la circuiterie en dérivation comprend une première résistance en dérivation connectée aux bornes d'un premier des trois enroulements secondaires, une deuxième résistance en dérivation connectée aux bornes d'un deuxième des trois enroulements secondaires, et une troisième résistance en dérivation connectée aux bornes d'un troisième des trois enroulements secondaires.

6. Transformateur de courant selon la revendication 5, dans lequel la première, la deuxième et la troisième résistance en dérivation sont connectées ensemble à une extrémité au niveau d'une masse commune, la chute de tension entre la masse commune et l'autre extrémité de chacune des première, deuxième et troisième résistances en dérivation fournissant des signaux de tension pour les phases respectives.

7. Transformateur de courant selon la revendication 1, dans lequel la circuiterie en dérivation comprend un premier groupe de résistances en dérivation connecté en parallèle aux bornes d'un premier des trois enroulements secondaires, un deuxième groupe de résistances en dérivation connecté en parallèle aux bornes d'un deuxième des trois enroulements secondaires, et un troisième groupe de résistances en dérivation connecté en parallèle aux bornes d'un troisième des trois enroulements secondaires.

8. Transformateur de courant selon la revendication 7, dans lequel le premier, le deuxième et le troisième groupe de résistances en dérivation sont connectés ensemble à une extrémité au niveau d'une masse commune, la chute de tension entre la masse commune et l'autre extrémité de chacun des premier, deuxième et troisième groupes de résistances en dérivation fournissant des signaux de tension pour les phases respectives.

9. Transformateur de courant selon l'une quelconque des revendications précédentes, dans lequel l'embase est un connecteur RJ45.

10. Système pour mesurer un courant électrique dans une barre omnibus ou un câble primaire, comprenant :

un transformateur de courant (100) selon l'une quelconque des revendications 1 à 9 ; et
un dispositif de mesure (200) pour recevoir les signaux de tension fournis depuis le transformateur de courant et pour estimer la quantité de courant portée par la barre omnibus ou le câble primaire en dépendance des signaux de tension reçus.

11. Transformateur de courant selon l'une quelconque des revendications 1 à 9, comprenant en outre une circuiterie de protection enfermée à l'intérieur de l'enveloppe et étant connectée aux bornes des enroulements secondaires de façon à limiter la tension accessible à l'embase de connecteur imposée par les enroulements secondaires.

12. Transformateur de courant selon la revendication 11, dans lequel la circuiterie de protection comprend une première diode connectée aux bornes de l'enroulement secondaire et une deuxième diode connectée en parallèle avec la première diode aux bornes de l'enroulement secondaire, ces première et deuxième diodes étant connectées aux bornes de l'enroulement secondaire dans des sens opposés.

13. Transformateur de courant selon la revendication 11 ou la revendication 12, dans lequel la circuiterie de protection comprend une diode Transil connectée aux bornes de l'enroulement secondaire.

14. Transformateur de courant triphasé, comprenant :

une enveloppe ayant trois ouvertures, chacune étant destinée à recevoir une barre omnibus ou câble primaire d'une phase respective d'une alimentation triphasée ;
trois noyaux magnétiques enfermés à l'intérieur de l'enveloppe et étant positionnés à proximité immédiate des ouvertures respectives de manière à ce qu'un champ magnétique soit produit dans les noyaux magnétiques respectifs lorsqu'un courant primaire s'écoule à travers une barre omnibus ou un câble primaire reçu à travers l'ouverture respective ;
trois enroulements secondaires enfermés à l'intérieur de l'enveloppe, chaque enroulement secondaire étant enroulé autour d'au moins une partie d'un noyau respectif des noyaux magnétiques de manière à ce qu'un courant secondaire soit induit dans l'enroulement secondaire lorsqu'un champ magnétique est produit dans le noyau magnétique respectif ;
une embase de connecteur (220) montée solidairement sur l'enveloppe pour fournir le courant généré par l'enroulement secondaire ; et
une circuiterie de protection enfermée à l'intérieur de l'enveloppe et connectée aux bornes des enroulements secondaires de façon à limiter la tension accessible à l'embase de connecteur imposée par les enroulements secondaires ;
dans lequel l'embase de connecteur est connectée électriquement à la circuiterie de protection et configurée de façon à fournir les signaux de courant générés par chacun des trois enroulements secondaires.

15. Système pour mesurer un courant électrique dans une barre omnibus ou un câble primaire, comprenant :

un transformateur de courant selon la revendication 14 ; et
un dispositif de mesure ayant une circuiterie en dérivation qui, lorsqu'il est connecté aux bornes des enroulements secondaires du transformateur de courant via l'embase de connecteur, peut être utilisé pour générer un signal de tension respectif pour chaque enroulement secondaire, et qui peut être utilisé pour estimer la quantité de courant portée par la barre omnibus ou le câble primaire en dépendance des signaux de tension reçus.

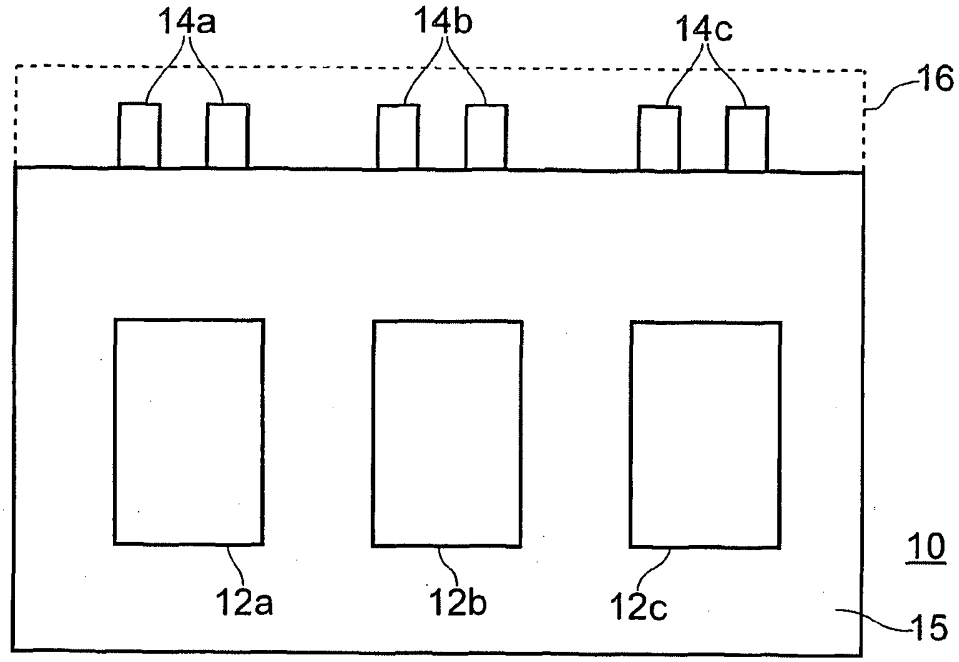
14a
14b
14c
16
10
12a
12b
12c
15

FIG. 1A

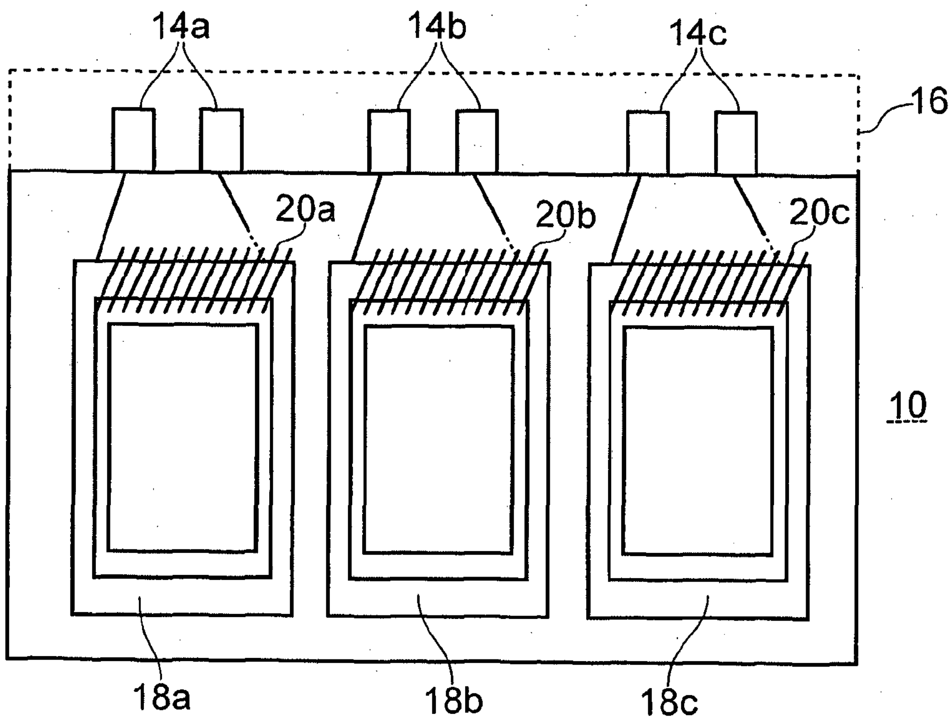
14a
14b
14c
16
20a
20b
20c
10
18a
18b
18c

FIG. 1B

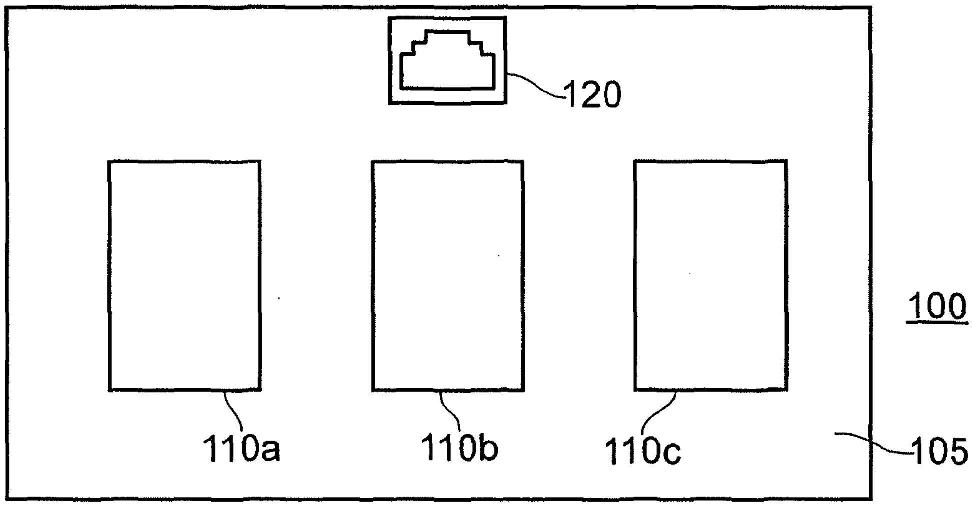
120
100
110a
110b
110c
105

FIG. 2A

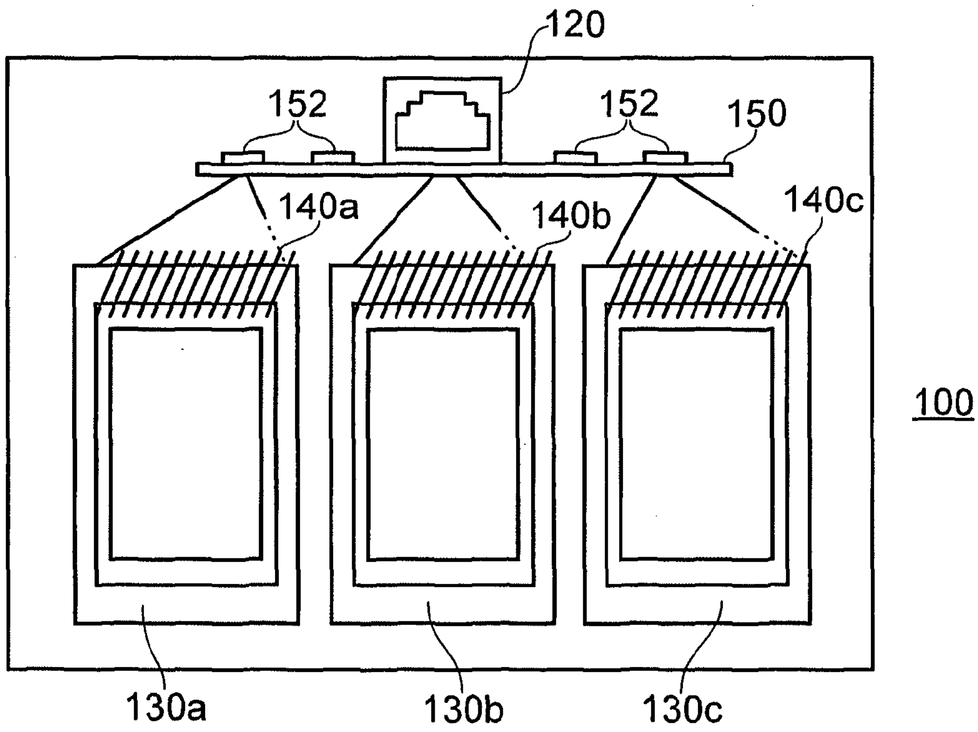
120
152
152
150
140a
140b
140c
100
130a
130b
130c

FIG. 2B

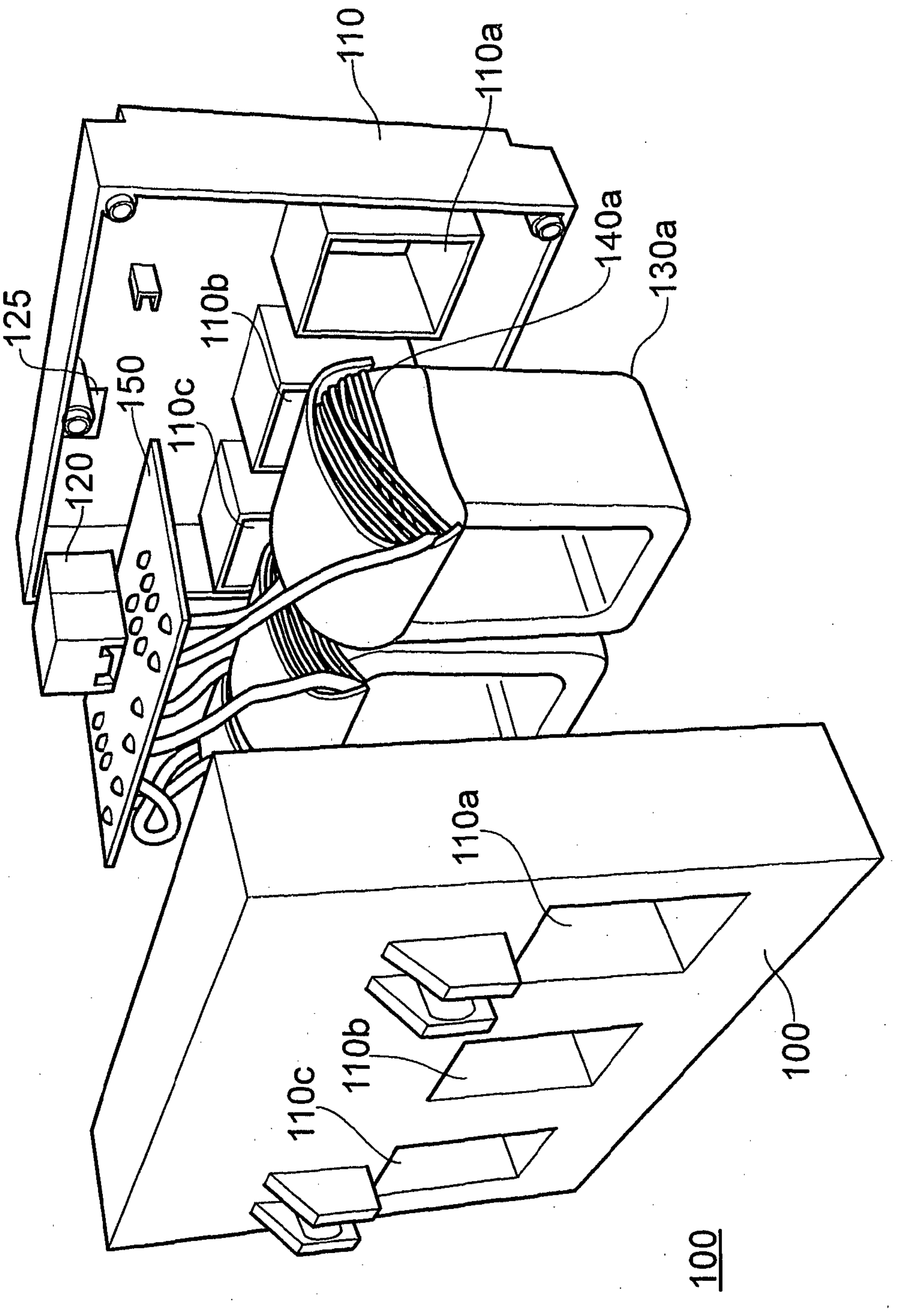
110
110a
125
110b
140a
130a
150
110c
120
110a
110c
110b
100
100

FIG. 3

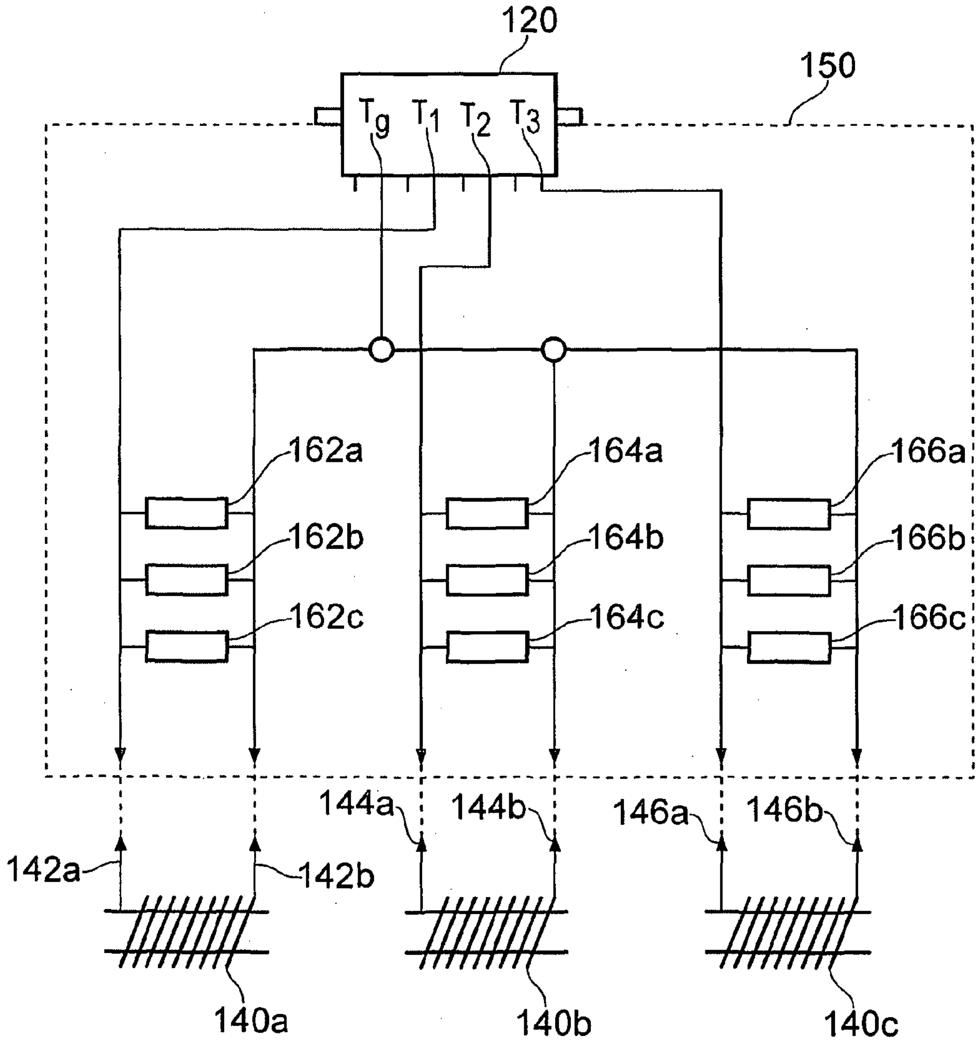
120
150
Tg T1 T2 T3
162a
162b
162c
164a
164b
164c
166a
166b
166c
144a
144b
146a
146b
142a
142b
140a
140b
140c

FIG. 4

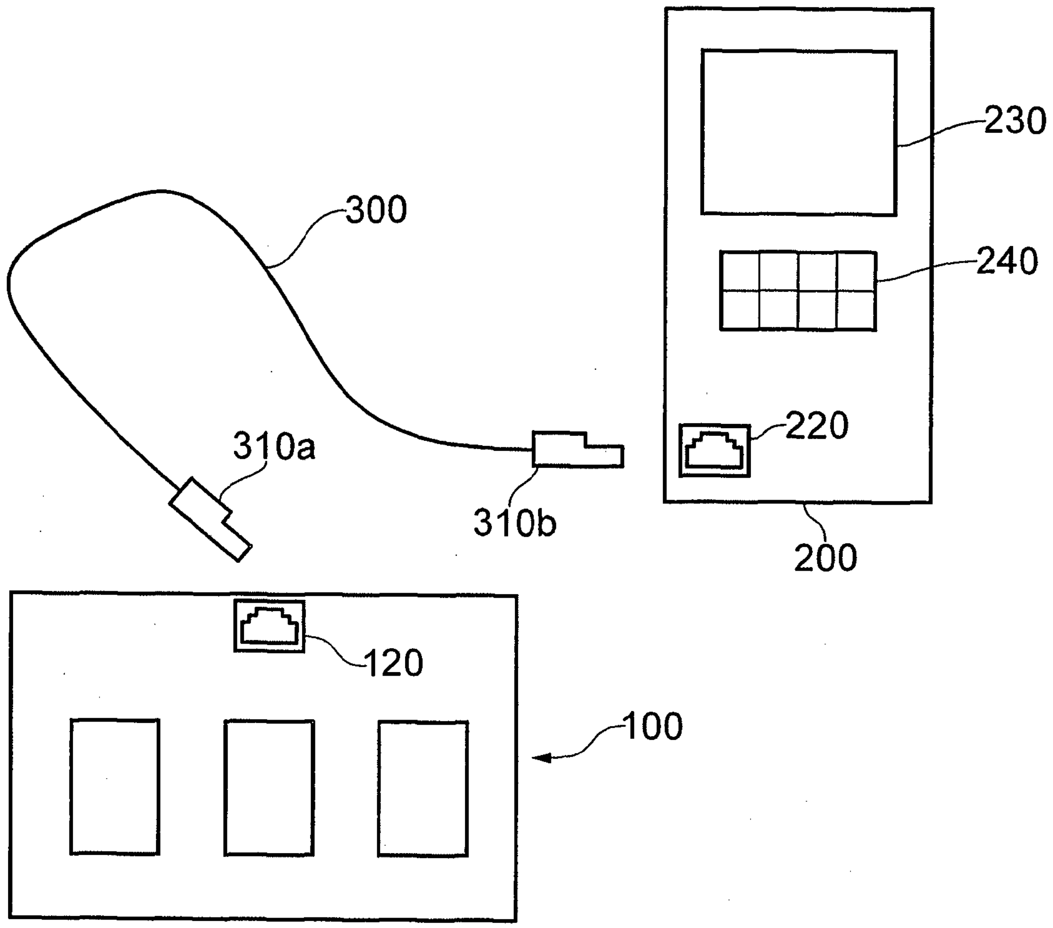

FIG. 5

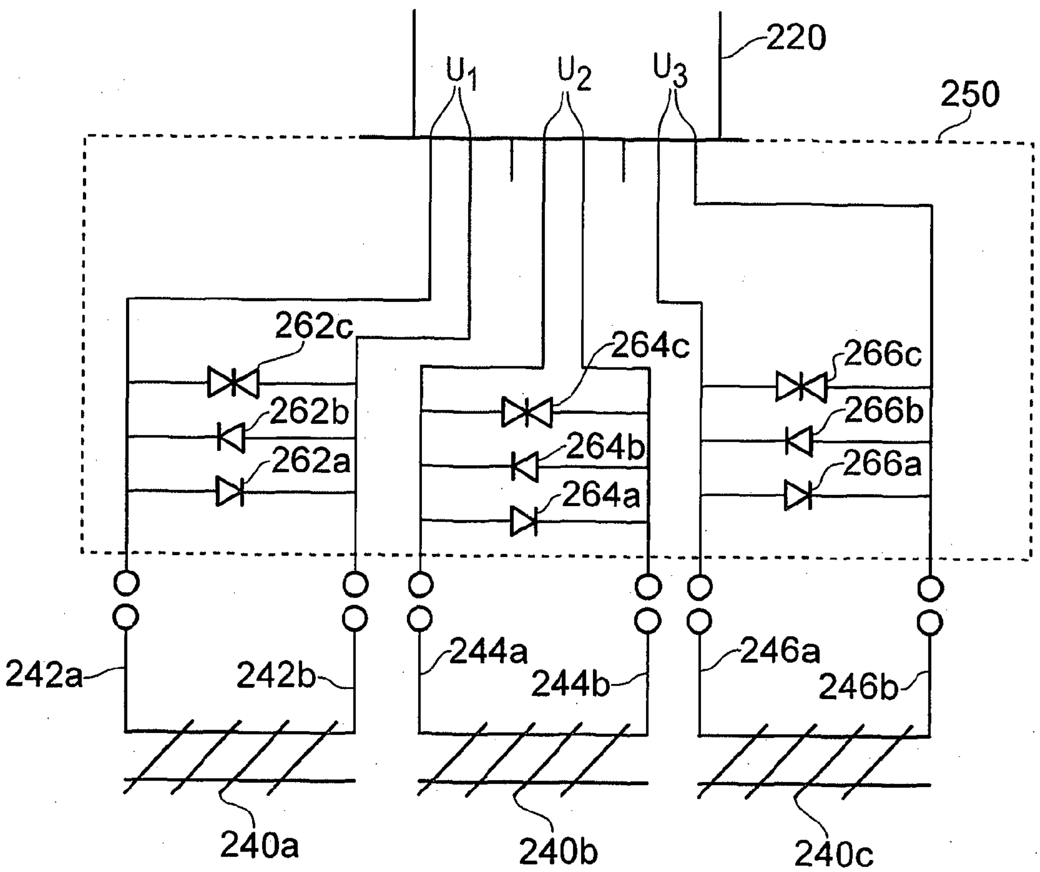
220
250
U1
U2
U3
262c
262b
262a
264c
264b
264a
266c
266b
266a
242a
242b
244a
244b
246a
246b
240a
240b
240c

FIG. 6

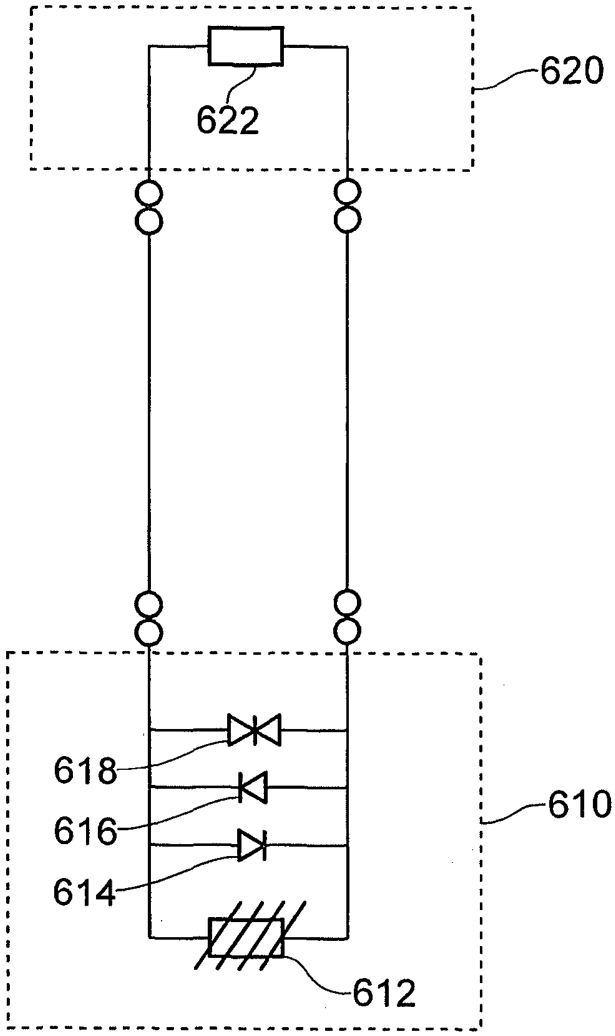

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 658297 A **[0009]**
- CN 201319314 Y **[0010]**
- GB 2183049 A **[0011]**
- CN 2771996 Y **[0012]**
- GB 1321806 A **[0013]**
- JP 2006344620 A **[0014]**

ÁRAMTRANSZFORMÁTOR

SZABADALMI IGÉNYPONTOK

1. Háromfázisú áramtranszformátor (100), amely tartalmaz:

egy házat (105), amelynek három nyílása (110a-110c) van, amely nyílások mindegyike egy háromfázisú tápegység megfelelő fázisának primer vezetékét vagy gyűjtősinjét fogadja;

három mágneses magot (130a-130c), amelyek a ház belsejében a megfelelő nyílás közelében vannak elhelyezve oly módon, hogy mágneses mező jöjjön létre a megfelelő mágneses magban, amikor egy primer áram folyik a megfelelő nyíláson keresztül beérkező primer vezetékben vagy gyűjtősinen;

három szekunder tekercset (140a-140c), amelyek a ház belsejében vannak elhelyezve, és ahol mindegyik szekunder tekercs a megfelelő mágneses mag legalább egy része köré van tekercselve oly módon, hogy szekunder áram indukálódik a szekunder tekercsben, amikor a megfelelő mágneses magban mágneses mező jön létre;

egy söntáramkört (152), amely a ház belsejében van elhelyezve és amely a szekunder tekercsekhez van kötve oly módon, hogy mindegyik szekunder tekercsben megfelelő feszültségjel jöjjön létre; és

egy csatlakozó foglalatot (120), amely a ház szerves részét képezi és elektromosan csatlakozik a söntáramkörhöz feszültségjelek kibocsátása céljából;

ahol a söntáramkör (152) úgy van konfigurálva, hogy a szekunder tekercseken keresztül olyan terhelést hozzon létre, amely független attól, hogy adott vezeték kapcsolódik-e a csatlakozó foglalathoz;

ahol a söntáramkör (152) egy megfelelő feszültségjelet állít elő a tápegység mindhárom fázisa számára; és ahol

a csatlakozó foglalat (120) úgy van kialakítva, hogy mindhárom fázis számára kiadja a feszültségjelet.

2. Az 1. igénypont szerinti áramtranszformátor, ahol a söntáramkör és a csatlakozó foglalat a ház belsejében elhelyezett áramköri kártyára van szerelve.

3. Az előző igénypontok bármelyike szerinti áramtranszformátor, ahol mindegyik mágneses mag lényegében körülveszi az ahhoz tartozó nyílást.

4. Az 1. igénypont szerinti áramtranszformátor, amely tartalmaz továbbá egy vagy több gyűjtősínt, amely rögzítve van az ahhoz tartozó nyílásban.

5. Az 1. igénypont szerinti áramtranszformátor, ahol a söntáramkör tartalmaz egy első söntellenállást, amely a három szekunder tekercs közül egy első tekerccsel van keresztbe kapcsolva, egy második söntellenállást, amely a három szekunder tekercs közül egy második tekerccsel van keresztbe kapcsolva, valamint egy harmadik söntellenállást, amely a három szekunder tekercs közül egy harmadik tekerccsel van keresztbe kapcsolva.

6. Az 5. igénypont szerinti áramtranszformátor, ahol az első, a második és a harmadik söntellenállás az egyik végükön közös földre van kötve, továbbá a közös föld és az első, a második és a harmadik söntellenállás másik vége közötti feszültségesés feszültségjelet biztosít a megfelelő fázisok számára.

7. Az 1. igénypont szerinti áramtranszformátor, ahol a söntáramkör tartalmaz egy első söntellenállás-csoportot, amely párhuzamosan van kapcsolva a három szekunder tekercs közül egy első tekerccsel, egy második söntellenállás-csoportot, amely párhuzamosan van kapcsolva a három szekunder tekercs közül egy második tekerccsel, valamint egy harmadik söntellenállás-csoportot, amely párhuzamosan van kapcsolva a három szekunder tekercs közül egy harmadik tekerccsel.

8. A 7. igénypont szerinti áramtranszformátor, ahol az első, a második és a harmadik söntellenállás-csoport az egyik végén össze van kapcsolva és közös földre van kötve, ahol a közös föld és az első, a második és a harmadik söntellenállás-csoport másik vége közötti feszültségesés feszültségjelet biztosít a megfelelő fázis számára.

9. Az előző igénypontok bármelyike szerinti áramtranszformátor, ahol a foglalat egy RJ45 csatlakozó.

10. Rendszer egy primer vezetékben vagy gyűjtősinben folyó elektromos áram mérésére, amely tartalmaz:

    egy, az 1-9. igénypontok bármelyike szerinti áramtranszformátort (100); és

    egy mérőeszközt (200) az áramtranszformátorból kilépő feszültségjelek fogadására és a primer vezetékben vagy a gyűjtősinen szállított áram nagyságának a beérkező feszültségjelektől függő becslésére.

11. Az 1-9. igénypontok bármelyike szerinti áramtranszformátor, amely tartalmaz továbbá egy védőáramkört, amely a ház belsejében van elrendezve, és amely keresztbe van kapcsolva a szekunder tekercsekkel a szekunder tekercsek által a csatlakozó foglalatnál elérhető feszültség korlátozására.

12. A 11. igénypont szerinti áramtranszformátor, ahol a védőáramkör tartalmaz egy első diódát, amely keresztbe van kapcsolva a szekunder tekerccsel és egy második diódát, amely párhuzamosan van kapcsolva az első diódával, amely első dióda keresztbe van kapcsolva a szekunder tekerccsel, továbbá ahol az első és a második dióda ellentétes irányban keresztbe van kapcsolva a második tekerccsel.

13. A 11. vagy 12. igénypont szerinti áramtranszformátor, ahol a védőáramkör tartalmaz egy Transil diódát, amely keresztbe van kapcsolva a szekunder tekerccsel.

14. Háromfázisú áramtranszformátor, amely tartalmaz:

    egy házat (105), amelynek három nyílása (110a-110c) van, amely nyílások mindegyike egy háromfázisú tápegység megfelelő fázisának primer vezetékét vagy gyűjtősinjét fogadja;

    három mágneses magot (130a-130c), amelyek a ház belsejében vannak elhelyezve és a megfelelő nyílás közelében vannak elhelyezve oly módon, hogy mágneses mező jön létre a megfelelő mágneses magban, amikor egy primer áram folyik a megfelelő nyíláson keresztül beérkező primer vezetékben vagy gyűjtősinen;

    három szekunder tekercset (140a-140c), amelyek a ház belsejében vannak elhelyezve és ahol mindegyik szekunder tekercs a megfelelő mágneses mag legalább egy része köré van tekercselve oly módon, hogy szekunder áram indukálódik a szekunder tekercselésben, amikor a megfelelő mágneses magban mágneses mező jön létre;

    egy csatlakozó foglalatot (220), amely a ház szerves részét képezi, és amely a szekunder tekercsek által előállított áramot szolgáltatja; és egy védőáramkört, amely a ház belsejében van elhelyezve, és amely keresztbe van kapcsolva a szekunder tekercsekkel a szekunder tekercsek által előállított, a csatlakozó foglalatnál elérhető feszültség korlátozása céljából;

ahol a csatlakozó foglalat elektromosan csatlakozik a védőáramkörhöz és úgy van kialakítva, hogy kimenetén megjelennek a három szekunder tekercs által előállított áramjelek.

15. Rendszer egy primer vezetékben vagy gyűjtősínben folyó elektromos áram mérésére, amely rendszer tartalmaz:

egy, a 14. igénypont szerinti áramtranszformátort; és

egy mérőeszközt, amelynek olyan söntáramköre van, amely ha az áramtranszformátor szekunder tekercseivel keresztbe van kapcsolva a csatlakozó foglalat révén, akkor úgy működik, hogy az egyes szekunder tekercsek számára egy megfelelő feszültségjelet állít elő, továbbá úgy működik, hogy a primer vezetékben vagy a gyűjtősínen továbbított áram nagyságát a beérkező feszültségjelek függvényében becsüli meg.