

Title of the Invention:

POWER CONVERTER APPARATUS

Background of the Invention:

5 (Technical Field of the Invention)

The present invention relates to a power converter apparatus and, in particular to a power converter apparatus suitable for a simplification system of a wiring work of components for constituting the above power converter apparatus such as a converter or a diode module as a means for converting an alternating current (AC) voltage to a direct current (DC) voltage, a smoothing capacitor, and an inverter as a means for converting a direct current (DC) voltage, which is an output of the smoothing capacitor, to an alternating current (AC) voltage and further suitable for an improvement in a reduction of noises in a high harmonic wave generated from a main circuit wiring of the converter and the inverter in the power converter apparatus.

(Prior Arts)

Up to now, in a main circuit wiring of such as a converter and an inverter for constituting an electric power use power converter apparatus, a bus bar structure (a plate shape copper conductor) has been used. In the main circuit wiring according to the above bus bar structure, each of the main circuit

electric mounting parts (a smoothing capacitor, a magnetic contactor, a starting current restraining resistor, a switching device, etc.) has a different dimension, respectively.

5           Also since the main circuit wiring of each of the bus bars is formed to not contact with each other, each of the bus bars having the different shape is manufactured one by one according to a cutting work and a bending work using a press machine etc. and in  
10           addition to the above it is necessary to connect and to wire with a three-dimensional structure using a complicated shape bus bar between the respective electric mounting part according to a manual work.

          As another prior art technique, there is an  
15           inverter apparatus technique which is disclosed in Japanese patent publication No. Hei 7-85,659. In this technique, the inverter apparatus comprises a diode module for converting the alternating current (AC) voltage to the direct current (DC) voltage, a  
20           transistor module for converting the direct current (DC) voltage to the alternating current (AC) voltage, a direct current smoothing capacitor, a three-phase power supply side terminal and a three-phase load side terminal, a printed substrate board of a base drive  
25           circuit for driving the transistor module, and a printed control board to which a control element is installed.

In this conventional inverter apparatus, the height of each of the terminals of the diode module, the transistor module and the smoothing capacitor and the heights of the power supply side input terminal and the load side output terminal are kept to arrange on the same plane surface. Further, this conventional inverter apparatus comprises a main circuit wiring board in which plural connection patterns for connecting each of the terminals are integrally provided according to an insulating member, and the above stated main circuit wiring board and each of the terminals are directly connected.

Further, as another prior art technique, there is a control apparatus technique which is disclosed in Japanese patent laid-open publication No. Sho 62-217,885. In this technique, the control apparatus comprises a package type converter for carrying out a regeneration control and an inverter for outputting a variable voltage and a variable frequency for use in the drive of an electric motor. The above stated inverter has the same characteristic of a transistor and a diode of the converter and also the inverter and the converter are constituted with the same package structure.

In the main circuit wiring of the power converter apparatus according to the prior art, so as to wire with a lot of bus bars, there are problems that for

manufacturing the bus bars it requires many cutting  
work and many bending work using the press machine,  
also it needs much time for the wiring work, and  
further it needs much time for the confirmation of the  
5 wiring connection state, and the like.

On the other hand, to carry out the actual drive  
using the conventional inverter apparatus technique  
shown in Japanese patent publication No. Hei 7-85,659,  
between the diode module and the smoothing capacitor,  
10 it is necessary to install separately a resistor for  
preventing an inflow of an excess charging current (the  
rush current) to the smoothing capacitor during a  
throw-in of the power supply and a magnetic contactor  
for short-circuiting between both end terminals of the  
15 resistor after the charging of the smoothing capacitor.

Further, it is necessary to carry out individually  
the main circuit wiring working between the resistor  
and the magnetic contactor and the main circuit wiring  
board. Further, since a regenerating consumption  
20 resistor for consuming the load side electric power  
(the electric power which generates during a  
deceleration time of an induction electric motor etc.)  
has a large size and generates the heat, the resistor  
is installed at an outside of the power converter  
25 apparatus.

As a result, it needs to carry out the security of  
an installation space of the regenerating consumption

resistor and the wiring work between from the power converter apparatus to the regenerating consumption resistor.

5 Accordingly, there is a serious problem that an idea does not yet make the best use, namely such an idea is to carry out only an installation work of the main circuit wiring board in which all of the main circuit of the power converter apparatus are embodied integrally but to abolish completely other circuit  
10 wiring works.

Further, in the conventional power converter apparatus, a base drive circuit for driving the transistor module, a microcomputer for carrying out PWM control (pulse width moderation control) of the  
15 converter, and a power supply circuit unit for supplying the electric power to a microcomputer surrounding circuit (a control circuit) etc. are provided separately and individually.

Therefore, it is necessary to carry out the  
20 electric wire wiring work between the transistor module and the base drive circuit, and also it is necessary to obtain the security of a space for installing separately and individually the base drive circuit and the security of a space for installing separately and  
25 individually the power supply unit for supplying the power supply to the microcomputer, etc..

Further, with respect to the main circuit wiring board itself, there is a problem that a countermeasure for reducing discharge noises is not performed. Such discharge noises are generated according to a high  
5 harmonic wave component having a high frequency flowing into a conductor of the main circuit wiring board, and the above stated component is generated in accordance with the switching operation of the transistor.

Further, to obtain a low noise structure in the  
10 power converter means including the inverter and the converter, there are a lot of the employment of IGBT (an insulating gate bipolar transistor) where a high frequency switching operation enables using the transistor module, or IPM (an intelligent power module:  
15 IGBT element and a drive circuit thereof, and a module installed inside a protection circuit), etc..

However, in a case where the above stated high frequency wave switching device is employed in the power converter means, since the high harmonic wave and  
20 the radiation noises increase, it is strongly desired to take a countermeasure for reducing the high harmonic wave and the radiation noises more than the case of the employment of the transistor element. However, in the conventional inverter apparatus technique disclosed in  
25 Japanese patent publication No. Hei 7-85,659, there is a defect where the above stated technique can not correspond to the above stated countermeasure.

Further, in the diode module, when the regeneration control is required, there a problem wherein without of a wide remodeling work for the power converter apparatus it is impossible to change a  
5 converter which enables to carry out the regeneration control.

On the other hand, in the conventional control apparatus technique shown in Japanese patent laid-open publication No. Sho 62-217,885, there includes totally  
10 the same problems similar to those in the conventional inverter apparatus technique shown in Japanese patent publication No. Hei 7-85,695.

#### Summary of the Invention:

15 An object of the present invention is to provide a power converter apparatus having a high reliability property wherein a simplification system for a wiring work of main circuit constituting parts on a substrate board in the power converter apparatus can be attained  
20 effectively.

Another object of the present invention is to provide a power converter apparatus having a high reliability property wherein a wiring miss of the power converter apparatus can be diminished remarkably.

25 A further object of the present invention is to provide a power converter apparatus having a high reliability property wherein a reduction in the high

harmonic wave current or a restraint in the radiation noises can be obtained widely.

5 A first aspect power converter apparatus for obtaining the variable frequency alternating current voltage according to the present invention comprises a first converting means for converting the supplied alternating current voltage to the direct current voltage, a smoothing means for smoothing the directed current from the first converting means, and a second  
10 converting means for converting an output voltage from the smoothing means to the alternating current voltage.

In the first aspect power converter apparatus, a wiring among the first converting means, the smoothing means and the second converting means is practiced on  
15 the same insulating substrate board.

A first voltage detecting means for detecting the direct current voltage of the first converting means and a second voltage detecting means for detecting the direct current voltage of the second converting means  
20 are provided on the insulating substrate board. A wiring of the first voltage detecting means and the second voltage detecting means is practiced on the insulating substrate board.

25 A first gate drive circuit for driving the first converting means and a first gate drive circuit power supply unit of the first gate drive circuit and a second gate drive circuit for driving the second

converting means and a second gate drive circuit power supply unit of the second gate drive circuit are provided on the insulating substrate board, and a wiring of the first gate drive circuit, the first gate drive circuit power supply unit, the second gate drive circuit and the second gate drive circuit power supply unit is practiced on the insulating substrate board.

A second aspect power converter apparatus for obtaining the variable frequency alternating current voltage comprises according to the present invention first plural converting means for converting the supplied alternating current voltage to the direct current voltage, plural smoothing means for smoothing the directed current from the first plural converting means, and a second plural converting means for converting an output voltage from the plural smoothing means to the alternating current voltage.

A wiring among the first plural converting means, the plural smoothing means and the second plural converting means is practiced on the same insulating substrate board.

A first voltage detecting means for detecting the direct current voltage of the first plural converting means and a second voltage detecting means for detecting the direct current voltage of the second plural converting means are provided on the insulating substrate board. A wiring of the first voltage

detecting means and the second voltage detecting means is practiced on the insulating substrate board.

5 A first gate drive circuit for driving the first plural converting means and a first gate drive circuit power supply unit of the first gate drive circuit and a second gate drive circuit for driving the second plural converting means and a second gate drive circuit power supply unit of the second gate drive circuit are provided on the insulating substrate board.

10 A wiring of the first gate drive circuit, the first gate drive circuit power supply unit, the second gate drive circuit and the second gate drive circuit power supply unit is practiced on the insulating substrate board.

15 A third aspect power converter apparatus for obtaining the variable frequency alternating current voltage comprises according to the present invention a first plural converting means for converting the supplied alternating current voltage to the direct current voltage, plural smoothing means for smoothing the directed current from the first plural converting means, and a second plural converting means for converting an output voltage from the plural smoothing means to the alternating current voltage

20 A wiring of the first plural converting means is practiced on a first insulating substrate board, a wiring of the second plural converting means is

practiced on a second insulating substrate board and a wiring of the plural smoothing means is practiced on one of the first insulating substrate board and the second insulating substrate board.

5           A first voltage detecting means for detecting the direct current voltage of the first converting means is provided on the first insulating substrate board, a second voltage detecting means for detecting the direct current voltage of the second converting means is  
10           provided on the second insulating substrate board.

          A wiring of the first voltage detecting means is practiced on the first insulating substrate board and a wiring of the second voltage detecting means is practiced on the second insulating substrate board.

15           A first gate drive circuit for driving the first plural converting means and a first gate drive circuit power supply unit of the first gate drive circuit are provided on the first insulating substrate board, a second gate drive circuit for driving the second plural  
20           converting means and a second gate drive circuit power supply unit of the second gate drive circuit are provided on the second insulating substrate board.

          A wiring of the first gate drive circuit and the first gate drive circuit power supply unit is practiced  
25           on the first insulating substrate board, and a wiring of the second gate drive circuit and the second gate drive circuit power supply unit is practiced on the

second insulating substrate board.

A fourth aspect power converter apparatus for obtaining the variable frequency alternating current voltage according to the present invention comprises a  
5 first converting means for converting the supplied alternating current voltage to the direct current voltage and having first plural switching devices, a smoothing means for smoothing the directed current from the first converting means, and a second plural  
10 converting means for converting an output voltage from the plural smoothing means to the alternating current voltage and having a second plural switching devices.

A wiring of the first converting means is practiced on a first insulating substrate board, a  
15 wiring of the second converting means is practiced on a second insulating substrate board.

A first voltage detecting means is provided on the first insulating substrate board, a second voltage detecting means is provided on the second insulating  
20 substrate board, a wiring of the first voltage detecting means is practiced on the first insulating substrate board, a wiring of the second voltage detecting means is practiced on the second insulating substrate board and a wiring of the plural smoothing  
25 means is practiced on one of the first insulating substrate board and the second insulating substrate board.

A first gate drive circuit and a first gate drive circuit power supply unit are provided on the first insulating substrate board, a second gate drive circuit and a gate second drive circuit power supply unit are provided on the second insulating substrate board, a wiring of the first gate drive circuit and the first gate drive circuit power supply unit is practiced on the first insulating substrate board and a wiring of the second gate drive circuit and the second gate drive circuit power supply unit is practiced on the second insulating substrate board.

A fifth aspect power converter apparatus according to the present invention comprises a diode module for converting the alternating current voltage to the direct current voltage, a smoothing capacitor for smoothing the direct current of the diode module, an inverter for converting the obtained direct current voltage from the smoothing capacitor to the alternating current voltage and supplying the obtained alternating current voltage to a load, and a regenerating consumption resistor for consuming an output electric power of the inverter.

In the fifth aspect power converter apparatus, a main circuit conductor connects each of components, the components are the diode module, the smoothing capacitor and the inverter and this main circuit conductor is provided on a single insulating substrate

board. The main circuit conductor comprises a plus  
side main circuit conductor for connecting to a plus  
terminal of each of the components and a minus side  
main circuit conductor for connecting to a minus  
5 terminal of each of the components.

By intervening an insulating member between the  
plus side main circuit conductor and the minus side  
main circuit conductor, each of the plus side main  
circuit conductor and each of the minus side main  
10 circuit conductor are contacted respectively to the  
insulating substrate board. And each of the plus side  
main circuit conductor and each of the minus side main  
circuit conductor are formed according to a patterning,  
and the obtained pattern of the main circuit conductor  
15 is connected to the plus terminal and the minus  
terminal of each of the components.

As stated in the above, since the main circuit  
conductor is carried out according to the pattern  
wiring, the simplification in the wiring work in the  
20 power converter apparatus can be obtained.

Further, the main circuit conductor according to  
the above stated fourth power converter apparatus  
connects each of components, the components are the  
diode module, the smoothing capacitor and the inverter.

25 Namely, (1) by intervening an insulating member  
between a plus side main circuit conductor and a minus  
side main circuit conductor, each of the plus side main

circuit conductor and each of the minus side main circuit conductor are contacted respectively to the insulating substrate board and each of the plus side main circuit conductor and each of the minus side main circuit conductor are formed according to a patterning, and in place of the main circuit conductor formed on the insulating substrate board, or (2) by approaching the plus side main circuit conductor and the minus side main circuit conductor in the interior portion of the insulating substrate board through an insulating wall, the main circuit conductor is buried according to the patterning.

Further, (3) by relatively positioning respectively one of the plus side main circuit conductor and the minus side main circuit conductor on an upper surface of the insulating substrate board and another the plus side main circuit conductor and the minus side main circuit conductor under a lower surface of the insulating substrate board, the main circuit conductor is formed according to the patterning, or (4) by intervening the plus side main circuit conductor and the minus side main circuit conductor the insulating member between the plus side main circuit conductor and the minus side main circuit conductor and laminating the plus side main circuit conductor and the minus side main circuit conductor on the insulating substrate board, the main circuit conductor is formed according

to the patterning.

In any one of the main circuit board conductor shown in from (1) to (4), by intervening the dielectric member of the insulating member or the insulating wall  
5 between the plus side main circuit conductor and the minus side main circuit conductor, the condenser structure is formed, the high harmonic wave current among the current flowing the main circuit conductor can be reduced and also the noises radiated from the  
10 main circuit conductor can be reduced.

Further, by the provision of a gate drive circuit and a gate drive power supply unit on the insulating substrate board, or the provision of a voltage detection means for detecting the voltage at the input  
15 side of the inverter, it is preferable to carry out the pattern wiring together with the main circuit conductor. Accordingly, the simplification in the wiring work of the power converter apparatus can be carried out  
furthermore.

20 Further, in the fifth aspect power converter apparatus according to the present invention, the diode module, the smoothing capacitor, the inverter, and the regenerating consumption resistor are arranged in an air duct. The diode module and the inverter are  
25 installed to a single cooling fin and the regenerating consumption resistor is installed to another single cooling fin. Accordingly, it is preferable to cover a

top portion of the air duct by the insulating substrate board.

Since the regenerating consumption resistor having the large exothermic heat property can be installed  
5 together with the diode module, the smoothing capacitor, and the inverter, as a result the power converter apparatus having the small size can be obtained.

Further, a sixth aspect power converter apparatus according to the present invention comprises a  
10 converter for converting the alternating current voltage to the direct current voltage, a smoothing capacitor for smoothing the direct current voltage of the converter and an inverter for converting an obtained direct current voltage from the smoothing  
15 capacitor to the alternating current voltage and for supplying the obtained alternating current voltage to a load.

In the sixth aspect power converter apparatus, a main circuit conductor connects each of components, the  
20 components are the converter, the smoothing capacitor and the inverter and the main circuit conductor is provided on a single insulating substrate board. The main circuit conductor comprises a plus side main circuit conductor for connecting to a plus terminal of  
25 each of the components and a minus side main circuit conductor for connecting to a minus terminal of each of the components.

By intervening an insulating member between the plus side main circuit conductor and the minus side main circuit conductor, each of the plus side main circuit conductor and each of the minus side main circuit conductor are laminated to the insulating substrate board and is formed according to the patterning and the pattern of the main circuit conductor is connected to the plus terminal and the minus terminal of each of the components.

As stated in the above, since the main circuit conductor is carried out according to the pattern wiring, the simplification in the wiring work can be obtained.

The sixth aspect power converter apparatus comprised of the regeneration control type converter differs from the fourth power converter apparatus comprised of the non-regeneration type diode module. In the fifth power converter apparatus, since an output of the inverter during the load reduction time can return to the alternating current power supply side of the converter, it is unnecessary to provide the regenerating consumption resistor which is comprised in the above fourth power conversion apparatus.

In the above stated sixth aspect power converter apparatus, by intervening the insulating member between the plus side main circuit conductor and the minus side main circuit conductor, the main circuit conductor

connects each of the components of the converter, the smoothing capacitor and the inverter.

5       The main circuit conductor is contacted on the insulating substrate board according to the patterning and the main circuit conductor is formed on the single insulating substrate board, this structure is the same one of the main circuit conductor of (1) in the above fifth power converter apparatus.

10       Further, in place of the main circuit conductor of (1) in the above stated fifth aspect power converter apparatus, following main circuits may employ, namely (2) in the interior portion of the insulating substrate board the main circuit conductor is buried according to the patterning, or (3) at the upper surface and the  
15       lower surface of the insulating substrate board the main circuit conductor is formed according to the patterning, or (4) on the insulating substrate board the main circuit conductor is laminated according to the patterning.

20       As stated in the above, each of the main circuit conductors (1)-(4) forms the condenser structure, the high harmonic wave current flowing the main circuit conductor can be reduced and further the noises radiated from the main circuit can be reduced.

25       Further, by the provision of a gate drive circuit for driving the converter and a gate drive power supply unit thereof on the insulating substrate board and by

the provision of a gate drive circuit for driving the inverter and a gate drive power supply unit thereof on the insulating substrate board, or the provision of a voltage detection means for detecting the voltage at the output side of the converter, or the provision of a voltage detection means for detecting the voltage at the input side of the inverter, it is preferable to carry out the pattern wiring together with the main circuit conductor. Accordingly, the simplification in the wiring work of the power converter apparatus can be obtained furthermore.

Further, a seventh aspect power converter apparatus according to the present invention comprises a diode module or a converter for converting the alternative current voltage to the direct current voltage, a smoothing capacitor, an inverter, or a regenerating consumption resistor.

In the seventh aspect power converter apparatus, each of components is provided in an air duct, such components are the diode module or the converter, the smoothing capacitor and the inverter. A main circuit conductor connects each of the components and the main circuit conductor is patterned on a single insulating substrate board. The air duct covers and connects the main circuit conductor pattern to each terminal of each components.

The diode module or the converter is selectively provided at the same area of the air duct, and on the insulating substrate board the diode module or the converter includes the respective main circuit conductor pattern.

Further, an eighth aspect power converter apparatus according to the present invention comprises a regeneration control type converter, a smoothing capacitor and an inverter. In the seventh power converter apparatus, the converter is constituted by plural variable control converter elements arranged on a single insulating substrate board.

A main circuit conductor connects between the plural variable converter elements by forming on the single insulating substrate board according to the patterning, and further the inverter is constituted by plural variable control inverter elements which are arranged on another insulating substrate board. Another main circuit conductor connects between the plural variable inverter elements by forming on the another single insulating substrate board according to the patterning.

Further, the functions and the installation positions of the components for constituting the seventh aspect and the eighth aspect power converter apparatuses are similar to those of the fifth aspect and the sixth aspect power converter apparatuses.

In the present invention, a converting means for converting the supplied alternating current (AC) voltage to the direct current (DC) voltage or an AC/DC converting means is comprised of a diode module or a converter. A converting means for converting the direct current voltage (DC) to the alternating current (AC) voltage or a DC/AC converting means is comprised of an inverter. In case of an employment of the diode module it is necessary to provide a regenerating consumption resistor, however in a case of an employment of the converter it is unnecessary to provide a regenerating consumption resistor.

Further, the conductor can be mounted on an upper surface or a lower surface of an insulating substrate board, in addition to the above the conductor can be inserted or buried in an interior portion of the insulating substrate board.

In the present specification, an integral insulating substrate board indicates the insulating substrate board in which a wiring among the converter (the diode module), a smoothing capacitor and the inverter is practiced, in other words the conductor is formed integrally to or in the insulating substrate board according to a patterning, etc..

The wiring among the converter (the diode module), a smoothing capacitor and the inverter can be practiced on a single insulating substrate board, a pair of

insulating substrate boards or a multi-laminated substrate board structure, etc..

Brief Description of Drawings:

5            Fig. 1 is an arrangement view showing one embodiment of a power converter apparatus according to the present invention, the power converter apparatus is constituted by the various kinds of electric mounting parts;

10           Fig. 2 is a plan view showing an arrangement of a main circuit electric mounting part in an air duct of the embodiment of the power converter apparatus shown in Fig. 1 according to the present invention;

            Fig. 3 is a plan view showing an integral  
15           insulating substrate board in which a main circuit conductor pattern is formed on one embodiment of the power converter apparatus shown in Fig. 1 according to the present invention and an arrangement of the electric mounting parts which corresponds to the above  
20           main circuit pattern;

            Fig. 4 is an explanation view showing a selective arrangement of a regeneration control type converter and a non-regeneration type diode module of one  
25           embodiment of a power converter apparatus according to the present invention;

            Fig. 5 is a circuitry construction view for explaining an exchange between the converter and the

diode module of one embodiment of a power converter apparatus according to the present invention;

Fig. 6 is a view for explaining a condenser structure of the main circuit conductor of one  
5 embodiment of a power converter apparatus according to the present invention;

Fig. 7 is an equivalent circuit of a condenser structure of one embodiment of a power converter apparatus according to the present invention;

10 Fig. 8 is a concept view for explaining a condenser structure of another main circuit condenser of one embodiment of a power converter apparatus according to the present invention;

Fig. 9 is a view for explaining a condenser  
15 structure of a further main circuit condenser of one embodiment of a power converter apparatus according to the present invention;

Fig. 10 is a view for explaining a condenser structure of a furthermore main circuit condenser of  
20 one embodiment of a power converter apparatus according to the present invention;

Fig. 11 is a view for explaining a condenser structure of a furthermore main circuit condenser of  
one embodiment of a power converter apparatus according  
25 to the present invention;

Fig. 12 is a circuitry construction view showing a power converter apparatus according to the present

invention comprising a non-regeneration type diode module;

Fig. 13 is a circuitry construction view showing a power converter apparatus according to the present invention comprising a regeneration control type converter;

Fig. 14 is a plan view of an integral insulating substrate board for use in a power converter apparatus according to the present invention comprising two converters and two inverters;

Fig. 15 is a circuitry construction view showing the power converter apparatus shown in Fig. 14;

Fig. 16 is a circuitry construction view explaining a division position of a case where an integral insulating substrate board is divided into two for use in another embodiment of a power converter apparatus according to the present invention comprising two converters and two inverters;

Fig. 17 is a view showing a conductor pattern which is used to constitute a converter and an inverter by combing plural elements of another embodiment of a power converter apparatus according to the present invention;

Fig. 18 is a view explaining a large capacity load operation according to a parallel arrangement employing another embodiment of a power converter apparatus according to the present invention; and

Fig. 19 is a view for explaining a parallel arrangement and a parallel operation employing another embodiment of a power converter apparatus according to the present invention.

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#### Description of the Invention:

First of all, a general power converter apparatus is constituted by various kinds of electric mounting parts such as a means for converting an alternating  
10 current (AC) voltage to a direct current (DC) voltage (in general, it comprises an inverter or a diode module and it is called commonly as a "converter"), a smoothing capacitor for smoothing the direct current (DC) voltage which is outputted from the converter, an  
15 a means for converting a direct current (DC) voltage, which is an output of the smoothing capacitor, to an alternating current (AC) voltage (in general, it is called commonly as an "inverter") or for converting the smoothing an output voltage of the smoothing capacitor  
20 to the variable voltage, the variable frequency, etc..

The general power converter apparatus is constituted further usually by a main circuit conductor for connecting those electric mounting parts, a control means for driving and controlling the various kinds of  
25 the power converter means, and a cooling means (this means is constituted by a cooling fin, a cooling fan, an air duct and the like) for cooling those electric

mounting parts.

Hereinafter, one embodiment (Mode 1) of a power converter apparatus according to the present invention will be explained referring from Fig. 1 to Fig. 6.

5        Fig. 1 is an arrangement view showing various kinds of electric mounting parts which constitute one embodiment (Mode 1) of a power converter apparatus according to the present invention. Fig. 2 is an arrangement view showing main circuit electric mounting  
10       parts which are installed in an air duct of the power converter apparatus. Fig. 3 is a plan view showing an integral insulating substrate board in which a main circuit conductor of the main circuit electric mounting part of the power converter apparatus is formed.

15       Fig. 4 is an explanation view for explaining a regeneration control type converter and a non-regeneration type diode module used in the power converter apparatus. Fig. 5 is a circuitry construction view for explaining an exchange a  
20       converter with a diode module used in the power converter apparatus. Fig. 6 is an explanation view for explaining a conductor structure for forming the main circuit of the power converter apparatus. In each of the above figures, the same structural matter (element)  
25       or a structural matter (element) having same function is denoted using the same reference numeral.

Mainly referring to Fig. 5, one embodiment of a power converter apparatus according to the present invention comprises a three-phase alternating current power supply 1 of a main circuit, an input wire line 2, and a regeneration control type converter 3. The regeneration control type converter 3 is constituted by IGBT or IPM, or a variable control element such as a power transistor, etc.. When a three-phase alternating current 1 is converted to the direct current voltage and when the voltage at a direct current side exceeds over a predetermined regulation value an electric power caused at a load side is regenerated at a three-phase alternating current power supply 1 side.

The power converter apparatus comprises further a diode module 4 (a non-regeneration type converter) for carrying out a full wave rectification and is used at a case of a comparative small load capacity where the electric power is not regenerated at the three-phase alternating current power supply 1 side. In a case where the converter 3 is attached to the power converter apparatus, this diode module 4 is taken off and, inversely in a case of an adoption of the diode module 4 the converter 3 is taken off.

The power converter apparatus comprises further a smoothing capacitor 5 and a starting current restraining resistor 6. The smoothing capacitor 5 smoothes the direct current voltage which is rectified

through the converter 3 or the diode module 4. The starting current restraining resistor 6 is one which can restrain a very large charging current for flowing into the smoothing capacitor 5 during a power supply  
5 throw-in initial period. This starting current restraining resistor 6 is mounted on an upper surface of a substrate board (confer Fig. 1) or provided on a lower surface of the substrate board.

The power converter apparatus comprises further a  
10 magnetic contactor 7 and a discharging resistor 8. The contactor 7 short-circuits both end terminals of the starting current restraining resistor 6 after the charging of the smoothing capacitor 5. When an operation of the power converter apparatus is stopped  
15 or when the three-phase alternating current power supply 1 is cut to check the power converter apparatus, the above discharging resistor 8 forces to discharge rapidly the charging voltage of the smoothing resistor 5.

20 The power converter apparatus comprises further an inverter 9, a switching device 10 and a regenerating consumption resistor 11. The inverter 9 comprises a variable control element (the variable control element is IGBT or IPM or a power transistor, GTO, etc. and a  
25 power switching device controlled according to a gate or a base) for converting the smoothed direct current voltage smoothed by the smoothing capacitor 5 to the

variable voltage or the variable frequency.

The switching device 9 is operated in a case where the load side electric power is consumed at the regenerating consumption resistor 11. Further, the  
5 above switching device 9 is used in a circuit where the diode module 4 is adopted and the electric power is consumed by the regenerating consumption resistor 11 without the regeneration of the electric power at the power supply side.

10 Further, the switching device 10 is adopted in the same module in which the inverter 9 is installed inside. As a result, the inverter 9 is the module which is comprised of six variable control elements for use in an original inverter and one element among the  
15 switching devices 10. The inverter 9 and the converter 3 or the diode module 4 are provided on the same cooling fin (confer Fig. 1).

In succession, P denotes a plus side conductor (hereinafter, it is called as "a main circuit conductor  
20 P") of the main circuit which is provided on the substrate board, and N denotes a minus side conductor (hereinafter, it is called as "a main circuit conductor N") of the main circuit which is provided on the substrate board. The main circuit conductor P and the  
25 main circuit conductor N, as shown in Fig. 3, are provided adjacently in parallel form.

Herein, Q denotes an insulating member having a high dielectric constant and this insulating member Q is provided adhesive with the conductors between the main circuit conductor P and the main circuit conductor N. The main circuit conductor P and the main circuit conductor N are conductors which can connect and wire on the substrate board each of the input terminals and the output terminals of the converter 3 or the diode module 4, the smoothing capacitor 5, the starting current restraining resistor 6, the magnetic contactor 7 and the inverter 9.

As shown in Fig. 3, the power converter apparatus comprises further an integral insulating substrate board 12. On this integral insulating substrate board 12 the main circuit conductors P and N are formed and also the starting current restraining resistor 6, a drive circuit (a gate drive circuit or a base drive circuit) for driving the converter 3 and the inverter 9, a direct current voltage detection circuit, and a control power supply unit are mounted in a manner of an integral embodied wiring work. On this integral insulating substrate board 12, the main circuit conductors P and N are formed and connect from the input wire line 2 to an output wire line 13 of the inverter 9.

As shown in Fig. 5, the power converter apparatus comprises further an induction electric motor 14 and a

connection line 15. The electric motor 14 is driven by the variable voltage or the variable frequency which is an output of the inverter 9. The connection line 15 is shown in a lower portion of Fig. 3, and in a case the  
5 diode module 4 is used in place of the converter 3, the connection line 15 forms one which connects the regenerating consumption resistor 11 to the switching device 10 in which the inverter 9 is installed inside.

In a case where the regeneration control type  
10 converter 3 is used, because that the regenerating consumption resistor 11 is unnecessary, the switching device 10 is forced to be always an OFF condition or the connection line 15 is taken off, therefore the regenerating consumption resistor 11 is cut off  
15 electrically or physically from the power converter apparatus.

The construction of the cooling means (the cooling fin, the cooling fan, the air duct, etc.) and a whole construction of the power converter apparatus will be  
20 explained referring to Fig. 1 and Fig. 2.

Fig. 1 and Fig. 2 shows the power converter apparatus using the converter 3, however according to the specification in a case where in place of the converter 3 the diode module 4 can be selected, the  
25 diode module 4 is provided at a substantially same installation position of that of the converter 3.

At an interior portion of an air duct 15 comparative large scale electric mounting parts among a main circuit electric mounting part of the power converter apparatus is arranged. When the integral  
5 insulating substrate board 12 is set in the air duct 16, as a matter of course the electric mounting parts in the air duct 16 are arranged in such a manner in which the connection terminals (passing-through hole terminal portions of the integral insulating substrate board 12)  
10 of the main circuit conductors P and N on the integral insulating substrate board 12 are consistent with the input and the output terminal of each of the electric mounting parts.

A cooling fin 17 provided in the air duct 16  
15 mounts the converter 3 or the diode module 4, and the inverter 9, and another cooling fin 18 mounts the regenerating consumption resistor 11. A suction port 19 of an cooling air 20 and this suction port is provided on the air duct 16, a cooling fan 21 is  
20 provided on the power converter apparatus.

The cooling air 20 generated according to the cooling fan 21 inflows from the cooling air suction port 19 and cools in sequence the cooling fin 17 for the power converter means, the smoothing capacitor 5,  
25 the regenerating consumption resistor 11 and the cooling fin 18 for cooling the regenerating consumption resistor 11 and is discharged through the cooling fan

21.

As stated in the above, since the cooling means is constituted, and then an amount of the cooling air 20 and a surface area of the cooling fin 21 are set that the maximum temperature generated by the exothermic of the regenerating consumption resistor 11 during the power generation consumption is less than the service life temperature of the respective variable control element of the converter 3 (or the diode module 4) and the inverter 9.

So that the compulsory cooling is carried out according to the cooling air 20, since the small size (the reduction in the resistor capacity) of the regenerating consumption resistor 11 can be attained, the regenerating consumption resistor 11 can be provided in the interior portion of the air duct 16. However, in the above stated prior arts such a regenerating consumption resistor is provided an outside portion of the power converter apparatus.

As a result, since the regenerating consumption resistor 11 is provided inclusively and integrally in the power converter apparatus, the regenerating consumption resistor 11 is unnecessary to provide separately or individually, therefore the small size of the apparatus as a whole including the regenerating consumption resistor 11 can be attained.

Further, the reason of the separated provision structure of the cooling fin 17 for the both power converter means and the cooling fin 18 for the regenerating consumption resistor 11 is that, in  
5 comparison with the installation portion for collecting the large scale cooling fin at only a single portion, with the separated one by one provision structure the size of the cooling fin can make small and a freedom degree in arrangement of the arrangement in the air  
10 duct 16 can be heightened.

On the air duct 16, the integral insulating substrate board 12 is installed to form a ceiling of the air duct 17. At an outlet port side of the air duct 16, the integral insulating substrate board 12 is  
15 supported through a supporting rod 22 and at an inlet port side is supported through the input and the output terminals of the converter 3 and the inverter 9, and further at a middle portion side the integral insulating substrate board 12 is supported through the  
20 input and the output terminals of the smoothing capacitor 5. The converter 3, the inverter 9 and the smoothing capacitor 5 can serve as the supporting means.

In Fig. 2, CTa denotes a current detector for measuring the three-phase alternating current which is  
25 inputted to the converter 3 and CTb denotes a current detector for measuring an output current of the inverter 9. A detection value of the current detector

CTa is used for the control of the converter 3 and also a detection value of the current detector CTb is used for the control of the inverter 9.

As shown in Fig. 1, on a control substrate board  
5 23, a microcomputer (not shown) for controlling the converter 3 and the inverter 9 and so on. The control substrate board 23 is provided at an upper portion of the integral insulating substrate board 12 and the both  
10 substrate boards 12 and 23 are connected through a connector 25a, signal lines 24 and 25b.

The microcomputer input each of the detection values of the current detectors CTa and CTb and also an input data such as an actual velocity, a speed command (not shown) and the like of the induction electric  
15 motor (IM) 14 which are shown in Fig. 5. The microcomputer carries out various execution proceedings under the basis of the above stated data and also output PWM control signal to each of the power converter means 3 and 9. The control substrate board  
20 23 and the integral insulating substrate board 12 are covered according to a cover 26 and among them the control substrate board 23 is attached on a flange member which stretches over from an inner wall of the cover 26.

25 In succession, a detail construction of the integral insulating substrate board 12 of the power converter apparatus according to the present invention

will be explained, on the eve of this explanation a general substrate board of the power converter apparatus will be described.

5 A conductor pattern of the general substrate board is used mainly with a thickness of 35 micron, however in accordance with the increase in the current capacity, recently a conductor pattern having the thickness of several hundreds micron is used, further on a conductor pattern having a thickness of several tens micron a  
10 method of arranging a bus bar shape conductor for use in the large current using a cream soldering method has been practiced.

Herein, the detailed construction of the integral insulating substrate board 12 of the power converter apparatus according to the present invention will be  
15 explained referring to Fig. 3 and Fig. 4.

Fig. 4 is a view showing a positional relationship of the converter 3 and the diode module 4 which are arranged on a base of the cooling fin 17.  $R_1$ ,  $S_1$  and  
20  $T_1$  denote are input terminals (the alternating current side terminals) of the regeneration control type converter 3, and  $P_2$  and  $N_2$  denote respectively a direct current plus output terminal and a direct current minus output terminal of the converter 3. 27a denotes an  
25 input terminal portion of PWM control signal for driving the converter 3.

$R_1'$ ,  $S_1'$ , and  $T_1'$  denote are input terminals of the non-regeneration type diode module 4 (indicted by a broken line), and  $P_1$  and  $N_1$  denote respectively a direct current plus output terminal and a direct current minus output terminal of the diode module 4. The height size of the converter 3 and the height size of the diode module 4 is same, therefore the same height sizes of the converter 3 and the diode module 4 are arranged on the integral insulating substrate board 12.

As shown in Fig. 3, the three-phase alternating current power supply 1 (confer Fig. 5) is connected to input portions R, S and T of the integral insulating substrate board 12 through the input wire line 2. A portion formed between  $P_1$ - $P_2$ - $P_3$ - $P_4$  terminals of the integral insulating substrate board 12 is connected through the main circuit conductor P (plus pole conductor) of the main circuit and also at a portion formed between  $N_1$ - $N_2$ - $N_3$  terminals of the main circuit the main circuit conductor N (minus pole conductor) of the main circuit is provided.

The converter 3 or the diode module 4 is arranged selectively just under portion of the input portions R, S and T and the output portions  $P_1$ ,  $P_2$ ,  $N_1$  and  $N_2$  of the integral insulating substrate board 12 as a standard of S-phase terminals ( $S_1$  terminal and  $S_1'$  terminal). Accordingly, only one of the converter 3 or

the diode module 4 is actually arranged, however the main circuit at this portion forms a circuitry construction where the converter 3 and the diode module 4 are connected in parallel.

5           Further, the positional differences ( $R_1$  and  $R_1'$ ,  $T_1'$  and  $T_1'$ ) in the input and the output terminals of the converter 3 and the diode module 4 are caused by a provision of a long sideways hole, this long sideways hole is provided on the integral insulating substrate board 12 as shown R and T of the integral insulating  
10           substrate board in Fig. 3. Where there is the large differences between  $P_1$ - $P_2$  and  $N_1$ - $N_2$  of the integral insulating substrate board 12 as shown in Fig. 3 the power converter apparatus is connected through the main  
15           circuit conductors P and N.

          As a matter of course, on the integral insulating substrate board 12 which is provided at the same position of the input and the output terminals of the respective electric mounting parts provided on the air  
20           duct 16, a passing-through hole for passing through the integral insulating substrate board 12 is provided and in this passing-through hole a conductive bush member Z comprising a copper pipe or a metal pipe having the substantially same conductivity of copper is provided.

25           Further,  $P_1$ - $P_2$  portion and  $N_1$ - $N_1$  portion are connected to the main circuit conductors P and N and to the conductive bush member Z. And allowing the pass of

a screw member 34 into the conductive bush member Z, the main circuit conductors P and N of the integral insulating substrate board 12 and the input and the output terminals of the converter 3 or the diode module 4 are connected and fixed (also the input wire line 2 is fixed through the screw member 34).

Namely, the conductive bush member Z can form the connection terminals of the main circuit conductors P and N, from the main circuit conductors P and N the current is allowed to flow to the input and the output terminals of the respective electric mounting parts but is not allowed extremely to flow toward the screw member 34.

With the above stated construction, according to the specification one of the converter 3 or the diode module 4 can be freely provided without the remodeling for the integral insulating substrate board 12 and can be carried out easily to return to the original state.

On the other hand, the smoothing capacitor 5 has a comparatively large size among the constituting components in the power conversion apparatus. As shown in Fig. 1, a hole portion or a notch portion to which the smoothing capacitor 5 is allowed to enter is provided on the integral insulating substrate board 12, through the hole portion (or the notch portion) an upper portion of the smoothing capacitor 5 can be set free.

Accordingly, the connections between the electrode portions  $P_5$  and  $N_5$  of the smoothing capacitor 5 and the main circuit conductors P and N provided on the integral insulating substrate board 12 are carried out according to a bending operation of the main circuit conductors P and N by adjusting the heights of the electrode portions  $P_5$  and  $N_5$  of the smoothing capacitor 5. And further the connections between the electrode portions  $P_5$  and  $N_5$  of the smoothing capacitor 5 and the main circuit conductors P and N is connected and fixed by projecting the main circuit conductors P and N from the integral insulating substrate board 12.

As stated in the above, the reasons why the smoothing capacitor 5 is taken in the integral insulating substrate board so far as to make the hole by opening the integral insulating substrate board 12 are that a whole arrangement area of the respective electric mounting part constituting the power converter apparatus is made to lessen small and further a whole power converter apparatus is made compact according to the cooling of the smoothing capacitor 5.

As a result, in a case where the smoothing capacitor 5 is provided an outside portion of the integral insulating substrate board 12, the smoothing capacitor 5 is provided a predetermined position near the integral insulating substrate board 12 and the main circuit conductors P and N on the integral insulating

substrate board 12 can lengthen and connect to the electrode portions  $P_5$  and  $N_5$  of the smoothing capacitor 5 which positions at the outside portion of the integral insulating substrate board 12.

5           Further, the connections between the input and the output terminals of the magnetic contactor 7 and the inverter 9 and the main circuit conductors P and N on the integral insulating substrate board 12 are connected and fixed by passing through the screw member  
10           to the conductive bush member Z which passes through the integral insulating substrate board 12 similarly to the case of the converter 3 or the diode module 4.

          Further, as Pa-Pb portion shown in Fig. 3, in a case where the main circuit conductors P and N are  
15           crossed each other on the integral insulating substrate board 12, using the conductive bush member Z which passes through the integral insulating substrate board 12, they can escape to a rear surface at Pa portion on the integral insulating substrate board 12 and through  
20           the main circuit conductor P which is connected to the conductive bush member Z at the rear surface of the integral insulating substrate board 12, they can come out again at Pb portion at the front surface.

          In a case where a part of the main circuit  
25           conductors P and N on the integral insulating substrate board 12 is arranged in a three-dimensional structure state, a following method can be adopted. Namely, at

Pa portion the main circuit conductor P is risen once in the air and by providing a predetermined space between the main circuit conductor P and the main circuit conductor N the main circuit conductor P is  
5 crossed by the main circuit conductor N in the air and again is returned to the integral insulating substrate board 12 at Pb portion.

Further, on the integral insulating substrate board 12, as shown in Fig. 3, a conductor extends over  
10 from a connection terminal B of the regenerating consumption resistor 11 in the inverter 9. Such a conductor is arranged from B<sub>1</sub> portion to B<sub>2</sub> portion at a rear side of the integral insulating substrate board 12 and at B<sub>2</sub> portion the conductor is connected to a  
15 connection line 15. On the other hand, the connection terminal portions P<sub>6</sub> and N<sub>6</sub> are arranged on the integral insulating substrate board 12 between the input and the output terminal portions of the inverter 9 and the main circuit conductors P and N, and further  
20 the inverter 9 has output terminals which are shown U, V, and W, respectively.

As shown in Fig. 3, the power converter apparatus comprises two gate drive circuits (GDC) 28a and 28b, and the gate drive circuit (GDC) 28a drives the  
25 converter 3 through a control signal terminal portion 27a and the gate drive circuit (GDC) 28b drives the inverter 9 through a control signal terminal portion

27b, respectively. These gate drive circuits (GDC) 28a and 28b are provided on the same integral insulating substrate board 12, namely the integral insulating substrate board 12 on which the main circuit conductors P and N are provided. A signal (PWM control signal) to each of the gate drive circuits (GDC) 28a and 28b is outputted through the connectors 25a and 25b from the microcomputer on which the control substrate board 23 is mounted.

As shown in Fig. 3, the power converter apparatus comprises a voltage detection circuit (VDC) 29a for the converter 3 and this voltage detection circuit (VDC) 29a detects the direct current voltage (the voltage of the smoothing capacitor 5) of the main circuit using an insulating amplifier (not shown in figure) and the like. This detection voltage is transmitted through the connector 25a to the microcomputer which is mounted on the control substrate board 23 and is used for the output voltage control of the converter 3.

As shown in Fig. 3, the power converter apparatus comprises a voltage detection circuit (VDC) 29b for the inverter 9 and this voltage detection circuit (VDC) 29b detects the direct current voltage (the voltage of the smoothing capacitor 5) of the main circuit. In accordance with a predetermined established detection level, the above stated voltage detection circuit (VDC) 29b judges a start and a stop of the power generating

consumption control and further transmits a result of the judgment through the connector 25b to the microcomputer which is mounted on the control substrate board 23.

5           Further, the voltage detection circuit (DVC) 29b for the inverter 9 has a following function. In a case where in place of the regeneration control type converter 3 a non-regeneration type diode module 4 is adopted, in normally there is no existence of means for  
10           controlling the direct current voltage of the main circuit such as the converter 3, even the direct current voltage becomes abnormally high, there is no means for protecting the smoothing capacitor 5 and the inverter 9.

15           Therefore, the voltage detection circuit (VDC) 29b has a function in which when the direct current voltage in the main circuit becomes abnormally high, according to another detection level which differs from the detection level of the voltage detection circuit (VDC)  
20           29b at a side of the inverter 9, a signal for stopping the inverter 9 is outputted to the microcomputer which is mounted on the control substrate board 23.

          Between from the control input signal terminal portions 27a and 27b to the gate drive circuits (GDC)  
25           28a and 28b are wired according to a conductor pattern g and further between from the direct current portions of the main circuit conductors P and N and the

respective voltage detection circuits (VDC) 29a and 29b are wired according to a conductor pattern f.

As shown in Fig. 3, the power converter apparatus comprises a control power supply unit (CPS) 30 and this  
5 control power supply unit (CPS) 30 is provided on the integral insulating substrate board 12 similar to those of the gate drive circuits (GDC) 28a and 28b and the voltage detection circuits (VDC) 29a and 29b. From two  
10 phases selected from among the three-phase alternating current input terminals R, S and T, the control power supply unit (CPS) 30 receives the alternating current electric power through a conductor pattern (not shown  
in figure) mounted on the integral insulating substrate board 12 and steps down the alternating current main  
15 circuit power supply voltage through a small size transformer (TR) 31 which is provided in the control power supply unit (CPS) 30.

The control power supply unit (CPS) 30 converts to a predetermined direct current voltage and supplies the  
20 electric power to each of the circuits and another control substrate board 23. The direct current prepared by the control power supply unit (CPS) 30 which is mounted on the integral insulating substrate board 12 is supplied to the separated control substrate  
25 board 23 through a repeating connector 32.

As shown in Fig. 3, the power converter apparatus comprises two gate drive power supply units (GDPS) 33a

and 33b and in accordance with the direct current voltage prepared by the respective control power supply unit (CPS) 30, each of the gate drive power supply units (GDPS) 33a and 33b makes and supplies a  
5 predetermined direct current voltage to each of the gate drive circuits (GDC) 28a and 28b, in which each of the elements of the converter 3 and the inverter 9 is insulated separately, using DC/DC converter (not shown in figure).

10 As a matter of course, the communication lines between the converter 3 and the inverter 9 and the gate drive circuits (GDC) 28a and 28b, between the direct current voltage portion and the voltage detection circuits 29a and 29b of the main circuit, and between  
15 the control power supply unit (CPS) 30 and the gate drive power supply units (GDPS) 33a and 33b, and the like are connected with the shortest distance using the conductor patterns.

20 Further the drive circuit conductor patterns and the control power supply conductor patterns of the above stated means are provided separately from the main circuit conductors P and N, thereby the contamination of the noises can be avoided.

25 Fig. 5 is a schematic circuit construction view (corresponds to the component arrangement view in Fig. 3) for altering from the non-regeneration type diode module to the regeneration control type converter. The

converter 3 and the diode module 4 of the main circuit form the parallel connection circuit and since the arrangement position is the substantially same place as stated in the above, only one of the converter 3 and the diode module 4 is connected. In this figure, an arrow mark (a) shows a construction where the diode module 4 is taken off from the integral insulating substrate board 12 and an arrow mark (b) shows a construction where after the take-off the diode module 4 the converter 3 is provided and connected to the integral insulating substrate board 12.

Accordingly, as a matter of course, to  $P_1$  and  $N_1$  after the alternation no component is connected, and to  $P_2$  and  $N_2$  the converter 3 is connected. The constituting components shown in a broken line are the circuits and the power supply portions which are mounted on the integral insulating substrate board 12 and the electric mounting parts which are provided at the lower portion of the integral insulating substrate board 12.

As stated in the above, on the same integral insulating substrate board 12 having the main circuit conductors P and N, the control power supply unit (CPS) 30, the voltage detection circuits (VDC) 29a and 29b, the gate drive circuits (GDC) 28a and 28b of the respective element, and the gate drive power supply units (GDPS) 3a and 33b are provided, (the main circuit

conductors and the respective circuit are integrally wired). And further the mainly electric mounting parts (the electric mounting parts which are arranged in the air duct shown in Fig. 2) are arranged at the lower  
5 portion of the integral insulating substrate board 12, therefore the main circuit conductors P and N and the electric mounting parts of the integral insulating substrate board 12 are directly connected.

As a result, it is unnecessary to secure the  
10 separate space for the respective circuits such as the gate drive circuits (GDC) 28a and 28b, the voltage detection circuits (VDC) 29a and 29b, the control power supply unit (CPS) 30, the gate drive power supply units (GDPS) 33a, 33b and the like.

15 Further, since there is no wire line drawing-around manual working in the three-dimensional structure state between the respective circuits including the main circuit wiring, it can be dispensed with the wiring miss work. Further, there is no  
20 anxious about the noise intrusion from the wire line drawing-around portion in the case of the separated provision, thereby the improvement in the reliability property of the power converter apparatus can be attained.

25 Further, without the remodeling of the integral insulating substrate board 12 and without the alternation of the wiring, according to demands the

conversion for converting from the diode module  
operation method in which the regeneration electric  
power is consumed in the regenerating consumption  
resistor 11 to the converter operation method in which  
5 the electric power can regenerate to the three-phase  
alternating current power supply can be carried out  
simply (the diode module 4 is merely exchanged with the  
converter 3) only by a fastening using the screws.

Therefore the improvement in the operation  
10 performance by the improvement in the power factor and  
the energy saving of the power converter apparatus can  
be improved. Inversely, in similarly the alternation  
for alternating from the converter operation method to  
the diode module operation method can be simply  
15 performed.

Further, in this embodiment (Mode 1) of the power  
converter apparatus according to the present invention,  
in a case where the main circuit electric mounting part  
breaks down, only pulling off the screw member of the  
20 integral insulating substrate board 12, since the  
electric mounting parts and the air duct 16 can  
separate from the integral insulating substrate board  
12; only the breakdown electric mounting part can be  
exchanged. Accordingly, the power converter apparatus  
25 having the very easy maintenance can be provided.

Further, in Fig. 3, means shown in the broken line  
in the power supply apparatus are the main circuit

electric mounting parts (the converter 3 or the diode module 4, the magnetic contactor 7, the inverter 9) and such main circuit electric mounting parts are provided on the air duct 17 which is provided at the lower  
5 portion of the integral insulating substrate board 12.

Next, as shown in Fig. 3, one example of a conductor structure comprising an insulating member Q having a high dielectric constant between the main circuit conductors P and N will be explained in detail  
10 referring to Fig. 6.

As shown in Fig, 6, one example of the conductor structure according to the present invention forms a condenser structure. Namely, the main circuit conductor N and the main circuit conductor N are  
15 provided in parallel on the integral insulating substrate board 12 and between the main circuit conductors P and N faced each other the insulating member Q (a glass epoxy resin member and the like) having the high dielectric constant is adhesively  
20 arranged.

Namely, on the same integral insulating substrate board 12 on which the respective gate drive circuits (GDC) 28a and 28b and the respective direct current voltage detection circuits (VDC) 29a and 29b and the  
25 control power supply unit (CPS) 30 and the like of the converter 3 and the inverter 9 are provided. The main circuit is formed as the condenser structure using the

main circuit conductors P and N and the insulating member Q having the high dielectric constant. Further, as a matter of course, the main circuit conductors P and N can be provided at any side of a right side and a left side.

Herein, the electrostatic capacity C of the conductor structure is requested a following next formula (1), where the dielectric constant of the insulating member Q is  $\epsilon$ , a distance between formed two main circuit conductors P and N is t, and a conductor area which is defined the two main circuit conductors P and N faced each other is A.

$$C = \epsilon \times A/t \quad \dots\dots\dots (1)$$

Accordingly, since the faced conductor area A formed between the two main circuit conductors P and N is determined by the current capacity or the wiring length, forming thinner (making t small) the insulating member Q having the high dielectric constant which can select freely as far as the withstanding voltage permits, the electrostatic capacity C between the main circuit conductors P and N can be increased.

On the other hand, the high harmonic wave current having the high frequency flows in the main circuit conductors P and N by in accordance with on and off control of the variable control element of the converter 3 or the inverter 9. According to this high harmonic wave current, the radiation noises are

discharged from the main circuit conductors P and N, therefore bad influences are given to other circuits and the machines and apparatus.

5        Herein, an equivalent circuit of a general condenser is shown in Fig. 7.  $C_0$  denotes electrostatic capacitor,  $r$  denotes an equivalent parallel resistor,  $R_0$  denotes an equivalent serial resistor, and  $L_0$  denotes an equivalent series inductance.

10        The high harmonic wave current, which flows in the main circuit provided on the integral insulating substrate board 12, flows bypassing between the main circuit conductor P, the insulating member Q having the high dielectric constant and the main circuit conductor N. In this time, a filter effect causes according to  
15        the electrostatic capacity C of the condenser structure comprising the main circuit conductor P, the insulating member Q and the main circuit conductor N which are provided on the integral insulating substrate board 12. And the high harmonic wave current having the high  
20        frequency can be reduced and further the noises radiated through the main circuit can be reduced.

25        Further, in a case where the variable control element of the converter 3 or the inverter 9 shields the current, a spike like shape large voltage generates under the influences of the self inductance of the main circuit wiring. And due to this large voltage value, there is an afraid that the variable control element of

the converter 3 or the inverter 9 may destroy.

However, as stated in the above, since the main circuit conductors P and N are provided adjacently in parallel, the self inductance of the main circuit conductors P and N is negated each other, the spike like shape voltage can be restrained. Further, the spike like shape voltage can be reduced (the snubber effect) according to the electrostatic capacity C of the condenser structure.

As another embodiment (Mode 2) of the power converter apparatus according to the present invention, a second structure of a combination of the main circuit conductors P and N will be explained referring to Fig. 8 and Fig. 9.

Fig. 8 and Fig. 9 show the structure where the high harmonic wave current, the reduction of the radiation noises, and spike voltage reduction effect according to the electrostatic capacity C are heightened. The above matters are explained in the first structure of the combination of the main circuit conductors shown in Fig. 6 and Fig. 7. Further, Fig. 8 shows a concept view for explaining the condenser structure of Fig. 9.

As to the integral insulating substrate board 12, the material (for example, a glass epoxy material, etc.) having the high dielectric constant is used. As shown in Fig. 9, similar to a conductor pattern of a

general multi-layer conductor, the main circuit  
conductors P and N are installed adjacently and  
horizontally in parallel each other at an intermediate  
portion of a thickness direction on the integral  
5 insulating substrate board 12.

With the above stated structure, as shown a broken  
line in Fig. 8, as to the equivalent electrostatic  
capacity C, three faces forms a condenser structure.  
Such a condenser structure comprises a condenser  
10 component  $C_1$  according to an upper face between the  
main circuit conductor P and the main circuit conductor  
N, a condenser component  $C_2$  according to a faced face  
of the main circuit conductors P and N, and a condenser  
component  $C_3$  according to a lower face of the main  
15 circuit conductors P and N, as a result the increase in  
the electrostatic capacity C can be obtained.

In other words, since the integral insulating  
substrate board 12 itself is formed using the  
dielectric material, the filter effect (the reduction  
20 in the high harmonic wave current and the restraint in  
the radiation noises) according to the condenser  
structure and the spike voltage reduction effect can be  
increased.

Further, as a further embodiment (Mode 3) of the  
power converter apparatus according to the present  
25 invention, a third structure (a condenser structure) of  
a combination of the main circuit conductors P and N

will be explained referring to Fig. 10.

5       The terminals of each of the electric mounting parts of the main circuit conductors P and N which are provided at a front face and a rear face by sandwiching the integral insulating substrate board 12, the converter 3 (or the diode module 4) provided at the lower portion of the integral insulating substrate board 12, the magnetic contactor 7, the smoothing capacitor 5, and the inverter 9, etc. are connected and  
10       fixed using a screw member 34.

      A passing-through hole is formed in the integral insulating substrate board 12 to pass through the screw member 34 and to this passing-through hole a conductive bush member Z, for example a copper pipe, is inserted,  
15       thereby this conductive bush member Z and the integral insulating substrate board 12 and the main circuit conductors P and N are strongly contacted and fixed.

      The insulating substrate board 12 used in this embodiment (Mode 3) uses the material having the high  
20       dielectric constant, the main circuit conductor P is provided on the upper face of the integral insulating substrate board 12 and the main circuit conductor N is provided on the lower face to face to the main circuit conductor P. Accordingly, as the integral insulating  
25       substrate board 12 serves as the dielectric material, the condenser structure is formed between the integral insulating substrate board 12, the main circuit

conductor P and the main circuit conductor N.

With the above stated condenser structure, the faced conductor area A shown in the formula (1) can make large, the electrostatic capacity C is made large and the filter effect against the high harmonic wave and the spike voltage can be heightened. Accordingly, the power converter apparatus which can correspond to the high harmonic wave regulation in feature can be provided.

Further, with respect to the arrangement position of the main circuit conductors P and N, the main circuit conductor N is provided on the upper face of the insulating substrate board 12 with the opposite state shown in Fig. 10, the main circuit conductor P is provided on the lower face of the insulating substrate board 12 which faces to the main circuit conductor N, in this case the effects similar to the above stated power converter apparatus structure can be obtained.

As a further embodiment (Mode 4) of the power converter apparatus according to the present invention, a fourth structure (a condenser structure) of a combination of the main circuit conductors P and N will be explained referring to Fig. 11.

On the integral insulating substrate board 12 on which the gate drive circuits (GDC) 28a and 28b, the direct current voltage detection circuits (VDC) 29a and 29b, and the control power supply unit (CPS) 30 etc.

are mounted. As shown in Fig. 11, a plate shape main circuit conductor N, the insulating member Q having the high dielectric constant and the main circuit conductor P are adhesively laminated in sequence and provided,  
5 respectively.

As stated in the above, since the insulating member Q having the high dielectric constant is provided all over between the main circuit conductors P and N which are provided on upper face of the integral  
10 insulating substrate board 12 and then the condenser structure is formed. Accordingly, the high frequency and the high harmonic wave current can be reduced, the magnetic noises which are radiated through the main circuit conductors P and N can be restrained, and  
15 further the spike voltage can be restrained.

Further, there a case where an installation space of the integral insulating substrate board 12 in the power converter apparatus is not a straight shape but is a L shape in plane and the integral insulating  
20 substrate board 12 is not received single in the power conversion apparatus.

In this case, as shown in Fig. 3, in place of the integral insulating substrate board 12 where the gate drive circuits (GDC) 28a and 28b, the direct current  
25 voltage detection circuits (VDC) 29a and 29b, and the control power supply unit (CPS) 30 and the like are integrally wired on the same integral insulating

substrate board 12, forming the smoothing capacitor 5 as the boundary another substrate board can be used by dividing into two a side of the converter 3 or the diode module 4 and a side of the inverter 9.

5           In other words, the two division substrate board structure is that the side of the converter 3 or the diode module 4 is formed by the starting current restraining resistor 6, the magnetic contactor 7 and the smoothing capacitor 5, on the other hand the side  
10 of the inverter 9 is formed from the smoothing capacitor 5 to the inverter 9, thereby L shape two division arrangement can be obtained. As stated in the above, employing the above two division substrate board structure, it is possible to align with the arrangement  
15 space shape and also to heighten the freedom degree of the arrangement.

          As stated in the above, as shown in Fig. 6, Fig. 9, Fig. 10 and Fig. 11, since the main circuit conductors P and N and the insulating member Q having the high  
20 dielectric constant are fixed strongly to the integral insulating substrate board 12, against the vibration etc. during the apparatus transportation, the peel-off and the position displacement of the main circuit conductors P and N and the insulating member Q from the  
25 integral insulating substrate board 12 can be prevented and the generation of the vibration due to the main circuit conductors P and N and the insulating member Q

can be prevented.

Fig. 12 is a circuitry construction view of a further embodiment (Mode 5) of the power converter apparatus according to the present invention, this  
5 circuitry construction view shows a case where the three-phase input power supply side is formed by a diode module operation system having only a full wave rectification.

With the above power converter apparatus  
10 construction, the same performance and the same effects in a case of the control of the power converter apparatus can be obtained, in such above case the converter 3 is taken off from the main circuit of the power converter apparatus shown in Fig. 5 but the diode  
15 module 4 is installed.

In other words, on the same integral insulating substrate board 12, the main circuit conductors P and N and the constituting components enclosed in a broken line are integrally wired and mounted on the same  
20 integral insulating substrate board 12 or installed on the lower face of the integral insulating substrate board 12. Also the main circuit conductors P and N employ one of the condenser structure shown in Fig. 6 and Fig. 9, Fig. 19 and Fig. 11.

25 Therefore, the power saving of the wiring work, the reduction of the wiring miss, the restraint in the radiation noises, the reduction in the spike voltage of

the power converter apparatus are obtained. Further, since the regenerating consumption resistor 11 is received in the air duct 18, a small size in a whole power converter apparatus can be obtained.

5           In Fig. 12, the magnetic contactor 7 has a contact point 7' and the constituting components enclosed in the broken line are the electric mounting parts which includes the main circuit conductors P and N and are mounted on the upper surface of the integral insulating  
10           substrate board 12 or are provided on the lower surface of the integral insulating substrate board 12.

          In the operation method of the power converter apparatus shown in Fig. 12, since the input side is the diode module 4, the electric power generated during the  
15           consumption of the induction electric motor (IM) 14 can not regenerate at the three-phase input power supply side but is charged in the smoothing capacitor 5.

          Then, the voltage (the main circuit direct current voltage) of the smoothing capacitor 5 becomes high, in  
20           a case where the voltage exceeds the detection level which is set in advance in the voltage detection circuit (VDC) 29b, a signal (an output of the voltage detection circuit (VDC) 29b) is transmitted to the microcomputer which is mounted on the control substrate  
25           board 23, thereby an ON and OFF control of the switching device 10 is carried out from the control substrate board (CSB) 23 through the gate drive circuit

(GDC) 28.

According to an ON operation of the switching device 10, the electric power at the load side is consumed in the regenerating consumption resistor 11, as a result the smoothing capacitor 5 and the inverter 9 is prevented from the excess voltage.

Fig. 13 is a circuitry construction view showing a further embodiment (Mode 6) of the power converter apparatus according to the present invention and also Fig. 13 is a circuitry view of the converter operation system where the electric power at the load side is regenerated at the three-phase alternating current power supply side.

With the above power converter apparatus construction, the same performance and the same effects in a case of the control of the power converter apparatus can be obtained, in such above case the diode module 4 is taken off from the main circuit shown in Fig. 5 but the converter 3 is installed. Further, the constituting components enclosed in the broken line are the electric mounting parts which are mounted on the upper surface of the integral insulating substrate board 12 or are mounted on the lower face of the integral insulating substrate board 12.

In the operation method of this power converter apparatus, since the regeneration control is carried out using the variable control element of the converter

3, the switching device 10 is forced to be an OFF state according to the signal from the control substrate board (CSB) 23, the electric power during a deceleration of the induction electric motor (IM) 14 is  
5 returned to the three-phase alternating current power supply 1 side.

Therefore, since the energetic saving is improved and further since during the power running the power factor can be improved according to the control of the  
10 converter 3, the power converter apparatus having a good operation performance can be obtained.

As a further embodiment (Mode 7) of the power converter apparatus according to the present invention, an integral insulating substrate board 12 corresponded  
15 to the capacity-up of the power converter apparatus and a circuitry view will be explained referring to Fig. 14 and Fig. 15. Herein, the converter 3 and the inverter 9 are established two more numbers.

Further, in Fig. 14, the inverter 9 and the gate  
20 drive circuits (GDC) 28b and 28b' of the inverter 9' and the gate drive power supply units (GDPS) 33b and 33b', the direct current voltage detection circuit (VDC) 29b and the control power supply unit (CPS) 30 are not shown. Namely, since the power supply  
25 apparatus has the same function explained in Fig. 3, the above stated elements are omitted in Fig. 14.

On the other hand, in the circuitry construction in Fig. 15, the enclosure portion by the broken line shows each of the main circuit conductors P and N, the electric mounting parts and each of the driving  
 5 circuits and the power supplies those of which are mounted on the upper surface of the integral insulating substrate board 12 and are mounted on the lower surface of the integral insulating substrate board 12.

In Fig. 15, the converter 3' constituted by the  
 10 variable control element which can carry out the regeneration control is integrally provided on the lower portion of the integral insulating substrate board 12.  $R_2$ ,  $S_2$  and  $T_2$  denote input terminals of the converter 3' and the input terminals  $R_2$ ,  $S_2$  and  $T_2$  are  
 15 provided on the integral insulating substrate board 12, and  $P_2'$  and  $N_2'$  denote direct current output terminals of the converter 3' and the direct current output terminals  $P_2'$  and  $N_2'$  are provided on the integral  
 insulating substrate board 12. 28a' and 33a' denote  
 20 the gate drive circuit (GDC) and the power supply unit thereof (GDPS) for driving the converter 3' and the gate drive circuit (GDC) 28' and the gate drive power supply unit (GDPS) 33' are provided on the integral  
 insulating substrate board 12.

25 The input terminals of the inverter 9' constituted by the variable control element are shown using the reference numerals  $P_6'$  and  $N_6'$ , the output terminals of

the inverter 9' constituted by the variable control element are shown using the reference numerals  $U_2$ ,  $V_2$ , and  $W_2$ , respectively

5 With respect to the capacity-up of the power conversion apparatus, another one converter 3' is provided on a base of the cooling fin 17 for cooling the power converter means at a vicinity of the converter 3, and at the same time another one inverter 9' is provided on the base of the cooling fin 17 for  
10 cooling the power converter means at a vicinity of the inverter 9'.

With respect to the connections of the input and the output terminals of the power converter means, the input main circuit conductor is provided on the  
15 integral insulating substrate board 12, such input main circuit conductor connects to each of the phases of the input terminals R, S and T, the input terminals  $R_1$ ,  $S_1$  and  $T_1$  of the converter 3 and the input terminals  $R_2$ ,  $S_2$  and  $T_2$  of the converter 3' which is provided on the  
20 integral insulating substrate board 12.

Further, another circuit is formed, in such another circuit the output terminals  $P_2$  and  $N_2$  of the converter 3 and the output terminals  $P_2'$  and  $N_2'$  of the converter 3' are connected respectively. The above  
25 stated circuit having input main circuit conductor and the another circuit form a parallel circuit structure. Further, the main circuit conductor P and the main

circuit conductor N are connected according to the output terminals  $P_2'$  and  $N_2'$  of the converter 3', respectively.

5        Herein, in the present specification each of the input terminals and each of the output terminals are connected respectively. However, in the input main circuit conductor of the actual converter, each of a portion formed between  $R-R_1-R_2$ , a portion formed between  $S-S_1-S_2$  and a portion formed between  $T-T_1-T_2$  forms an integral conductor. As to the output terminals each of a portion formed between  $P_2-P_2'-P_3-P_4$  and a portion formed between  $N_2-N_2'-N_6$  forms an integral main circuit conductors P and N and this integral main circuit conductors P and N are provided on the integral insulating substrate board 12.

10       

15       

20        Further, a space is formed between the conductor at the portion between  $P_2-P_2'$  and the conductor at the portion between  $N_2-N_2'$  and this space is provided narrow to the utmost, and further between the above two conductors the insulating member Q having the high dielectric constant is adhered closely, then the condenser structure is formed. Accordingly, the reduction in the high harmonic wave current and the restraint in the radiation noises and the restraint in the spike voltage of the power converter apparatus can be obtained.

25

The connections of the input and the output terminals of the inverter 9 and the inverter 9' are carried out similarly to the above stated method. On the other hand, as shown in Fig. 14, as to the capacity-up of the smoothing capacitor 5, there is only single condenser using the large size condenser. However, by connecting plural small size condensers and/or plural middle size condensers in parallel, the capacity-up of the smoothing capacitor 5 can be corresponded and the effects similar to the above stated structure can be obtained.

Further, among all wiring lengths of the main circuit conductor shown in Fig. 14, at least one part portion by employing any of the condenser structures shown in Fig. 11, Fig. 12 and Fig. 13, the reduction in the high harmonic wave current and the restraint in the radiation noises of the power converter apparatus can be obtained.

As a matter of course, by forming a whole main circuit conductors P and N all over including the portions formed between  $P_6$ - $P_6'$  and between  $N_6$ - $N_6'$  of the inverters 9 and 9', then the condenser structure is formed, the restraint in the radiation noises according to the high harmonic wave current of the power converter apparatus can be further obtained and also the power converter apparatus for corresponding to the further high harmonic wave regulation in future can be

obtained.

Further, on the same substrate board by employing the integral insulating substrate board 12 where the main circuit conductors P and N, the gate drive  
5 circuits (GDC), the voltage detection circuits (VDC) and the gate drive power supply unit (GDPS) units and the control power supply unit (CPS) are integrally wired, the power saving of the wiring work, the reduction in the wiring miss, the effective utilization  
10 of the arrangement space for each of the circuits and the power supply units can be obtained, as a result the power converter apparatus having the improved reliability property can be provided.

As stated in the above, so as to obtain the  
15 capacity-up in the power converter means, it can be corresponded by connecting in parallel the plural converters 3 and 3', the plural smoothing capacitors 5 and the plural inverters 9 and 9'. Accordingly, a series of the power converter apparatus constituting by  
20 from the small size parts to the large size parts can be easily obtained.

Herein, in a case where the plural converters 3 and 3', the plural smoothing capacitor 5 and the plural inverters 9 and 9', as shown in Fig. 15, are connected  
25 in parallel, the integral insulating substrate board 12 becomes the large size one. Therefore, there are problems in which the warp and the bending cause and

also there is a problem about the freedom degree of the electric mounting parts arrangement and the like.

In the above case, as shown in Fig. 16, forming the smoothing capacitors 5 as the boundary part, the  
5 integral insulating substrate board 12 is divided into two integral insulating substrate boards 12a and 12b.

Namely, the part from the input terminals R, S and T of the converter 3 to the smoothing capacitor 5 is provided the one integral insulating substrate board  
10 12a. On the other hand, the part from the smoothing capacitor 5 to the output terminals U, V and W of the inverter 9 is provided the another integral insulating substrate board 12b. The two integral insulating substrate boards 12a and 12b are connected and fixed  
15 through the electrode portions  $P_5$  and  $N_5$  of the smoothing capacitor 5. In other words, the one integral insulating substrate board 12a and the another integral insulating substrate board 12b are joined and fixed.

20 On the other hand, by combining six variable control element modules having a large size and a single element shape for enable to flow the large current, the converter 3 or the inverter 9 is constituted. In this time the integral insulating  
25 substrate board becomes large there is a problem about the strength according to the warp etc. of the integral insulating substrate board.

In the above stated case, as shown in Fig. 17, on one of the integral insulating substrate board 12a, the converter 3 is constituted by providing the main circuit conductor for connecting and wiring each of the input and the output terminals of the plural variable control element modules. Further, another one of the integral insulating substrate board 12b, the inverter 9 is constituted by providing the main circuit conductor for connecting and wiring each of the input and the output terminals of the plural variable control element modules.

Further, on the same substrate boards of the integral insulating substrate boards 12a and 12b on which the main circuit conductor is provided, the gate drive circuits (GDC) 28a and 28b for driving each of the variable control elements, the gate drive power supply units (GDPS) 33a and 33b, and the voltage detection circuits (VDC) 29a and 29b are provided respectively.

At the outside portion of the integral insulating substrate boards 12a and 12b, the starting current restraining resistor 6, the magnetic contactor 7, the plural smoothing capacitors 5 are arranged and these elements and the two integral insulating substrate boards 12a and 12b are wired using the bus bar etc..

As stated in the above, according to the provision by dividing the integral insulating substrate board 12,

for example two boards such as two integral insulating substrate boards 12a and 12b, since the warp and the bending caused by the large size of the integral insulating substrate board is avoided, the assembling work of the power converter apparatus can be easily carried out.

Further, in a case where one of the two integral insulating substrate boards 12a and 12b is damaged, since it can exchange only the damaged substrate board, the exchanging work can be easily carried out. Further, since a number of the substrate board mounting components is about half, the cost for the exchange components and the cost for manufacturing the integral insulating substrate board can be dispensed at the low cost.

As another large capacity method in the power converter apparatus, a multi-operation system of the collective power converter apparatus according to the present invention will be explained referring to Fig. 18 and Fig. 19.

As shown in Fig. 18, in The multi-operation system for the collective power converter apparatus 36 comprises two power converter apparatuses 35a and 35b, the converter 3, the starting current restraining resistor 6, the magnetic contactor 7 connected in parallel to the starting current restraining resistor 6, the smoothing capacitor 5, and the inverter 9, etc..

Two power converter apparatuses 35a and 35b, the converter 3, the starting current restraining resistor 6, the magnetic contactor 7, the smoothing capacitor 5, and the inverter 9 etc. are connected according to the main circuit conductors P and N and these main circuit conductors P and N are provided on the integral insulating substrate board.

In Fig. 18, the large capacity collective power converter apparatus 36 receives the small capacity power converter apparatuses 35a and 35b and this collective power converter apparatus 36 can be operated and controlled using the six-phase electric motor 37 having the large capacity.

As shown Fig. 19, another collective power converter apparatus 36 according to the present invention receives plural power converter apparatuses (PCA) 35a, 35b, 35c and 35d using the integral insulating substrate board 12. In the collective power converter apparatus 36, the induction electric motor 14 (14a-14d) are connected to the output of each of the power converter apparatuses (PCA) 35a, 35b, 35c and 35d and the induction electric motor 14 is separately or unify operated and controlled. According to the above stated multi-operation system in the power converter apparatus, the large scale capacity collective power converter apparatus can be obtained.

As shown in Fig. 18 and Fig. 19, by collecting the plural power converter means the collective power converter apparatus 36 is formed, therefore the radiation noises countermeasure (the installation of the shield cover etc.) can be carried out easily. Namely, in comparison with the radiation noises countermeasure which is carried out by separating the respective power converter apparatus, the radiation noise countermeasure which is carried out collectively by covering a whole collective power conversion apparatus 36 using the shield cover and the like can be carried out at the low cost and simply.

Further, in the embodiments shown in Fig. 1 - Fig. 5 and Fig. 12 - Fig. 16, all of the converter 3 or the diode module 4, and the inverter 9 are explained using the semiconductor module (the semiconductor which is constituted the multi-element is installed inside). However, in a case where each of the converter means may constitute by combining a plurality of the semiconductors having one element as shown in Fig. 17 or by combining three two-element inside modules having a two-element unit comprised of an upper arm and a lower arm, the function and effects of these power converter apparatuses similar to those of the above stated embodiments can be obtained.

Further, the various characteristic properties of the variable control element which installs the

converter 3 and the variable control element which  
installs the inverter 9 differ in the power converter  
apparatus. In a case where the characteristic property  
of the converter means which are connected in parallel  
5 matches each other, the power converter apparatus has  
same function and same effects stated in the above  
stated embodiments according to the present invention.

As stated in the above, according to the present  
invention, the main circuit conductor connects the  
10 diode module or the regeneration control type converter,  
the inverter and the other main components, each of the  
above elements constitutes the power converter  
apparatus and the main circuit conductor is formed on a  
single insulating substrate board or the interior  
15 portion thereof according to the patterning and the  
insulating substrate board is connected to the terminal  
of the respective component.

The abbreviation in the wiring work in the power  
converter apparatus can be improved and the wiring miss  
20 in the power converter apparatus can be dispensed with  
and further in the maintenance accompany with the  
exchange of the broken-down component and the like the  
wiring work can be finished by taking off the substrate  
board from the terminal of the respective component and  
25 by installing the respective component, the improvement  
of the maintenance property in the power converter  
apparatus can be attained.

The main circuit conductor is constituted by the plus side main circuit conductor, the minus side main circuit conductor and the insulating member intervened between these conductors and then the condenser structure is formed. Accordingly, the reduction in the high harmonic wave current having the high frequency, the restraint in the radiation noises and the restraint in the spike voltage in the power converter apparatus can be obtained.

Further, since the drive circuits for driving each of the converter means, the voltage detection circuits, the power supply units are installed on the substrate board on which the above stated main circuit conductor is formed, these wiring are formed according to the patterning. Accordingly, there is no drawing-around of the control lines, the abbreviation in the wiring work can be improved furthermore.

Further, together with the diode module, the inverter and the other main components, the regenerating consumption resistor is installed in the air duct. Accordingly, the regenerating consumption resistor having the large size in essential can be formed small and can be installed in the power converter apparatus, accordingly the reduction of the installation space in the whole power converter apparatus can be obtained.

Further, in the power conversion apparatus, the diode module or the regeneration control type converter is installed selectively at the same region and both of the main circuit conductors thereof are constituted to form according to the patterning on the substrate board or the interior portion of the substrate board.

Accordingly, without the remodeling etc. of the integral insulating substrate board, only the exchange of the semiconductor module according to the specification, it can vary from the diode module to the converter which enable to carry out the regeneration control, it is possible to carry out reversal, namely from the converter to the diode module. As a result, utilizing at optimum the both converter means the power factor in the power converter apparatus can be improved and further using the regeneration control the energetic saving can be obtained.

## Claims:

1. A power converter apparatus for obtaining the variable frequency alternating current voltage  
5 comprises:

a first converting means for converting the supplied alternating current voltage to the direct current voltage,

10 a smoothing means for smoothing said directed current from said first converting means, and

a second converting means for converting an output voltage from said smoothing means to the alternating current voltage,

15 the power converter apparatus characterized in that

a wiring among said first converting means, said smoothing means and said second converting means is practiced on the same insulating substrate board.

20 2. A power converter apparatus according to claim 1, characterized in that

a first voltage detecting means for detecting the direct current voltage of the first converting means is provided on said insulating substrate board,

25 a second voltage detecting means for detecting the direct current voltage of the second converting means is provided on said insulating substrate board, and



a wiring of said first voltage detecting means and said second converting means is practiced on said insulating substrate board.

- 5        3. A power converter apparatus according to claim 1, characterized in that

10        a first gate drive circuit for driving said first converting means and a first gate drive circuit power supply unit of said first gate drive circuit are provided on said insulating substrate board,

a second gate drive circuit for driving said second converting means and a second gate drive circuit power supply unit of said second gate drive circuit are provided on said insulating substrate board, and

15        a wiring of said first gate drive circuit, said first gate drive circuit power supply unit, said second drive circuit, said second gate drive circuit power supply unit is practiced on said insulating substrate board.

20

4. A power converter apparatus for obtaining the variable frequency alternating current voltage comprises:

25        a first plural converting means for converting the supplied alternating current voltage to the direct current voltage,



plural smoothing means for smoothing said directed current from said first plural converting means, and

a second plural converting means for converting an output voltage from said plural smoothing means to the alternating current voltage,

the power converter apparatus characterized in that

a wiring among said first plural converting means, said plural smoothing means and said second plural converting means is practiced on the same insulating substrate board.

5. A power converter apparatus according to claim 4, characterized in that

a first voltage detecting means for detecting the direct current voltage of said first plural converting means is provided on said insulating substrate board,

a second voltage detecting means for detecting the direct current voltage of said second plural converting means is provided on said insulating substrate board, and

a wiring of said first voltage detecting means and said second voltage detecting means is practiced on said insulating substrate board.

6. A power converter apparatus according to claim 4, characterized in that



a first gate drive circuit for driving said first plural converting means and a first gate drive circuit power supply unit of said first gate drive circuit are provided on said insulating substrate board,

5 a second gate drive circuit for driving said second plural converting means and a second gate drive circuit power supply unit of said second gate drive circuit are provided on said insulating substrate board, and

10 a wiring of said first gate drive circuit, said first gate drive circuit power supply unit, said second gate drive circuit and said second gate drive circuit power supply unit is practiced on said insulating substrate board.

15

7. A power converter apparatus for obtaining the variable frequency alternating current voltage comprises:

20 a first plural converting means for converting the supplied alternating current voltage to the direct current voltage,

plural smoothing means for smoothing said directed current from said first plural converting means, and

25 a second plural converting means for converting an output voltage from said plural smoothing means to the alternating current voltage,



the power converter apparatus characterized in that

a wiring of said first plural converting means is practiced on a first insulating substrate board,

5 a wiring of said second plural converting means is practiced on a second insulating substrate board, and

a wiring of said plural smoothing means is practiced on one of said first insulating substrate board and said second insulating substrate board.

10

8. A power converter apparatus according to claim 7, characterized in that

a first voltage detecting means for detecting the direct current voltage of said first plural converting means is provided on said first insulating substrate board,

15

a second voltage detecting means for detecting the direct current voltage of said second plural converting means is provided on said second insulating substrate board,

20

a wiring of said first voltage detecting means is practiced on said first insulating substrate board, and

a wiring of said second voltage detecting means is practiced on said second insulating substrate board.

25

9. A power converter apparatus according to claim 7, characterized in that



a first gate drive circuit for driving said first plural converting means and a first gate drive circuit power supply unit of said first gate drive circuit are provided on said first insulating substrate board,

5 a second gate drive circuit for driving said second plural converting means and a second gate drive circuit power supply unit of said second gate drive circuit are provided on said second insulating substrate board,

10 a wiring of said first gate drive circuit and said first gate drive circuit power supply unit is practiced on said first insulating substrate board, and

a wiring of said second gate drive circuit and said second gate drive circuit power supply unit is practiced on said second insulating substrate board.

15

10. A power converter apparatus for obtaining the variable frequency alternating current voltage comprises:

20 a first converting means for converting the supplied alternating current voltage to the direct current voltage and having first plural switching devices,

a smoothing means for smoothing said directed current from said first converting means, and

25

a second plural converting means for converting an output voltage from said plural smoothing means to the



alternating current voltage and having a second plural switching devices,

the power converter apparatus characterized in that

5 a wiring of said first converting means is practiced on a first insulating substrate board, and

a wiring of said second converting means is practiced on a second insulating substrate board.

10 11. A power converter apparatus according to claim 10, characterized in that

a first voltage detecting means for detecting the direct voltage of said first converting means is provided on said first insulating substrate board,

15 a second voltage detecting means for detecting the direct current of said second converting means is provided on said second insulating substrate board,

a wiring of said first voltage detecting means is practiced on said first insulating substrate board,

20 a wiring of said second voltage detecting means is practiced on said second insulating substrate board, and

a wiring of said plural smoothing means is practiced on one of said first insulating substrate board and said second insulating substrate board.

25



12. A power converter apparatus according to claim 10, characterized in that

5 a first gate drive circuit for driving said first converting means and a first gate drive circuit power supply unit of said first gate drive circuit are provided on said first insulating substrate board,

10 a second gate drive circuit for driving said second converting means and a gate second drive circuit power supply unit of said second gate drive are provided on said second insulating substrate board,

a wiring of said first gate drive circuit and said first gate drive circuit power supply unit is practiced on said first insulating substrate board, and

15 a wiring of said second gate drive circuit and said second gate drive circuit power supply unit is practiced on said second insulating substrate board.

20 13. A power converter apparatus comprise a diode module for converting the supplied alternating current voltage to the direct current voltage, a smoothing capacitor for smoothing the direct current voltage of said diode module, an inverter for converting an obtained direct current voltage from said smoothing capacitor to the alternating current voltage and for  
25 supplying the obtained alternating current voltage to a load, and a regenerating consumption resistor for consuming an output electric power of said inverter,



the power converter apparatus characterized in that

a main circuit conductor for connecting each of components is provided on a single insulating substrate board, said components are said diode module, said  
5 smoothing capacitor and said inverter,

said main circuit conductor comprises a plus side main circuit conductor for connecting to a plus terminal of each of said components and a minus side main circuit conductor for connecting to a minus  
10 terminal of each of said components,

by intervening an insulating member between said plus side main circuit conductor and said minus side main circuit conductor, each of said plus side main circuit conductor and each of said minus side main  
15 circuit conductor are contacted to said insulating substrate board,

each of said plus side main circuit conductor and each of said minus side main circuit conductor are formed according to a patterning, and

20 said pattern of said main circuit conductor is connected to said plus terminal and said minus terminal of each of said components.

14. A power converter apparatus comprises, a diode  
25 module for converting the supplied alternating current voltage to the direct current voltage, a smoothing capacitor for smoothing the alternating current voltage



of said diode module, an inverter for converting an  
obtained direct current voltage from said smoothing  
capacitor to the alternating current voltage and for  
supplying said obtained alternating current voltage to  
5 a load, and a regenerating consumption resistor for  
consuming an output electric power of said inverter,  
the power converter apparatus characterized in that

a main circuit conductor for connecting each of  
components is provided on a single insulating substrate  
10 board, said components are said diode module, said  
smoothing capacitor and said inverter,

said main circuit conductor comprises a plus side  
main circuit conductor for connecting to a plus  
terminal of each of said components and a minus side  
15 main circuit conductor for connecting to a minus  
terminal of each of said components,

by approaching said plus side main circuit  
conductor and said minus side main circuit conductor  
through an insulating wall, each of said plus side main  
20 circuit conductor and each of said minus side main  
circuit conductor are buried in said insulating  
substrate board according to a patterning, and

said pattern of said main circuit conductor is  
connected to said plus terminal and said minus terminal  
25 of each of said components.



15. A power converter apparatus comprises, a diode module for converting the supplied alternating current voltage to the direct current voltage, a smoothing capacitor for smoothing the direct current voltage of  
5 said diode module, an inverter for converting an obtained direct current voltage from said smoothing capacitor to the alternating current voltage and for supplying said obtained alternating current voltage to a load, and a regenerating consumption resistor for  
10 consuming an output electric power of said inverter, the power converter apparatus characterized in that

a main circuit conductor for connecting each of components is provided on an upper portion or on a lower portion of a single insulating substrate board,  
15 said components are said diode module, said smoothing capacitor and said inverter,

said main circuit conductor comprises a plus side main circuit conductor for connecting to a plus terminal of each of said components and a minus side  
20 main circuit conductor for connecting to a minus terminal of each of said components,

by forming relatively one of said plus side main circuit conductor and said minus side main circuit conductor on said upper portion of said insulating  
25 substrate board and another of said plus side main circuit conductor and said minus side main circuit conductor on said lower portion of said insulating



substrate board each other according to a patterning,  
and

5        said pattern of said main circuit conductor is  
connected to said plus terminal and said minus terminal  
of each of said components.

10        16. A power converter apparatus comprises, a diode  
module for converting the supplied alternating current  
voltage to the direct current voltage, a smoothing  
capacitor for smoothing the direct current voltage of  
said diode module, an inverter for converting an  
obtained direct current voltage from said smoothing  
capacitor to the alternating current voltage and for  
supplying the alternating current voltage to a load,  
15        and a regenerating consumption resistor for consuming  
an output electric power of said inverter, the power  
converter apparatus characterized in that

20        a main circuit conductor for connecting each of  
components is provided on a single insulating substrate  
board, said components are said diode module, said  
smoothing capacitor and said inverter,

25        said main circuit conductor comprises a plus side  
main circuit conductor for connecting to a plus  
terminal of each of said components and a minus side  
main circuit conductor for connecting to a minus  
terminal of each of said components,



by intervening an insulating member between said plus side main circuit conductor and said minus side main circuit conductor, each of said plus side main circuit conductor and each of said minus side main circuit conductor are laminated to said insulating substrate board,

each of said plus side main circuit conductor and each of said minus side main circuit conductor are formed according to a patterning, and said pattern of said main circuit conductor is connected to said plus terminal and said minus terminal of each of said components.

17. A power converter apparatus according to any one of from claim 13 to claim 16, characterized in that

a gate drive circuit for driving said inverter and a gate drive power supply unit are provided on said insulating substrate board, and said gate drive circuit and said gate drive power supply unit are carried out through a pattern wiring.

18. A power converter apparatus according to any one of from claim 13 to claim 16, characterized in that

a voltage detection means for detecting the voltage of at an input side of said inverter is mounted on said insulating substrate board, and a wiring of said voltage detection means is carried out on said



insulating substrate board with said main circuit conductor through a pattern wiring.

19. A power converter apparatus according to any one  
5 of from claim 13 to claim 16, characterized in that  
said diode module, said smoothing capacitor, said inverter and said regenerating consumption resistor are arranged in an air duct,

10 said diode module and said inverter are installed to a single cooling fin, said regenerating consumption resistor is installed to another single cooling fin, and

a top portion of said air duct is covered through said insulating substrate board.

15

20. A power converter apparatus comprises, a converter for converting the supplied alternating current voltage to the direct current voltage, a smoothing capacitor for smoothing the direct current  
20 voltage of said converter, an inverter for converting an obtained direct current voltage from said smoothing capacitor to the alternating current voltage and for supplying said obtained alternating current voltage to a load, and a regenerating consumption resistor for  
25 consuming an output electric power of said inverter, the power converter apparatus characterized in that



a main circuit conductor for connecting each of components is provided on a single insulating substrate board, said components are said converter, said magnetic contactor, said smoothing capacitor and said inverter,

said main circuit conductor comprises a plus side main circuit conductor for connecting to a plus terminal of each of said components and a minus side main circuit conductor for connecting to a minus terminal of each of said components,

by intervening an insulating member between said plus side main circuit conductor and said minus side main circuit conductor, each of said plus side main circuit conductor and each of said minus side main circuit conductor are contacted respectively to said insulating substrate board,

each of said plus side main circuit conductor and each of said minus side main circuit conductor are formed according to a patterning, and

said pattern of said main circuit conductor is connected to said plus terminal and said minus terminal of each of said components.

21. A power converter apparatus comprises, a converter for converting the supplied alternating current voltage to the direct current voltage, a smoothing capacitor for smoothing the direct current



voltage of said converter, and an inverter for  
converting an obtained direct current voltage from said  
smoothing capacitor to the alternating current voltage  
and for supplying said obtained alternating current  
5 voltage to a load, the power converter apparatus  
characterized in that

a main circuit conductor for connecting each of  
components is provided on a single insulating substrate  
board, said components are said converter, said  
10 starting current restraining resistor, said magnetic  
contactor, said smoothing capacitor and said inverter,

said main circuit conductor comprises a plus side  
main circuit conductor for connecting to a plus  
terminal of each of said components and a minus side  
15 main circuit conductor for connecting to a minus  
terminal of each of said components,

by approaching said plus side main circuit  
conductor and said minus side main circuit conductor  
through an insulating wall, each of said plus side main  
20 circuit conductor and each of said minus side main  
circuit conductor are buried in said insulating  
substrate board according to a patterning, and

said pattern of said main circuit conductor is  
connected to said plus terminal and said minus terminal  
25 of each of said components.



22. A power converter apparatus comprises, a  
converter for converting the supplied alternating  
current voltage to the direct current voltage, a  
smoothing capacitor for smoothing the direct current  
5 voltage of said converter, and an inverter for  
converting an obtained direct current voltage from said  
smoothing capacitor to the alternating current voltage  
and for supplying said obtained alternating current  
voltage to a load, the power converter apparatus  
10 characterized in that

a main circuit conductor for connecting each of  
components is provided on an upper portion or on a  
lower portion of a single insulating substrate board,  
said components are said converter, said smoothing  
15 capacitor and said inverter,

said main circuit conductor comprises a plus side  
main circuit conductor for connecting to a plus  
terminal of each of said components and a minus side  
main circuit conductor for connecting to a minus  
20 terminal of each of said components,

by forming relatively one of said plus side main  
circuit conductor and said minus side main circuit  
conductor at said upper portion of said insulating  
substrate board and another of said plus side main  
25 circuit conductor and said minus side main circuit  
conductor on said lower portion of said insulating  
substrate board each other according to a patterning,



and

said pattern of said main circuit conductor is connected to said plus terminal and said minus terminal of each of said components.

5

23. A power converter apparatus comprises, a converter for converting the supplied alternating current voltage to the direct current voltage, a smoothing capacitor for smoothing the direct current voltage of said converter, and an inverter for converting an obtained direct current voltage from said smoothing capacitor to the alternating current voltage and for supplying said obtained alternating current voltage to a load, the power converter apparatus characterized in that

10

15

a main circuit conductor for connecting each of components is provided on a single insulating substrate board, said components are said converter, said smoothing capacitor and said inverter,

20 said main circuit conductor comprises a plus side main circuit conductor for connecting to a plus terminal of each of said components and a minus side main circuit conductor for connecting to a minus terminal of each of said components,

25 by intervening an insulating member between said plus side main circuit conductor and said minus side main circuit conductor, each of said plus side main



circuit conductor and each of said minus side main  
circuit conductor are laminated to said insulating  
substrate board and each of said plus side main circuit  
conductor and each of said minus side main circuit  
5 conductor are formed according to a patterning, and

said pattern of said main circuit conductor is  
connected to said terminal of each of said components.

24. A power converter apparatus according to any one  
10 of from claim 20 to claim 23, characterized in that

a gate drive circuit for driving said inverter and  
a gate drive power supply unit are provided on said  
insulating substrate board, and said gate drive circuit  
and said gate drive power supply unit are carried out  
15 through a pattern wiring.

25. A power converter apparatus according to any one  
of from claim 20 to claim 23, characterized in that

a voltage detection means for detecting the  
20 voltage of at an input side of said inverter is mounted  
on said insulating substrate board, and a wiring of  
said voltage detection means is carried out on said  
insulating substrate board with said main circuit  
conductor through a pattern wiring.

25

26. A power converter apparatus comprises, a diode  
module or a converter for converting the supplied



alternative current voltage to the direct current voltage, a smoothing capacitor for smoothing the alternating current voltage of said diode module or the alternating current voltage of said converter enable to the regeneration control, an inverter for converting an obtained direct current voltage from said smoothing capacitor to the alternating current voltage and for supplying said obtained alternating current voltage to a load, and a regenerating consumption resistor for consuming an output electric power of said inverter, the power converter apparatus characterized in that

each of components is provided in an air duct, said component are said diode module or said converter, said smoothing capacitor and said inverter,

a main circuit conductor for connecting said each of said components is patterned on a single insulating substrate board,

said air duct covers and connects said main circuit conductor pattern to each of plus terminals and each of minus terminals of each components,

said diode module said converter is selectively provided at the same area of said air duct, and

on said insulating substrate board said diode module or said converter includes said respective main circuit conductor pattern.



27. A power converter apparatus comprises, a  
converter for converting the supplied alternative  
current voltage to the direct current voltage, a  
smoothing capacitor for smoothing the direct current  
5 voltage of said converter, and an inverter for  
converting an obtained direct current voltage from said  
smoothing capacitor to the alternating current voltage  
and for supplying said obtained alternating current  
voltage to a load, the power converter apparatus  
10 characterized in that

said converter is constituted by plural variable  
control converter elements arranged on an insulating  
substrate board and a main circuit conductor for  
connecting between said plural variable converter  
15 elements by forming on said single insulating substrate  
board according to a patterning, and

said inverter is constituted by plural variable  
control inverter elements arranged on another  
insulating substrate board and another main circuit  
20 conductor for connecting between said plural variable  
inverter elements by forming on said another single  
insulating substrate board according to a patterning.

