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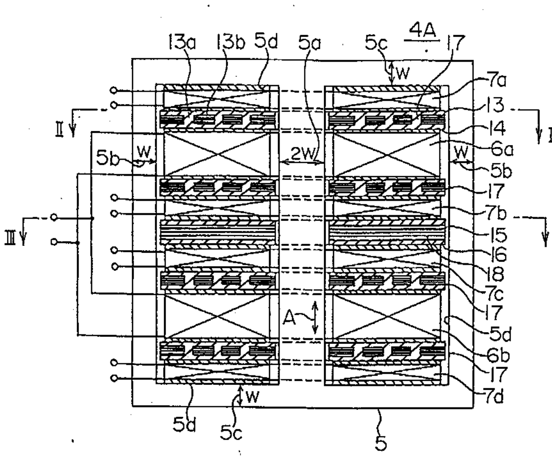
(54) **Vehicle mounting transformer.**

(57) A light-weight and compact vehicle mounting transformer capable of providing a required reactive voltage and stable loose coupling characteristics between the output side windings is provided. The vehicle mounting transformer 4 comprises a shell-type iron core 5, an input side winding 6 and output side windings 7 wound around the iron core 5 in a magnetically inductive relationship relative to each other, a magnetic member assembly 17 with air gaps disposed between the input and output side windings, and a second magnetic member assembly 18 is disposed between the output side windings 7 for a magnetically loose coupling therebetween. The second magnetic member assembly 18 comprises air gap-less magnetic member 15 disposed within the space 5d surrounded by the iron core 5 and an insulating member 16 insulatingly supporting the air gap-less magnetic member 15 relative to the iron core and the windings.

FIG. 1



EP 0 551 555 A1

FIELD OF INDUSTRIAL APPLICATION

This invention relates to a vehicle mounting transformer and, more particularly, to a vehicle mounting transformer for use in a vehicle operating electric system for achieving the power and regenerative running control by means of a power conversion system such as a pulse width modulation control conversion system.

PRIOR ART

Fig. 9 is a schematic diagram illustrating one example of a conventional shell-type vehicle mounting transformer 4 disclosed in Japanese Patent Laid-Open No. 1-133311 and Japanese Patent Laid-Open No. 2-184007. The vehicle mounting transformer 4 comprises a shell-type iron core 5, an input side winding 6 wound on the iron core 5 and a plurality of output side windings 7 disposed in a magnetic inductance relationship with respect to the iron core 5 and the input side winding 6. The vehicle mounting transformer 4 further comprises a magnetic member assembly 17 including a plurality of magnetic elements 13 disposed between the input side winding 6 and the output side windings 7 and arranged in a space surrounded by the iron core 5 with air gaps therebetween and insulating material 14 insulatingly supporting the magnetic elements 13 relative to each other and relative to the iron core 5 and the windings 6 and 7. The magnetic elements 13 are insulatingly supported with air gaps formed by the insulating material 14, so that a magnetic member with air gap is generally constructed.

Fig. 10 is a circuit diagram illustrating a vehicular operating electric system using the vehicle mounting transformer illustrated in rig. 9. In Fig. 10, the electric power is supplied to the input side windings 6 wound on the iron core 5 of the vehicle mounting transformer 4 through an interrupter 3. Four output side windings 7 of the vehicle mounting transformer 4 are related to the magnetic member 13 and directly connected respectively to the inputs of the pulse width modulation (PWM) converter 9. The output of the PWM converter 9 is connected to the input of the VVVF inverter 11 through a capacitor 10. The output of the VVVF inverter 11 is connected to a three-phase induction motor 12 for driving wheels of an electric vehicle.

The leakage flux generated during the operation of the vehicle mounting transformer 4 under the load increases since a magnetic member assembly 17 which is a magnetic member with air gap, whereby the leakage impedance increases.

PROBLEM TO BE SOLVED BY THE INVENTION

The conventional vehicle mounting transformer thus constructed is desirable in that the requisite reactive voltage can be obtained with a light-weight and compact structure. However, while it is required that the respective windings divided from the output side windings 7 in view of the load control or the like are magnetically loosely coupled to each other when it is used as a vehicle mounting transformer, it has been difficult to realize a winding arrangement which satisfies the need of the loose coupling between the output side windings.

That is, in the power conversion system of the PWM inverter control used in a vehicle electric system, a multi-phase PWM converter control, which is a circuit system in which the converter units controlled at the different phases are connected to the output winding of the transformer. For example, in the four-phase PWM converted control system, the output winding of the transformer is divided into four, each is connected by the converter units, and the GTO thyristor gate control is achieved at the different phases.

In this case, if the magnetic coupling between the output windings are strong, one converted unit may be subjected to a magnetic interference by the operation of another converter unit whereby the wave form of the converter input current is disturbed, resulting in increase of the noise flow to the trolley line due to the increase in the harmonic current component and the increase of the peak of the current ripples, whereby the current interrupting capacity of the GTO element is exceeded and the GTO will be destroyed.

For these reasons, it is required that the magnetic coupling between the output windings of the transformer used in the PWM converter control is loose, i.e., the transformer is required to have loose coupling characteristics in which load conditions of one output winding does not magnetically interfere the other output windings.

Accordingly, the object of the present invention is to provide a vehicle mounting transformer in which magnetically loose coupling characteristics between each of the output side windings can be stably obtained.

MEASURE FOR SOLVING THE PROBLEM

With the above object in view, the vehicle mounting transformer of the present invention comprises a shell-type iron core, an input side winding wound around the iron core, a plurality output side windings wound around the iron core and disposed in a magnetic induction relationship with respect to the input side winding, and a loose coupling magnetic member assembly including a gap-less magnetic member disposed between the neighboring out of the output side windings and within a space surrounded by the iron core.

If desired, an air-gap reactor magnetic material assembly may be provided between the input side and the output side windings.

According to the present invention, necessary stable loose coupling between each of the output side windings can be obtained by the gap-less magnetic core inserted between the output side windings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more readily apparent from the following detailed description of the embodiment of the present invention taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic sectional side view illustrating a vehicle mounting transformer of one embodiment of the present invention;

Fig. 2 is a sectional front view of the vehicle mounting transformer taken along line II - II of Fig. 1;

Fig. 3 is a perspective view illustrating the reactor magnetic member assembly of the vehicle mounting transformer illustrated in Fig. 1;

Fig. 4 is a sectional front view of the vehicle mounting transformer taken along line III - III of Fig. 1;

Fig. 5 is a perspective view illustrating the loose coupling magnetic member assembly of the vehicle mounting transformer illustrated in Fig. 1;

Fig. 6 is a schematic diagram illustrating the vehicle operating electric system employing the vehicle mounting transformer illustrated in Figs. 1 to 5;

Fig. 7 is a vector diagram illustrating the phase relationship of the vehicle mounting transformer of the present invention;

Fig. 8 is a schematic sectional side view illustrating the vehicle mounting transformer of another embodiment of the present invention;

Fig. 9 is a schematic sectional side view illustrating a conventional vehicle mounting transformer; and

Fig. 10 is a schematic diagram illustrating the vehicle operating electric system employing, the conventional vehicle mounting transformer illustrating in Fig. 9.

EMBODIMENTS

Fig. 1 is a schematic diagram illustrating one embodiment of the shell-type vehicle mounting transformer of the present invention. In Fig. 1, the general arrangement of the iron core 5 and the windings 6 and 7 of the vehicle mounting transformer 4A is similar to that of the conventional vehicle mounting transformer 4 illustrated in Fig. 9. That is, the iron core 5 comprises a main core 5a of a width 2W, legs 5b of width W disposed in parallel at the both sides of the main core 5a and yokes 5c of width W connecting the main core 5a and the legs 5b. The main core 5a has wound thereon, in a space 5d surrounded by the iron core 5, input side windings 6a and 6b, which are spaced in the direction of axis of the windings and connected in parallel to each other. The main core 5a has also wound thereon, in a space 5d surrounded by the iron core 5, four output side windings 7a to 7d, and while the output side windings 7a and 7b are disposed at the both sides of the input side winding 6a to sandwich it in the axial direction, the output side windings 7c and 7d are disposed at the both sides of the input side winding 6b to sandwich it in the axial direction.

The vehicle mounting transformer 4A comprises a reactor magnetic member assembly 17 disposed within an axial space between the input side windings 6a and 6b and the output side windings 7a to 7d. The transformer also comprises a loose coupling magnetic member assembly 18 disposed within an axial space between the neighboring output side windings 7b and 7c.

The reactor magnetic member assembly 17 comprises, as illustrated in detail in Figs. 2 and 3, a substantially rectangular, suitably rigid insulator 14 having a substantially rectangular central opening 17a for accommodating the main core 5a of the iron core 5 and a plurality of magnetic member elements 13b embedded within the insulator 14 and disposed in parallel with air gaps 13a therebetween so that an air gap magnetic member 13 is constituted within the, space 5d surrounded by the iron core 5. Each magnetic member element 13b is a lamination in which an elongated rectangular magnetic plates are stacked in the same direction as the direction of stack (arrow A of Fig. 1) of the rectangular pancake coils, and this lamination is arranged in parallel to the direction of extension of the coil conductors (arrow B of Fig. 2). In the illustrated embodiment, four magnetic member elements 13b are disposed at each side of the main core 5a and three air gaps are defined. As shown in Fig. 3, the insulator 14 comprises two insulating plates 14b and 14c sandwiching the magnetic member elements 13b therebetween to securely support by means of insulating pins 14a, insulations 14d for filling the spaces defined between the insulating plates 14b and 14c at each end which is not occupied by the magnetic member elements 13b and insulations 14e inserted between the magnetic member elements 13b to define air gaps 13a therebetween, thereby to generally insulatingly support the magnetic member elements 13b with air gaps therebetween relative to each other and to the windings 6 and 7.

The loose coupling magnetic member assembly 18 comprises, as shown in detail in Figs. 4 and 5, a substantially rectangular, suitably rigid insulator 16 having a substantially rectangular central opening 18a for accommodating the main core 5a of the iron core 5 and gap-less magnetic member 15 embedded within the insulator 16 and disposed within the space 5d surrounded by the iron core 5. The gap-less magnetic member 15 comprises a plurality of (four in the illustrated embodiment) magnetic member elements 15b which are disposed in the direction perpendicular to the direction of extension of the coil conductors (arrow B) and spaced from each other by insulators 16e in the direction of extension of the coil conductors. Each magnetic member element 15b is also spaced from each other by the insulations 16e made such as of glass epoxy in a manner similar to the magnetic member elements 13b of the reactor magnetic member assembly 17. However, this spaced arrangement of the magnetic member elements 15b is for the purpose of minimizing the eddy losses generated in the magnetic member 15 due to the leakage flux intruding perpendicularly to the surface of the magnetic member 15 and has the orientation different from those in the reactor magnetic member assembly 17, so that the magnetic member 15 may be considered as an air-gap-less magnetic member in a magnetic sense. Each magnetic member element 15b is a lamination in which rectangular magnetic plates are stacked in the direction parallel to the direction of stack (arrow A) of the rectangular pancake coils.

As illustrated in Fig. 5, the insulator 16 comprises two insulating plates 16b and 16c sandwiching the magnetic member elements 15b therebetween to securely support them by means of insulating pins 16a, insulations 16d for filling the spaces defined between the insulating plates 16b and 16c at each end which is not occupied by the magnetic member elements 15b and insulations 16e inserted between the magnetic member elements 15b, thereby to generally insulatingly support the magnetic member elements 15 relative to the iron core 5 and the windings 6 and 7. The insulating pins 16a are inserted into holes formed in the magnetic member elements 15b as well as the insulating plates 16b and 16c. The loose coupling magnetic member assembly 18 thus assembled is varnish impregnated into a unitary structure.

The outer shape of the insulator 16 of the loose coupling magnetic member assembly 18 is similar to that of the insulator 14 of the reactor magnetic member assembly 17 and is adapted to be stacked between the windings 6 and 7 to constitute a coil group to be supported by the iron core 5. Accordingly, in manufacturing the coil group, the loose coupling magnetic member assembly 18 and the reactor magnetic member assembly 17 can be handled and stacked in the same way as the coils, so that the iron core assembly and the coil group assembly can be easily carried out by the same transformer assembling process as that heretofore has been used.

As illustrated in Fig. 1, each reactor magnetic member assembly 17 is sandwiched and supported between the output side winding 7a and the input side winding 6a, the input side winding 6a and the output side winding 7b, the output side winding 7c and the input side winding 6b and between the input side winding 6b and the output side winding 7d. The magnetic member elements 13b of each assembly 17 are embedded and supported within the rigid insulating plate 14, so that they are electrically insulated relative to the charged portion while they are mechanically supported at places within the iron core 5 by the iron core 5 and the windings 6 and 7. The loose coupling magnetic member assembly 18 is inserted and supported between the output side winding 7b and the neighboring output side winding 7c. The magnetic members 15 of the loose coupling magnetic member assembly 18 are also electrically insulated by the rigid insulator 16 and mechanically supported by the iron core 5 and the windings 6 and 7 at the predetermined position within the iron core 5.

In other respects, the arrangement may be identical to that of the conventional vehicle mounting transformer illustrated in Fig. 9.

Fig. 6 is a circuit diagram illustrating the vehicle operating electric system partly in block diagram employing the vehicle mounting transformer of the present invention illustrated in Figs. 1 to 5. In Fig. 4, the electric power is supplied from the trolley line 1 through a pantograph 2 and is supplied to the input side windings 6 wound on the iron core 5 of the vehicle mounting transformer 4 through an interrupter 3. Four output side windings 7a to 7d of the vehicle mounting transformer 4A are related to the first and the second magnetic members 17 and 18 and directly connected respectively to the inputs of the pulse width modulation (PWM) converter 9. The output of the PWM converter 9 is connected to the input of the VVVF inverter 11 through a capacitor 10. The output of the VVVF inverter 11 is connected to a three-phase induction motor 12 for driving wheels of an electric vehicle.

In the vehicle operating electric system of Fig. 4 employing the vehicle mounting transformer 4A of the present invention, the voltage supplied from the trolley line 1 through the pantograph 2 and the interrupter 3 is inputed into the input side winding 6 of the vehicle mounting transformer 4A and transformed therein to be outputed to the output side windings 7 of the vehicle mounting transformer 4A. The outputs from the output side windings 7 are supplied to the PWM converter 9 through the AC reactor 8, where the single phase AC power is converted into DC power. This DC power, after smoothed by the capacitor 10, is supplied to the VVVF inverter 11, where it is converted into three-phase AC power. This three-phase AC power drives the three-phase induction motor 12 to drive the wheels of the vehicle (not shown)

The leakage flux generated during the operation under the load of the vehicle mounting transformer 4A is increased by the reactor magnetic member assembly 17 which is an air-gap magnetic member and, as its result, the leakage impedance increases. By suitably selecting the numbers and the dimensions of the magnetic member elements 13b and the air gaps 13a of the reactor magnetic member assembly 17, a suitable leakage impedance Z_{TA} capable of providing a necessary reactive voltage V_L.

Therefore, the phase relationship between the input side terminal voltage (which is referred to converter voltage) V_C of the PWM converter 9 and the input voltage V of the vehicle mounting transformer 4A as converted in the equal transforming ratio is as illustrated in Fig. 5. That is, the input voltage V of the vehicle mounting transformer 4A is a vector sum of the converter voltage V_C and the reactive voltage V_L which is generated during the power running operation at the power factor = 1 at the product ($Z_{TA} \cdot I$) of the leakage impedance Z_{TA} of the vehicle mounting transformer 4A and the input current I of the PWM converter 9.

Also, the loose coupling magnetic member assembly 18 which is an gap-less iron core disposed between the output side windings 7b and 7c magnetically isolates the output side windings 7b and 7c, whereby the loose coupling suitable for the pulse width modulation control can be realized.

Fig. 8 illustrates a vehicle mounting transformer 4C of another embodiment of the present invention in which six output side windings 37a to 37f are provided and two loose coupling magnetic member assemblies 18 are employed. Thus, while the output side winding is divided into four in the embodiment illustrated in Figs. 1 to 5, it is to be understood that the present invention is equally applicable where the output side winding is divided into more than four windings, and that similar advantageous results can be obtained.

ADVANTAGEOUS RESULTS OF THE INVENTION

As has been described, according to the present invention, a loose coupling magnetic member assembly inserted between the neighboring output side windings and having a magnetic member supported by an insulator is provided, so that magnetic loose coupling characteristics necessary for the pulse width modulation converter control can be electrically and mechanically stably obtained.

Also, by providing a reactor magnetic member assembly disposed between the input side winding and the output side windings and having a plurality of magnetic member elements with air gaps therebetween and disposed within a space surrounded by the iron core, a reactive voltage necessary for the pulse width modulation control can at the same time be obtained.

The loose coupling magnetic member assembly and the reactive magnetic member assembly are both supported by the plate-shaped insulators having the substantially rectangular central opening for accommodating the iron core therein and insulatingly supporting the magnetic members. Therefore, these magnetic member assemblies can be stacked together with the coils in the same assembling process as that heretofore used to constitute coil groups, so that the transformer assembly process can be carried out in the same manner as that heretofore done without the need for any change in assembly equipments and facilities.

Claims

1. A vehicle mounting transformer comprising a shell-type iron core, an input side winding wound on said iron core and a plurality of output side windings disposed in a magnetically inductive relationship relative to said iron core and said input side winding, characterized by a loose coupling magnetic member assembly disposed between the neighboring output side windings out of said output side windings and having an air gap-less magnetic member disposed within a space surrounded by said iron core, said loose coupling magnetic member assembly magnetically loosely coupling said neighboring output side windings to each other.

2. A vehicle mounting transformer as claimed in claim 1, wherein said loose coupling magnetic member assembly comprises an insulating member for insulatingly supporting said gap-less magnetic member relative to said iron core and said windings.

3. A vehicle mounting transformer as claimed in claim 2, wherein said insulating member of said loose coupling magnetic member assembly is a substantially rectangular plate member having a substantially rectangular central opening for accommodating said iron core, and said gap-less magnetic member comprises a plurality of magnetic member elements embedded within said insulating member and arranged in the direction perpendicular to the direction of extension of the coil conductors and spaced from each other in the direction of extension of the coil conductors by said insulating member.

4. A vehicle mounting transformer as claimed in claim 1, wherein each of said magnetic member elements is a lamination body of rectangular magnetic plates stacked in the same direction as the direction of stack of rectangular pancake coils.

5. A vehicle mounting transformer as claimed in claim 2, wherein said insulating member comprises two insulating plates sandwiching and securely supporting said magnetic member elements therebetween by insulating pins, insulators filling spaces between said insulating plates at both ends not occupied by the magnetic member elements and insulators inserted between said magnetic member elements, thereby to generally insulatingly support said magnetic member relative to said iron core and said windings.

6. A vehicle mounting transformer as claimed in claim 1, further comprising a rector magnetic member assembly disposed between said input side winding and said output side windings and having a magnetic member including a plurality of magnetic member elements arranged with air gaps therebetween within a space surrounded by said iron core.

7. A vehicle mounting transformer as claimed in claim 6, wherein said reactor magnetic member assembly comprises an insulating member insulatingly supporting said magnetic member relative to said iron core and said windings.

8. A vehicle mounting transformer as claimed in claim 7, wherein said insulating member of said reactor magnetic member assembly is a substantially rectangular plate member having a substantially rectangular central opening for accommodating said iron core, and said magnetic member elements are embedded within said insulating member and arranged in the direction parallel to the direction of extension of the coil conductors and spaced from, each other in the direction perpendicular to the direction of extension of the coil conductors by said insulating member.

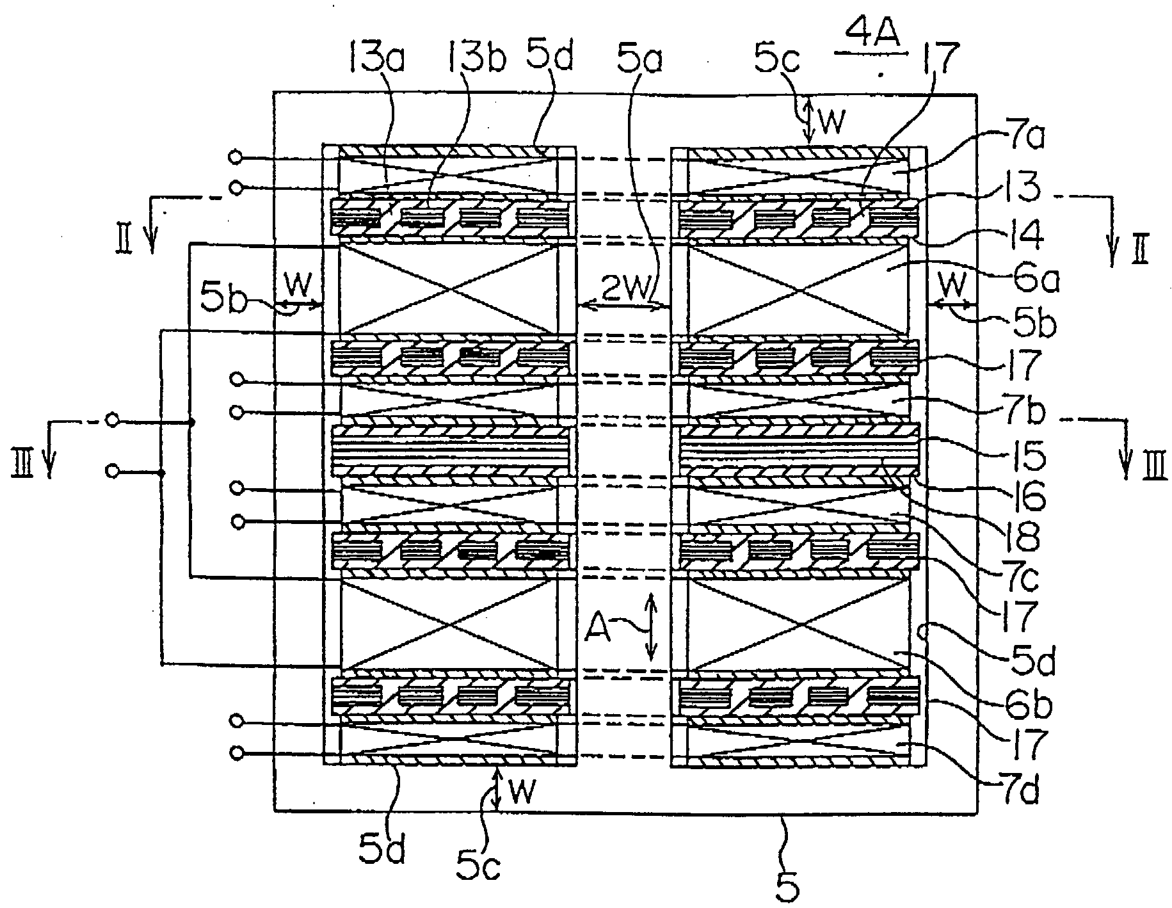
9. A vehicle mounting transformer as claimed in claim 7, wherein each of said magnetic member elements is a lamination body of rectangular magnetic plates stacked in the same direction as the direction of stack of rectangular pancake coils.

10. A vehicle mounting transformer as claimed in claim 7, wherein said insulating member comprises insulating plates sandwiching and holding said magnetic member elements therebetween, insulating pins for securing said magnetic member elements and said insulating plates together, insulators filling spaces between said insulating plates not occupied by the magnetic member elements and insulators inserted between said magnetic member elements, thereby to generally insulatingly support said magnetic member relative to said iron core and said windings.

11. A vehicle mounting transformer as claimed in claim 6, wherein the outer configuration of said loose magnetic member assembly is substantially the same as that of said reactor magnetic member assembly, said loose magnetic member assembly and said reactor magnetic member assembly are stacked between said windings to constitute a coil group to be supported by said iron core.

12. A coil group comprising an input side winding to be wound on a shell-type magnetic iron core, a plurality of output side windings disposed in a magnetically inductive, stacked relationship relative to said input side winding, a loose coupling magnetic member assembly having air gap-less magnetic member disposed between the neighboring output side member insulatingly supporting said air gap-less magnetic member, for magnetically loosely coupling said neighboring output side windings to each other, and a rector magnetic member assembly having a plurality of magnetic member elements disposed between said input side winding and said output side windings and an insulating member insulatingly supporting said magnetic member elements relative to each other and to said windings.

FIG. 1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13b
5d
5a
5c
4A
17
W
7a
13
14
6a
5b
W
2W
17
7b
15
16
18
7c
17
A
5d
6b
17
7d
II
III
5c
5

FIG. 2

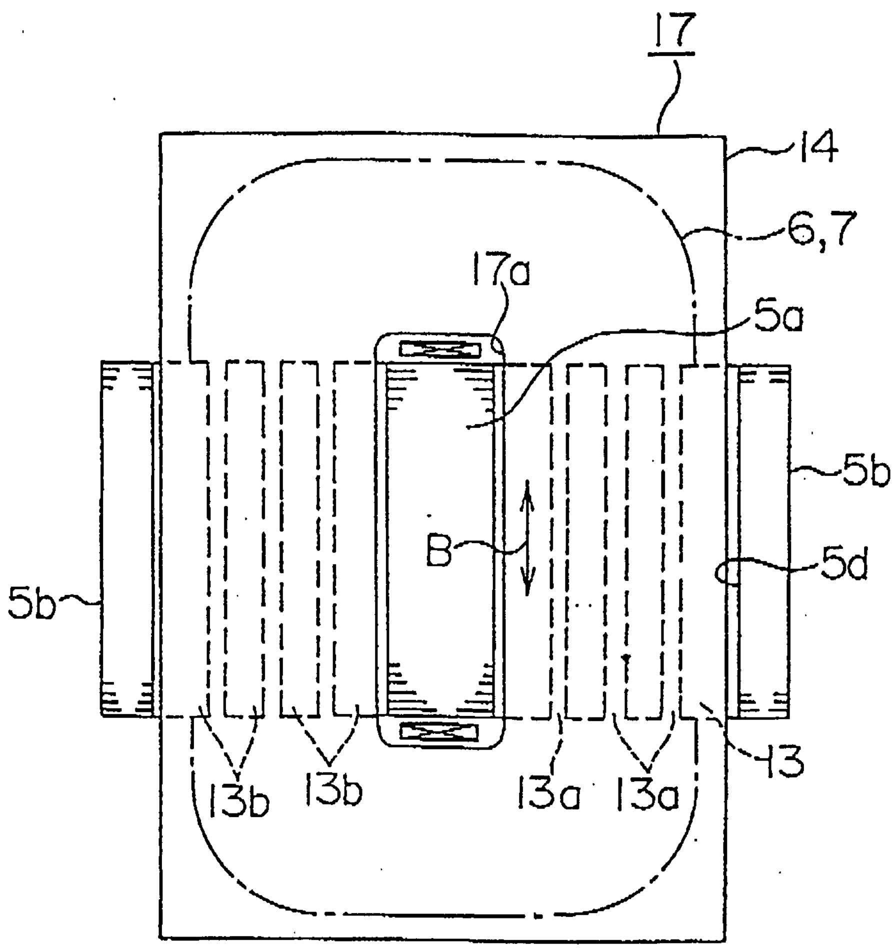


FIG. 3

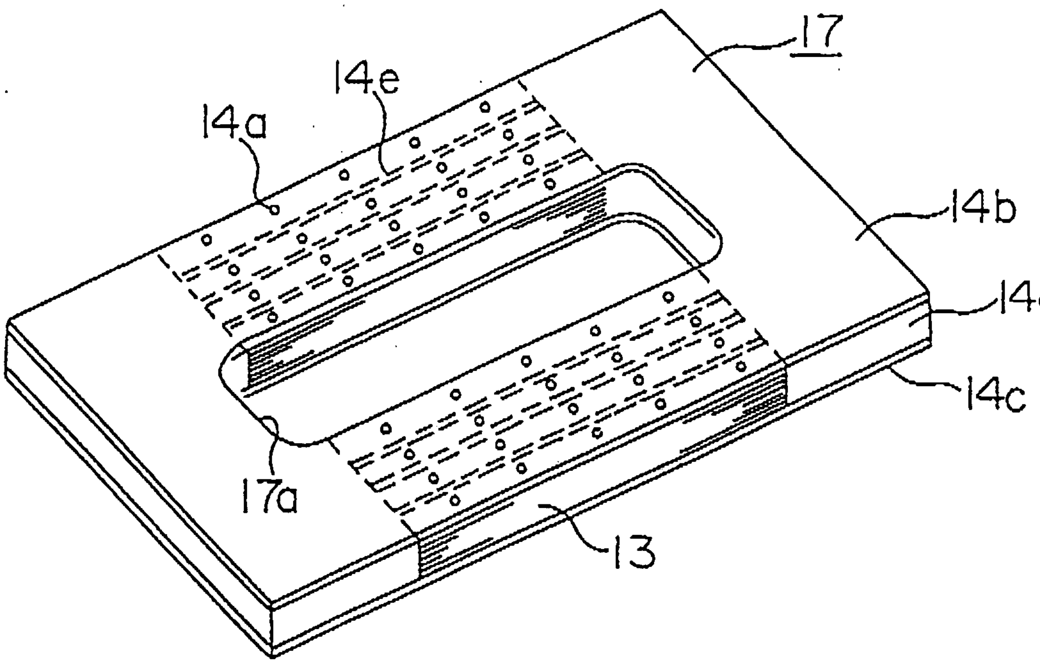


FIG. 4

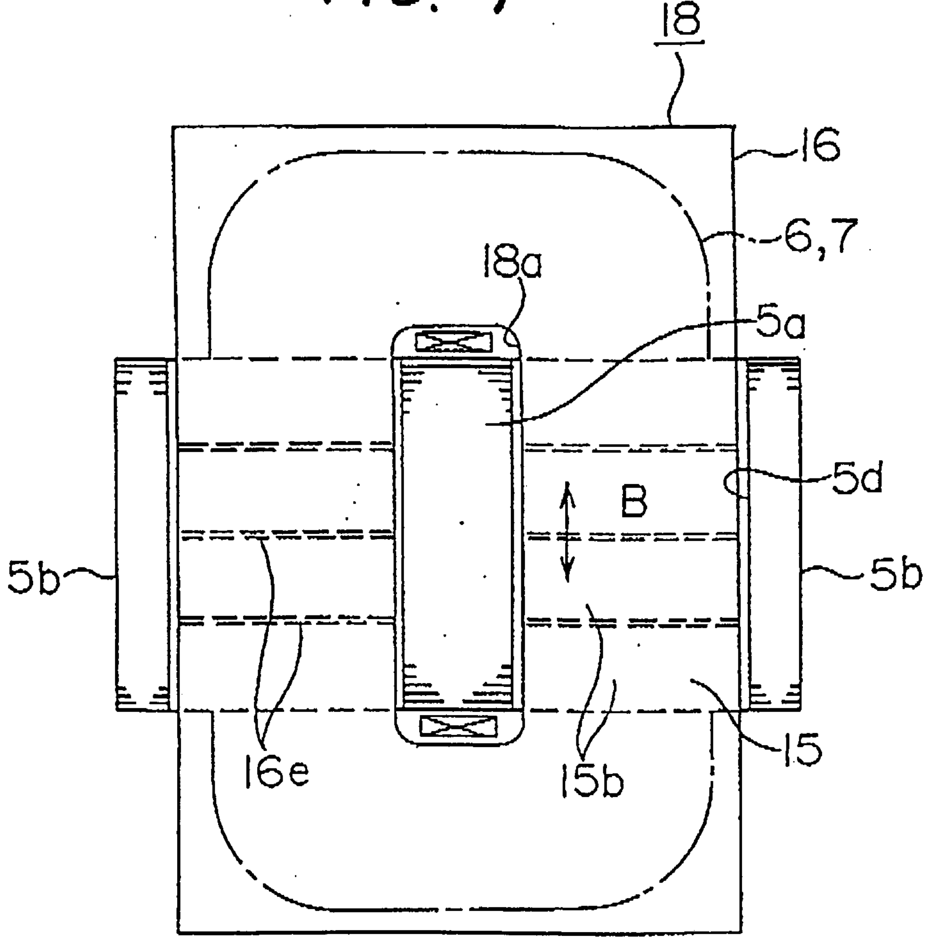


FIG. 5

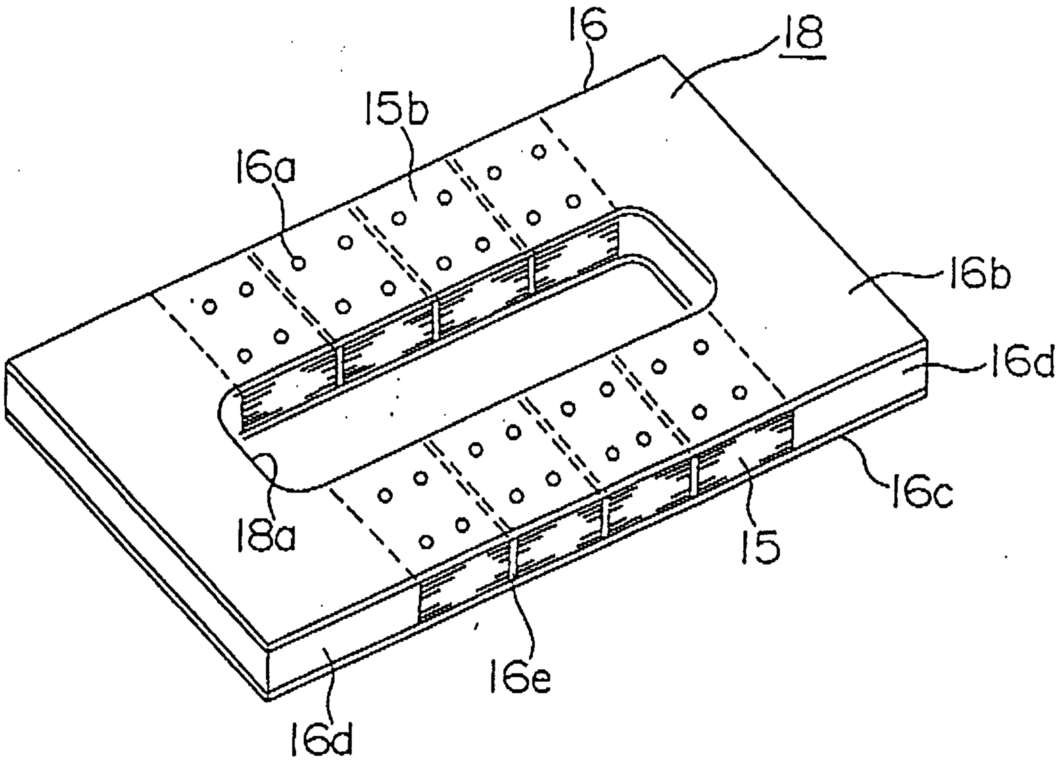
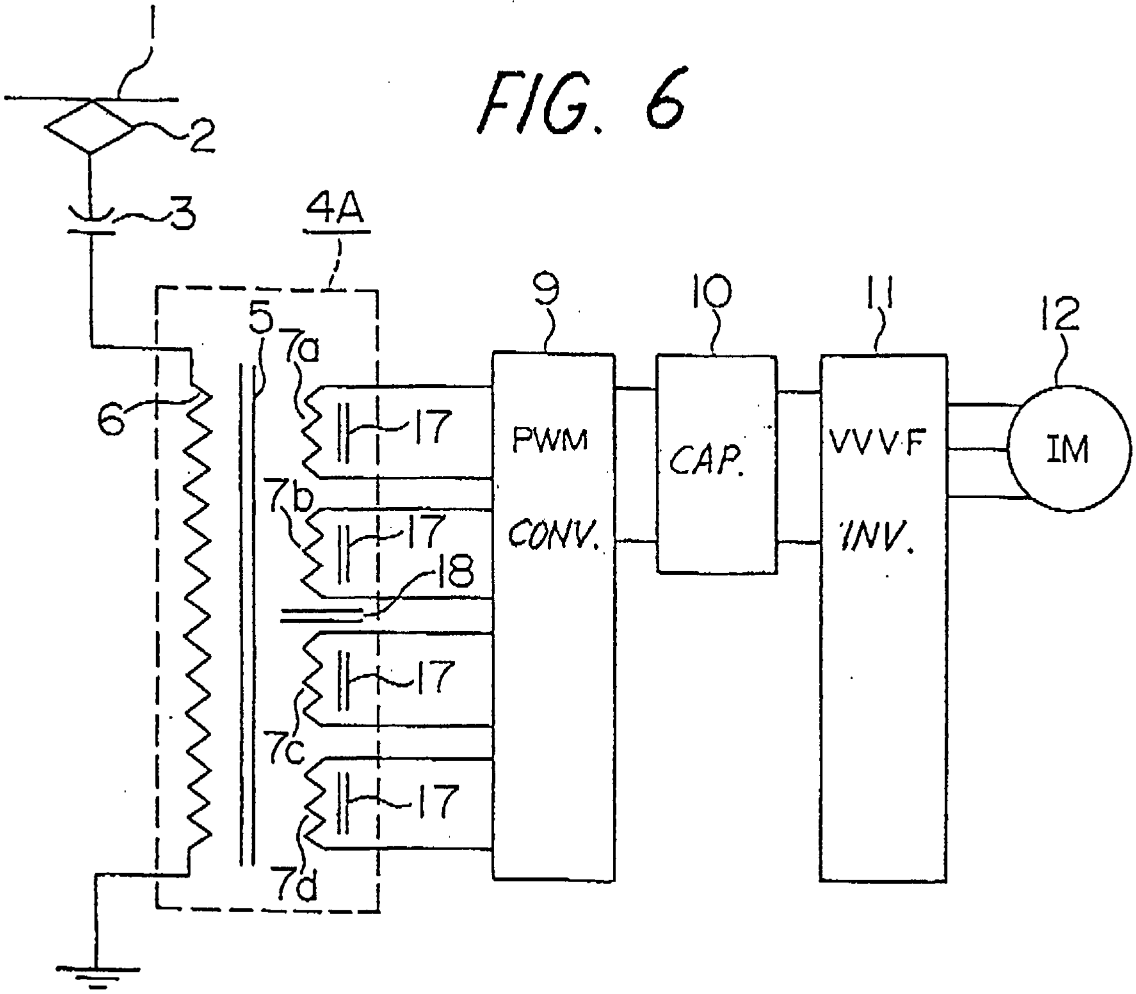


FIG. 6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VVVF
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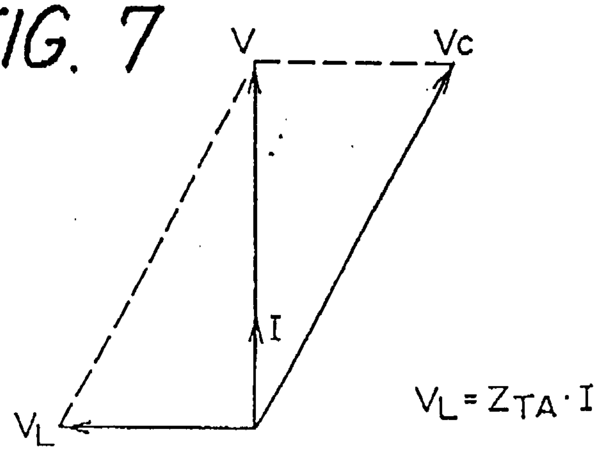
FIG. 7


V
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VL = ZTA · I

FIG. 8

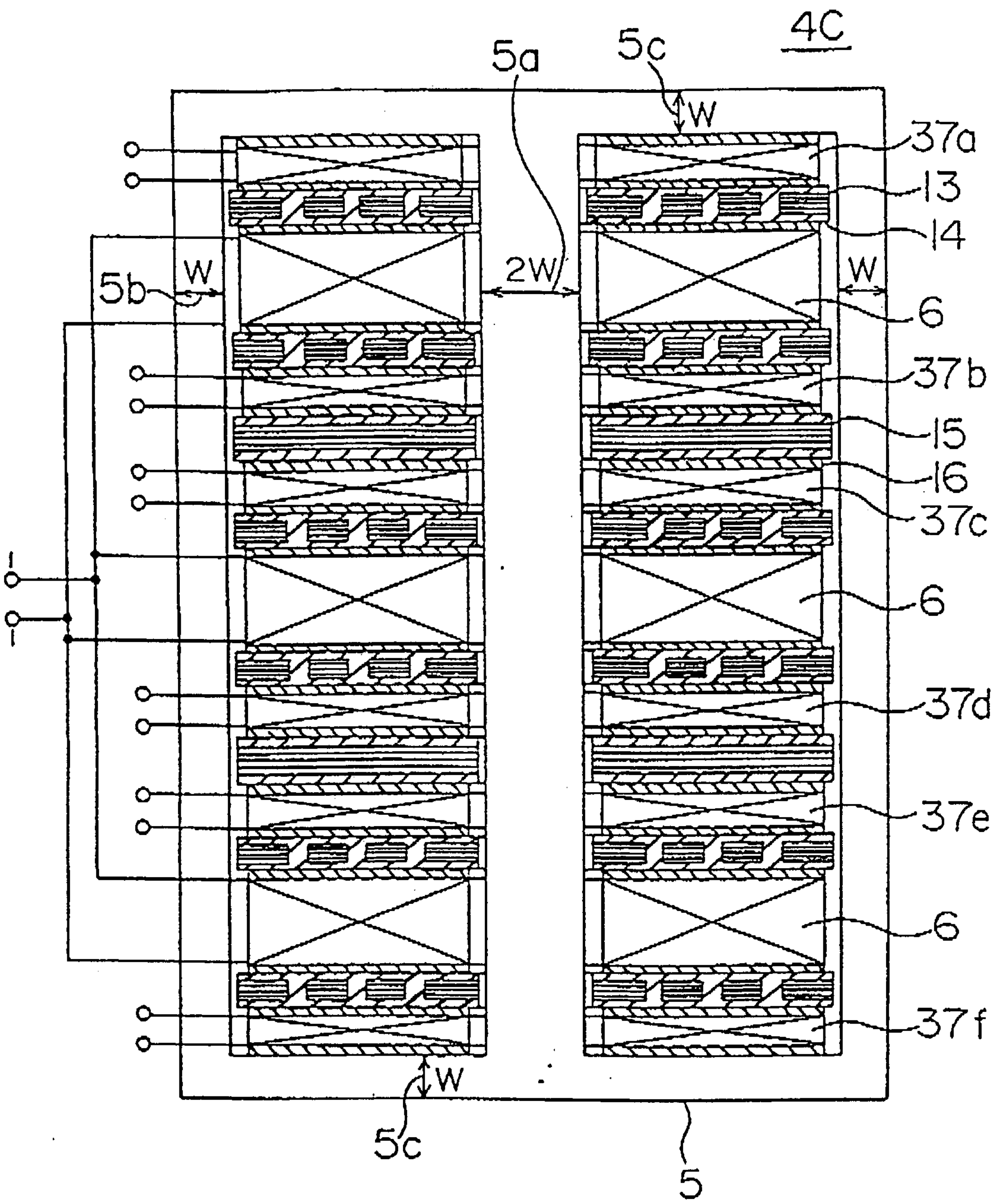

FIG. 9

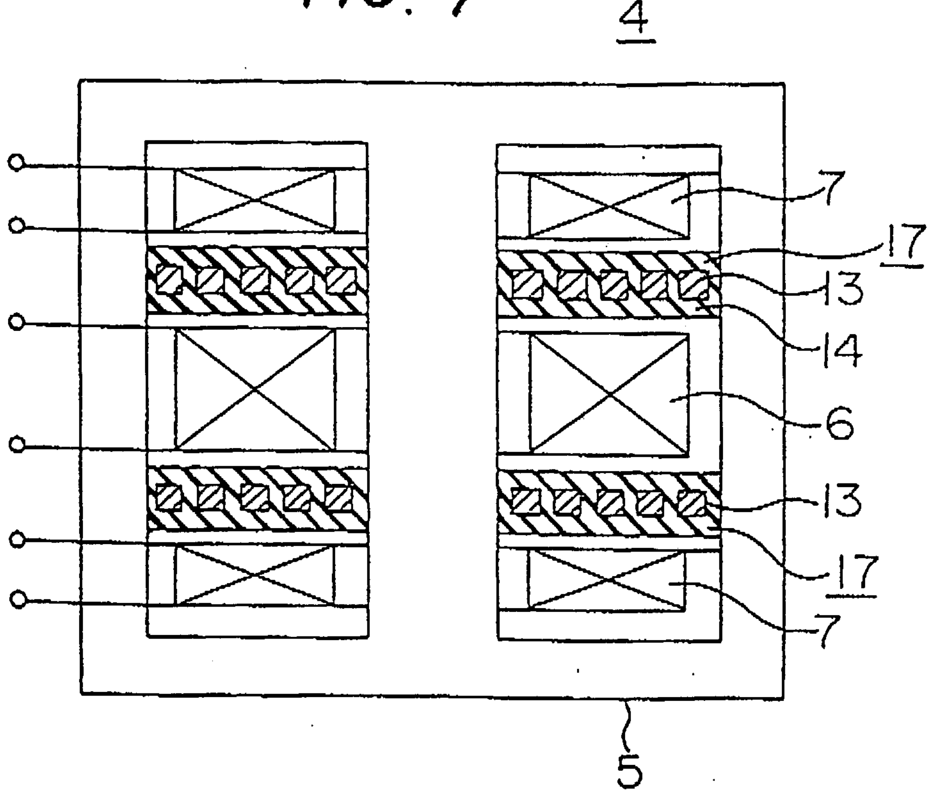
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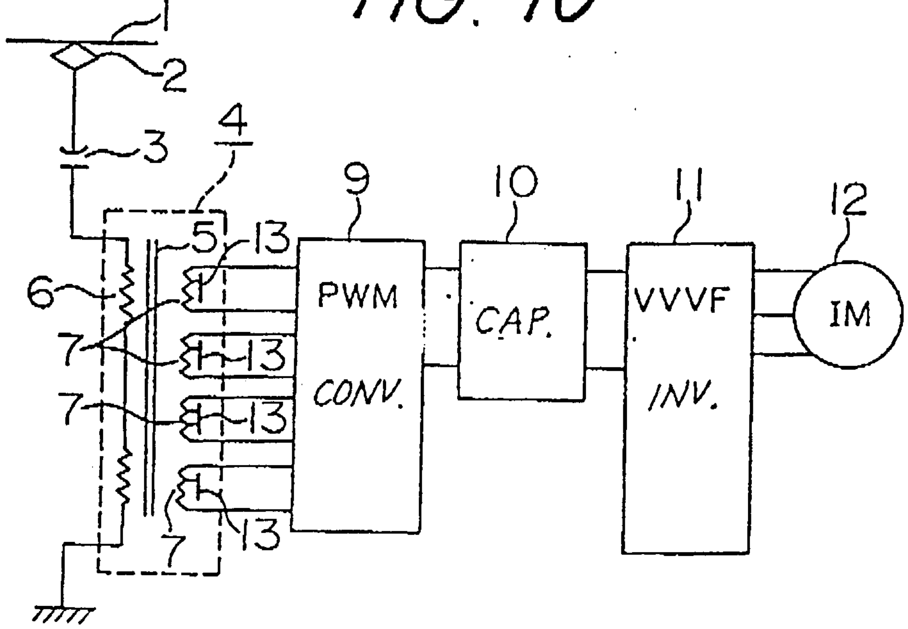
FIG. 10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European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92107435.7

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,A	JP - A - 2-184 007 * Fig. 1-7 * --	1-12	H 01 F 31/06
D,A	JP - A - 1-133 311 * Fig. 1-6 * --	1-12	
A	EP - A - 0 406 555 (SOKAI) * Abstract; fig. 1-7 * ----	1-12	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 01 F 31/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	29-03-1993	VAKIL

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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