CONVENTION

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NOTICE OF ENTITLEMENT

We, ROTELEC S.A. Les Mercuriales - Tour du Ponant, 40, rue Jean-Jaures, 93176 Bagnolet, France state the following in connection with Australian Application No. 80831/91:

1. The nominated person is the assignee of the actual inventors.

2. The nominated person is the applicant of the basic application listed in the declaration under Article 8 of the PCT.

3. The basic application is the application first made in a Convention country in respect of the invention.

Dated: 4 February 1992

By PHILLIPS ORMONDE & FITZPATRICK
Patent Attorneys for the Applicant
By:

David B Fitzpatrick
.....

To: The Commissioner of Patents

Our Ref: 278220

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INDUCTIVE HEATING COIL

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(56) Prior Art Documents
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US 4176237

(57) Claim

1. An inductive heating coil comprising a plurality of electrical conductors forming a group and being connected in parallel between two electrical terminals of said coil, each of said conductors comprising:

a cooling tube for carrying a cooling fluid, and strands for carrying electrical current, said strands being connected in parallel between said terminals of said coil, being electrically insulated from each other and being in thermal contact with walls of said tube,

said conductors being electrically insulated from each other and from said tube and including deformations along a length of said conductors, with said conductors being transposed in said coil, and said strands being transposed in each conductor to reduce formation of unwanted current loops;

and wherein positions of said strands relative to the walls of said tube and relative to each other in a cross-section of said each conductor are substantially unchanged over a complete length of each said conductor, and said transposition between said strands being locally

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effected by a twist of at least one half-turn of each said conductor about a conductor axis in at least one relatively substantial deformation section of limited length of each said conductor.

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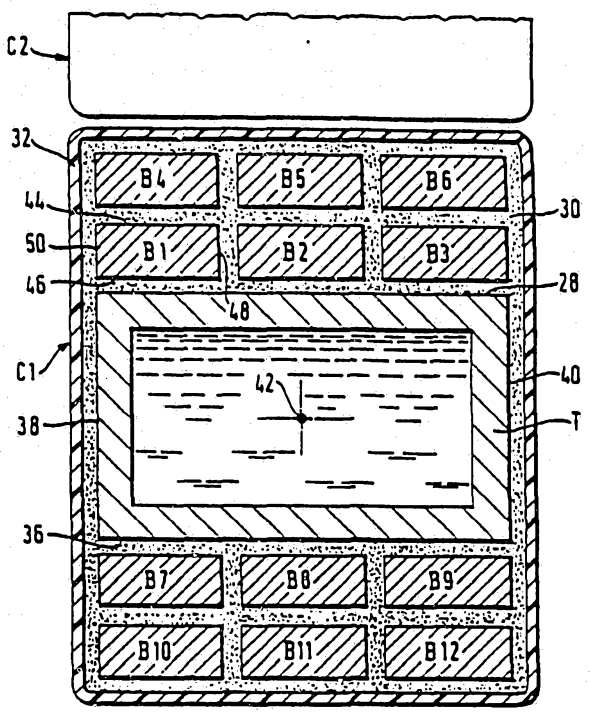
(54) Titre: BOBINE DE CHAUFFAGE INDUCTIF

(57) Abstract

A cooling pipe (T) is incorporated in each of the coil's conductors (C1). Current flow in this conductor is split between cords (B1...B12) which remain in thermal contact with the pipe even in transposition or twist areas where the conductor has been particularly intensely deformed. Said conductor has at least one 180° twist between the electrical terminals of the coil. The coil can be used particularly in metallurgy for on the fly heating of the edges of flat materials.

(57) Abrégé

Un tube de refroidissement (T) est incorporé dans chaque conducteur (C1) de la bobine. Le transport du courant dans ce conducteur est réparti entre des brins (B1...B12) qui restent appliqués en contact thermique contre ce tube même dans des zones de transposition ou de vrillage où ce conducteur a subi des déformations particulièrement intenses. Ce conducteur présente au moins un vrillage d'un demi-tour entre les bornes électriques de la bobine. L'invention s'applique notamment en sidérurgie, pour le chauffage au défilé de rives de produits plats.



Inductive heating coil

The present invention is generally concerned with electromagnetic induction heating. It applies in particular, although not exclusively, to heating the moving edges of flat metallurgical products to be deformed at raised temperature. This includes products of the iron and steel industry that have to be heated or reheated before they are flattened and/or widened by passing them between the rolls of a rolling mill.

This heating is typically provided by a device comprising:

- a magnetic circuit including an airgap,
- transport means for moving the product to be heated through said air gap,
- a coil surrounding said magnetic circuit in the vicinity of said air gap,
- a capacitive system typically comprising a battery of capacitors and connected to said winding to constitute a circuit which resonates at an operating frequency which is generally between 100 and 1 000 Hz and typically around 250 Hz, and
- an electrical generator feeding current into the resonant circuit at the operating frequency.

The presence of the capacitive system enables a current to be passed through the coil that is much higher than the current provided by the electrical generator. The latter then supplies only an active power that is actually consumed by the device, a "reactive" power of perhaps ten times this amount being provided by the capacitive system.

The product to be heated is often travelling at high speed and may feature irregularities which make it necessary to provide a wide gap. Also, the product temperature is often such that a thermally insulative layer must be provided to either side of the gap to

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protect the coil and the nearby electrotechnical equipment. As a result the airgap of the magnetic circuit must be large, which results in a high leakage of magnetic flux in the region of the coil. Part of this leakage flux is of no benefit for heating the product and induces current into the coil conductors which causes significant unwanted heating of said conductors.

To reduce this unwanted heating and to increase the energy efficiency of the device, in other words the ratio of the heating power developed by the current induced in the product to be heated to the active power supplied by the electrical generator, it is known:

- to make the heating coil as compact as possible,
- to use for the electrical conductors of the coil a form that is sufficiently subdivided, given their electrical resistivity and the operating frequency, in other words giving them sufficiently small transverse dimensions, to reduce the generation of induced current in the metal mass of each conductor, multiple conductors being then grouped in parallel and insulated from each other except at their two ends where they are joined to two terminals common to all the conductors of a group,
- to transpose the conductors within the same group to reduce the induced current that may flow in a closed loop comprising two conductors and the two terminals of the group, and
- to cool the coil strongly using a cooling circuit to enable a high usable heating power to be applied by means of a compact coil.

For this reason one known heating coil comprises certain features which are, as to their function as explained hereinafter, common to this coil and to a coil in accordance with the invention, these common features comprising:

- a ferromagnetic core,

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- two electrical terminals adapted to receive an alternating current,

- a group of electrical conductors connected in parallel between said two electrical terminals, said group being in the form of a winding around said ferromagnetic core, said conductors being transposed within said group so as to equalize approximately the various alternating magnetic fluxes enclosed by the respective conductors of said group, said transposition being achieved by means of transposition deformations of said conductors in transposition areas of said conductors,

- a cooling pipe around said core in thermal contact with said conductors, and

- hydraulic terminals for circulating a cooling fluid in said cooling pipe.

US patent 4 176 237 describes an induction furnace for liquid metals. It is provided with an inductive heating coil comprising conductors connected in parallel between two electrical terminals of said coil, each said conductor comprising a cooling tube, the current carried by said conductor being divided between strands in thermal contact with the walls of said tube, the length of said conductor including strongly deformed areas in which it is subject to particularly marked deformations which transpose conductors and strands to reduce the formation of unwanted current loops.

Known coils of this kind leave much to be desired with regard to their compactness, their cost and the energy efficiency of the heating device of which they form part.

One object of the present invention is to enable the simple manufacture of a compact heating coil which reduces the energy losses of an inductive heating device.

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According to one aspect of the present invention, there is provided an inductive heating coil comprising a plurality of electrical conductors forming a group and being connected in parallel between two electrical terminals of said coil, each of said conductors comprising:

a cooling tube for carrying a cooling fluid, and strands for carrying electrical current, said strands being connected in parallel between said terminals of said coil, being electrically insulated from each other and being in thermal contact with walls of said tube,

said conductors being electrically insulated from each other and from said tube and including deformations along a length of said conductors, with said conductors being transposed in said coil, and said strands being transposed in each conductor to reduce formation of unwanted current loops;

and wherein positions of said strands relative to the walls of said tube and relative to each other in a cross-section of said each conductor are substantially unchanged over a complete length of each said conductor, and said transposition between said strands being locally effected by a twist of at least one half-turn of each said conductor about a conductor axis in at least one relatively substantial deformation section of limited length of each said conductor.

According to a further aspect of the present invention there is provided a method of manufacturing an inductive heating coil, said method comprising the following operations:

- fabricating a cooling tube having an external surface at least a part of which constitutes a thermal contact surface extending lengthwise of said tube which is made of a material having a relatively high electrical resistivity,
- fabricating current carrying strands having transverse dimensions less than transverse dimensions of said tube and made of a material having an electrical resistivity less than that of said material of said tube,
- connecting said strands to said tube by means of

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connecting means providing continuous thermal contact between said tube and said strands without producing electrical contact between said strands or between said strands and said tube,

- forming a group of said conductors,

- winding said group of conductors coil-fashion so that said conductors undergo relatively moderate winding deformations,

- transposing said conductors within said group and said strands within each conductor, with said transpositions accompanying said winding and being effected by relatively substantial deformations locally along a length of said conductors,

- fitting electrical terminals to the ends of said group of conductors, and

- fitting hydraulic terminals to the ends of said cooling tubes,

- and wherein said operation of transposing said strands within said conductors is effected solely by twisting said conductors by at least one half-turn about the axis of each of said conductors, and said connecting means mechanically maintains the continuity of thermal contact during the operation of effecting said relatively substantial deformations to said conductors.

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings wherein:

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Figure 1 shows an edge heating device in accordance with the invention incorporating two coils.

Figure 2 is an electrical circuit diagram of said device.

Figure 3 is a general view in elevation of a coil from figure 1.

Figure 4 is a bottom view of the coil from figure 3.

Figure 5 is a partially cut away perspective view of a lower part of said coil.

Figure 6 shows one bar of said coil in said lower part developed in the flat.

Figure 7 shows a transverse cross-section of a conductor of said bar.

Referring to figure 1, an edge heating device is used in an iron and steelworks on the entry side of a rolling mill. A flat product in the form of a thick steel plate 1 runs on transport rollers 2 in a direction perpendicular to the plane of the drawing as shown by the end view of an arrow V.

It passes at high speed through the air gap of a magnetic circuit 4 whose two ends constitute the ferromagnetic cores 5 and 6 of two identical heating coils 7 and 8.

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Said coils are protected from the heat by insulative layers 8A, etc.

The magnetic circuit is hinged about an axis 9 to enable a device 10 to increase temporarily the size of the airgap 3 if the plate 1 features a projecting defect which could strike and damage one end of the magnetic circuit.

Referring to figure 2, the coils 7 and 8 are connected in series with each other and in parallel with a capacitive system 11 between the terminals of a generator 12. This supplies an alternating current voltage at an operating frequency of 250 Hz. The resonant circuit formed by the coils 7 and 8 and the capacitive system 11 is tuned to this frequency.

Various advantageous features of the coil 7 will now be described with reference to figures 3 through 7. It must be understood that words such as top, bottom, up, down, above, below, etc are used purely to distinguish between different parts of the coil, without reference to the various orientations that the coil might have relative to the gravitational field in various heating devices.

The coil comprises:

- a core 5 which is typically made from a ferromagnetic material and which extends along a coil axis A,
- two electrical terminals 20, 22 receiving an alternating current at an operating frequency of 250 Hz, and
- a group of electrical conductors connected in parallel between said two electrical terminals and wound around the core 5. The conductors are transposed within the group so as approximately to equalize the various alternating magnetic fluxes surrounded by the various conductors of said group. This embodiment requires

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"transposition" deformations to be applied to each of said conductors in a "transposition" area of said conductor. To cool it, the coil further comprises:

- a cooling tube T incorporated into each of said conductors, and

- hydraulic terminals 24, 26 for circulating a cooling fluid in said cooling pipe.

In accordance with the present invention, each tube T has an external surface of which at least part constitutes a thermal contact surface 28 extending lengthwise of said tube. It is made from a material having sufficient electrical resistivity, given its transverse dimensions, to limit the current induced in this material at the operating frequency.

A plurality of current carrying strands B1 through B12 extends lengthwise of the tube T. They are made from an electrically conductive material which has an electrical resistivity lower than that of the material of said tube. Each has transverse dimensions which are less than those of said tube and which are chosen, given this lower resistivity, in such a way as to limit the current induced into the strand at the operating frequency. What is more, it performs at least one half-turn around said tube between the two electrical terminals in order to achieve transposition of the strands within the conductor.

Some strands at least belong to a first layer of strands B1, B2, B3. They are applied to the thermal contact surface 28 of said tube in such a way as to achieve thermal contact without electrical contact.

- Electrically insulating means 30 are provided to insulate the strands at least from each other between the electrical terminals together with connection means 30, 32 which are sufficiently strong mechanically to maintain the strands in continuous thermal contact with said

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thermal contact surface, even in said transposition areas such as the area ZT1. Each conductor C1, etc comprises to this end a known type substance 30 that will be referred to hereinafter as an "internal resin" and which is selected to be electrically insulative, mechanically strong and strongly adherent to the tube T and to the strands B1 through B12. An electrically insulative and mechanically strong strip 32 surrounds the assembly comprising the tube T, the strands B1 through B12 and the internal resin 30. This strip is itself impregnated with a known type resin which can be different than the internal resin 30.

- The tube T has a substantially rectangular flattened profile with two major surfaces 28, 36 extending widthwise of said tube and two lateral surfaces 38, 40 in the direction of the thickness of the tube, which is less than said width. Each of said two major surfaces constitutes one of said thermal contact surfaces. At least two strands such as the strands B1 and B2 of the first layer B1 through B3 are in thermal contact with each of the two major surfaces of the tube T. They are offset from each other widthwise of said tube. At least one twist of said conductor C1, etc is formed in a twist area ZV1, etc which is specific to said conductor and which extends over a limited fraction of the latter's length. This twist is a half-turn twist of said conductor about an axis 42 of the tube T so that each of the two major surfaces 28, 36 progressively takes the place of the other. In this way the strands B1 through B12 are transposed within this conductor. In this example the tube T is made from bronze and the strands B1 through B12 are made from pure copper.

Each of the strands B1, etc has a flattened substantially rectangular cross-section with two major surfaces 44, 46 extending widthwise of said strand



parallel to the width of the tube T. The strand also has two lateral surfaces 48, 50 extending in the direction of the thickness of said strand which is smaller than the width of said strand and parallel to the thickness of said tube. Some of the strands constitute two first layers of strands B1 through B3 and B7 through B9 which are respectively applied to the two major surfaces 28, 36 of the tube T. Other strands constitute two second layers of strands B4 through B6 and B10 through B12 superposed on said first two layers in such a way as to obtain indirect thermal contact between said two major surfaces of the tube and said two second layers through said two first layers.

Each of said first and second layers comprises the same number of strands, between 2 and 5, inclusive. This number is preferably equal to 3, as shown in figures 3 through 6.

Each group of conductors constitutes a bar 52 within which conductors C1 through C5 form a succession in an axial direction parallel to said coil axis A.

The coil 7 extends in said axial direction between two circular end areas each surrounding the coil axis A. One of these areas comprises said electrical terminals 25, 26 and constitutes an upper area ZA. The other constitutes a lower area ZB. There are two possible directions of vertical displacement: a downward direction from said upper area to said lower area and an opposite upward direction. The bar 52 starts from a first electrical terminal 20 and turns in a forward direction 54 around the coil axis A and in a downward direction. It thus forms an external winding 56 having a first diameter. A first conductor C1 within this winding is at the bottom of said bar. A second conductor C2 is above said first conductor, and so on up to the last conductor C5 placed at the top of said bar over a penultimate

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conductor C4. This bar turns and descends within said winding until the first conductor C1 reaches the lower area ZB of the coil. The first conductor then undergoes a transposition deformation in the transposition area ZT1 of said conductor so that it joins an inner winding 58 formed by the same bar 52. This winding has a second diameter smaller than said first diameter and the bar 52 rises within it as it turns about the coil axis A in said forward direction.

The second conductor C2 in the external winding in turn reaches the lower area of the coil. It then undergoes the same transposition deformation in its own transposition area ZT2 which is offset angularly in said forward direction from the transposition area of the first conductor. This deformation causes said second conductor to join the inner winding 58 on passing under the first conductor C1, and so on until the final conductor C5 reaches the lower area ZB of the coil. This latter conductor then undergoes the same transposition deformation in a transposition area ZT5 offset angularly in the same direction from a transposition area ZT4 of the penultimate conductor C4. This transposition deformation causes the conductor C5 to join the internal winding on passing under said penultimate conductor. As a result the first conductor C1 is positioned within the internal winding 58 at the top of the bar 52, the second conductor C2 under said first conductor, and so on up to the final conductor C5 which is at the bottom of said bar. The latter turns and rises within said winding to the second electrical terminal 22 in the upper area ZA of the coil.

In the coil described by way of example there are five conductors in a bar and the thicknesses of the tube and of the strands of each conductor are oriented in the axial direction. The twisting areas ZV1 through ZV5 are

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disposed alongside the transposition areas ZT1 through ZT5 in order to form regular angular successions about the axis A.

One object of the present invention is a method of manufacturing an inductive heating coil of this kind. This method comprises the following known operations:

- fabrication of a group of conductors 52 made up of deformable electrical conductors C1 through C5,
- fabrication of a deformable cooling pipe T,
- fabrication of a ferromagnetic core 5,
- winding of said group of conductors around said core including application to said conductors of relatively moderate winding deformations,
- transposing said conductors within said group, said transposition accompanying said winding operation and being achieved by means of relatively marked transposition deformations applied locally to said conductors,
- winding said cooling pipe around said core,
- fitting electrical terminals 20, 22 to the ends of said group of conductors, and
- fitting hydraulic terminals 24, 26 to the ends of said cooling pipe.

This method is characterized by the fact that the combination of the operations of fabricating a group of conductors 52 and a cooling pipe is carried out in the form of the following operations:

- fabrication of a tube T constituting said cooling pipe and having an external surface of which part at least constitutes a thermal contact surface 28 extending lengthwise of said tube and is made from a material having a given electrical resistivity,
- fabrication of current carrying strands B1 through B12 having transverse dimensions less than those of said tube and made from a material having an

electrical resistivity lower than that of said material of said tube, and

- connection of said strands to said tube by means of connecting means 30, 32 which provide continuous thermal contact between said tube and said strands without causing electrical contacts between said strands and each other or between said strands and said tube, by virtue of which one conductor C1, etc is obtained, said connecting means being chosen to be sufficiently strong mechanically to maintain the continuity of said thermal contact even when said transposition deformations are applied to said conductor.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An inductive heating coil comprising a plurality of electrical conductors forming a group and being connected in parallel between two electrical terminals of said coil, each of said conductors comprising:

a cooling tube for carrying a cooling fluid, and strands for carrying electrical current, said strands being connected in parallel between said terminals of said coil, being electrically insulated from each other and being in thermal contact with walls of said tube,

said conductors being electrically insulated from each other and from said tube and including deformations along a length of said conductors, with said conductors being transposed in said coil, and said strands being transposed in each conductor to reduce formation of unwanted current loops;

and wherein positions of said strands relative to the walls of said tube and relative to each other in a cross-section of said each conductor are substantially unchanged over a complete length of each said conductor, and said transposition between said strands being locally effected by a twist of at least one half-turn of each said conductor about a conductor axis in at least one relatively substantial deformation section of limited length of each said conductor.

2. A coil according to claim 1 for heating moving metallurgical flat products to be deformed at raised temperature, said coil comprising:

- two electrical terminals for receiving an alternating current,

- a group of electrical conductors connected in parallel between said two electrical terminals, said group being in the form of a winding around a coil axis, transposition of said conductors being achieved within said group by means of transposition deformations of said conductors in said relatively substantially deformed areas which constitute transposition areas of said conductors,

- said cooling tube being incorporated into each

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said conductor and having an external surface at least part of which constitutes a thermal contact surface extending lengthwise of said tube which is made from a material having a given electrical resistivity,

- a plurality of current carrying strands extending lengthwise of said tube and being made from an electrically conductive material having an electrical resistivity lower than that of said material of said tube, each of said strands having transverse dimensions less than said transverse dimensions of said tube, each of said strands performing at least one half-turn around the tube between said two electrical terminals so that said strands are transposed within said conductor, at least some of said strands belonging to a first layer of strands and being applied to said thermal contact surface of said tube to achieve thermal contact with no electrical contact,

- electrical insulation means for insulating said strands at least from each other between said electrical terminals,

- connecting means for holding said strands near said thermal contact surface, and

- hydraulic terminals for circulating a cooling fluid in said cooling tube,

- said coil being characterized in that said connecting means have sufficient mechanical strength to maintain substantially the relative positions of said strands and of said tube in said relatively substantially deformed areas.

3. A coil according to claim 2 characterized in that each conductor incorporates an internal resin constituting at least part of said electrical insulating means and said connecting means.

4. A coil according to claim 3 characterized in that said connecting means further comprise a mechanically strong and electrically insulative strip surrounding a combination of said tube, said strands and said internal resin.

5. A coil according to claim 2 characterized in that said tube has a flattened substantially rectangular

cross-section and two major surfaces extending widthwise of said tube and two lateral surfaces extending in the direction of the thickness of said tube which is smaller than said width, each of said two major surfaces constituting a thermal contact surface,

- at least two said strands of said first layer being in thermal contact with each of said two major surfaces of said tube and being offset relative to each other widthwise of said tube.

6. A coil according to claim 5 characterized in that each of said strands has a flattened substantially rectangular cross-section and two major surfaces which extend widthwise of said strand parallel to said width of said tube, said strand also having two lateral surfaces extending in the direction of a thickness of said strand which is smaller than said width of said strand and parallel to said thickness of said tube, some only of said strands constituting two said first layers of strands respectively applied to said two major surfaces of said tube, others of said strands constituting two second layers of strands respectively superposed on said two first layers so as to obtain indirect thermal contact between said two major surfaces of said tube and said two second layers through said two first layers.

7. A coil according to claim 6 characterized in that each of said first and second layers comprises the same number of strands, which number is between two and five inclusive and preferably equal to three.

8. A coil according to claim 2 characterized in that said group of conductors constitutes a bar within which a plurality of said conductors from a succession in an axial direction parallel to said coil axis,

- said coil extending in said axial direction between two circular end areas each surrounding said coil axis, one of said areas comprising said electrical terminals and constituting an upper area, the other of said areas constituting a lower area, two axial directions constituting a downward direction from said upper area towards said lower area and an upward direction opposite

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to said downward direction, said bar starting from a first said electrical terminal and turning in a forward direction around said coil axis and downwards to form an exterior winding having a first diameter, a first said conductor being placed in said winding at the bottom of said bar, a second conductor being placed over the first conductor and so on up to a last conductor at the top of said bar over a penultimate conductor, said bar turning and descending in said winding until said first conductor reaches said lower area of the coil, said first conductor then undergoing a transposition deformation in a said transposition area of said conductor so as to join an inside winding formed by said bar and having a second diameter smaller than said first diameter, said bar rising within said inside winding and turning around said coil axis in said forward direction, said second conductor in said external winding reaching said lower area of the coil and then undergoing a transposition deformation in a transposition area of said conductor offset angularly in said forward direction from said transposition area of said first conductor, said transposition deformation causing said second conductor to join said internal winding by passing under said first conductor, and so on until said last conductor reaches said lower area of the coil, said last conductor then undergoing a transposition deformation in a transposition area of said last conductor offset angularly in said forward direction from a transposition area of said penultimate conductor, said transposition deformation causing said last conductor to join said internal winding by passing under said penultimate conductor so that said first conductor is placed in said internal winding at the top of said bar, said second conductor under said first conductor and so on to the last conductor which is placed at the bottom of said bar, said bar turning and rising within said winding to said second electrical terminal in said upper area of the coil.

9. A coil according to claim 8 characterized in that said twisting area of said conductor is adjacent said

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transposition area of said conductor.

10. A coil according to claim 8 characterized in that said tube has a flattened substantially rectangular cross-section and two major surfaces extending widthwise of said tube and two lateral surfaces extending in the direction of the thickness of said tube which is smaller than said width, each of said two major surfaces constituting one thermal contact surface,

- at least two said strands of said first layer being in thermal contact with each of said two major surfaces of said tube and being offset relative to each other widthwise of said tube.

11. A method of manufacturing an inductive heating coil, said method comprising the following operations:

- fabricating a cooling tube having an external surface at least a part of which constitutes a thermal contact surface extending lengthwise of said tube which is made of a material having a relatively high electrical resistivity,

- fabricating current carrying strands having transverse dimensions less than transverse dimensions of said tube and made of a material having an electrical resistivity less than that of said material of said tube,

- connecting said strands to said tube by means of connecting means providing continuous thermal contact between said tube and said strands without producing electrical contact between said strands or between said strands and said tube,

- forming a group of said conductors,

- winding said group of conductors coil-fashion so that said conductors undergo relatively moderate winding deformations,

- transposing said conductors within said group and said strands within each conductor, with said transpositions accompanying said winding and being effected by relatively substantial deformations locally along a length of said conductors,

- fitting electrical terminals to the ends of said group of conductors, and

- fitting hydraulic terminals to the ends of said cooling tubes,

- and wherein said operation of transposing said strands within said conductors is effected solely by twisting said conductors by at least one half-turn about the axis of each of said conductors, and said connecting means mechanically maintains the continuity of thermal contact during the operation of effecting said relatively substantial deformations to said conductors.

12. A coil according to claim 1 substantially as herein described with reference to the accompanying drawings.

13. A method according to claim 11 substantially as herein described with reference to the accompanying drawings.

DATED: 8 APRIL 1993.

PHILLIPS ORMONDE & FTIZPATRICK
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David B Fitzpatrick

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80831/91

FIG.1

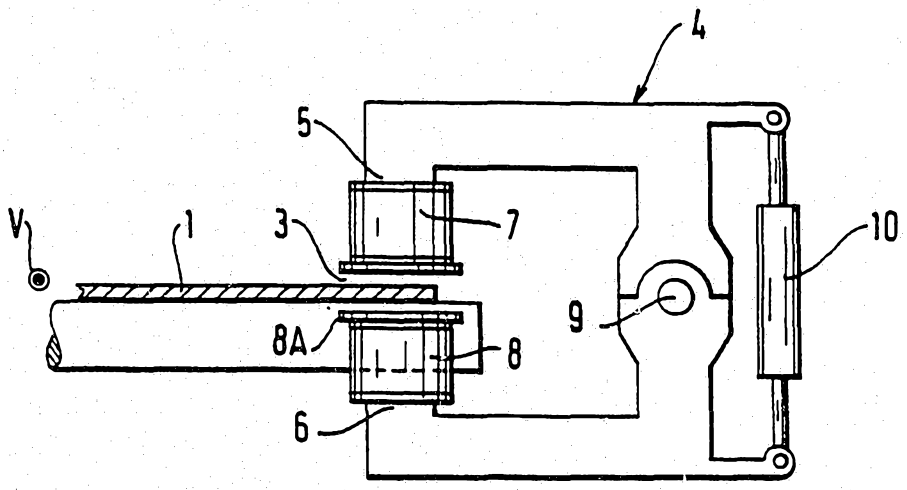


FIG.2

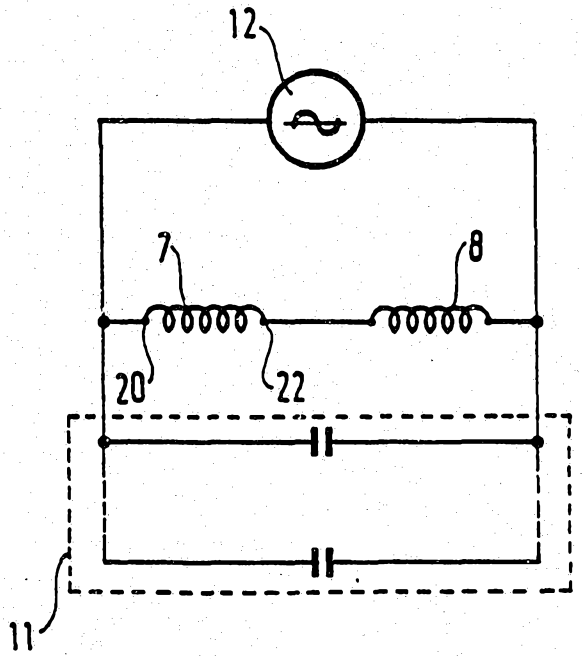


FIG.3

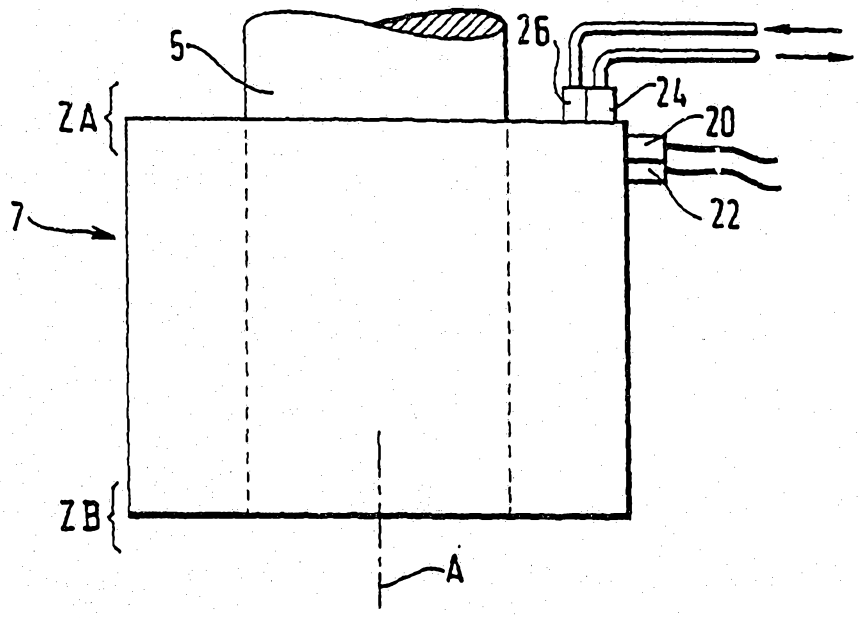
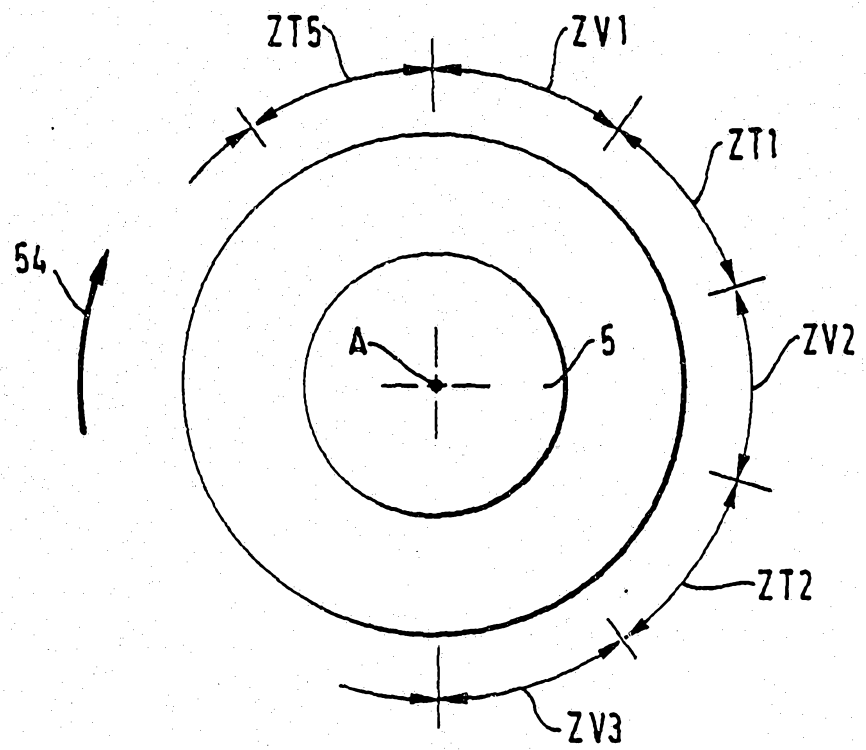


FIG.4



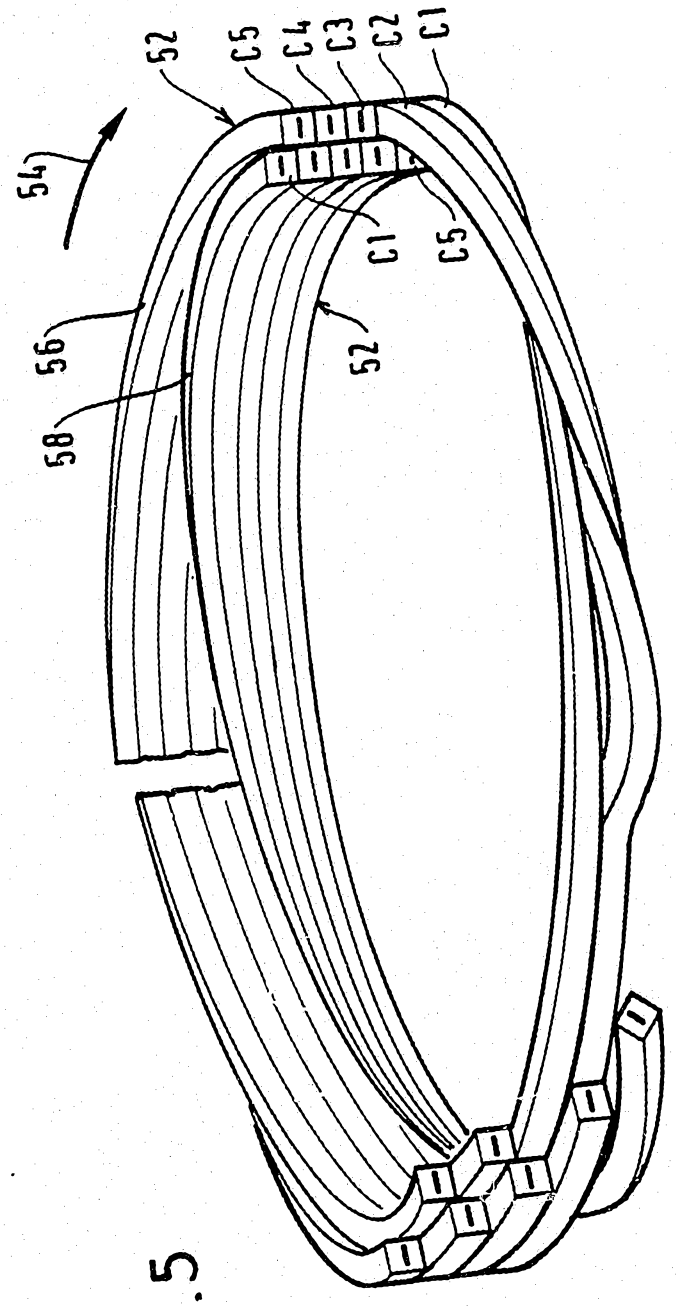


FIG.5

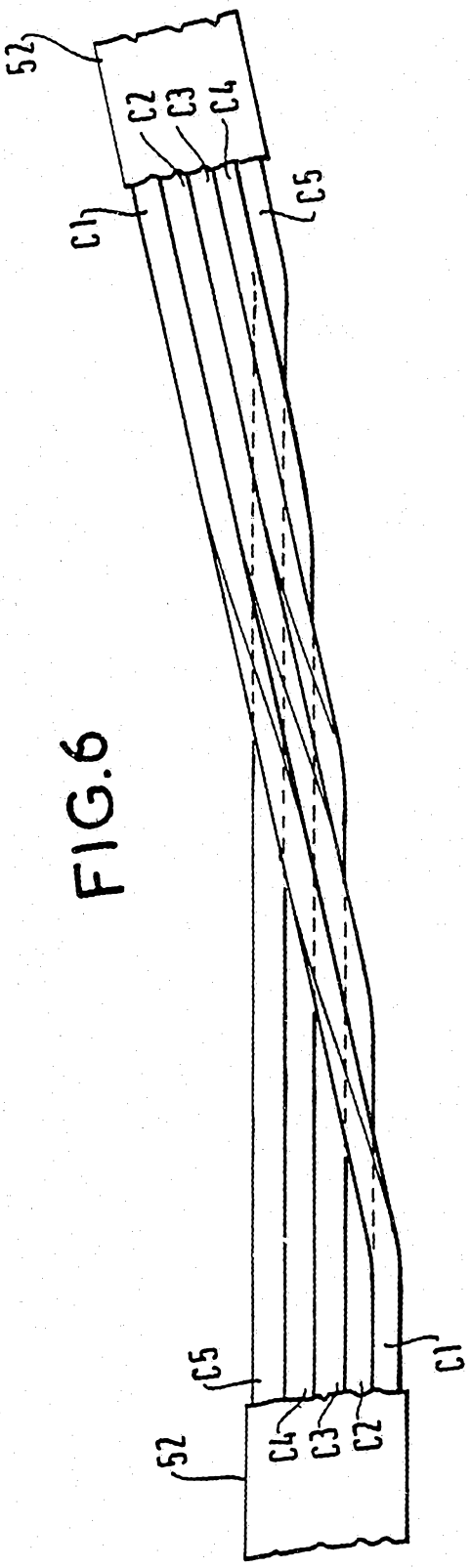
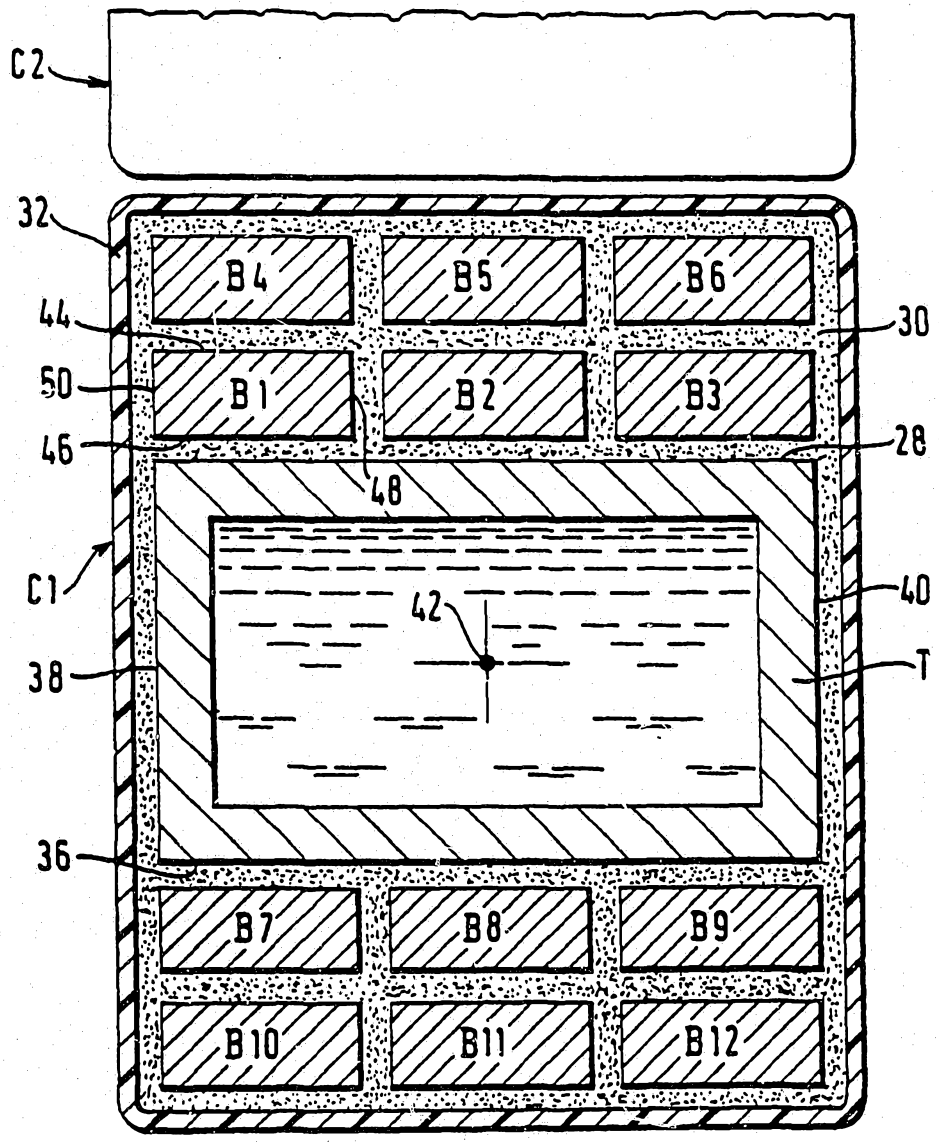


FIG.6

FIG.7


C2
32
B4
B5
B6
44
30
50
B1
B2
B3
46
28
48
C1
42
40
38
T
36
B7
B8
B9
B10
B11
B12

INTERNATIONAL SEARCH REPORT

International Application No PCT/FR 91/00476

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5] H05B6/02; H05B6/42

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	H05B; H01F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US,A,4176237 (BINGEN) 27 November 1979 see column 1, line 56 - column 2, line 56; figures 3-9 (cited in the application)	1, 2, 4-8, 11
A	FR,A,2555353 (CEM, COMPAGNIE ELECTRO-MECANIQUE) 24 May 1985 see page 4, line 31 - page 5, line 22; figures 3, 4	1, 2
A	FR,A,1150187 (ALLMANNA SVENSKA ELEKTRISKA AKTIEBOLAGET) 8 January 1958 see page 1, right-hand column, paragraph 5,6; figures 1-3C	1, 2
A	DE,A,2347592 (ALLMÄNNA SVENSKA ELEKTRISKA AB) 18 April 1974	
A	FR,A,1371223 (WESTINGHOUSE ELECTRIC CORPORATION) 4 September 1964	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
2 September 1991 (02.09.91)	17 September 1991 (17.09.91)
International Searching Authority	**Signature of Authorized Officer**
European Patent Office	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

FR9100476

SA 48528

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 02/09/91

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4176237	27-11-79	BE-A- 850954	01-08-77
		DE-A- 2804121	03-08-78
		FR-A- 2379185	25-08-78
		SE-A- 7801085	02-08-78
FR-A-2555353	24-05-85	None	
FR-A-1150187		None	
DE-A-2347592	18-04-74	SE-B- 367272	20-05-74
		CA-A- 1005537	15-02-77
		CH-A- 558588	31-01-75
		US-A- 3878492	15-04-75
FR-A-1371223		None	

RAPPORT DE RECHERCHE INTERNATIONALE

Demande Internationale No PCT/FR 91/00476

I. CLASSEMENT DE L'INVENTION (si plusieurs symboles de classification sont applicables, les indiquer tous) 7

Selon la classification internationale des brevets (CIB) ou à la fois selon la classification nationale et la CIB

CIB 5 H05B6/02 ; H05B6/42

II. DOMAINES SUR LESQUELS LA RECHERCHE A PORTE

Documentation minimale consultée[8]

Système de classification	Symboles de classification
CIB 5	H05B ; H01F

Documentation consultée autre que la documentation minimale dans la mesure où de tels documents font partie des domaines sur lesquels la recherche a porté[9]

III. DOCUMENTS CONSIDERES COMME PERTINENTS[10]

Catégorie °	Identification des documents cités, avec indication, si nécessaire,[12] des passages pertinents[13]	No. des revendications visées[14]
A	US,A,4176237 (BINGEN) 27 novembre 1979 voir colonne 1, ligne 56 - colonne 2, ligne 56; figures 3-9 (cité dans la demande)	1, 2, 4-8, 11
A	FR,A,2555353 (CEM, COMPAGNIE ELECTRO-MECANIQUE) 24 mai 1985 voir page 4, ligne 31 - page 5, ligne 22; figures 3, 4	1, 2
A	FR,A,1150187 (ALLMANNA SVENSKA ELEKTRISKA AKTIEBOLAGET) 08 janvier 1958 voir page 1, colonne de droite, alinéa 5,6; figures 1-3C	1, 2
A	DE,A,2347592 (ALLMÄNNA SVENSKA ELEKTRISKA AB) 18 avril 1974	

-/--

° Catégories spéciales de documents cités:[11]

"A" document définissant l'état général de la technique, non considéré comme particulièrement pertinent

"E" document antérieur, mais publié à la date de dépôt international ou après cette date

"L" document pouvant jeter un doute sur une revendication de priorité ou cité pour déterminer la date de publication d'une autre citation ou pour une raison spéciale (telle qu'indiquée)

"O" document se référant à une divulgation orale, à un usage, à une exposition ou tous autres moyens

"P" document publié avant la date de dépôt international, mais postérieurement à la date de priorité revendiquée

"T" document ultérieur publié postérieurement à la date de dépôt international ou à la date de priorité et n'appartenant pas à l'état de la technique pertinent, mais cité pour comprendre le principe ou la théorie constituant la base de l'invention

"X" document particulièrement pertinent; l'invention revendiquée ne peut être considérée comme nouvelle ou comme impliquant une activité inventive

"Y" document particulièrement pertinent; l'invention revendiquée ne peut être considérée comme impliquant une activité inventive lorsque le document est associé à un ou plusieurs autres documents de même nature, cette combinaison étant évidente pour une personne du métier.

"&" document qui fait partie de la même famille de brevets

IV. CERTIFICATION

Date à laquelle la recherche internationale a été effectivement achevée	Date d'expédition du présent rapport de recherche internationale
02 SEPTEMBRE 1991	17.09.91
Administration chargée de la recherche internationale	**Signature du fonctionnaire autorisé**
OFFICE EUROPEEN DES BREVETS	RAUSCH R.G.

Formulaire PCT/ISA/210 (deuxième feuille) (Janvier 1985)

III. DOCUMENTS CONSIDERES COMME PERTINENTS [14] (SUITE DES RENSEIGNEMENTS INDIQUES SUR LA DEUXIEME FEUILLE)

Catégorie [15]	Identification des documents cités, [16] avec indication, si nécessaire des passages pertinents [17]	No. des revendications visées [18]
A	FR,A,1371223 (WESTINGHOUSE ELECTRIC CORPORATION) 04 septembre 1964 ---	

ANNEXE AU RAPPORT DE RECHERCHE INTERNATIONALE RELATIF A LA DEMANDE INTERNATIONALE NO.

FR9100476
SA 48528

La présente annexe indique les membres de la famille de brevets relatifs aux documents brevets cités dans le rapport de recherche internationale visé ci-dessus.
Lesdits membres sont contenus au fichier informatique de l'Office européen des brevets à la date du 02/09/91
Les renseignements fournis sont donnés à titre indicatif et n'engagent pas la responsabilité de l'Office européen des brevets.

Document brevet cité au rapport de recherche	Date de publication	Membre(s) de la famille de brevet(s)	Date de publication
US-A-4176237	27-11-79	BE-A- 850954	01-08-77
		DE-A- 2804121	03-08-78
		FR-A- 2379185	25-08-78
		SE-A- 7801085	02-08-78
FR-A-2555353	24-05-85	Aucun	
FR-A-1150187		Aucun	
DE-A-2347592	18-04-74	SE-B- 367272	20-05-74
		CA-A- 1005537	15-02-77
		CH-A- 558588	31-01-75
		US-A- 3878492	15-04-75
FR-A-1371223		Aucun	

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