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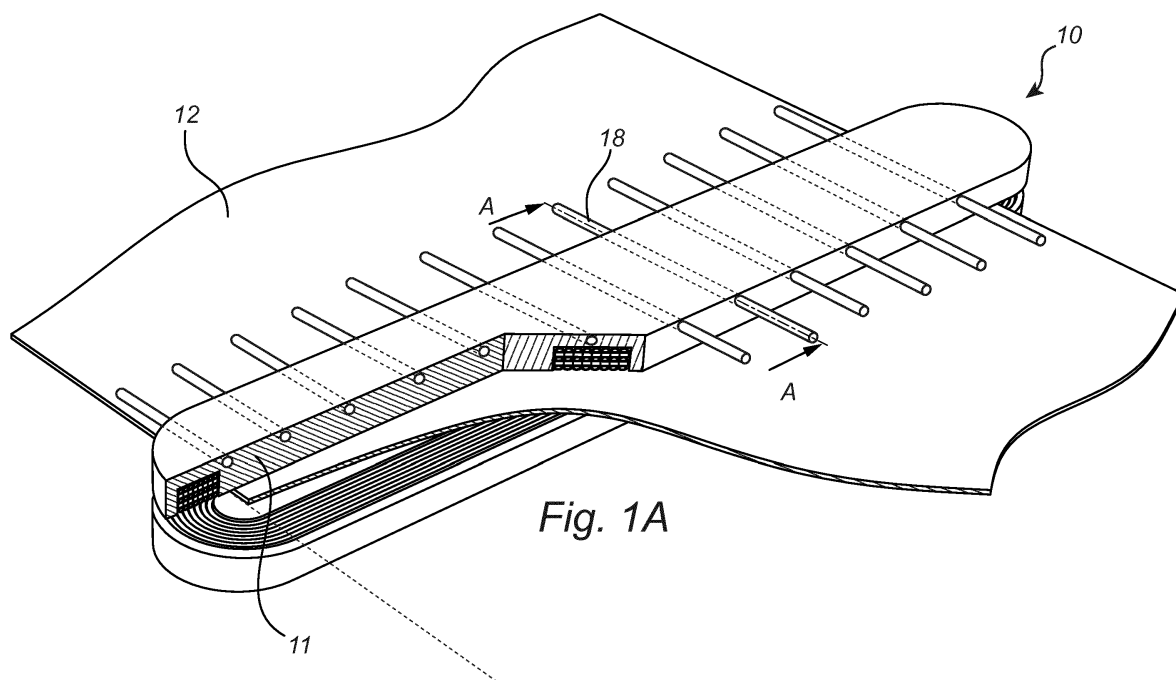
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(54) **High power induction heater**

(57) The invention relates to an induction heater unit comprising a power unit, a work coil unit, a core, and a work head unit adapted to mate the output of the power unit to said work coil unit. The induction heater unit is characterized in that the work coil unit comprises a plurality of coils, wherein the coils are wound interlaced and

said work head unit comprises the same amount of work heads as coils. Each work head is adapted to feed one coil and each work head comprises a separate transformer and a separate capacitor. The power unit comprises at least one inverter.



**Fig. 1A**

## Description

### Technical field

**[0001]** The present invention relates generally to an induction heating unit for heating magnetic metal materials. More particularly, the present invention relates to an induction heater unit as defined in the introductory parts of claim 1 and the use of such an induction heater.

### Background art

**[0002]** Induction heating is a method of providing fast, consistent heat for manufacturing applications. The process relies on induced electrical currents within the material to produce heat and works on all conductive materials, e.g. sheets, rolls or dies of metal. The heat is created from resistive losses and for ferromagnetic materials also from magnetic hysteresis losses. The hysteresis losses decrease with the temperature up to the Curie temperature (770°C for iron), where the material converts to paramagnetic and no magnetic effect is remaining.

**[0003]** Although the basic principles of induction are well known, modern advances in solid state technology have made induction heating a remarkably simple, cost-effective heating method. The basic components of an induction heating system are a switched mode frequency inverter, transformer, and phase advancing filter capacitor, induction coil, and workpiece, i.e. material to be heated or treated.

**[0004]** The traditional induction coil, typically made from copper tubing, is normally cooled with water. The size and shape of the coil, single or multiple turn; helical, round or square; internal or external, reflects the shape of the workpiece and variables of the process.

**[0005]** A number of drawbacks of the traditional induction heating technology with copper tube coils can be identified:

- Water cooling of the coils is always necessary, which adds a separate support system with pumps and connections, bringing extra costs and complexity to the heating system.
- Many conventional induction heating coils show relative low energy efficiency due to current displacement, i.e. skin effects, combined with proximity effects. As energy is expensive this is a major drawback.
- Conventional induction coils often represent a high production cost, with tailor made solutions to each specific heating task. This combined with a limited coil life span often gives expensive coils.
- Geometrical restrictions. Traditional coil technology is not suited for sheet metal heating, heating of flat and curved surfaces etc.
- Uniform heating of large areas is a requested property in many applications but hard to obtain with traditional induction methods.

**[0006]** If some or all problems were to be solved, induction heating could be introduced in a vast number of new applications, where electrical furnaces, open flames or combustion are used today.

**[0007]** The development of high efficient transversal flux induction heaters have improved the performance of induction heating technology and made it possible to address some of the drawbacks from the traditional induction heating technology. The transversal flux induction heater utilizing high efficient litz wire in combination with soft magnetic flux conductor material increase the efficiency of induction heating and minimize the need for cooling system capacity. It is also possible to do uniform heating of larger areas as well as apply it to strip heating or roller heating.

**[0008]** However when the power level is increased the current transversal flux solution becomes bulky and require a very large space for integration in production lines. This is due to the low power density of the existing efficient transversal flux induction heaters.

**[0009]** In order to overcome the drawbacks a new type of induction heater unit is required a unit that combines high efficiency, high power density and a small dimension for easy integration in production equipment. Further, in many applications an induction heater is desired that is efficient also for heating sheets or large surface areas.

### Summary of the invention

**[0010]** It is an object of the present invention to improve the current state of the art, to solve the above problems, and to provide an improved induction heater for high power applications that is more compact, more efficient, have a longer lifetime, is less vulnerable to disruptions, and may be used on large surface areas and moving surfaces. These and other objects are achieved by an induction heater unit comprising a power unit, a work coil unit, a core, and a work head unit adapted to mate the output of the power unit to said work coil unit. The induction heater unit is characterized in that the work coil unit comprises a plurality of coils, wherein the coils are wound interlaced; and said work head unit comprises the same amount of work heads as coils. Each work head is adapted to feed one coil and each work head comprises a separate transformer and a separate capacitor. The power unit comprises at least one inverter. The coil unit may be built up by any number of interlaced coils, the number of interlaced coils chosen in the design, is determined by the desired power output or heating effect.

**[0011]** The coil unit may have a oblong, stadium, elliptical or circular/toroidal shape, depending on the area of application. For using the induction heater unit for heating moving sheets of metal an oblong shape of the coil unit is preferred, e.g. a stadium shape, so that the wires are wound back and forth across the distance of the width of the sheet presenting a uniform magnetic field across the width of the metal sheet.

**[0012]** The coils may be molded into a soft magnetic

core, the core functioning as a magnetic flux conductor. The soft magnetic core may preferably be made of a Soft Magnetic Mouldable Composite (SM2C) material made of metallic particles and a binder material, said particles are in the range of 1  $\mu\text{m}$  - 1000  $\mu\text{m}$ , where a certain part of the particles, i.e. larger than 150  $\mu\text{m}$ , are coated with a ceramic surface to provide particle to particle electrical insulation, wherein the metal packing ratio of magnetic, metallic particles to total core volume is 0,5 - 0,9.

**[0013]** The moulding process provides a good thermal coupling between the core and the coil by avoiding air or gas voids between coil and core. The binder material can be a polymer, e.g. epoxy or a ceramic based binder. The core having said metal volume packing ratio will have good heat conduction properties and high bulk resistivity due to the particle to particle insulation. The particle to particle insulation also enhances the high frequency properties. Since the core is moulded any shape of the core may be created.

**[0014]** It is further preferred that the particles of the SM2C are in the range of 10  $\mu\text{m}$  - 800  $\mu\text{m}$ , further optimizing the core properties and increasing its magnetic properties. The size chosen depends to some extent to the intended use of the core. Smaller particles give better high-frequency properties of the core.

**[0015]** The metallic particles of the SM2C may have a composition consisting of: 6, 5%-7, 5% Si, preferably 6, 8%-7%Si, and remaining particles consisting of Fe. The powder may be produced through gas atomization, giving it an almost spherical particle shape. The metallic particles may also have a composition consisting of: 8%-10% Si, preferably 9% Si; 5%-7% Al, preferably 6% Al; and remaining particles consisting of Fe.

**[0016]** The coil unit of the induction heater according to the invention is further preferably arranged so that each coil has the same circumference and thus the same enclosed surface area (of the magnetic flow). The reason for this feature is to avoid that coils with smaller enclosed surface area are exposed to higher currents than the ones with a larger enclosed surface area.

**[0017]** The power unit of the induction heater unit preferably comprises multiple inverters, feeding different work heads. The power unit preferably comprises as many inverters as coils present in the work coil unit, where each inverter is adapted to feed a single work head and a single coil in the large interlaced coil.

**[0018]** The large, interlaced coil is more energy efficient, thus requiring less cooling, which in turn leads to a compact design of the coil(s). High efficiency leads to reduced energy costs in terms of electricity needed for a given heating effect. The cost for cooling is also reduced since the cooling requirement is smaller. Installation costs are also vastly reduced since the large induction heater unit replaces a number of traditional induction heaters. A number of separate installation procedures of installing several induction heater can be replaced by only one installation as the induction heater unit of the invention may have a power of more than 10 MVA, or

more than 100 MVA or above.

**[0019]** Having multiple coils wound interlaced in the same core further leads to a more compact and more energy dense coil, leading to higher energy efficient, reduced energy costs, and reduced space when operating mounted in-line.

**[0020]** As each interlaced coil is driven by a separate inverter, simple, cost-efficient standard inverters of 10-100 kW may be used. The system operation is less sensitive, due to redundancy since the system still can be used with a slightly reduced maximum output power despite a broken inverter, transformer or phase advancing capacitor. As standard inverters are used, spare parts are easy to acquire and the time of operating at reduced power can be minimized.

**[0021]** The inverters are preferably phase synchronized and the capacitors of the work heads are coupled, i.e. connected to the other capacitors of the other work heads, forming a large distributed capacitor, so as to synchronize the resonance of the magnetic fields of the interlaced coils. Since the inverters of the work heads use synchronized output switching pulses, an electric connection between the interlaced coils is essential for ensuring that all circuits work in resonance. The connection can be made either on both sides of the capacitor or on both sides of the heating coil. Parallel coupling of all of the phase-advancing capacitors leads to all coils having one resonance frequency, i.e. the induction heater unit will present one single frequency. In turn, this increases the maximum output power by utilizing all inverters/transformers/capacitors equally, minimizing losses.

**[0022]** According to a further aspect of the present invention the work coil unit of the induction heater unit comprises cooling pipes abutting said interlaced coils. The cooling pipes are preferably wound interlaced with said coils. The interlaced coils may e.g. be arranged in layers on top of each other in the direction of the symmetry axis of the coil, wherein at least one intermediate layer is a layer of cooling pipes. The cooling pipes are preferably made of an electrically isolating material, such as a plastic material, so as to not interfere electrically with the interlaced coils. Cooling is facilitated by circulating a liquid in the pipes, transporting heat from the interlaced coils. Such a distributed cooling system facilitates the use of high frequency litz wire in the interlaced coils, which, in turn, results in a highly energy efficient heating system.

**[0023]** According to a further aspect of the present invention the soft magnetic core material of the induction heater unit comprises core cooling pipes molded into the core, wherein the cooling pipes are directed in the transverse direction to the coil, i.e. in the same direction as the major direction of the flux lines of the coil. This cooling arrangement of the core leads to an efficient, distributed cooling which is easy to mould/integrate into the soft magnetic return flux path. Locating electrically conducting cooling tubes in the direction of the flux lines, perpendicular to the coil, minimizes the disturbance of the magnetic field of the coils and reduces magnetic reluctance, thus

avoiding losses, and keeping the efficiency high.

**[0024]** The core cooling pipes are preferably thin-walled and made of a non-ferromagnetic metal with high thermal conductivity, as e.g. non-ferromagnetic stainless steel, so as to maximize the heat transfer between the core and the liquid flowing in the core cooling pipes and transporting heat away from the core.

**[0025]** According to a further aspect of the present invention two induction heater units as presented above are used together, wherein the induction heater units are placed on either side of an object to heat, one induction heater unit being rotated 180 degrees so that they face each other on either side of the object, and wherein the coil units of the two induction heater units are driven in counter-phase with each other, so that the magnetic fields of the coil units will cooperate as one magnetic field. The magnetic field will then flow as one magnetic field through the object that is to be heated. This will increase the efficiency e.g. when heating a moving band, if the penetration depth is greater than the thickness of the band, e.g. a thin stainless steel band.

**[0026]** According to a further aspect of the present invention two induction heater units are placed on either side of an object to heat, one induction heater unit being rotated 180 degrees so that they face each other, and the coil units of the two induction heater units are driven in phase with each other, so that the magnetic fields of the coil units will cooperate and meet in the middle of said object. This will prevent over heating the edges of a heated band.

**[0027]** As presented above, the problems of the prior art are thus addressed by the presented induction heater unit, presenting a high energy induction heater that is more compact, more efficient, have a longer lifetime, is less vulnerable to disruptions, and may be used on large surface areas and moving surfaces.

#### Brief description of the drawings

**[0028]** The above objects, as well as additional objects, features and advantages of the present invention, will be more fully appreciated by reference to the following illustrative and non-limiting detailed description of preferred embodiments of the present invention, when taken in conjunction with the accompanying drawings, wherein:

Fig. 1A is a schematic figure of two induction heater units of the present invention applied to heating of a metal sheet.

Fig. 1B is a cross-sectional view of an induction heater unit according to the invention having multiple interlaced coils in layers, with integrated cooling pipes in the coil and integrated cooling pipes in the core.

Fig. 2A is a circuit diagram over the circuitry of the induction heater unit according to a first embodiment of the invention.

Fig. 2B is a circuit diagram over the circuitry of the induction heater unit according to a second embodiment of the invention.

#### Detailed description of preferred embodiments of the invention

**[0029]** Fig. 1B is a cross-sectional view of an induction heater unit 10 according to the invention. The induction heater unit 10 has coil unit 19 built up by multiple interlaced coils 1-8, in layers. Each coil wire 1-8, abuts the neighboring coil wire with only a thin insulating layer (not shown) between them. The coils are interlaced so that the first turn of the winding comprises the wire of the first coil 1 running alongside the wire of the second coil 2, the third coil 3 and the fourth coil 4 and so on. The second turn is located in a second layer (below the first layer) of the winding and comprises the wire of the coils in the following order: 5, 6, 7, 8, 1, 2, 3, 4. The order of the coils are made so that they all have substantially the same circumference and substantially enclose the same area so that the current of the coils 1-8 are the same during operation. In Fig. 1B the coil unit has eight interlaced coils in two turns in two layers, one turn per layer. Between each layer of coil turns, cooling pipes 9 are integrated in the coil. The coil cooling pipes 9 are made of a non-ferromagnetic, and electrically isolating material, as e.g. plastic. The cooling pipes 9 should preferably have high thermal conductivity, thereby preferably being thin-walled.

**[0030]** As can be seen in Fig. 1A and Fig. 1B, the coil unit 19 has an oblong or stadium shape so as to cover the all of the width of the metal sheet 12 that is to be heated with the induction heater unit 1. The induction heater unit will thus present a uniform magnetic field across the width of metal sheet 12 changing with the frequency of the fed current from the inverters of the power unit 20.

**[0031]** The coil unit 19 is molded into a soft magnetic core 11, using a soft magnetic core material according to the state of the art. Core cooling pipes 18 are integrated in the core 11 to be able to transport heat away from the core material so that the core can be made compact and more efficient. The core cooling pipes are arranged in the core to follow the magnetic flux lines from the coil unit, i.e. the core cooling pipes 18 are directed perpendicular to the elongation of the coil unit 19 as seen from the top of the entire induction heater unit 1. The reason is to minimize disturbance of the magnetic field due to the core cooling pipes 18, since the core cooling pipes 18 naturally will take up volume on the expense of the core. The core is open towards the object that is to be heated, in Fig. 1A a sheet of metal 12.

**[0032]** The soft magnetic core 11 is in one embodiment of the invention made by Soft Magnetic Mouldable Composite (SM2C). The permeability of the SM2C can be adjusted to adapt to the design. The shape of the core may be adapted to both function and space requirements

since it is moulded and thus relatively easy to adapt in shape. By running current through the coil, during the moulding and hardening phase of the material, it is possible to enhance its permeability by 10-15%. The H-field of the coil then optimally aligns the surrounding powder particles in the same or similar direction as the flux path of each individual unit. Maintaining the current during hardening ensures that the particles maintain their altered and optimized position. This creates an easier path for the flux to run through which increases the inductance and decreases the inductors losses.

**[0033]** The core 11 is placed in an axially symmetrical fashion so that the area of the core material, perpendicular to the flux lines, is more or less the same in all parts of the inductor. The particle size distribution of the soft magnetic core is chosen to provide a good packing of the powder in combination with optimized static and dynamic magnetic properties. To avoid particle-to-particle electrical conduction in the core, the particles are coated with a thin insulating layer before the moulding process. The insulating layer may e.g. be made of ceramic nanoparticles, which enhances the bulk resistivity of the moulded core and thus reduces the high frequency induced eddy currents.

**[0034]** Fig. 1A shown a schematic figure of two induction heater units 1 of the present invention applied to a metal sheet 12. As can be seen induction heater units according to the invention are placed on both sides of the sheet for effective heating of the sheet.

**[0035]** Fig. 2B is a circuit diagram over the circuitry of the induction heater unit 1 according to the invention. Each of the interlaced coils (inductors), 1-8 are shown to the right. They are each connected in parallel with the next coil so as to ensure total phase synchronization and resonance of the interlaced coils 1-8. Each coil 1-8 is connected to one work head 13. Each work head 14-16 of the work head unit 13 is composed by one phase advancing filter capacitor 14 connected in series with a transformer 15. On the left side of each transformer 15, a capacitor 16 is connected in series with an inverter 17. Each inverter 17 thus feeds one work head 14, 15, 16 which work head drives one of the interlaced coils 1-8. The arrows between the inverters 17 indicate that the inverters are phase synchronized. The dotted lines downwards in Fig. 2A indicate that an arbitrary number N of interlaced coils 1-8 may be added, each individual coil being fed by one inverter 17 via one work head 14-16.

**[0036]** Fig. 2B is a circuit diagram over the circuitry of the induction heater unit 1 according to an alternative embodiment the invention where the phase advancing filter capacitor 14 are connected in parallel instead of the parallel coupling of the coils 1-8 as in Fig. 2a.

**[0037]** It is understood that other variations in the present invention are contemplated and in some instances, some features of the invention can be employed without a corresponding use of other features. E.g. any number of interlaced coils may be contemplated within the scope of the invention and other configuration of coil

cooling pipes may be used, e.g. interlaced in other ways in the core or only surrounding the core, without changing the scope of the invention. Accordingly, it is appropriate that the appended claims be construed broadly in a manner consistent with the scope of the invention.

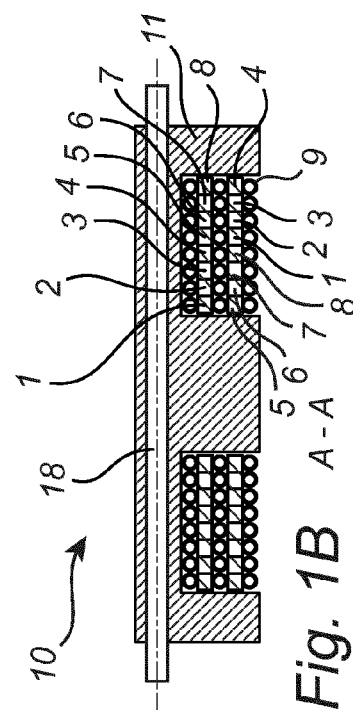
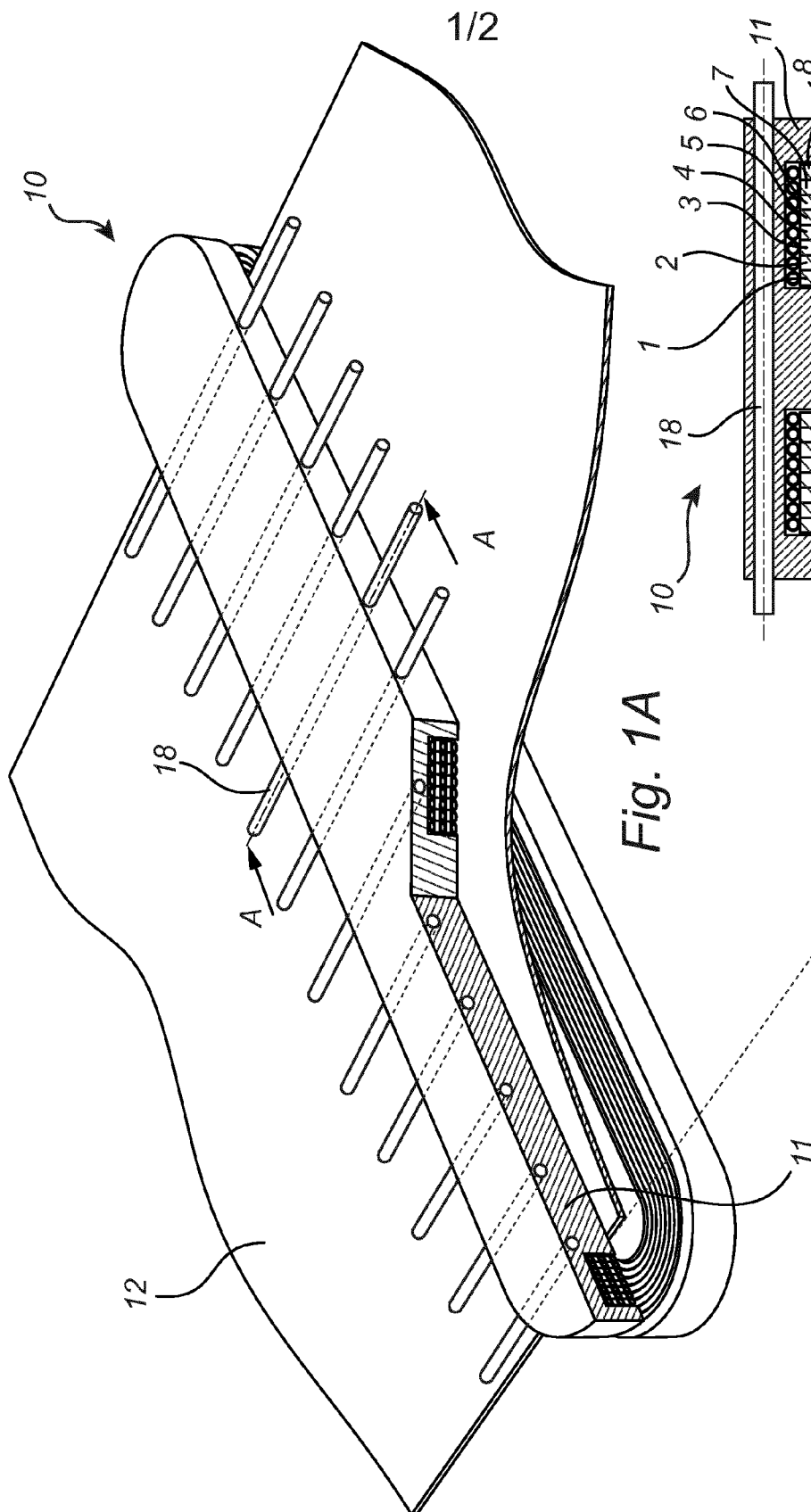
## Claims

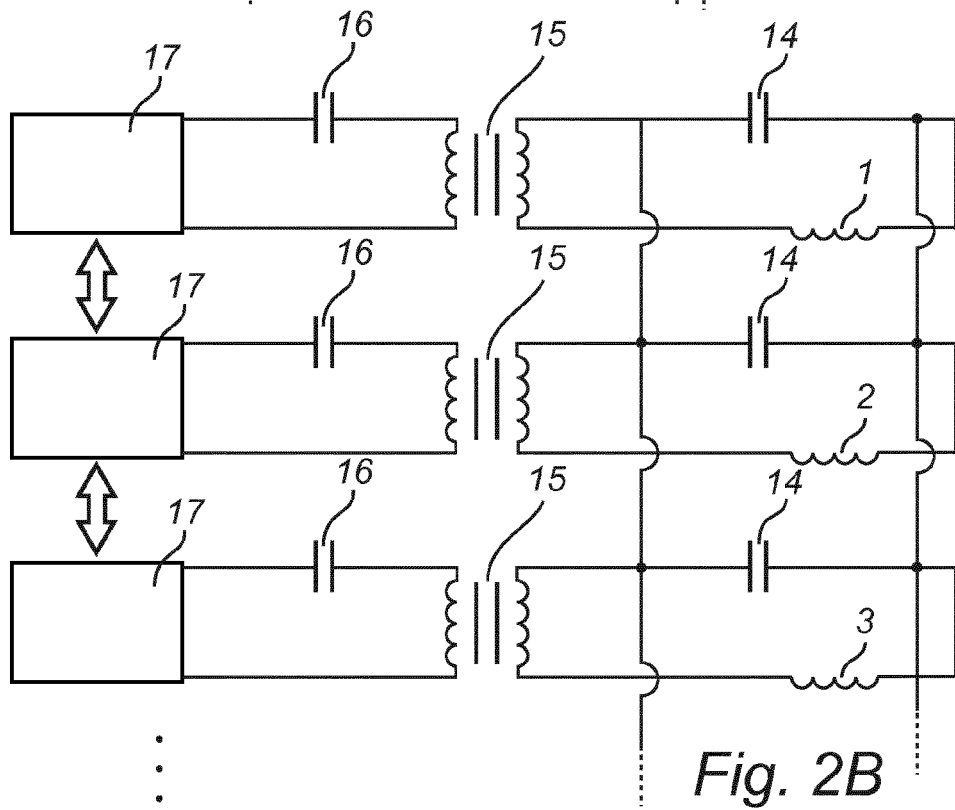
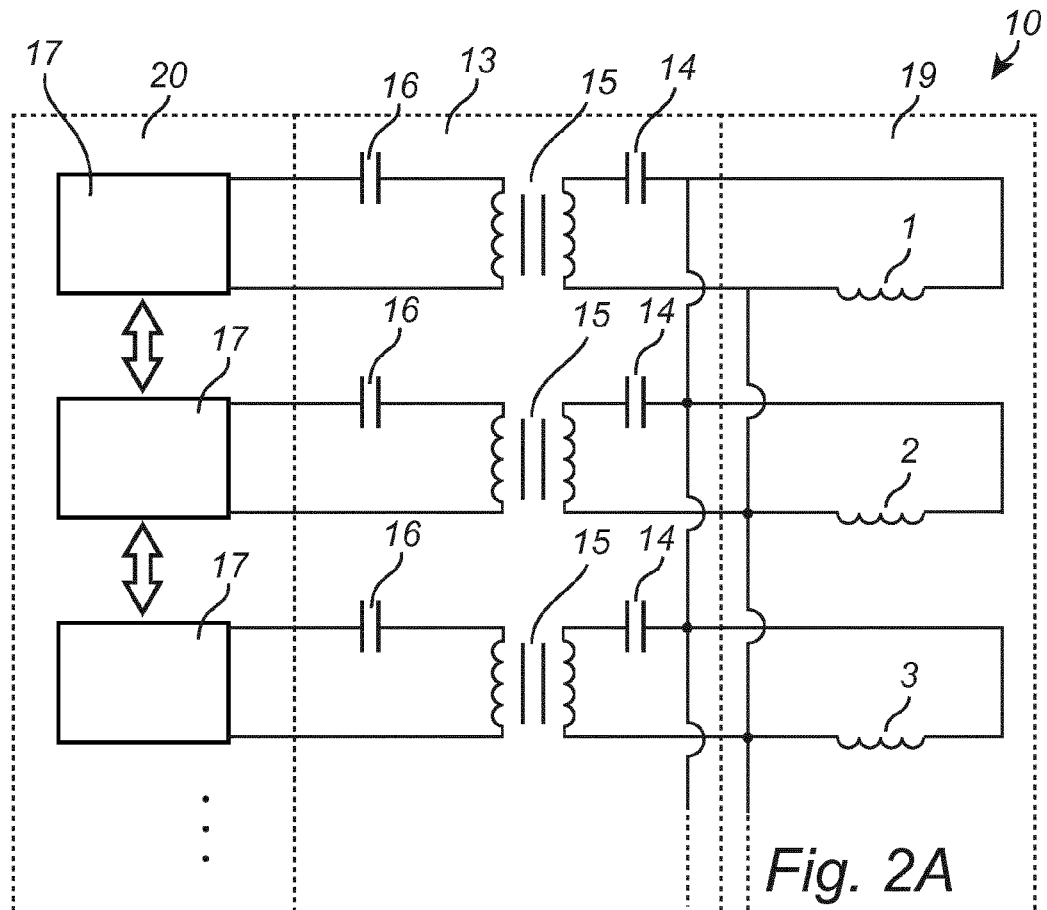
1. Induction heater unit (10) comprising  
a power unit (20),  
a work coil unit (19)  
a core (11), and  
a work head unit (13) adapted to mate the output of the power unit (16) to said work coil unit (19),  
**characterized in that**  
said work coil unit (19) comprises a plurality of coils (1-8), wherein the coils (1-8) are wound interlaced ,  
said work head unit (13) comprises the same amount of work heads (14-16) as coils(1-8), wherein  
each work head (14-16) is adapted to feed one coil (1-8), and  
each work head (14-16) comprises a separate transformer (15) and a separate phase advancing filter capacitor (14),  
said power unit (16) comprises at least one inverter (17).
2. Induction heater unit (10) according to claim 1, wherein said coils (1-8) are molded into a soft magnetic core (11).
3. Induction heater unit (10) according to claim 2, wherein said soft magnetic core (11) is made of a Soft Magnetic Mouldable Composite (SM2C).
4. Induction heater unit (10) according to any one of the preceding claims, wherein each coil (1-8) of the coil unit (19) has the same enclosed surface area.
5. Induction heater unit (10) according to any one of the preceding claims, wherein the power unit (20) comprises multiple inverters (17), feeding different work heads (14-16).
6. Induction heater unit (10) according to any one of the preceding claims, wherein the power unit (20) comprises the same amount of inverters (17) as coils (1-8) present in the work coil unit, wherein each inverter (17) is adapted to feed a single work head and coil (1-8) and said inverters (17) are phase synchronized.
7. Induction heater unit (10) according to any one of the preceding claims, wherein the phase advancing capacitors (14) of the work heads (14-16) are con-

nected to the other phase advancing capacitors (14) of the other work heads (14-16), forming a large distributed capacitor, so as to synchronize the resonance of the magnetic fields of the coils (1-8).

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8. Induction heater unit (10) according to any one of the preceding claims, wherein the work coil unit (19) comprises cooling pipes (9) abutting said interlaced coils (1-8), said cooling pipes being wound interlaced with said coils. 10
9. Induction heater unit (10) according to claim 8, wherein the interlaced coils (1-8) are arranged in layers on top each other in the direction of the symmetry axis of the coil (1-8, 19), wherein at least one intermediate layer is a layer of cooling pipes (9). 15
10. Induction heater unit according to any one of the claims 8-9, wherein said cooling pipes (9) are made of an electrically isolating material. 20
11. Induction heater unit according to any one of the claims 2-10, wherein the soft magnetic core (11) material comprises core cooling pipes (18) molded into the core, wherein the core cooling pipes (18) are directed in transverse direction to the coil (1-8, 19). 25
12. Induction heater unit according to claim 10, wherein said core cooling pipes (18) are made of a non-ferromagnetic metal. 30
13. Use of an induction heater unit (10) according to any one of the preceding claims for heating a magnetic material. 35
14. Use of two induction heater units (10) according to any one of claims 1-13, wherein the induction heater units are placed on either side of an object to heat, one induction heater unit being rotated 180 degrees so that they face each other, and 40 wherein the coil units of the two induction heater units are driven in counter-phase with each other, so that the magnetic fields of the coil units will cooperate. 45
15. Use of two induction heater units (10) according to any one of claims 1-13, wherein the induction heater units are placed on either side of an object to heat, one induction heater unit being rotated 180 degrees so that they face each other, and 50 wherein the coil units of the two induction heater units are driven in phase with each other, so that the magnetic fields of the coil units will cooperate meet in and the middle of said object. 55







## EUROPEAN SEARCH REPORT

Application Number  
EP 14 16 3080

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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                     |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                              |                                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| Category                                                                                                                                                                                                                | Citation of document with indication, where appropriate, of relevant passages                                                                                                                                                                        | Relevant to claim                                                                                                                                                                                                                                                            | CLASSIFICATION OF THE APPLICATION (IPC) |
| X                                                                                                                                                                                                                       | US 2013/140298 A1 (UCHIDA NAOKI [JP] ET AL) 6 June 2013 (2013-06-06)                                                                                                                                                                                 | 1,4-10, 12-15                                                                                                                                                                                                                                                                | INV.<br>H05B6/10                        |
| Y                                                                                                                                                                                                                       | * abstract *                                                                                                                                                                                                                                         | 2,3,11                                                                                                                                                                                                                                                                       | H05B6/42                                |
|                                                                                                                                                                                                                         | * figures 1-3 *                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                              | H05B6/44                                |
|                                                                                                                                                                                                                         | * paragraphs [0035] - [0050] *                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                              |                                         |
|                                                                                                                                                                                                                         | -----                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                              |                                         |
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|                                                                                                                                                                                                                         | * abstract *                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                              |                                         |
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| Y                                                                                                                                                                                                                       | US 4 321 444 A (DAVIES EVAN J) 23 March 1982 (1982-03-23)                                                                                                                                                                                            | 11                                                                                                                                                                                                                                                                           |                                         |
|                                                                                                                                                                                                                         | * abstract *                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                              |                                         |
|                                                                                                                                                                                                                         | * column 5, lines 9-20; figures 2,4 *                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                              |                                         |
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|                                                                                                                                                                                                                         | * abstract *                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                              |                                         |
|                                                                                                                                                                                                                         | * figures 1-3 *                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                              |                                         |
|                                                                                                                                                                                                                         | * column 3, line 18 - column 5, line 46 *                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                              |                                         |
|                                                                                                                                                                                                                         | -----                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                              |                                         |
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|                                                                                                                                                                                                                         | * pages 1-8 *                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                              |                                         |
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|                                                                                                                                                                                                                         | * column 2, line 5 - column 3, line 10; figures 1-4 *                                                                                                                                                                                                |                                                                                                                                                                                                                                                                              |                                         |
|                                                                                                                                                                                                                         | -----                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                              |                                         |
| The present search report has been drawn up for all claims                                                                                                                                                              |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                              |                                         |
| Place of search<br>Munich                                                                                                                                                                                               |                                                                                                                                                                                                                                                      | Date of completion of the search<br>9 September 2014                                                                                                                                                                                                                         | Examiner<br>de la Tassa Laforgue        |
| CATEGORY OF CITED DOCUMENTS                                                                                                                                                                                             |                                                                                                                                                                                                                                                      | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                         |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                              |                                         |

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 16 3080

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