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(54) **YANKEE CYLINDER FOR PAPER PRODUCTION**

(57) Yankee (1) for paper production consisting of a body comprising a metal mantle (2) with circular cross-section and two side heads (3) on which are formed or mounted two respective coaxial pins (4) arranged along a rotation axis (x-x) of the Yankee, said body being configured to rotate with a predetermined angular speed around said rotation axis (x-x). Inside said body is arranged a fixed electromagnetic induction heating system comprising one or more inductors (H; HN) interacting electromagnetically with the mantle (2) to produce induced electric currents in the same mantle, said one or more inductors (H; HN) being arranged in proximity of the radially innermost surface of the mantle (2).

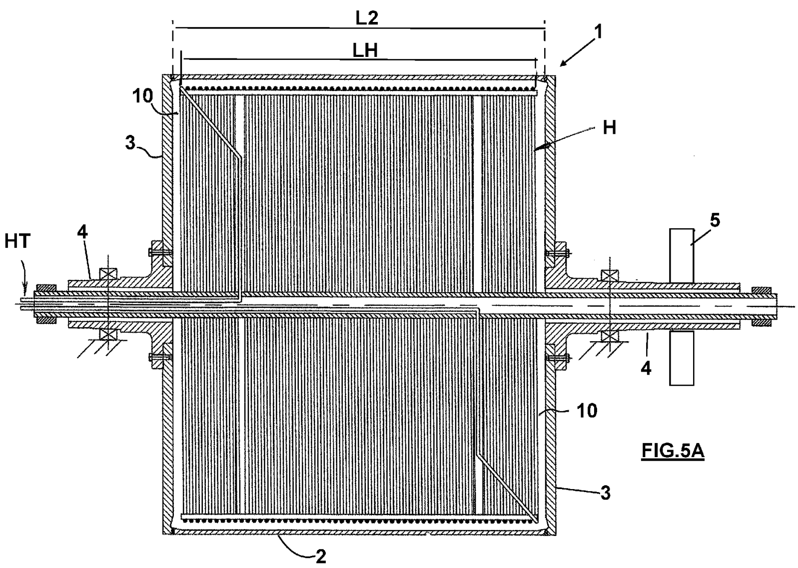

FIG.5A

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Description

[0001] The present invention relates to a Yankee drier for the production of paper.

[0002] It is known that, in general terms, tissue paper is produced using a fibrous suspension containing cellulose fibers normally called pulp. In continuous machines, the pulp is introduced on draining web-like supports. In this phase the formation of the sheet takes place, that is, the fibers overlap and create bonds to form what, once the water has been removed, will be the sheet. The removal of water takes place progressively through actions of drainage, suction, pressing and evaporation until obtaining rolls of paper with a residual humidity of around 5%. According to a consolidated production scheme, the water present in the fibrous suspension is drained through a forming cloth, after which the formed sheet passes through a pressing section in which other water is eliminated and, subsequently, passes over a cylinder, commonly called "Yankee", heated from the inside by introducing high pressure steam. The combined action of the heat transmitted to the sheet through the external surface of the Yankee and of the blowing of hot air and the suction operated by hoods arranged around the Yankee itself finally determines the achievement of the desired degree of dryness. The sheet of paper can be detached from the Yankee by means of a creping blade and wound up in the form of a reel. In alternative systems, the detachment of the sheet from the Yankee can take place in different known ways. The term "tissue" generally refers to low-weight paper products intended for hygienic and sanitary use, such as toilet paper, rolls of kitchen paper or towels, handkerchiefs, napkins, etc.

[0003] The present invention relates to a Yankee drier whose surface in contact with the sheet of paper is heated avoiding the use of steam.

[0004] This result has been achieved, in accordance with the present invention, by adopting the idea of realizing a Yankee drier having the features indicated in claim 1. Other features of the present invention are the subject of the dependent claims.

[0005] The present invention provides for the construction of a Yankee drier with an electromagnetic induction system inside it and a mantle made of any electrically conductive material, such as for example carbon steel or cast iron, suitable to exploit the thermal effects connected to the electromagnetic induction. At the two ends of the mantle there are two respective end heads.

[0006] In accordance with the present invention, the Yankee mantle can also be stratified, with a primary layer, in correspondence with the radially inner surface of the cylindrical mantle, on which the electromagnetic field acts, made of electrically conductive material. In this case, the mantle layers adjacent to the primary layer heat up by conduction by being in contact with the material of the primary layer.

[0007] Preferably, the induction system placed inside the Yankee is static, i.e. it does not rotate together with the Yankee, and is supported by an axis passing through two pins formed on the end heads of the Yankee.

[0008] The internal surface of the Yankee, i.e. the internal surface of the mantle, is free from circumferential grooves. These grooves are normally present in Yankees heated by steam and perform the dual function of increasing the convective exchange surface with the internal steam (which according to the present invention is not used) and to collect the condensed steam (which according to the present invention is not formed as a result of the steam not being used).

[0009] In accordance with the present invention, the electromagnetic induction system comprises a single inductor or more inductors, at a radial distance preferably between 30 cm and 1 mm from the inner surface of the mantle without contact with the latter. More preferably, said radial distance is between 5cm and 2mm and, still more preferably, between 2cm and 5mm. In this case, the term radial distance means the radial distance between the internal electrically conductive cylindrical surface of the Yankee and the point of the induction system closest to it.

[0010] The inductors can be made in many ways.

[0011] The inductors are configured to heat the metallic inner surface of the mantle. The heating is obtained by generating alternating electromagnetic fields through the inductors, with variable frequency and amplitude according to the power to be transmitted. The electromagnetic fields, which vary over time, generate induced currents in the metallic material of the mantle which, due to the Joule effect, produce localized overheating. In this way, the heat required for drying the paper is generated.

[0012] The heat produced at the internal surface of the Yankee diffuses by conduction through the thickness of the mantle, until it reaches the external surface with which the sheet being dried is in contact. A part of the heat will diffuse inside the cylinder itself both by radiation and by convection. However, since the internal volume of the Yankee is substantially closed, the heat diffused inside will not be dispersed but will cause a rise in the temperature of the air contained inside it. In this way, the corresponding portion of thermal energy will not be dispersed into the external environment, with the exception of the part transmitted to the outside through the end heads. In any case, similarly to what occurs in the case of steam Yankee dryers, the heads can be suitably insulated with per se known systems so as to limit to a minimum the part of thermal energy transferred to the external environment, such that the maximum portion of thermal energy is transferred to the sheet being dried.

[0013] The electrical power to be transformed into thermal power for drying the sheet is of the same order of magnitude as the thermal power provided by the steam in traditional systems. In fact, the thermal power does not depend on the source, but on the use that must be made of it. The function of the Yankee is to provide heat to the paper in order to bring the dryness degree of the sheet adhered to it from a minimum value (normally in the range of 25%-50%) when the paper comes into contact with the external surface of the mantle, up to a maximum value (typically in the range of 55%-99%) when the paper is detached from the Yankee. The thermal energy required for the correct functioning of the Yankee will therefore depend on the programmed production parameters and, for example, on: paper weight, sheet width, input dryness degree and output dryness degree from the Yankee, Yankee rotation speed and input sheet temperature. These parameters make it possible to calculate the exact amount and enthalpy content of the water that must be removed from the sheet. Overall, the power required to evaporate the water contained in the sheet until the desired degree of dryness is reached varies approximately between 2MW and 15MW, depending on the production rate, the inlet temperature of the sheet on the Yankee and various other parameters (grammage, degree of creping, etc.).

[0014] In accordance with particular embodiments of the present invention, the Yankee may have an external cylindrical surface with an external layer that is harder than the base metal in order to increase its resistance to wear (due to the presence of paper and scrapers used for remove and/or crepe the dried sheet and/or clean the surface upstream of the sheet adhesion area). For example, said outer layer can be made by means of a metal deposition, or by a plating deposition (deposited by fusion) or by a surface treatment, for example by laser hardening.

[0015] Among the advantages offered by the present invention the following can be mentioned in particular.

[0016] Decarbonisation: in traditional Yankee dryers, steam is normally produced in boilers that burn fossil fuels. Steam generation represents a large amount of the energy used to operate a paper mill. Increasingly, national and international regulations, in addition to the need to reduce the impact of the greenhouse effect on the climate, require that the production of carbon dioxide, one of the main greenhouse gases, be limited and possibly cancelled. The electrification of the heat production to be used in the Yankee for drying paper in accordance with the present invention can allow to reduce (up to canceling) the production of CO_2 necessary for the operation of the Yankee since the required electrical energy can be produced using renewable sources and not the use of fossil fuels. Assuming that only electricity generated from renewable sources is used, it is possible to estimate a potential reduction of CO_2 emissions between 2500tons/year and 25000tons/year, depending on the productivity of the machine.

[0017] Another advantage deriving from the invention concerns the simplification of the system and a greater controllability: in traditional Yankee dryers, the heat is introduced by using steam as a fluid carrier. The steam, following the heat exchange with the sheet being dried, condenses, therefore, at the Yankee outlet there is a two-phase fluid composed of condensate and steam (introduced in excess precisely to maintain the driving force necessary for the extraction of the condensate, in order to avoid flooding inside the cylinder). The steam must have a sufficiently high temperature to allow the paper to be dried while maintaining high productivity (the heat exchanged will be a function of the gradient between the steam temperature and the sheet temperature). Therefore, the steam pressure will have to be kept above a minimum value depending on the process equilibrium. Modern, more performing machines, in order to produce paper with speeds even higher than 2000 mpm, require that the temperature of the internal steam exceeds 150-160°C, with peaks close to 190°C. These temperatures, being saturated steam, require that the pressure inside the Yankee can reach 10bar. All of this requires the construction of a steam generation, treatment and transport plant completed with a series of components and pipes that have a heavy impact on the complexity of the paper production plant. In particular, the following components are present in most applications: steam generation boiler, transport pipes, thermo-compressors to raise, using higher pressure steam, the pressure of the exhausted steam in the cycle in order to regenerate it and keep it in the cycle itself, safety systems (safety and regulating valves), heat recovery systems, condensate separators and others. Furthermore, a system must be created inside the Yankee which allows the continuous removal of the condensate itself. These systems normally consist of a multiplicity of cannulas immersed in the grooves (in the case of grooved Yankees): the steam is introduced into the cylinder in excess with respect to what is necessary for the heat transfer to the paper; the excess steam under pressure finds the only way out through the openings of the cannulas, connected to manifolds distributed circumferentially inside the cylindrical surface of the Yankee and, from these, to a manifold coaxial to the Yankee itself. The action of the excess steam causes the condensate accumulated on the bottom of the grooves following the passage of heat to the paper to be forced to go back up through the cannulas themselves. In this way, following the steam flow, the condensate is continuously removed from inside the Yankee, avoiding flooding. In the case of non-grooved Yankees (typically used in less performing applications or for particular types of paper to be produced, such as MG paper), the condensate extraction system involves the use of large collection spoons rotating together with the Yankee: in this case, given the lower rotation speed of these systems, the condensate tends to accumulate on the lower part of the cylinder. The spoons (in number depending on the diameter of the cylinder) when they rotate, pass from the lower part, collect the condensate and guide it towards a central collector by exploiting the gravity and the particular path of the condensate removal ducts.

[0018] All these systems are at the service of the correct flow of steam and condensate, in order to allow the transport of the required heat. Every single component requires checking and maintenance in order to keep the system efficient and to avoid corrosive/erosive phenomena. The steam circuit requires constant quality control of the flowing substances. For example, it is necessary to keep the PH level within pre-established limits and it is necessary to constantly guarantee the absence of free oxygen in the circuit in order to prevent corrosive phenomena which could cause damage not only to the components of the circuit, but also to the Yankee itself. For this reason, it is necessary to constantly monitor the operating condition and check the quality of the steam also through the use of specific chemicals.

[0019] All these problems and the resources required to keep these systems efficient are eliminated, in accordance with the present invention, by avoiding the use of steam as a heat transfer fluid.

[0020] The use of induction heaters makes it possible to eliminate the use of steam and all the components, systems and technical problems associated with the use of steam.

[0021] The need to use pressurized steam (up to 10 bar) inside traditional Yankee dryers also leads to a series of construction complications. Given the large volume of pressurized steam contained in the Yankee (even over 7m in diameter and over 5.6m wide), the resulting forces on the internal surfaces of the Yankee are significant (a circular head with an internal diameter of 6.6m, exposed to steam under pressure at 10bar, bears a resulting thrust equal to about 14000tons). Furthermore, the use of pressurized steam means that the Yankee must be designed in compliance with the stringent rules imposed by national and international regulations for pressure vessels in order to avoid catastrophic accidents, such as an explosion of the Yankee. Therefore, the structure itself and the connection systems of the various structural components require care and very high levels of control in order to absolutely guarantee the structural reliability of the cylinder throughout its operating life, with a great increase in costs both for the materials used and for the necessary construction and control procedures, the latter to be repeated periodically during the life of the product.

[0022] Normally, the surface of the Yankee, before coming into contact with the paper to be adhered, is sprinkled with substances whose function is to promote adhesion of the paper, to facilitate its detachment after drying, to give particular characteristics to the adhered paper and to protect the outer cylindrical surface of the Yankee. This is normally referred to as an organic coating and its chemical composition can vary greatly depending on the product, the condition of the Yankee surface and the recipe used by the paper mill. Some of the chemical substances contained in the coating (for example epichlorohydrin polyaminoamide resins which can be used in the adhesion components) require, in order to function correctly, to create cross-linking bonds which are facilitated by high temperatures. This aspect also has an impact on the sizing of the Yankee and of the machine configuration; in fact, having to guarantee the cross-linking of the coating before contact with the paper, this causes the coating spray bar (or more simply, the coating bar) to be placed at a certain distance from the point of contact with the paper (depending on the type of coating and the rotation speed of the Yankee). The surface between the coating bar and the point of contact with the paper develops along an arc which, in fact, is unused: the purpose of the Yankee is to transfer thermal power to the paper to dry and this can only take place in the zone where the paper adheres to the Yankee; if a part of the Yankee cannot accommodate the paper because the coating distributed on it is not "ready" to ensure correct adhesion, then the Yankee, in condition of same performance, must have a larger diameter to compensate for the unused area (the development of the wrapping of the paper around the Yankee and, therefore, the diameter of the Yankee, depend on the overall performance of the machine and of the Yankee, as well as on the grammage). On the other hand, the use of an induction system placed inside the Yankee and not rotating together with it, allows, by adopting a modular design, to adjust the intensity of thermal power also according to the involved sectors. In this way it is possible to control the temperature of the sector dedicated to the cross-linking of the coating. By optimizing the crosslinking process, it is possible to reduce the space dedicated to it. Reducing the space required for crosslinking allows a reduction of the Yankee diameter in conditions of same performance.

[0023] Another potential advantage concerns the greater energy efficiency: the current system provides for the generation of thermal power outside the Yankee (the steam is produced in a boiler outside the Yankee and, from this, via ducts and regulation components, is brought inside the Yankee). The system object of the present invention instead provides that the thermal power is produced, thanks to the Joule effect caused by the induced currents, directly in the metal coat of the Yankee, i.e. in correspondence with the exchange zone with the paper being dried. This allows to reduce all the losses due to the transport of fluid at high temperature from a remote area inside the Yankee. This fact, if associated with a source of electricity production from renewable sources (i.e. without the need to produce a heat transfer fluid for the production of electricity via combustion), allows the path of the thermal power to be significantly shortened, thus improving the overall efficiency.

[0024] In the drawings attached by way of example, not to be considered in a limiting sense:

- Fig.1 shows a papermaking machine provided with a Yankee in accordance with the present invention;
- Fig.2 represents a schematic vertical sectional view illustrating some parts of a Yankee dryer according to the present invention;
- Fig.3 represents a possible operating configuration of a Yankee dryer in accordance with the present invention;
- Fig.4 represents another possible operating configuration of a Yankee dryer in accordance with the present invention;

- Fig.5A represents a schematic longitudinal section view of a Yankee in accordance with the present invention;
- Fig.5B represents an enlargement of Fig.5A and highlights the magnetic field lines intercepting the Yankee mantle;
- Fig.5C is similar to Fig.5B but it represents turn coils having a higher diameter (d);
- Figs. 5D and 5E schematically represent the magnetic field lines produced in the configurations of Fig.5A and respectively Fig.5B;
- Figs.6-8 show three different views of a possible embodiment of an inductor for a Yankee drier in accordance with the present invention;
- Figs.9-12 show four different views of a further possible embodiment of an inductor for a Yankee drier in accordance with the present invention;
- Figs.13-15 show three different views of a possible embodiment of an inductor group for a Yankee dryer according to the present invention;
- Figs. 16-20 show five different views of a further possible embodiment of a group of inductors for a Yankee drier according to the present invention.

[0025] Reduced to its essential structure and with reference to the figures of the attached drawings, a Yankee drier (1) according to the present invention is a body comprising a metal mantle (2) with a circular cross section and two end heads (3) on which two respective coaxial pins (4) are formed or mounted, arranged along an axis of rotation (x-x) of the Yankee. A transmission (5) acts on the pins (4) by which the rotation speed of the Yankee around the axis (x-x) is controlled. The outer surface of the mantle (2) forms a heat exchange surface with a sheet of paper produced upstream of the Yankee to reduce its water content, i.e. increase its dryness. The sheet of paper can be produced, with methods per se known to those skilled in the art, in a machine for the production of structured paper which, for example, comprises a forming zone (A) in which the sheet is formed starting from a fibrous suspension of predefined composition, a pre-drying zone (B) of the sheet downstream of the formation zone (A), along which the water content of the sheet is progressively reduced, and a drying zone (C) downstream of the pre-drying area (B), where the Yankee (1) is installed.

[0026] In Fig.1 the arrow "NM" shows the direction of the sheet along the machine.

[0027] Downstream of the Yankee (1) a section (D) can be arranged for collecting the sheet in the form of reels (R1, R2).

[0028] In the entry section of the drying area (C) there is a presser (6) which compresses the sheet of paper on the Yankee (1) with a pre-set pressure. For example, the presser (6) can consist of a shoe press, a blind-holes roller or a suction roller.

[0029] The section (B) can eventually integrate systems for reducing the water content of the sheet based on multiple concepts (application of vacuum using suction boxes or suction rollers in order to facilitate water drainage, pressing areas, devices for supplying thermal energy, devices based on the removal of water from the sheet through the principle of capillarity, forced blowing of hot air through the sheet, etc...). All these systems, even in combination with each other, are known per se. A hood (7) can be arranged on the Yankee (1).

[0030] In the drying section (C) the sheet is in contact with the outer surface of the mantle of the Yankee (1) from the entry point (P1) to the exit point (P2) for a section with an angular extension (a) greater than 180°. In the scheme of Fig.2, the sheet is indicated by the reference "S". At said exit point (P2) a creping scraper (8) can be arranged for detaching the sheet from the Yankee (1) and, downstream of the creping scraper (8) with respect to the direction of rotation (1C) of the Yankee, there is a cleaner scraper (80). The sheet, in alternative configurations, could be detached from the Yankee even without the use of a scraper, but through the use of support belts which collect the sheet at the end of its passage from the Yankee surface.

[0031] The sheet (F) is conveyed by a web (9) from the forming area (A) to the drying area (C) and is associated with the web (4) in the compression nip defined by the presser (6) in cooperation with the Yankee (1).

[0032] In the diagram of Fig.3 the presser (6) is a shoe press and web belt (9) is a felt. The same diagram shows a suction roller (SR) onto which the web (9) is guided upstream of the presser (6).

[0033] In the diagram of Fig.4, the presser (6) is associated with a further presser (60), arranged downstream with respect to the direction of rotation (1C) of the Yankee. In this configuration, the web (9) is associated with the sheet in both the nips defined by the presser (6) and by the further presser (60) in cooperation with the Yankee (1). For example, the additional presser (60) consists of a blind-holes press.

[0034] The linear pressure exerted by the presser (6) in correspondence of the Yankee is preferably between 60 and 200 kN/m, more preferably between 90 and 150 kN/m and, even more preferably, between 90 and 120 kN/m. In a configuration of the type shown in Fig.4, the linear pressure exerted by the additional presser (60) at the Yankee is preferably between 90 and 120 kN/m.

[0035] For example, the Yankee (1) has an external diameter comprised between 2.00 m and 7.500 m, and an axial length comprised between 3.00 m and 7.400 m.

[0036] Inside the Yankee (1) there is a fixed electromagnetic induction heating system made up of one or more inductors (H; HN) positioned and configured to produce alternating electromagnetic fields with pre-established frequency and amplitude according to the thermal power to be generated. In case of installation of a plurality of inductors (HN) distributed in the axial direction and fed independently or in groups, it is possible to carry out a partial control of the thermal power generated, in the axial direction, in the mantle. In this way it is possible to compensate for any unevenness in the transversal humidity profile of the paper being dried, by acting on the solenoids acting on the areas corresponding to the bands where the paper has greater humidity, by increasing the electric power supply. The electromagnetic fields produced by the inductors, which vary over time, induce the generation of electric currents in the metallic material of the Yankee mantle and, due to the Joule effect, the mantle itself is subject to heating. The heat thus generated is used to dry the sheet (F). The induction heating system makes it possible to generate a uniform thermal imprint on the surface of the mantle (2) of the Yankee, i.e. a uniform heat distribution along the generatrix lines of the cylindrical surface which defines the mantle. The electromagnetic induction heating system extends axially, i.e. parallel to the axis (x-x) of the Yankee, along the inner surface of the mantle (2) but is preferably shorter than the latter, leaving a free space (10) in front of each of the end heads (3).

[0037] Preferably, the radially outer side of the electromagnetic induction system is at a radial distance from the inner surface of the mantle (2) comprised between 20cm and 1mm, more preferably said radial distance is comprised between 5cm and 2mm and, even more preferably, between 2cm and 5mm.

[0038] In the diagrams of Fig.5A, Fig.6, Fig.7 and Fig.8 there is a single inductor (H) in the form of a solenoid developed around the (x-x) axis of the Yankee. The solenoid is formed by coil turns concentric with said axis (x-x).

[0039] With reference to Fig.5, the inductor (H) extends axially inside the Yankee (1) for a length (LH) shorter than the length (L2) of the mantle (2).The terminals (HT) of the inductor (H) can be passed through one of the pins (4).

[0040] In the diagrams of Figs. 9-12 there is a single toroidal inductor (H) developed parallel to the axis (x-x) of the Yankee. The toroidal inductor is formed by coils parallel to the inner surface of the cladding (2). Also in this case, preferably the radially outer side of the inductor (H) is at a radial distance from the inner surface of the shell (2) between 20cm and 1mm, more preferably said radial distance is between 5cm and 2mm and, even more preferably, between 2cm and 5mm. Also in this case, the terminals (HT) of the inductor (H) can be passed through one of the pins (4).

[0041] In the diagrams of Figs. 13-15 there are a plurality of inductors (HN) each of which consists of a solenoid developed around the axis of the Yankee and formed by coil turns concentric to said axis. In this example, the inductors (HN) are arranged axially side by side. Also in this case, the terminals (HT) of the inductors (HN) can be passed through one of the pins (4).

[0042] In the diagrams of Figs. 16-20 more inductors (HN) are provided, each of which is formed by a solenoid consisting of coil turns wound around respective radial axes (RHN). The inductors (HN) in this case are arranged circumferentially around the axis of the Yankee. Also in this case, the terminals (HT) of the inductors (HN) can be passed through one of the pins (4). In the drawings, the reference "HP" indicates cores of ferromagnetic material which can optionally be used to realize the inductors (HN).

[0043] By using a plurality of inductors (HN) arranged as in the diagrams of Figs. 13-15 it is also possible to control the thermal power transmitted to the mantle (2) in a differentiated manner along the axial direction of the Yankee to produce axially variable thermal profiles.

[0044] By using a plurality of inductors (HN) arranged as in the diagrams of Figs. 16-20 it is also possible to control the thermal power transmitted to the mantle (2) in a radially differentiated way to produce radially variable thermal profiles.

[0045] Preferably in accordance with the present invention, the following condition is satisfied:

S > P - d, where "S" is the radial distance of the inductor from the internal surface of the Yankee mantle, "d" is the diameter of the conductors forming the coil turns (HS) and "P" is the pitch between the coil turns of the inductor (or the individual inductors).

[0046] It is noted that, in general, all other conditions being equal, turns more spaced apart from each other will imply a lower spatial density of the local field, therefore a lower temperature generated on the mantle, compared to turns wound with a smaller winding pitch, i.e. closer coil turns.

[0047] Accordingly, according to the present invention, a geometric configuration of the inductor system (understood as a single solenoid or as a plurality of solenoids) is achieved in which the distance between the spiral windings of the inductor system and the internal surfaces of the armature consisting of the Yankee mantle is higher than the pitch between the coil turns (HS) reduced by said diameter (d).

[0048] In this way, the magnetic fields of the individual turns intercepted the mantle material is not influenced by possible non-uniformity of the pitch of the coil turns and/or the diameter of the conductors forming the coil turns and/or possible non-uniformity of the material of which are made the single coil turns.

[0049] Figs, 5A and 5B schematically show two possible dispositions of the coil turns (HS) formed by conductors having a different diameter (d).

[0050] With reference to the example shown in Figs.9-12, the inductor (H) has a side (HM) radially closer to the mantle (2) and a side (HW) radially more distant from the mantle (2), and said side (HM) radially closest to the mantle (2) is at a given radial distance from the inner surface of the mantle (2) and also in this case the inductors are formed by turns (HS) made up of conductors of predefined diameter spaced apart of a pitch of predefined value (P). This case is characterized by the fact that the value of the radial distance of the side (HM) from the inner surface of the mantle (2) is less than or equal to the difference between said pitch (P) and said diameter (d). The same applies if instead of the single inductor (H) there are several inductors thus constructed and aligned along the axis of the Yankee.

[0051] From the description provided above, it is evident that a Yankee cylinder for the production of paper is a body comprising a metal mantle (2) with circular cross-section and two end heads (3) on which are formed or mounted two respective coaxial pins (4) arranged along a rotation axis (x-x) of the Yankee, said body being configured to rotate with a predetermined angular speed around said rotation axis (x-x), wherein inside said body is arranged a fixed electromagnetic induction heating system comprising one or more inductors (H; HN) interacting electromagnetically with the mantle (2) to produce induced electric currents in the same mantle, said one or more inductors (H; HN) being arranged in proximity of the radially innermost surface of the mantle (2).

[0052] From the description provided above, it is also evident that a Yankee cylinder according to the present invention may also have one or more of the following features possibly combined between them:

- the Yankee has an external diameter comprised between 2.00 m and 7.500 m, and the mantle (2) has an axial length comprised between 3.00 m and 7.400 m.
- the electromagnetic induction heating system extends axially, i.e. parallel to the axis (x-x) of the Yankee, along the inner surface of the mantle (2) but is shorter than the latter, leaving a free space (10) in front of each of the end heads (3).
- the radially outermost side of the electromagnetic induction system is at a radial distance from the internal surface of the mantle (2) comprised between 20 cm and 1 mm, more preferably at a radial distance comprised between 5 cm and 2 mm and, even more preferably, comprised between 2cm and 5mm.
- the electromagnetic induction system comprises a single inductor (H) in the form of a solenoid developed around the axis (x-x) of the Yankee, the solenoid being formed by coil turns concentric to said axis (x-x).
- the electromagnetic induction system comprises a single toroidal inductor (H) formed by coils developed parallel to the axis (x-x) of the Yankee.
- the electromagnetic induction system includes a plurality of inductors (HN) each of which consists of a solenoid developed around the axis of the Yankee and formed by coil turns concentric to said axis.
- the electromagnetic induction system comprises a plurality of inductors (HN) axially placed side by side.
- the electromagnetic induction system comprises a plurality of inductors (HN) each of which is formed by a solenoid formed by coils parallel to the inner surface of the mantle (2).
- the electromagnetic induction system comprises a plurality of inductors (HN) arranged circumferentially around the axis of the Yankee.
- the inductor (H) or the inductors (HN) are at a radial distance (S) from the inner surface of the mantle (2), the inductors are formed by coil turns (HS) consisting of conductors with a predefined diameter (d) spaced apart by a pitch of predefined value (P), and the value of the said radial distance (S) is higher than the difference between said pitch (P) and said diameter (d).
- the inductor (H) or the inductors (HN) are at a radial distance (S) from the inner surface of the mantle (2), the inductors are formed by coils (HS) consisting of conductors with a predefined diameter (d) spaced apart by a pitch of predefined value (P), and the value of the said radial distance (S) is higher than the difference between said pitch (P) and said diameter (d).

[0053] In practice, the execution details can in any case vary in an equivalent way as regards the individual elements described and illustrated, without thereby departing from the scope of the solution adopted and therefore remaining within the limits of the protection granted by the present patent in accordance with the attached claims.

Claims

1. Yankee (1) for paper production consisting of a body comprising a metal mantle (2) with circular cross-section and two side heads (3) on which are formed or mounted two respective coaxial pins (4) arranged along a rotation axis (x-x) of the Yankee, said body being configured to rotate with a predetermined angular speed around said rotation axis (x-x), **characterized in that** inside said body is arranged a fixed electromagnetic induction heating system comprising one or more inductors (H; HN) interacting electromagnetically with the mantle (2) to produce induced electric currents in the same mantle, said one or more inductors (H; HN) being arranged in proximity of the radially innermost surface of the mantle (2).

2. Yankee according to claim 1 **characterized in that** it has an external diameter comprised between 2.00 m and 7.500 m, and the mantle (2) has an axial length comprised between 3.00 m and 7.400 m.

3. Yankee according to claim 1 **characterized in that** the electromagnetic induction heating system extends axially, i.e. parallel to the axis (x-x) of the Yankee, along the inner surface of the mantle (2) but is shorter than the latter, leaving a free space (10) in front of each of the heads (3).

4. Yankee according to claim 1 **characterized in that** the radially outermost side of the electromagnetic induction system is at a radial distance (S) from the internal surface of the mantle (2) comprised between 20 cm and 1 mm, more preferably at a radial distance

comprised between 5 cm and 2 mm and, even more preferably, comprised between 2cm and 5mm.

5. Yankee according to claim 1 **characterized in that** the electromagnetic induction system comprises a single inductor (H) in the form of a solenoid developed around the axis (x-x) of the Yankee, the solenoid being formed by coil turns concentric to said axis (x-x).

6. Yankee according to claim 1 **characterized in that** the electromagnetic induction system comprises a single toroidal inductor (H) formed by coil turns developed parallel to the axis (x-x) of the Yankee.

7. Yankee according to claim 1 **characterized in that** the electromagnetic induction system includes a plurality of inductors (HN) each of which consists of a solenoid developed around the axis of the Yankee and formed by coil turns concentric to said axis.

8. Yankee according to claim 1 **characterized in that** the electromagnetic induction system comprises a plurality of inductors (HN) axially placed side by side.

9. Yankee according to claim 1 **characterized in that** the electromagnetic induction system comprises a plurality of inductors (HN), each of which consists of a solenoid formed by coil turns wound around respective radial axes (RHN).

10. Yankee according to claim 1 **characterized in that** that the electromagnetic induction system comprises a plurality of inductors (HN) arranged circumferentially around the axis of the Yankee.

11. Yankee according to any one of claims 5-8, wherein the inductor (H) or the inductors (HN) are at a radial distance (S) from the inner surface of the mantle (2), the inductors are formed by coils (HS) consisting of conductors with a predefined diameter (d) spaced apart by a pitch of predefined value (P), **characterized in that** the value of the said radial distance (S) is higher than the difference between said pitch (P) and said diameter (d).

12. Yankee according to any one of claims 5-8, wherein the inductor (H) or the inductors (HN) have a side (HM) radially closer to the mantle (2) and a side (HW) radially more distant from the mantle (2), in which said side (HM) radially closest to the mantle (2) is at a radial distance (S) from the inner surface of the mantle (2), the inductors are formed by coils (HS) made up of conductors of predefined diameter (d) spaced from each other by a pitch of predefined value (P), **characterized in that** the value of said radial distance (S) is higher than the difference between said pitch (P) and said diameter (d).

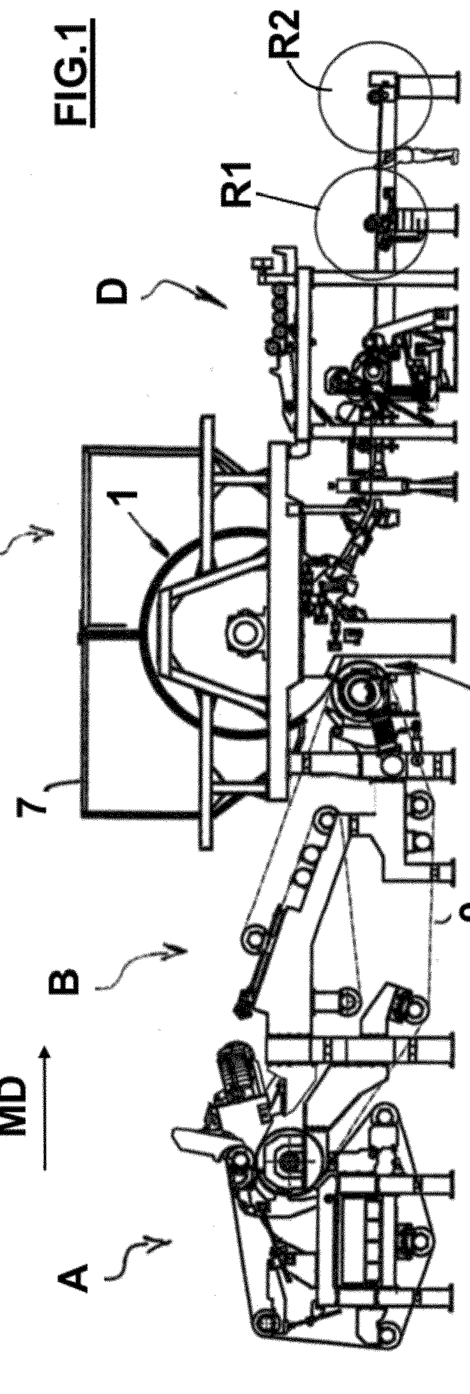

FIG.1

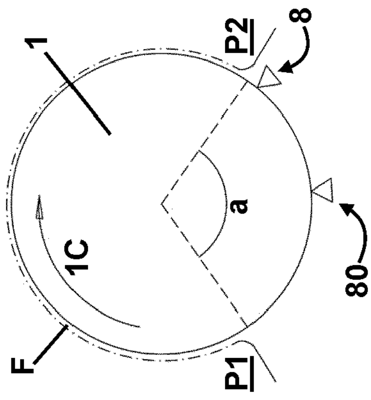

FIG.2

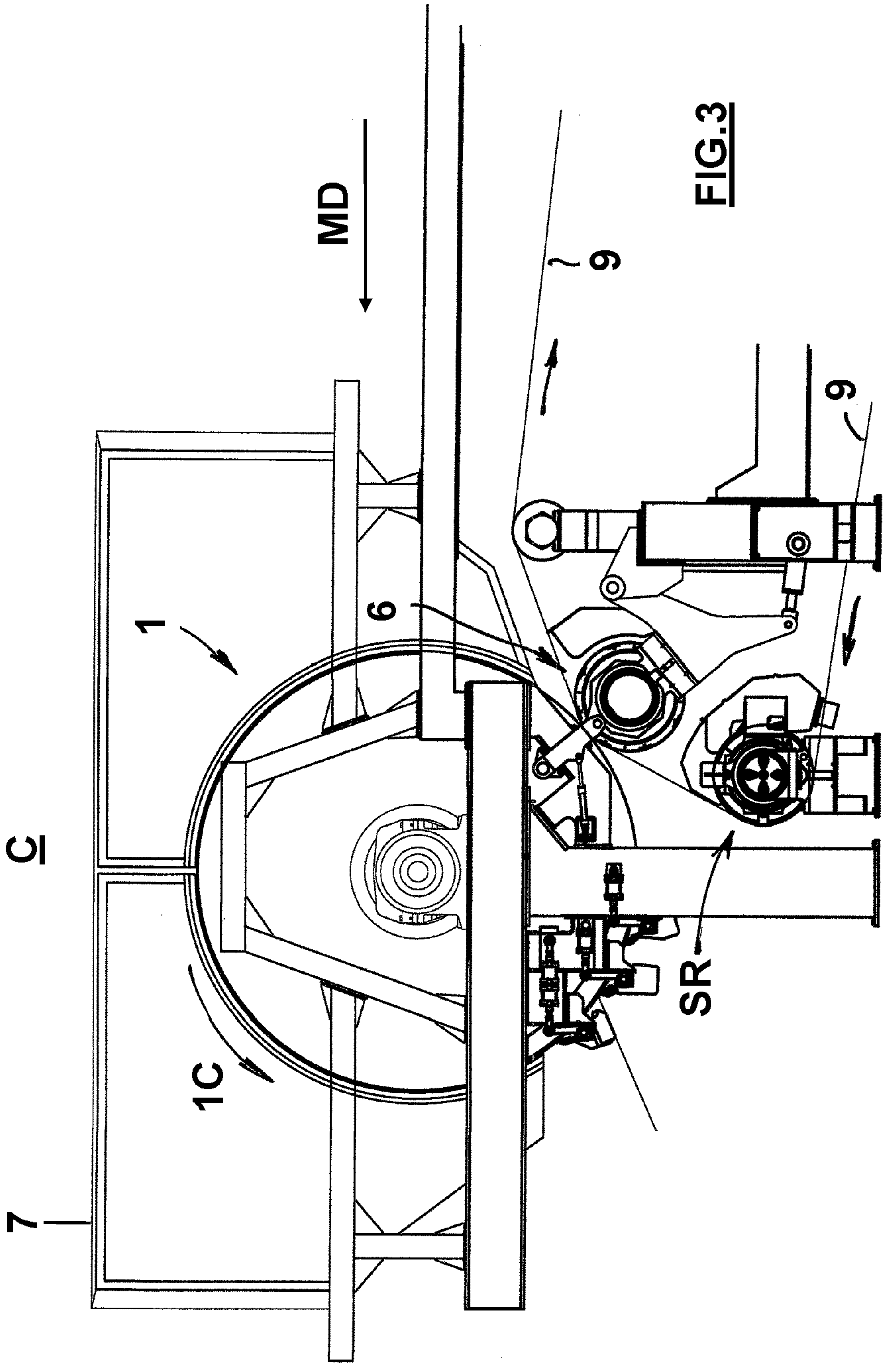

FIG.3

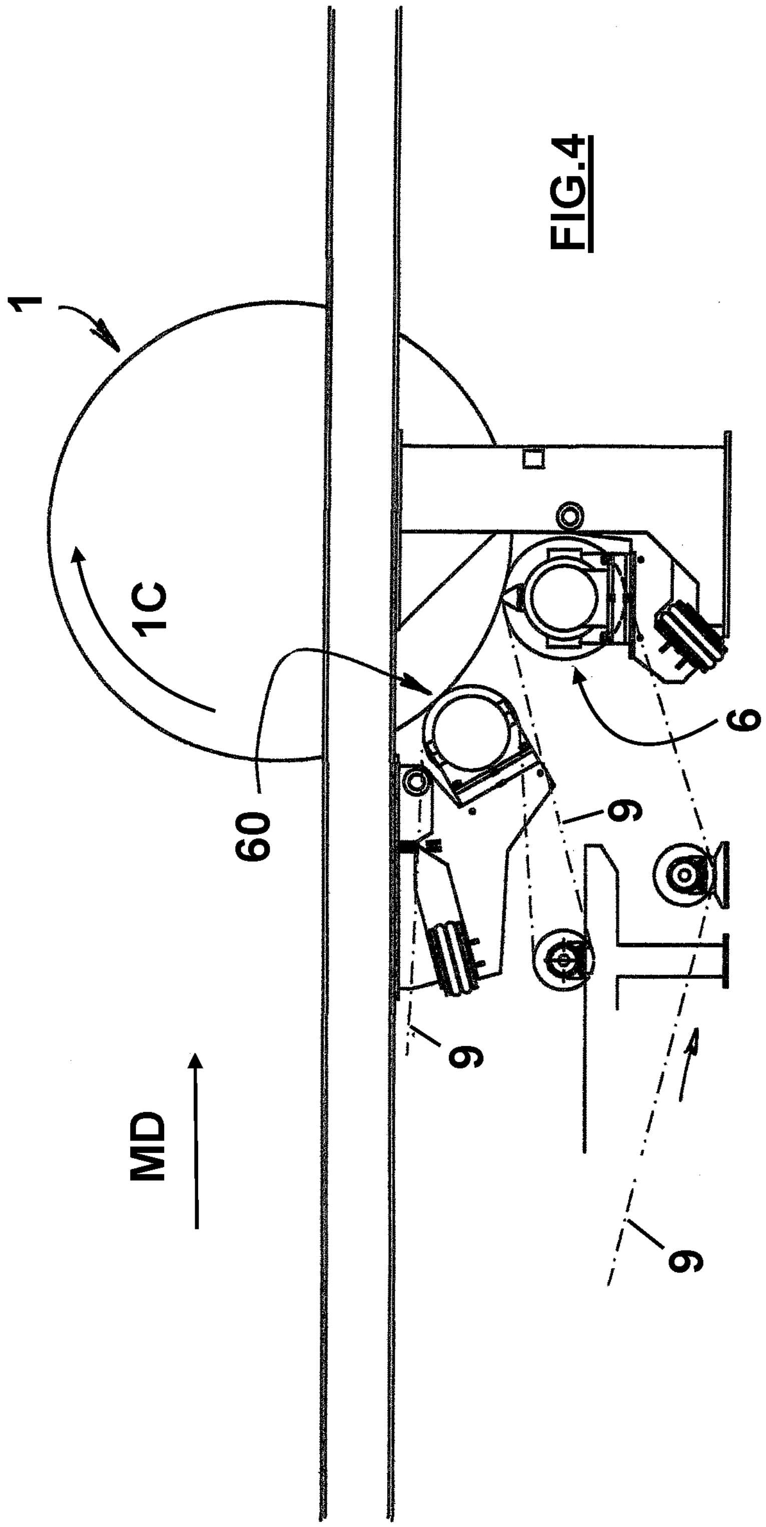

FIG.4

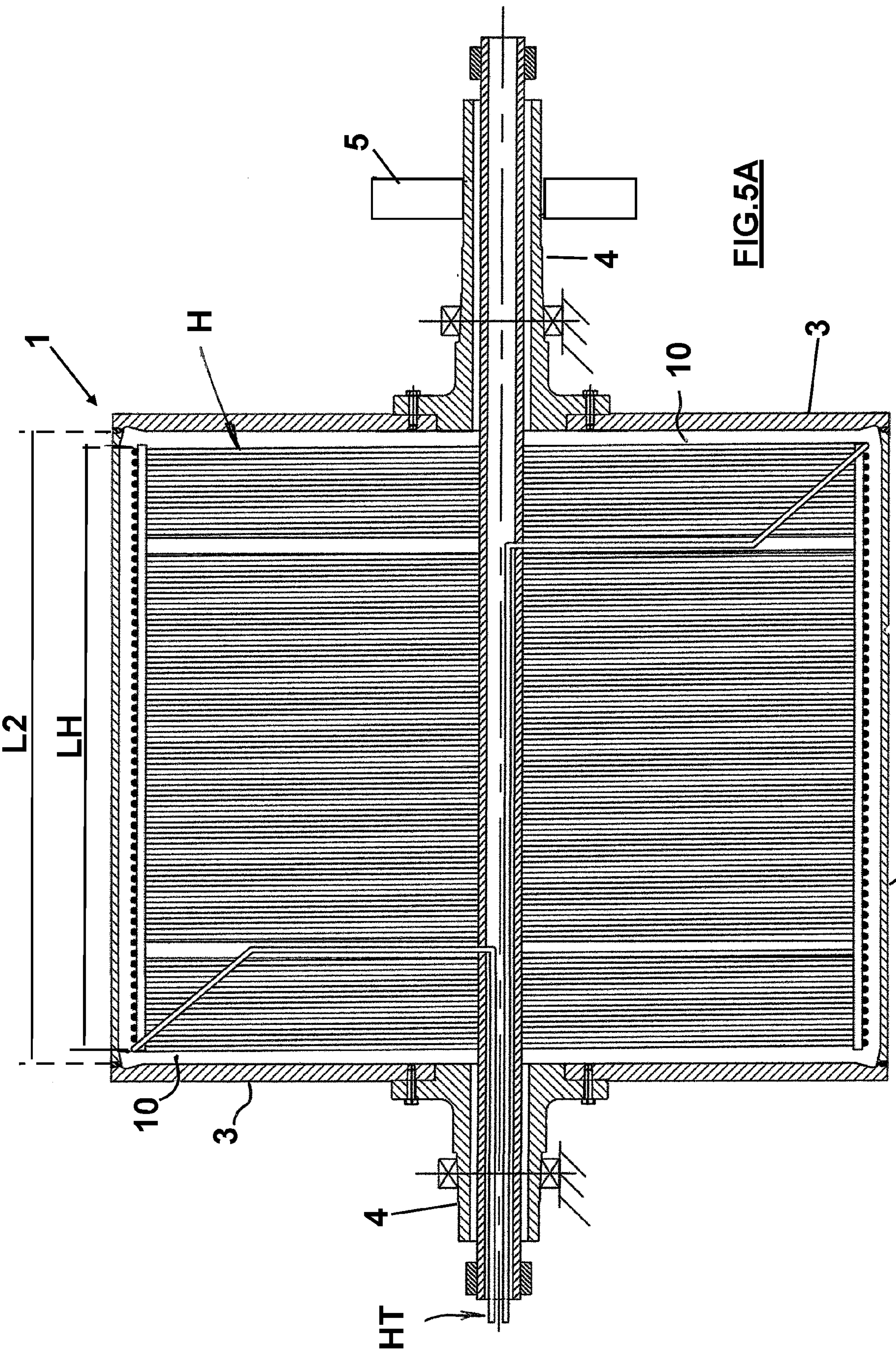

FIG.5A

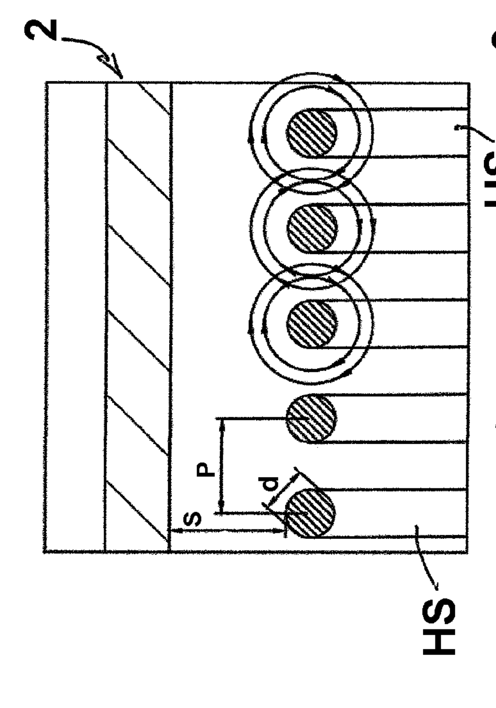

FIG.5B

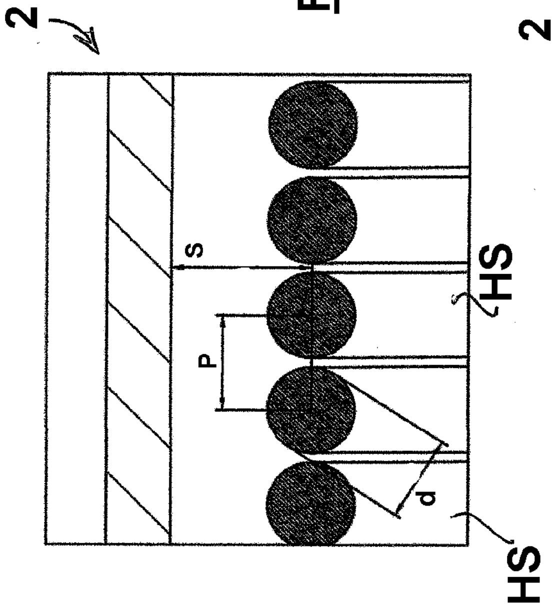

FIG.5C

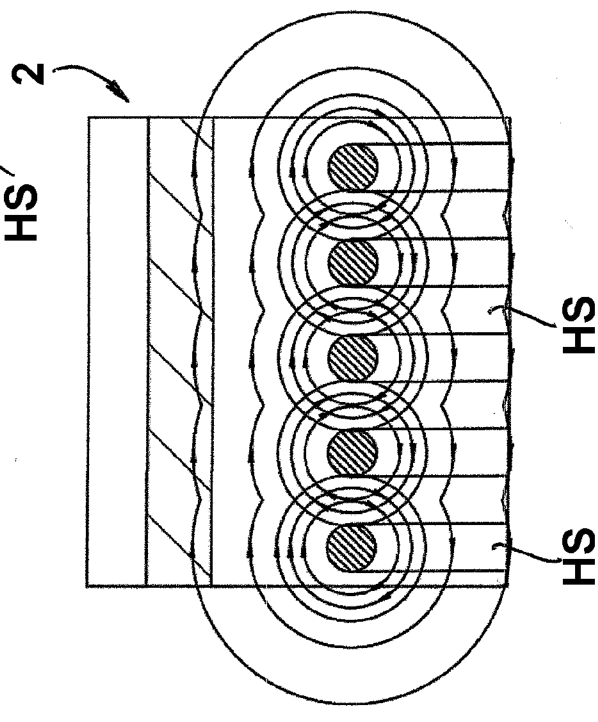

FIG.5D

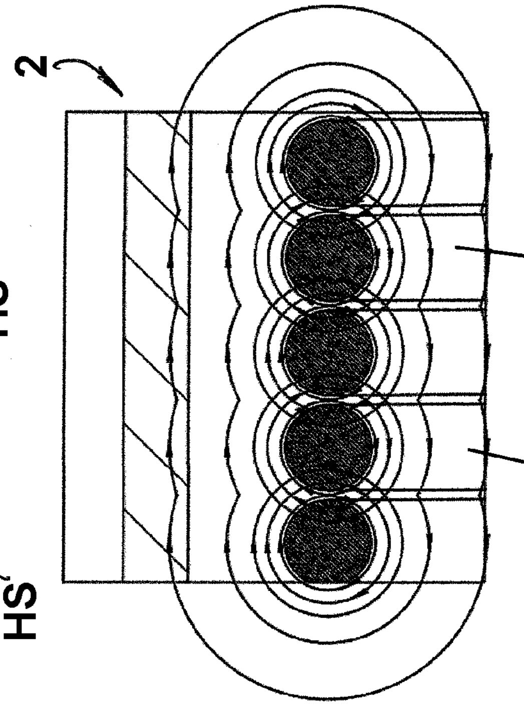

FIG.5E

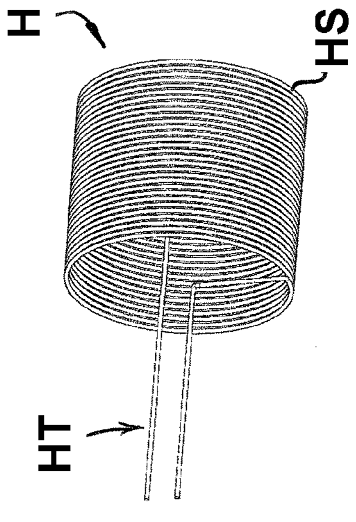

FIG.6

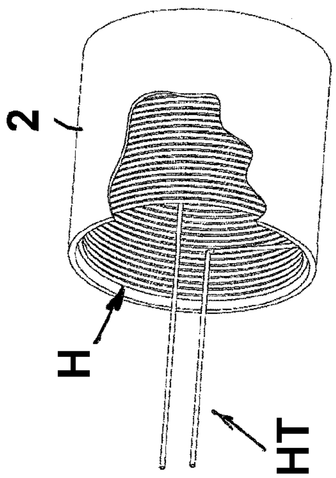

FIG.7

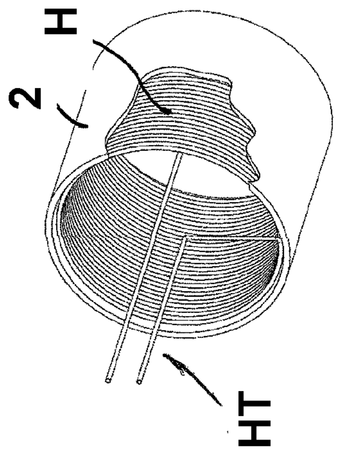

FIG.8

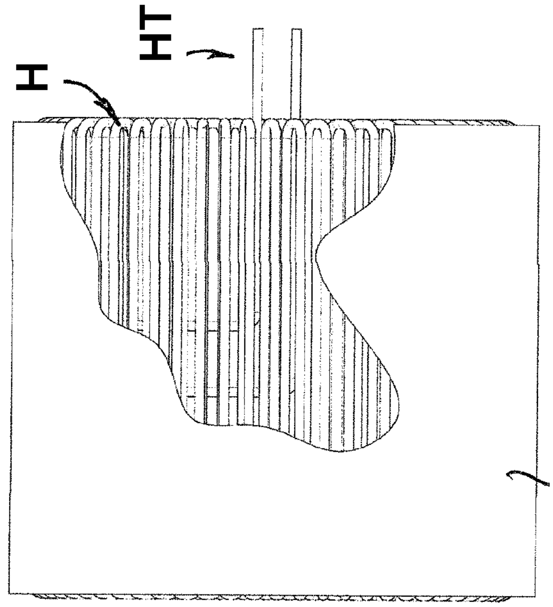

FIG.10

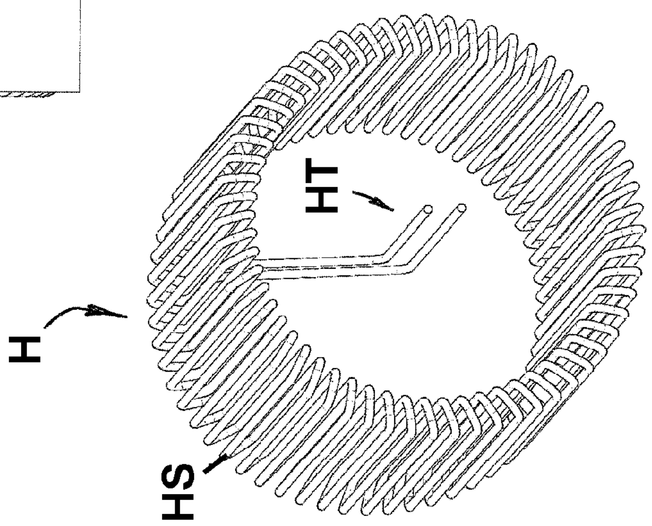

FIG.12

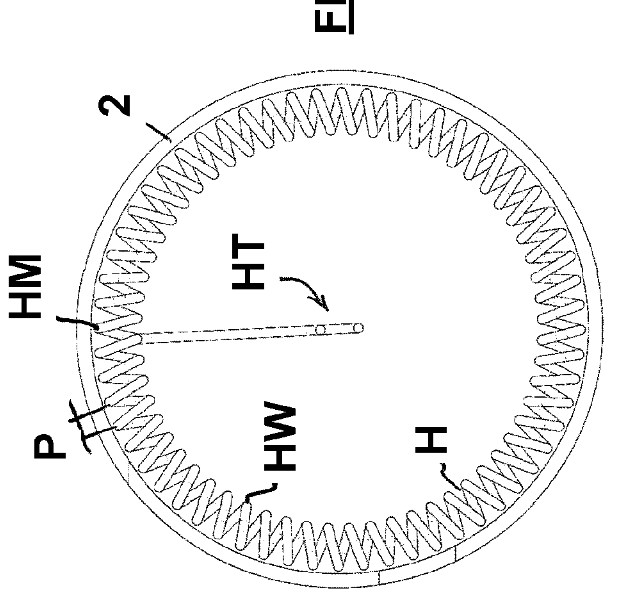

FIG.9

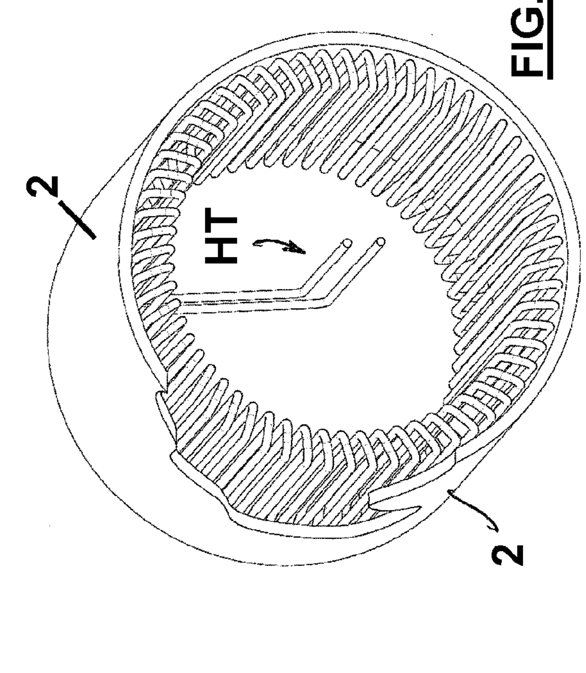

FIG.11

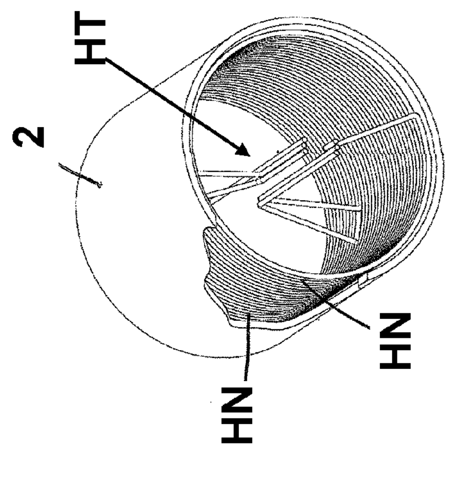

FIG.13

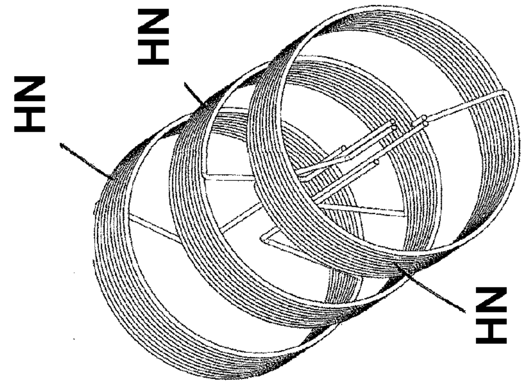

FIG.14

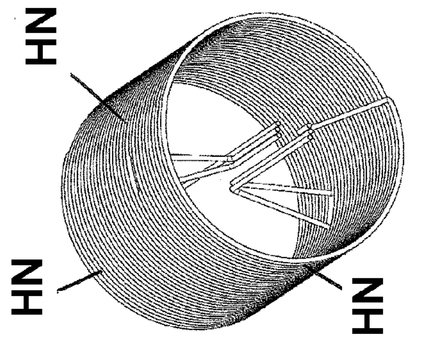

FIG.15

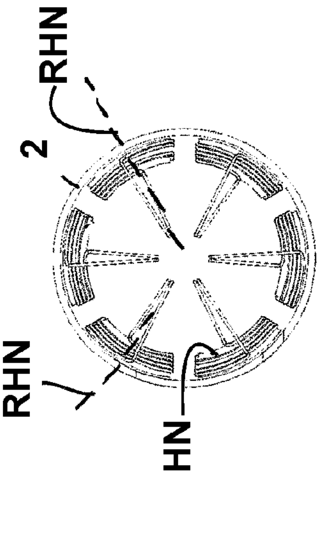

FIG.16

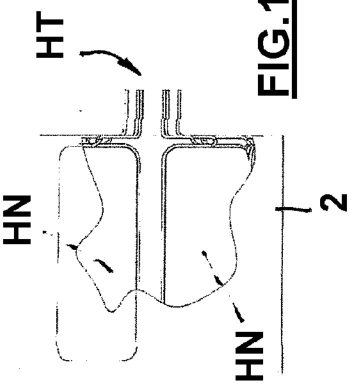

FIG.17

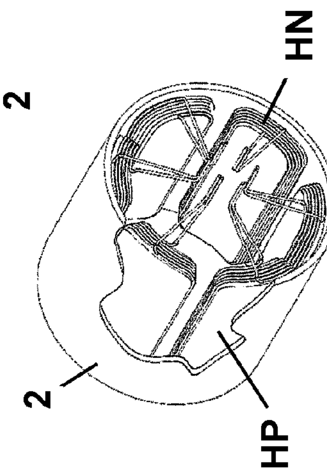

FIG.18

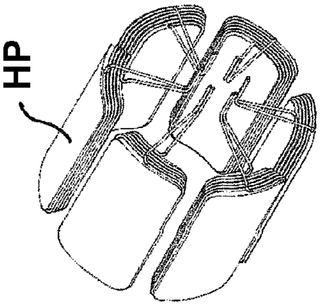

FIG.19

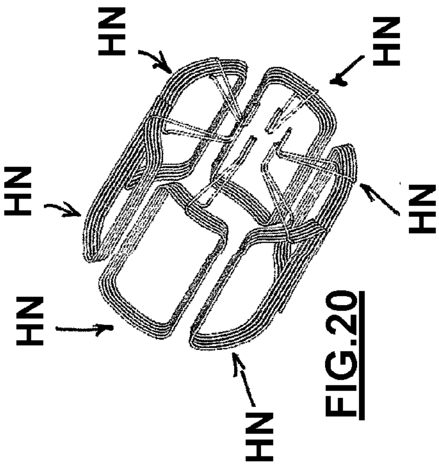

FIG.20

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EUROPEAN SEARCH REPORT

Application Number
EP 23 02 0259

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2010/206505 A1 (CLARAHAN DAN [US] ET AL) 19 August 2010 (2010-08-19) * paragraphs [0024], [0037]; figures * -----	1-12	INV. D21F5/02 D21F5/18
A	DE 202 17 966 U1 (KUESTERS EDUARD MASCHF [DE]) 1 April 2004 (2004-04-01) * claim 1 * -----	1-12	
A	EP 0 277 905 A2 (BELOIT CORP [US]) 10 August 1988 (1988-08-10) * claim 1; figures * -----	1-12	

TECHNICAL FIELDS SEARCHED (IPC)

D21F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	26 October 2023	Pregetter, Mario

CATEGORY OF CITED DOCUMENTS

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26-10-2023

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82