



- (51) International Patent Classification:
H05B 3/00 (2006.01) *C02F 1/32* (2006.01)
- (21) International Application Number:
PCT/IT2016/000310
- (22) International Filing Date:
28 December 2016 (28.12.2016)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
102015000088217
29 December 2015 (29.12.2015) IT
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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,

DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

[Continued on next page]

- (54) Title: TUBULAR CONCENTRATOR FOR CONCENTRIC RADIATION OF ELECTROMAGNETIC WAVES

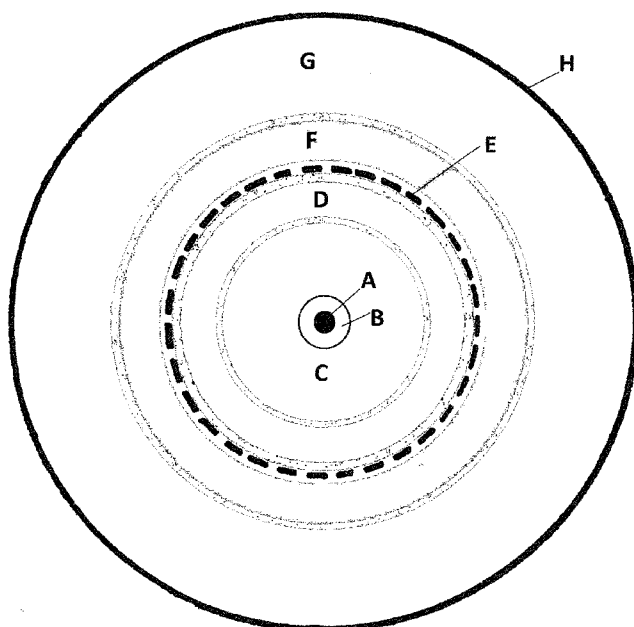


Fig. 1

(57) Abstract: The invention relates to an electric machine (fixed, mobile or portable) suitable to the physical, dynamic, continuous conditioning of materials having the ability to absorb electromagnetic radiation, which have the need to be treated through the irradiation of UV or IR, even without entering into contact with the machine and this also through the vacuum. The invention mainly uses the Lambert and Stefan-Boltzmann postulates, or rather the physical assumptions of the transmission of energy by radiation and in particular the concentration and the emission proximity of energy between transmitter and receiver (which varies with the square of the distance) and the emission intensity (which varies with the fourth power of the temperature). The extremely small distances between transmitter and receiver of electromagnetic energy and the cylindrical shape and concentric electromagnetic emission source (reflected from the outside towards the centre) are the main essence and novelty of the invention. The electric machine, the section of which is represented in the attached drawing of which are hereby provided in the description the letters as a reference, is composed of a suitable current generator that feeds an emitter of electromagnetic waves (EMW) represented by a coiled heating wire (heater function) or by a strip of LEDs (germicidal function) (E), which envelops a fused quartz tube (or a substitute material) of suitable thickness (D), which in turn can contain an internal (or more) further tube (C) of the same or similar transparent material of the first, adapted to the passage of materials to be treated (A); the tube (D) wrapped with the spiral emitter (E) is in turn encased by a tube (F) in suitably appropriate

material to shield electromagnetic emissions towards the outside. Such screening tube will (eventually) in turn be inserted in a relatively thick insulating cup (G), coated in turn with reflecting material (H), to further isolate and insulate the system as much as possible from the external environment.



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- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

TUBULAR CONCENTRATOR FOR CONCENTRIC RADIATION OF ELECTROMAGNETIC WAVES

DESCRIPTION

5 **Foreword:** field of technique to which the invention refers

The use of electromagnetic waves (EMW) radiation systems, based on plates with or without the use of quartz tubes with internal resistance (IR) or mercury UV emitters, as well as the armoured resistance, or the lamps made of quartz tubes, are known systems for both industry and equipment so-called "consumer appliances" (hot plates, stoves,
10 heaters and wall heaters, ceiling heaters, sterilizers UV-C for environment, tools, water, aquariums, etc.).

Description of the drawing

The letters of the drawing are corresponding to the following descriptions:

A. material to be treated

15 B. void/empty

C. 2 - fused quartz tube

D. 1 - fused quartz tube

E. IR or UV emission device

F. reflective ceramic casing

20 G. insulating shell

H. metal sheet

The existing technique and diversity state

In a general sense today's invention bases its foundations on topics well known to the state of the art and some patents have even been released in the nineteenth century (i.e.

25 27.01.1898 - US631360 A).

It is useful to note that, while the principle of irradiation and manufacturing techniques are the same, the current technological status of the art is better described in the two main groups of EMW frequencies embraced by the hereby described apparatus: these are the heating infrared systems and the germicidal treatment systems by means of the short wave
30 length ultraviolet light (UV-C). They are placed at the two extremes of the EMW wavelength scale affecting the present invention, namely the electromagnetic field lies between 100 nanometres (UV-C) and the millimetre (IR-C) wavelength.

infrared

The present state of science and industrial production knows the tubular or microtubular
35 heaters used in many industrial environments, such as hot runner injection systems (so-called "Hot Runners") for the plastics moulding, for the vulcanization presses, welding machines and for the hot branding, as well as for the heating of vacuum furnaces, sterilization systems and many other systems that require small heating tubes.

In part conceptually similar are also the heaters as the patent n. EP 0287772 A1 (Heating
40 element for household electrical appliances) as the water to be heated should flow within the resistance, instead of outside.

Also patent US6674054 B2 (Method and apparatus for heating a gas-solvent solution) shows remarkable similarities with today's invention but we will see below to highlight the peculiar differences.

45 These mentioned heaters designed for using the heating energy towards the interior of the machine, rather than the outside, are perhaps the applications that are closest to today's invention for the infrared part but there is the opportunity to consider that today's invention assembles at the same time:

- i. the electromagnetic radiation;
- 50 ii. a frequency spectrum between infrared and ultraviolet;
- iii. the absence of any kind of filters between the emitter and the receiver;
- iv. the intimate proximity between the transmitter and receiver;
- v. the reflection of the radiation towards the interior of the machine;
- vi. the thermal insulation to limit the heat conduction towards the outside;
- 55 as disclosed in detail below, just to highlight the differences in the following construction details and the fundamental concept, the comparison shows that the already known heaters:

- i. they are manufactured by the use of so-called "armored resistors" instead of the resistive wire at sight; in fact, in the cited armored resistors (i.e. EP 0287772 A1),
60 the resistive wire is drowned in a magnesium (MgO) sand which has the electric insulating function beside the one of thermal conductor ;
- ii. the emitting source EMW is not to be so relatively "close" to the materials to be heated;
- iii. are not equipped with a screen that reflects the EMW of the infrared spectrum
65 towards the inside of the tube, if not by means of a metal band that reflects yes but scatters the radiation to thermal conduction first and then through the radiant surface, a large amount of heat towards the 'exterior, reducing energy efficiency.

iv. structures are conceived and designed for relatively small lengths that do not accord with some industrial need for measures also well above the meter.

70 v. The US6674054 patent above mentioned does not use the use of irradiation if not in an embodiment in which separates the heating pipes from the material to be heated, flowing in the main pipe, gathering all in a further tube, with greater distance, different incidence and less efficiency, in addition to the construction costs higher than in today's invention;

75 vi. always the above patent, when applied on the quartz tube the inductive resistors or conductors, does not transfer the energy by means of irradiation but by conduction or electromagnetic induction, and in fact is not specified, the quartz tube used (if translucent, transparent or opaque);

vii. a comparison with the existing state of the art should be considered not so
80 much with the individual peculiarities of the mentioned machines as the fact to compare them with today's invention which, in one machine collects a series of coexisting and cooperating functions between them.

The combination of these differences gives rise to a remarkable diversity of the various electrical mentioned machines characterizing the innovation of the invention here

85 described.

The present invention in fact shows a radiator, whose EMW transmitter combines all of the following characteristics simultaneously:

i. It is adherent to the quartz substrate, and therefore is close to the material to be treated;

90 ii. It is devoid of shielding or filters against the material to be treated;

iii. It is equipped with a reflective screen for the radiations, placed around the emitter;

iv. It is insulated and shielded to the outside to prevent and / or slow conduction and radiation of energy;

v. It is mainly based on radiation instead of conduction / convection / induction

95 (although all present);

vi. It is useful to process materials in solid, liquid, gaseous and powdery forms;

vii. It is not aimed only for heat purposes but to the entire range in the spectrum from UV to IR;

100 viii. for its particular characteristics it is aimed at energy saving, and consequently at a high yield.

The particular nature of the emitter denotes a higher entry speed regime at the working temperature (lower thermal inertia): this happens precisely because devoid of screens or filters of any kind towards the target side, and because of the different winding of resistive material which take place "naked", around the fused quartz tube, instead to be housed
105 inside it or drowned in the magnesia sand in a steel casing. The tubular heaters, known at the current state of technology, are grounded on the armoured resistors which interpose two different screens between the resistive wire, a source of infrared emission, and the material to be heated; these screens are constituted by the layer of magnesium oxide (MgO) used to electrically isolate the winding of resistive wire and the external metallic
110 container (generally made of steel or other metals like).

The characteristic properties of MgO sands are those of electrically insulate the resistive wire which is traversed by electrical current and the metal container (generally of steel

nature), as well as those to transmit by thermal conduction the Joule energy resulting from the powered resistors (it should be minded that we are speaking of thermal conduction, no
115 heat radiation as in today's invention).

It is therefore evident that the heat transmission of these armoured heaters occurs only partially to radiation (irradiation) but rather, and above all, by conduction and convection; however, the aspect that differentiates this type of heaters with the invention is represented by the difference of thermal inertia: the microtubular heaters are inherently
120 subject to greater thermal inertia in relation to today's invention, which instead does not oppose whatsoever filters (quartz is perfectly transparent to infrared and ultraviolet radiation), and therefore immediately radiates on the material in transit in the tube (transparent) its electromagnetic energy and this happens, even in the presence of vacuum, at the speed of light (the same principle of global warming originated from the sun).

125 In fact, mainly exploiting the Lambert and Stefan-Boltzmann postulates, today's invention, at the same electric power applied to the machine, is able to transfer more energy to the material to be heated, when compared with the current state of the art and technologies. The thermal conductivity of the said MgO and metal container is on average estimated at around 50 (W/(m-K)): this is the additional barrier between the EMW emitter and material
130 to be treated, when compared with the invention.

There are products that use quartz tubes in which the materials to be heated are sliding in them but the source of emission of electromagnetic radiation, which is also arranged circularly with respect to said quartz tube, remains embedded in the "insulating" walls of the casing, carrying the distance between emitter and user to several centimetres, reducing
135 therefore, at least with quadratic factors, the efficiency of the machine where it was

compared with today's solution.

These considerations are also valid for those few heating products which offer a constructive technology similar to today's discover, with the infrared emitter arranged concentrically outward with respect to the materials to be treated and which sometimes
140 also use a small central tube in translucent quartz in which slide the wires to be heated but which differ from today's discover for the relatively large distance between the emission source (resistance) and material to be heated (we are speaking of at least a few centimetres). Today's invention, having the EMW emission source in contact with the tube in which the materials to be heated are sliding, increases the efficiency of the machine with
145 the square of the distance and continuously reflects towards the centre of the duct all the radiation not absorbed by the treated materials with a constant redundant effect.

Germicidal ultraviolet

The germicidal lamp has long been known and is normally used in many fields ranging from the drinking to the waste waters, as well as the disinfection of the surgery rooms and
150 the tools contained and used therein, as well as in the treatment of other beverages for human and animal consumption.

For actual applications the present known conventional technique foresees the manufacture of bulbs very similar to fluorescent lamps or, in recent history, by means of light emitting diodes, commonly called LEDs (light emitting diodes) still not widespread,
155 however.

The so-called "conventional" lamps, low and medium pressure, are constructed by exploiting the ionisation of mercury vapours but, instead of using a conventional boron-silicate glass, which would be opaque to the ultraviolet wavelengths, they employ tubes

made of very pure fused quartz (SiO₂) as containers of the lamp itself: in short, in other
160 words, the use of germicidal lamps are enclosed in a phial of pure fused quartz.

The use of such lamps with liquids is basically achieved in two ways:

- i. the positioning of the lamps above the materials to be sterilized or, generally, in the environments to be sterilized;
- ii. they are inserted into a container (generally) of tube-shaped steel, with two
165 perpendicular flanges at the ends of the external cylindrical surface, which act as inlet and outlet of the fluids, so as to screen the harmful UV-C radiation useful for the sterilizing effect. The centre of the tube is reserved for the insertion of the germicidal lamp which projects from the two ends of the cylinder.

It is therefore normal to observe that, in the first system (external positioning) the emission
170 points remain particularly far away from the bodies to be sterilized and the sterilization is performed by a single angle (except multiplying the lamps) while in the second solution (container), in addition to having only one angle of the source radiant light, the liquids are forced to particular deviations which cause the pressure drop in the pressure of the circulating fluid, as well as the homogeneity of the treatment remains incomplete for the
175 different distances of the radiation absorption of liquids with respect to the emission source.

Description of concentrated radiant heater for the concentric radiation of electromagnetic waves

The electric machine (fixed, mobile or portable) is used to irradiate a material in solid,
180 liquid or gaseous form or in a mixture of these, by means of EMW designed to deal with it

or change the physical state, through the use of the physical principle of electromagnetic radiation.

The absence of contacts with heating elements (heat generators or electrodes) avoids the typical problems of resistive heaters, where otherwise applicable, as in the example of

185 metal wires. The resistive heaters are in fact limited in their use only to conductive materials (Joule effect) and therefore not usable for the almost entire range of textile materials and minerals; another important problem existing in the resistive heaters is due by the action of the arcs inevitably produced in the coupling with the electric poles from which the Joule heating energy is applied to, which produce molten material craters which
190 ruin the surface of the heated product (often rendering it unusable).

Very often this electric stress also leads to a situation of "descaling" (flakes of oxides that detach from the surface of the wires), especially for those metal materials previously subjected to thermal treatment to change the metallurgical characteristics (annealing for changing the strength, elongation and yield strength);

195 Such "descaling" prevents the correct co-extrusion of the wires, thus making unusable the resistive wire heating system: conversely today's invention avoids these problems.

The particularity of this electric machine also concerns the possibility to heat/treat those materials which otherwise might be heated by convection or by conduction but with much lower energy yields than the system of the present patent.

200 As many times evidenced the machine has a remarkable efficiency: it can be easily intuited by observing the peculiar constructive characteristics that are considered useful to list hereunder:

i the coaxial construction of the EMW emitting bodies and the treated materials,

involve an energy concentration towards the centre of the duct in which the
205 material to be irradiated flow;

ii the more reflective materials will be continuously irradiated due to the reflexivity of
the walls of the machine which will bounce again at the centre the reflected energy;

iii the construction by means of suitable material, in particular quartz materials for
IR and UV energy transmission produced by special radiators, as well as through
210 clear, reflective ceramic sheaths (toward the centre), are designed to contain inside
the machine energy loss;

iv the invention has only two relatively "small" openings, the entrance and exit of the
system, greatly limiting the dispersion of the energy both by conduction and by
convection since the entire outer surface of the electrical machine will be
215 abundantly and suitably insulated.

The flexibility of the length of the machine, that each designer can choose according to its
desired aims, allows to use the invention in many different systems, both for the virtual
"lack of contact" between materials to be treated and radiating elements, and the sliding
speed of the materials inside it, which can also be very high because the transfer of the
220 radiated energy occurs at the speed of light and varies "only" in function of the power of
absorption of different materials.

It will also be much easier and less expensive than other systems, slide gases
simultaneously (maybe inert) within the passage of the wires concentric pipe (or other
materials).

225 Only by way of example one can cite the preheating apparatus of the metal wires used in
galvanizing plants but also in lacquering systems of electric wires or polymeric coating with

co-extrusion processes.

The useful temperature limits are those relating to the materials which are used, but the
aforementioned quartz and alumina, melt at 2000 – C and 2070 –; it is useful to recall that
230 in fact the electronics industry uses since decades translucent quartz crucibles for melting
inside them (at 1450 – C) silicon, which then will be used for the production of electronic
chips.

As in physics the relevant elements to the transfer of energy between two bodies,
according to the principle of irradiation, are based on a number of variables such as:

- 235 i. composition of matter of the bodies
- ii. the form of their surface
- iii. colour of the surface
- iv. wavelengths irradiated
- v. irradiation angle
- 240 vi. radiation intensity.

the fact of having an emitter of infrared rays (or UV) disposed on the entire outer
circumference of the material to be treated, allows to have constantly perpendicular
infrared rays on the object to be treated (heat or sterilize) increasing the amount of energy
transmitted the same material as compared to other treatment systems.

245 The most important novelty, generally speaking, can be represented by the concept of
having reversed the positions of the emission sources of electromagnetic radiation with
respect to the materials treated: up to yesterday the emission sources were placed inside a
quartz cylinder and the material to be treated on the outside; today the invention
demonstrates the ability to insert inside the quartz tube the material to be treated which is

250 enveloped by the electromagnetic source that radiates it, which surrounds it completely at a very close range without any kind of filter interposed in between.

In fact, up to the current state of the art, the emission sources (whether they were IR rather than UV) were housed inside a quartz tube, emitting towards the outside of the same tube their electromagnetic radiation (IR and UV) forcing the use of a number of lamps in order
255 to obtain conditions similar to those shown in the invention: thus, more space, more energy, more dispersion and less effectiveness of angular penetration.

Such latter most important evolution of the technique allows a much closer positioning to the electromagnetic emission source of the material to be treated, so as to better exploit the physical postulates (Lambert / Stefan-Boltzmann), gaining in efficiency of the electric
260 machine if it was to be compared with other heating systems which intrude significantly greater distances between emitters and receivers of EMW or intruding third materials, non-transparent to radiation but harnessing the principles of thermal conductivity instead of the thermal radiation.

Summarizing, the previously described "hot runners", even if in contact with the objects to
265 be heated, they interpose a layer of material "non-transparent" between the emitter and receiver of EMW, while the other two mentioned systems, simply interpose a relatively large distance, highlighting the "newness" of the invention represented today from associating concentricity at close range joined by the reflection of the outer tube (F) to the emitter of
270 EMW with a concentration of the rays almost exclusively addressed within the irradiating system.

Developments of the invention compared to the state of the art

Despite the electric machine (static) uses common industry components (and not only), for
275 the purpose of heating or electromagnetic radiation, the novelty requirement is met mainly
through the inversion of the positioning of the various components useful to the realization
of the electrical machine itself as well as the extreme approximation of the emitter to the
receiver, combined with a highly reflection system.

The particular structure of the invention, with the material to be heated / treated (A)
280 located at the centre of the pipe (C) allows the same material sliding into it to be hit always
perpendicularly from radiation (UV or IR), thus exploiting the best physical location for
thermal and UV energy exchange; also the reflected EMW within the opaque tube will
contribute greatly to the energy transfer to the treated material.

Systems of polymers forming, of paint drying, surface preparation (ie screen printing)
285 already use these systems but today's invention greatly enhances the energy used because
it focuses solely and exclusively on the (moving) material to be heated (to be these: wires,
liquids, dust, gases or other materials).

Today's invention in facts, having the emitter (E) of the electromagnetic radiation (IR and
UV) that externally surrounds the tube (D - made of transparent materials to IR and UV) in
290 which runs the materials to be treated, obtains the following advantages and
improvements:

- i. the points of emission of radiation are consistently "close" to the materials to be
treated (starting with tenths of a mm), making the most of the energy emitted
available;
- 295 ii. the radiation points mainly affecting the material at a perpendicular angle and the

radiation is constantly reflected within the 360° of the tube by way of the screens placed externally to the coverage of the radiating spiral (either IR or UV);

iii. the section of passage of the material volume is perfectly cylindrical and, during operation of the machine, each molecule flowing within the irradiated area always

300 finds a maximum and minimum distance known, with respect to the radiating source (this fact allows best settings and dosages besides lower consumption);

iv. the proximity of the emitter of the rays at the material which must absorb the radiation (which can also be less than one millimetre) is obtained as a function of the thickness of the walls of the quartz tube chosen: this means that the energy

305 efficiency of the radiation is much more effective when compared to conventional systems ;

v. The absence of any interposed wall, beyond the transparent SiO₂, allows to drastically reduce the (thermal) inertia that otherwise would be encountered with the systems currently in use.

310 These peculiarities allow today's invention to operate with materials particularly sensitive to the temperature; these materials require a sudden change of the energy radiated during operation of the machine to avoid accidental melts or damages of materials that will slide inside. The melts would interrupt the cycles of industrial production, for example in the interlacing and texturizing known in the textile industry processes but also in the processes
315 of "thermosetting" provided for in the industry of thermosetting polymers and in the preheating systems provided instead for thermoplastic polymers.

Flowing materials that change suddenly the speed of 18-20 m/s to 3 or 4 m/s and vice versa are common to different industry fields (especially at the start, settings, stops) and

conventional sheathed armoured tubular elements would not have ability to adapt to these
320 sudden changes, unlike today's invention which virtually has no thermal inertia according to
the production and construction methods of the irradiating machine.

The commercial technical literature shows these concepts that distinguish the state of the
art of microtubular heaters compared with the concentrate radiant heater based on tubes
of pure fused quartz (the invention).

325 The innovative idea of the invention is thus based on the concept of enclosing in a tube (F
- called outer tube - reflective ceramic casing), concentric and opaque towards IR/UV
outwards radiation, the emitter (E) of such EMW to ensure that the same waves can only
hit the materials sliding inside a second tube (D or C), transparent and concentric with the
first, made of fused quartz (perfectly transparent to the wavelengths concerned), concentric
330 and inside the first (F - which is rather exterior and matte), without scattering in the
environment (or dispersing only minimally). Indeed it is mostly to use the radiated IR energy
rather than the convectional or conductive one. Conduction and thermal convection require
in fact other materials that act as a "bridge" and these interposed materials always act as
an inertia element in the transfer of energy from the heating body (such as the resistive
335 wire crossed by current) towards the elements to be heated.

Depending on the frequencies and the used materials, this system also allows the transfer
of energy through the physical principle of electrical induction. The quartz material is also
an excellent dielectric element to separate the wires to be heated by contact with the
electrical resistance crossed by relatively large voltages and currents.

340 Conventional heating systems of metal wires, mostly inductive or resistive (in contact or
sliding) involve considerable problems of adjustment practices (induction systems) or

practices (resistive systems) that mostly spoil, deteriorate and even make it unusable, heated wire because mutated in colour or appearance and/or superficial aspect.

In particular the resistive systems involve a difficult management of the electric machine

345 both for the electric arc ignition problems and for the changed resistivity whilst changing temperature conditions (both of the wires and the electrodes); in most metals the temperature increase leads to an increase of the intrinsic resistivity of the material, making it extremely difficult to control the homogeneous heating of it. The heating resistive systems then, are not able to transfer thermal energy (Joule) to the electrically non-
350 conductive materials.

The inductive systems instead, in addition to working only with metals (except for the use of a special "susceptor"), they would need a continuous regulation of the emitted frequency of the energy in function of the wire diameter and the nature introduced in the inductor itself. This adjustment industriousness involves high plant costs and management.

355 For what regards the UV-C, the innovation is represented by bringing the sources of concentric electromagnetic emissions almost in fluid contact (or materials in general) to be treated (ie sterilize): in this way decreases the energy required for the treatment of the same expected result and consequently reduces installation, operating costs and system encumbrance.

360 **Realization**

For the realization of such a machine it will be needed:

a suitable electric generator calculated on the basis of the necessary powers and with the wave generation requests in terms of amplitude and frequency (not shown in the accompanying drawing);

365 i.a quartz tube (D) (SiO_2) or substitute material, translucent or transparent, and in any case the most suitable material to the transparency of the wavelength of the desired rays, having relatively important thickness of the wall, on which wrap respectively:

(a) for the IR, an electrical heating resistance realized in the conventional materials for this type of use but with particular regard to the temperatures reached and the
370 irradiation frequencies;

(b) for UV (in particular the UV-C), a strip of light emitting diodes (LED) with the emitting face facing towards the inside of the quartz tube on which the strip is wound, so as to point the emissions towards the centre of the duct of the fused quartz tube, where the materials to be treated flow ;

375 ii.a possible second tube (C) of translucent (or transparent) quartz, always of particular thickness, smaller than the inner bore of the previous tube (D) so as to be introduced in it, which in turn can contain a residual space, of the desired diameter, necessary for running inside the material to be treated through the electromagnetic radiation resulting from the winding made on the previous tube (D) - this second tube (C) (for protection/wear) will be
380 easily replaceable without disassembling the entire electric machine;

iii.The first tube (D), that one on which is wound by the resistive wire or of the LED strip, will in turn be inserted into another opaque tube (F), reflective, insulating and resistant to radiation and to heat transmission, realized with a ceramic or similar material, which (materials) should easily meet the most common needs. Ceramic materials seem to be the
385 most suitable because they are very resistant to heat and thermal shock (a few of them) and at the same time, their light colour tends to reflect inwards (there where the materials to be treated are sliding) radiation from resistive wires (or UV-C led) which act to produce

the radiated heat, as well as to contain them as much as possible within the heart of the electric machine;

390 iv. The opaque tube of ceramic or similar material, will in turn be insulated with insulation material (G) to further avoid release of thermal energy or radiated to the outside of the machine, as well as thermally isolating it to avoid burns to operators that operate on the machine itself as well as for the avoidance of UV rays leaks.

v. Finally, a metal or a metallized plastic sheet will enclose the whole and oppose the last
395 filter to the dispersion of the radiation to the outside (H) .-

Operation

The materials to be treated will be made pass inside through the smaller diameter pipe, the one wrapped by the radiant spiral, which will then have the walls completely smooth and very hard, of vitreous nature (the fused quartz in fact), almighty resistant to acids also
400 concentrated, and therefore with an expectation of long durability. If arranged with two quartz tubes, as previously described, the innermost tube to the system, the one closest to the material to be treated, may be in turn replaced with that of material and most appropriate size relative to the material to be treated, without having to disassemble the entire irradiating machine.

405 The infrared irradiating resistive wire (or the UV LED thread) string will be controlled by an electric generator (for example an inverter), which will be back-driven by a speed sensor (or by a flow meter) and/or by a thermocouple (or other sensor) that will follow the movement of materials within the quartz tubes and control the amount of energy to be irradiated to the material itself as a function of the desired sought-outlet temperature or
410 the germicidal treatments.

The length of the tubes, of the resistors, the powers and frequencies used, of UVC LEDs, will be proportioned to the amount of radiated energy and to the mass and nature of materials that must be raised in temperature, as well as by the desired temperature difference or by the amount of radiation necessary to the sterilization processes; al will be
415 in relation of the transit designed speed.

It is more than obvious, with regards to the IR treatment, that a part of the useful heating energy will arrive to the materials to be heated not only by radiation (and induction ed), but by convection.

Using particular construction features, such as to carry out a longitudinal cut on the tube
420 and borrowing the use of "open metal coils", used by more than half a century for binding of calendars, blocks, notebooks and books (called commercially "wire- o "), it will be possible to interchange different emitters without disassembling the quartz tubes already installed in the plants.-

Utility

425 The utility of the electrical machine thus conceived is highlighted in the possibility of treating materials having different physical forms (solid, liquid or gas or mixtures thereof), compared to the current known technique, obtaining the following contemporary benefits:

- i. the materials to be treated are very close to the source of emission of electromagnetic radiation but never coming into contact with them;
- 430 ii. the treated materials are no longer subjected to the well-known unwanted physical changes of the treated materials such as in electric arcs and the problems of "descaling";
- iii. the same system may either treat various materials without having to change the

heating equipment or treatment. In other words metals or polymers may be
435 processed in the same facilities;

iv. adjustments will be easier and immediate because, mainly taking advantage of
the radiation instead of the convection and conduction systems, the important
inertia which physically interpose in conventional installations are almost cancelled
with those found in the invention, which can instead be described as "residual"

440 (many materials will simply be suspended, and therefore without any physical
contact with the parts of the "radiant tube");

v. the current running speed of the industrial plants that use radiation systems such
as those described here will not suffer decreases, but will be increases (where
possible);

445 vi. for the design and the forms of construction of the machine itself an important
energy saving is expected: it derives from the lack of physical contact with the
heated material which allows the realization of excellent insulation (to heat and
EMW) causing the 'power (which is in high prevalence radiated) compacted
remains inside the electrical machine itself, well insulated on the outside, low mass
450 and small openings entry and exit, allows a much higher energy yield than used the
systems (conventional and not) known to date.

vii. As regards the UV, the treatments performed with the concentric radiation
system at 360 degrees around the materials improve the current state of the art:

a) increasing the specific energy radiated per unit surface area (and therefore
455 volume);

b) eliminating the load losses in consequence of the application of the treatment

carried out on sections of straight pipe instead of the described box;

c) spreading the UV-C rays, only where they are needed;

d) irradiating the predominantly perpendicularly materials.

460 As for a practical application, among many you can think to a milk which, without use of
steam treatment plant, is able, on the same line, both to fulfill the UHT treatment (by IR)
that sterilization (by UV) and everything in spaces much more content and a low power
waste generated by the dispersion of the plants (ie steam plant which provides a heat
exchange at the origin and one in the exchanger with the milk in addition to the energy loss
465 in the steam transport).

As for more conventional applications, below we provide a list of synthesis absolutely not
exhaustive but only relatively explanatory:

- i. instant hot water heaters;
- ii. in-line air/gas process heaters;
- 470 iii. instant steam generators;
- iv. pre heaters for coextrusion of wires;
- v. heaters for producing enamelled wire for transformers, bobbins and coils;
- vi. in-line heat treatment facilities line of metal wires;
- vii. UHT treatment plants;
- 475 viii. thermosetting lines for polymers;
- ix. commingling textile fixation plants;
- x. prepreg plants;
- xi. industrial sterilization of liquids;
- xii. industrial sterilization of finished products even in blisters;

- 480 **xiii.** tubular flash pasteurization;
- xiv.** industrial in-line sterilizer;
- xv.** outdoors, solar powered, portable sterilizer for potable water

CLAIMS

485 1. A tubular concentrator for concentric irradiation of electromagnetic waves with high efficiency, consisting of at least two concentric tubes with an emitter interposed between them, to treat or affect various materials whether they are in liquid form, powdery, solid in wire-form or in a slurry form, the section of which is represented in the attached drawing:

490 I. that mainly uses electromagnetic radiation as a mean of energy transfer,
II. which mainly radiates electromagnetic energy in close range mode, in the wavelength fields comprehended between 100 nanometres (UV-C) and the millimeter (IR-C),

III. radiating towards materials flowing into the system in a manner:

495 • close,
• concentric,
• perpendicular;

IV. or with the emitter of electromagnetic waves wrapped in contact with a tube which can have wall thickness of less than one millimetre;

500 V. which can also work under vacuum or pressure;

VI. which may be devoid of physical contact with the materials to be treated;
which could be realized indiscriminately in a fixed, movable or portable form

The machine comprises:

I. at least two concentric tubes (D and F) open at both ends,

505 II. of which one, the inner one (D), transparent to the concerned wavelengths, for

example made of pure quartz (SiO_2), so that the same waves are attenuated as little as possible from the walls of this tube (D) during the process of radiated electromagnetic energy transfer from the emitter to the material to be treated.

III. at least one electromagnetic wave generator (not visible in the illustration);

510 IV. at least one emitter of electromagnetic waves (E) represented for example by a spiral of resistive wire or a sequence of light-emitting diodes (LEDs) of the desired frequencies, which surmounts, wrapping it, the outside of the inner concentric tube (D) and it emits radiation towards the inside of the tube (D) itself; V. from the outer tube (F), of the two concentric, which will hold features and electromagnetic waves emitted by the emitter of electromagnetic
515 waves contained inside the container, referred to in the previous point, in order to concentrate the greatest possible amount of energy towards the centre of the inner pipe in which flows the material to be treated (A); for ideal values of reflective functions it is meant a physical coefficient of reflection which is tending to and near to the unity, associated with the transmission and absorption coefficients which are tending and close to zero, having regard
520 to the concerned wavelengths; the special opaque quartz tubes engineered to reflect electromagnetic waves could be appropriate form the case;

V. within the said inner quartz tube (D) can slide various materials, of various nature and features such as: thread-like solids, liquids, powders, slurries, which are irradiated by a concentric beam of electromagnetic waves generated by an emitter wrapped on the outer
525 surface of the inner tube (D) with the aim of reducing to the minimum possible the distance between the said emitter and the material to be treated, which passes inside the said quartz tube and which ensures the maximum exploitation of the Lambertian theories and Stefan-Boltzmann;

VI. for short distances between the transmitter and receiver, it is intended that measures are

530 ranging from near contact, or 50 micrometers and 30 millimetres, which can be increased as appropriate to the powers involved, or if there are major powers issued, there will be a greater distances; in any case the best remains the "near to contact" distance;

VII. the outer tube (F) which shows its primary concentric mode reflective function, essentially with a high electromagnetic reflection index in the concerned spectrum of frequencies and which
535 has also, preferably, a high insulating power; for high insulating power are meant those materials which can offer a low thermal conductivity, less than 5 W / m K at 20 ° C, besides a high reflection, next to an index-1, combined with the smaller or almost absent transmission and / or electromagnetic absorption.

2. Device according to the previous arrangement 1. in which the outer tube (F) is made of materials
540 having a reflection coefficient, in the electromagnetic field of the affected frequencies, close to unity and in any case greater than 0.5; electromagnetic reflection is understood against the emitter wavelengths;

3. A device made according to the two preceding claims which contemplate that the tube (F) associates to the reflective power also a high insulating power or rather, in addition to the reflection
545 as to 2. also provides a thermal insulation or present a low thermal conductivity at 20° C (λ - l) comprised between 0 and 5 W / m K.- -

4. A device realized according to the preceding claims which is incorporated within an efficient insulator cupola (G) which has the task of reducing the dispersions of electromagnetic radiation or simply thermal energy towards the outside . The materials of the insulating cupola will be chosen as a
550 function of temperature and of design frequencies of the machine;

5. A device realized according to the preceding claims which is however provided with a second tube (C), named the wear, placed inside the tube (D) on which is wound the emitting spiral of electromagnetic waves.

6. A device realized according to the preceding claims which has a way to work in the
555 absence of gas (vacuum) or in the presence of specific gases, as well as liquids.
7. The device realized according to the preceding claims constructed with the tube (D) which
supports the emitter of electromagnetic waves (E) provided with a longitudinal cut (not
shown in the figure) adapted to the insertion of wires or other materials to be treated,
without having to interrupt the continuity of the material to be treated; consequently also the
560 emitter of electromagnetic waves (E) will have the shape of an "open spiral" as the binding
systems wires called double spiral, wire-or, WireBind, double-loop, twin-loop, or the like;
8. A device realized according to the preceding claims constructed inside a
transportable casing which may have or lack the necessary generators of
electromagnetic waves and the appropriate electrical power supplies functional to the
565 autonomous operation of the tubular concentrator;
9. A device realized according to the first claim, but which instead of the second
reflective outer tube (F) simply uses the concentric winding emitter of electromagnetic
waves on the transparent tube (D) and has no additional shielding to the outside. It
will maintain though the transparency and the proximity concept between emitter and
570 receiver

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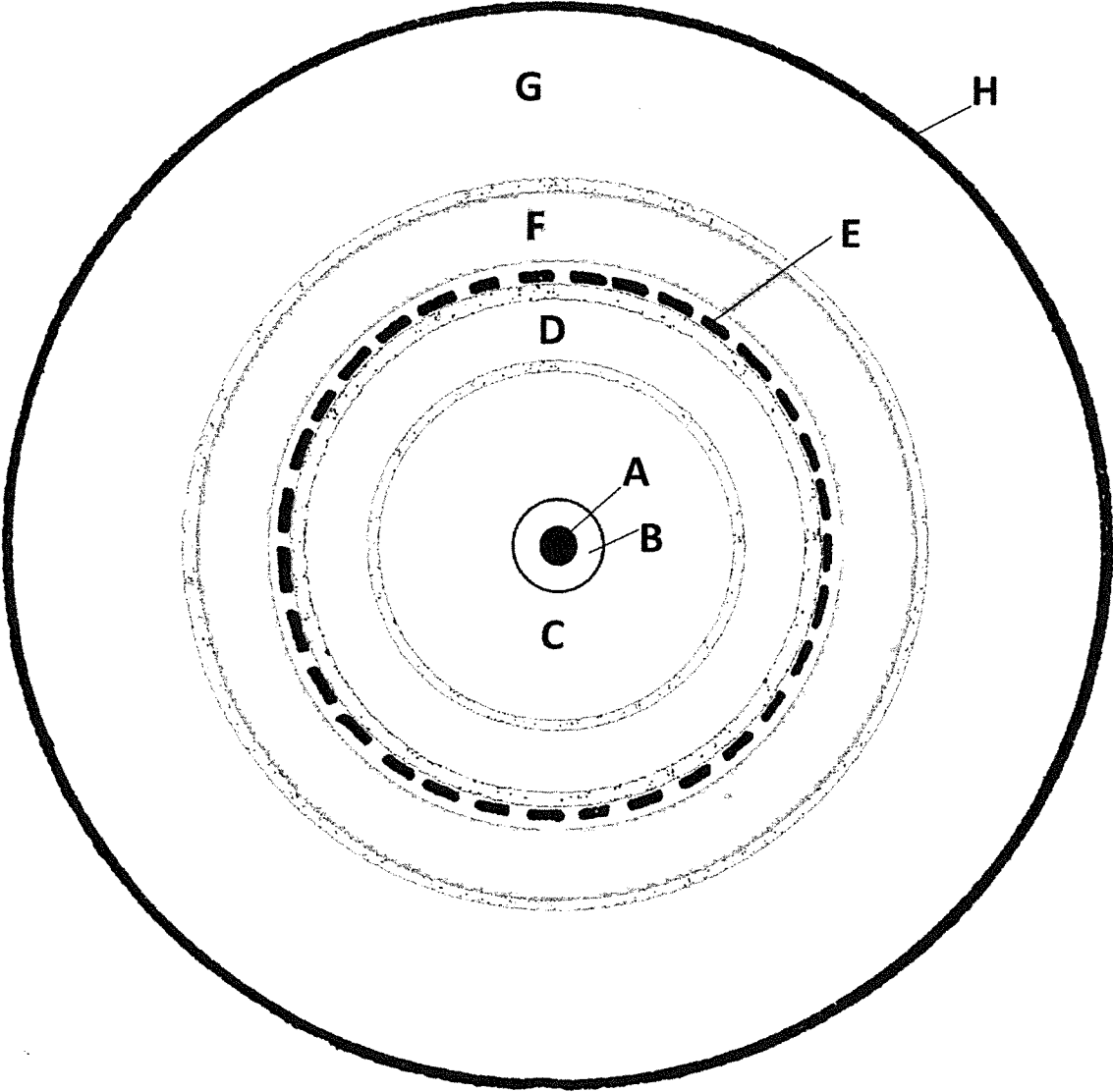


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2016/000310

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B3/00 C02F1/32
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

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X	US 6 398 970 B1 (JUESTEL THOMAS [DE] ET AL) 4 June 2002 (2002-06-04) abstract; claims 1,7; figures 2-5 -----	1-9
X	WO 2011/057015 A2 (UV CLEANING SYSTEMS INC [US]; HAWKINS THOMAS R [US]; OWENS MARK D [US]) 12 May 2011 (2011-05-12) abstract; claims 1,2,13,14; figures 1,3 -----	1,9
A	EP 0 867 916 A2 (SILICON VALLEY GROUP [US]) 30 September 1998 (1998-09-30) abstract; figures 1-9 -----	1,9
A	US 2014/178057 A1 (HAYDEN CHRIS [US] ET AL) 26 June 2014 (2014-06-26) abstract; figures 1-6 ----- -/-	1,9



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

2 June 2017

Date of mailing of the international search report

19/06/2017

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INTERNATIONAL SEARCH REPORT

International application No

PCT/IT2016/000310

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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