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(54) **Sinuuous-belt-processor for thermal recording**

(57) A thermal processor (10) for thermal processing of a thermographic material(1) having an imaging element le provides good dimensional stability without undesirable density differences. The thermal processor comprises means for supplying (16) the thermographic material to the thermal processor, a processing chamber (12), means for heating (17) the processing chamber,

ber, means for transporting the thermographic material through the processing chamber, means for exporting (19) the thermographic material out of the thermal processor, characterised in that the means for transporting comprise a first belt (21) and a second belt (22) arranged with respect to the first belt so that transporting the thermographic material through the processing chamber is carried out in a sinuous way (4).

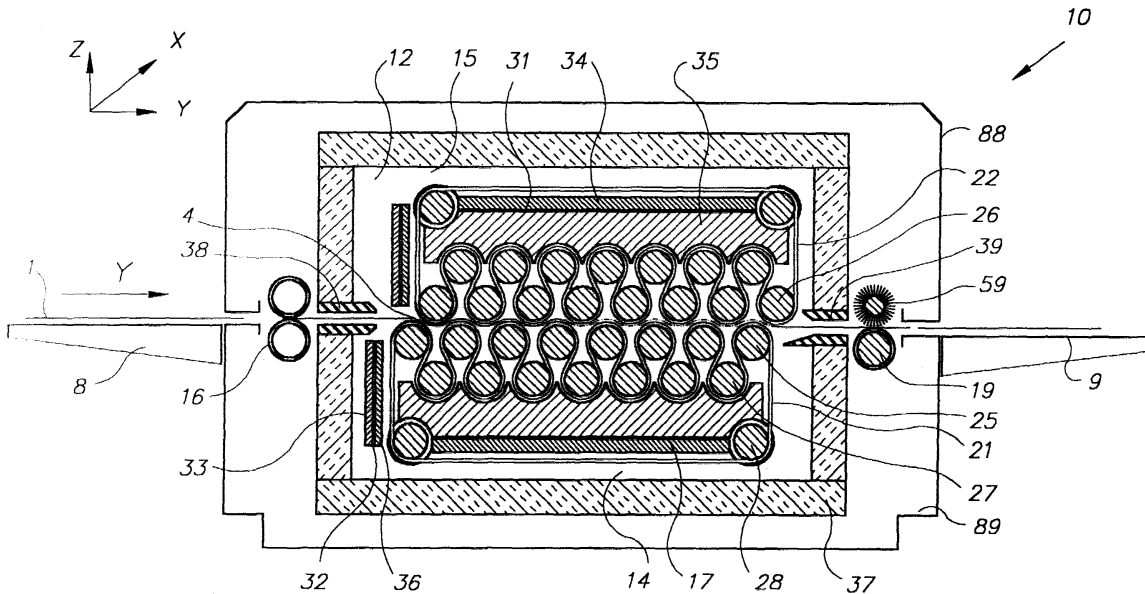


FIG. 2

Description

FIELD OF APPLICATION OF THE INVENTION

5 **[0001]** This invention relates to an apparatus and a method for processing a thermographic material, in particular for developing a photothermographic material.

BACKGROUND OF THE INVENTION

10 **[0002]** Thermally developable silver-containing materials for making images by means of exposure and then heating are referred to as photothermographic materials and are generally known. For example: "Dry Silver®" materials from Minnesota Mining and Manufacturing Company. A typical composition of such thermographically image-forming elements contains photosensitive silver halides combined with an oxidation-reduction combination of, for example, an organic silver salt and a reducing agent therefor. These combinations are described, for example, in US Patent No. 15 3,457,075 (Morgan) and in "Handbook of Imaging Science" by D. A. Morgan, ed. A. R. Diamond, published by Marcel Dekker, 1991, page 43.

[0003] A review of thermographic systems is given in the book entitled "Imaging systems" by Kurt I. Jacobson and Ralph E. Jacobson, The Focal Press, London and New York, 1976, in Chapter V under the title "Systems based on unconventional processing" and in Chapter VII under the title "7.2 Photothermography".

20 **[0004]** Photothermographic image-forming elements are typically imaged by an imagewise exposure, for example, in contact with an original or after electronic image processing with the aid of a laser, as a result of which a latent image is formed on the silver halide. Further information about such imagewise exposures can be found in EP-A-810 467 (of Agfa-Gevaert N.V.).

25 **[0005]** In a heating step which then follows, the latent image formed exerts a catalytic influence on the oxidation-reduction reaction between the reducing agent and the nonphotosensitive organic silver salt, usually silver behenate, as a result of which a visible density is formed at the exposed points. For example, the development temperature is in a range between 90 to 140 °C, preferably between 100 and 130 °C, and this for about 5 to 30 seconds, preferably between 10 to 20 seconds.

30 **[0006]** Further information about said thermographic materials can be found, for example, in the above mentioned patent EP-A-810 467.

[0007] The development of photothermographic image-forming elements often poses practical problems. A first problem is that heat development causes a plastic film support to deform irregularly, losing flatness.

35 **[0008]** A second problem is that heat development often degrades dimensional stability. As the developing temperature rises, plastic film used as the support undergoes thermal shrinkage or expansion, incurring dimensional changes. Dimensional changes can result in wrinkling. Moreover, such dimensional changes are especially undesirable in preparing printing plates, because as a result, colour shift and noise associated with white or black lines appear in the printed matter.

40 **[0009]** In the prior art, many solutions for this dimensional problem have been disclosed, comprising the use as a support of a material which experiences a minimal dimensional change at elevated temperatures. All of these materials have their disadvantages as e.g. solvent crazing, low transparency in UV, high cost, etc.

[0010] For example, EP 0 803 765 (of Fuji Photo Film) discloses a specially prepared type of polycarbonate, having high transparency and light transmission in the UV region, recommended as a printing plate film support, and EP 0 803 766 (of Fuji Photo Film) discloses a photothermographic material comprising a support in the form of a plastic film having a glass transition temperature of at least 90 °C.

45 **[0011]** US-P 2,779,684 (of Du Pont de Nemours) discloses a polyester film with improved dimensional stability, which does not show any significant shrinkage when exposed to a temperature of 120°C for five minutes under conditions of no tension. Claim 1 reads: "In a process of making a dimensionally-stable polyester film which comprises forming a sheet of film from a molten highly polymeric ester substantially composed of the polyesterification product of a dicarboxylic acid and a dihydric alcohol, said ester being capable of being formed into filaments which when cold drawn show by characteristic X-ray patterns molecular orientation along the fibre axis, biaxially orienting the film by stretching it at an elevated temperature, heat-setting the film at a temperature between 150°C and 210°C under conditions such that no shrinkage occurs; the step which comprises modifying the heat-set film by heating it to a temperature of 110°C to 150°C for a period of 60 to 300 seconds while maintaining said film under a tension of about 10 to 300 psi (0.7 and 21 kg/cm²)."

55 **[0012]** Among the polyesters, poly-ethylene-terephthalate (PET) is a widely used and inexpensive material. However, it is not dimensionally stable at elevated temperatures. Dimensional stability of PET can be improved by a thermal stabilisation, thus rendering a thermally stabilised poly-ethylene-terephthalate film.

[0013] In "Plastics Materials", 4th edition by J.A. Brydson, Butterworth Scientific, 1982, pp. 649-650 thermal stabili-

sation of a poly-ethylene-terephthalate film PET is described as follows: "PET is produced by quenched extruded film to the amorphous state and then reheating and stretching the sheet approximately threefold in each direction at 80-100°C. In a two-stage process machine direction stretching induces 10-14% crystallinity and this is raised to 20-25% by transverse orientation. In order to stabilise the biaxially oriented film it is annealed under restraint at 180-210°C, this increasing the crystallinity to 40-42% and reducing the tendency to shrink on heating."

[0014] Also C. J. Heffelfinger and K.L. Knox, in "The Science and Technology of Polymer Films" Volume II, edited by Orville J. Sweeting, Wiley-Interscience, New York (1971), pages 616-618, describe thermal stabilisation of PET by heat setting.

[0015] In JP 08-211 547 (of applicant 3M) a special type of thermographic material is disclosed in claim 1, reading 'Heat-developing image formation element which is a heat-developing image formation element that develops at a temperature of 100°C-150°C, which consist of a heat-developing image-forming composition coated on top of a polymer support, and in which this polymer support is made dimensionally stable at development temperature by heat treatment of this polymer support at low tension and at a temperature which is higher than the glass transition temperature of the polymer, lower than the melting point of the polymer, but not lower than the development temperature plus 30°C'.

In the comparative examples of the specification, 35 mm wide strips were tested and showed a low thermal instability, i.c. a crimp which was up to 10 times lower on strips with a preconditioned support than on strips without preconditioning.

[0016] As one can see from the above, many solutions to the problem of dimensional stability have been disclosed which relate to the photothermographic material itself or to its support, or to a special method of preparation. However, in practice, such heat setting produces sheets which still deform too much during thermal processing of an imaged sheet.

[0017] From another point of view, in the specialist literature, also various apparatuses have been described for the development of thermographic materials.

[0018] Belt & drum-processors, as disclosed i.e. in US 6.975.772 (of Fuji Photo Film) have a disadvantage of high thermal inertia, e.g. a too slow heat supply, as a result of which the processing time becomes prohibitive.

[0019] In WO 97/28488 and in WO 97/28489 (both of applicant 3M), a thermal processor is disclosed which comprises an oven and a cooling chamber, more particularly a two-zone configured oven and a two-section configured cooling chamber.

[0020] This two-zone configuration results in uneven physical and thermal contact. Indeed, in the second zone of this oven, processing heat is transmitted to the upper side of the photothermographic material by convection, whereas processing heat is transmitted to the lower side of the photothermographic material both by conduction and by convection, which results in a degree of thermal asymmetry in the heating of the two sides of the photothermographic material. By consequence, for some highly sensitive kind of photothermographic materials the imaging quality imaging may decrease, e.g. density unevenness may appear.

[0021] Moreover, film transport by means of rollers as disclosed e.g. in said WO 97/28488 and in WO 97/28489 has further disadvantages: (i) due to a thermal discharge or unload of the roller, a repetition mark (comprising a mark per revolution of a roller) or a troublesome pattern is perceptible on the photothermographic material, (ii) in case of dust particles or flaws being present on a roller, repetitive pinholes appear on the thermographic material, (iii) automatic-cleaning of the apparatus-rollers is also rather difficult to achieve; (iv) jams of photothermographic material occur more frequently and are less easy to solve.

[0022] In summary, the prior art still needs a solution to the problem of dimensional stability of the photothermographic material while thermally processing.

[0023] The present application presents an alternate thermally processing with good dimensional stability and without undesirable density differences. In particular, the present invention does not need a complicated photothermographic material, nor a special method of preparation for the photothermographic material.

OBJECT OF THE INVENTION

[0024] The object of this invention is to provide an apparatus for thermally processing a thermographic material with improved dimensional stability.

[0025] Other objects and advantages of the present invention will become clear from the detailed description and examples/ experiments.

SUMMARY OF THE INVENTION

[0026] We have now discovered that these objectives can be achieved by constructing an apparatus according to the independent claims.

[0027] Specific features for preferred embodiments of the invention are disclosed in the dependent claims.

[0028] Further advantages and embodiments of the present invention will become apparent from the following de-

scription and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

5 **[0029]** While the present invention will hereinafter be described in connection with preferred embodiments thereof, it will be understood that it is not intended to limit the invention to those embodiments.

Fig. 1 is a pictorial view of a thermal processor according to the present invention;

Fig. 2 is a cross- section of one embodiment of a thermal processor according to the present invention;

10 Figs 3 and 4 are partial sectional views of two embodiments of a thermal processor according to the present invention;

Fig. 5 is a sectional view of another embodiment of a thermal processor according to the present invention and comprising backing rollers being substantially thicker than the driving rollers;

15 Fig. 6 is a sectional view of another embodiment of a thermal processor according to the present invention comprising backing rollers and stationary shoes;

Fig. 7 is a perspective view showing means for driving the first and the second belt comprising a cascade free drive;

Fig. 8 is a perspective view of a heating element suitable for use in the present invention;

Fig. 9 is a cross- section of another embodiment of a thermal processor according to the present invention and comprising cleaning means and internal imaging means;

20 Fig. 10 is a partial view of a belt, a driving roller, and a backing roller being crowned and flanged according to the present invention;

Fig. 11 is a fragmentary side view of another embodiment of a thermal processor wherein one belt is a finite belt;

Fig. 12 is a fragmentary side view of another embodiment of a thermal processor wherein at least one belt is replaced by at least two other belts;

25 Fig. 13 is a fragmentary section of another embodiment of a thermal processor wherein one belt is replaced by at least one other belt and one contacting roller;

Fig. 14 is a flow chart showing a concise embodiment of a method for thermally processing a thermographic material according to the present invention;

30 Fig. 15 is a flow chart showing an extended embodiment of a method for thermally processing a thermographic material according to the present invention;

Fig. 16 shows the composition of a thermographic material suitable for use with the present invention;

Fig. 17 is a functional block diagram of an image recording system according to the present invention comprising an external imager;

35 Fig. 18 is a functional block diagram of an image recording system according to the present invention comprising an internal imager;

Figs. 19.1 - 19.3 show the evolutions over time of the temperature of a photo-thermographic material in a thermal processor with internal imaging means;

Figs. 20.1 - 20.3 show the evolutions over time of the temperature of a direct-thermographic material or a laser-thermographic material in a thermal processor with internal imaging means;

40 Fig. 21 shows the temperature of a resistive print head heating element during an activation pulse;

Fig. 22 illustrates an empirical registration of intermediate films;

Figs. 23.1 to 23.3 are different views of a belt comprising inherent means for guiding;

Fig. 24.1 shows a hardware compensation in transversal direction by means of different installed powers in a heating element;

45 Fig. 24.2 shows a hardware compensation in transversal direction and in transport direction;

Fig. 25 shows a test equipment for evaluating the flatness of a thermographic material;

Figs. 26.1 - 26.3 show evaluation templates usable for evaluating the flatness of a thermographic material.

DETAILED DESCRIPTION OF THE INVENTION

50 **[0030]** The description given hereinafter mainly comprises eight sections, namely (i) terms and definitions used in the present application, (ii) preferred embodiments of a thermal processor according to the present invention, (iii) preferred embodiments of a method according to the present invention, (iv) photothermographic applicability of the present invention, (v) direct-thermographic and laserthermographic applicability of the present invention, (vi) imager integrated applicability of the present invention, (vii) comparative experiments, (viii) further applicability of the present invention.

[0031] In some paragraphs of the instant application, reference is made to a co-pending application, entitled "Thermal recording method with a sinuous-belt-processor", filed on the even day and incorporated herein. And for the sake of

conciseness, no redundant description is repeated in the instant specification.

(i) Introductory explanation of terms and definitions

5 **[0032]** For the sake of greater clarity, the meaning of some specific terms applying to the specification and to the claims are explained before use.

The term "thermographic material" (being a thermographic recording material, hereinafter indicated by symbol m) comprises both a thermosensitive imaging material (being substantially light-insensitive, and often described as a 'direct thermographic material') and a photosensitive thermally developable imaging material (often described as heat-developable light-sensitive material, or as an indirect thermographic material, or a 'photothermographic material').

10 **[0033]** For the purposes of the present specification, a thermographic imaging element le is a part of a thermographic material m (both being indicated by ref. nr. 3).

Hence, symbolically: $le \in m$

15 **[0034]** By analogy, a thermographic imaging element le, comprises both a direct thermographic imaging element and an indirect or photothermographic imaging element. In the present application the term thermographic imaging element le will mostly be shortened to the term imaging element.

[0035] By the wording "laserthermography" is meant an art of direct thermography comprising a uniform preheating step not by any laser and an imagewise exposing step by means of a laser.

20 **[0036]** A so-called "conversion temperature or threshold T_c " is defined as being the minimum temperature of the thermosensitive imaging material m necessary during a certain time range to cause reaction between the organic silver salt and reducing agent so as to form visually perceptible metallic silver

[0037] In the present application, the term "recording on a thermographic material" comprises as well an imagewise exposing by actinic light (e.g. on a photothermographic material), as an imagewise heating by a thermal head (e.g. on a direct thermographic material) or by a laser (e.g. in laserthermography).

25 **[0038]** The wording "image", and by consequence also "imagewise", comprises as well the usual meaning of an image, as well as any other information, such as names, data, barcodes, etc.

[0039] In the present application, the term "sinuous" is understood as comprising, at least partially, a serpentine or a sinuated or a tortuous or a wavy form. The term sinuous is not meant as a synonym to sinusoidal; sinuous does not necessarily coincide mathematically exact with a goniometric sinus.

30

(ii) Preferred embodiments of a thermal processor according to the present invention

[0040] Fig. 1 is a pictorial view of a thermal processor according to the present invention. As the method of processing and all functionally important working components will be illustrated and explained in full depth in the following description, here only some externally perceptible features are indicated. Thermal processor 10 comprises an apparatus frame having a lower frame 88 and an upper frame 89, which are connected to each other by means of hinges 86 and which can be opened by means of a handle 85 fastened on a cover 84. Piston mechanism 87 facilitates the opening and closing of the processor. A thermographic material 1 can be introduced via an input tray 8 into the processor, and leave via output tray 9. Arrow Y indicates the transport direction of the thermographic material through the thermal processor, sometimes also called subscanning direction or slowscan direction.

40 Sheets of thermographic material (being mostly a thermographic film) 1 can be processed by feeding them into the entrance, preferably with the emulsion side up. If an attempt is made to insert the thermographic material 1 into the entrance, a transport-in sensor (not shown) may detect the attempt and drives the thermal processor 10.

45 **[0041]** The dwell time of the sheet within the processor 10 (i.e. the speed at which the belts are driven versus the length of the transport path) and the temperature within the processor are optimised to properly process the sheet. These parameters will, of course, vary with the particular characteristics of the sheet being processed.

[0042] The processor preferably also comprises a display means (not illustrated) for outputting a visual display of the status of the thermal processor. By doing so, a system operator is able to determine whether a sheet is being processed, whether the processor is ready to process another sheet or whether the processor is not yet ready to receive another sheet.

50 For the ease of further references, Fig. 1 also indicates three perpendicular axes, being a transversal direction X, a transport direction Y, and a so-called vertical direction Z. Transversal direction X is also called mainscanning direction, or fastscan direction. (For sake of clear understanding, it may be remarked that in some paragraphs which relate specifically to 'colour-selections', as illustrated in Figs. 22.1 and 22.2, the symbol Y does not indicate a transport direction, but does indicate a yellow colour selection. This will be explained further on in full depth.)

55 **[0043]** Referring now to the specific subject matter of the present invention, there is illustrated in FIG. 2 a cross-section of a preferred embodiment of an apparatus in accordance with the present invention. Specifically, there is shown an apparatus 10 including in combination a plurality of pairs of rollers, including driving rollers and idler rollers,

and two flexible belts. Yet, Fig. 2 is a somewhat simplified view and does not really show all components of the apparatus for the sake of clarity. It should be noted that in addition to the components shown, e.g. various kinds of sensors may be provided as needed in the apparatus.

Moreover, an image recording system which uses thermographic material to produce prints or hard copies having a visible image formed in accordance with image data supplied from an image data supply source (not shown in Fig. 2; but e.g. enclosed within the control equipment 98 of Figs. 17-18) basically comprises, in the order of transport of the thermographic material 1 a thermographic material supply section (see input tray 8), an image exposing section (not shown in Fig. 2; but e.g. indicated by ref. nr. 95 in Fig. 17-18), a thermal processor 10, and a delivery section (cf. exit tray 9). In order to process the thermographic material properly, it is desirable to maintain close temperature tolerances. Thereto, various thermally insulated walls 37 (at least the bottom, upper, left and right walls) are located within the processor chamber.

[0044] Now, according to the present invention, a thermal processor 10 for thermal processing a thermographic material 1 having an imaging element le comprises means for supplying 16 said thermographic material to said thermal processor, a processing chamber 12, means for heating 17 said processing chamber, means for transporting said thermographic material through said processing chamber, and means for exporting 19 said thermographic material out of said thermal processor. Herein, said means for transporting comprise a first belt 21 and a second belt 22 arranged with respect to said first belt so that transporting said thermographic material through said processing chamber is carried out in a sinuous way 4.

[0045] Now reference is made to Fig 3 and Fig. 4, which are partial sectional views of two embodiments of a thermal processor according to the present invention.

It may be clear from Fig. 2 and especially from Fig. 3 and Fig. 4 that said first belt 21 is conveying said thermographic material, at least partially, at a first side 6 of the thermographic material and that said second belt 22 is conveying said thermographic material, at least partially, at a second side 7 of the thermographic material. Belts 21 and 22 move in the direction as indicated by arrow Y and are driven by various driving rollers 25-26. The belts 21 and 22 cooperatively engage one another between lower driving roller 25 and upper driving rollers 26.

As shown in Figs. 2, 3 and 4, the lower driving rollers 25 and the upper driving rollers 26 are mounted for rotation on parallel axes. The driving rollers 25, 26 are so positioned as to force the belts 21, 22 to follow a sinuous path 4 between the two sets of driving rollers. As the belts travel between the driving rollers, the thermographic material 1 is alternately displaced laterally (nearly perpendicular to the direction Y of the belt), indicated as vertical direction Z. The deflection of the material 1 e.g. by an upper driving roller 26 acting on the material 1 in opposition to the two nearest lower driving rollers (which are staggered) 25 causes the material 1 to assume a curve.

[0046] Although the embodiments of the present invention shown in the drawings illustrate an apparatus having eight pairs of rollers, it is to be understood that the specific embodiments shown are only examples of the types of apparatus that are covered by the present invention, and that it is clearly within the scope of the present invention for the apparatus to have less or more pairs of driving rollers 25-26.

[0047] The belts are in close contact with the thermographic material, substantially without exercising a pressure thereupon, a nipping force does not act between them. Thereto, the size of the gap G provided between the lower belt 21 and the upper belt 22 preferably is substantially equal to or greater than the thickness f of the thermographic material m. It suffices if the belts are capable of reliably transporting the thermographic material by imparting a transporting force to it. This force is influenced by the angle at which the thermographic material is, the rigidity of the thermographic material, and the like.

In this embodiment, a thermographic material in which the thickness of a base is e.g. 175 μm and the thickness of the emulsion layer is e.g. 20 μm may be used. For this reason, the dimension of the aforementioned gap G is at least 0.2 mm. That is, the arrangement provided is such that this gap G prevents a nipping force to be imparted to the thermographic material 1 which enters between the lower belt and the upper belt.

Even if the dimension of the gap is made 0.5 mm or even about 1 mm larger than the thickness f of the thermographic material m, the thermographic material can be transported smoothly by frictional resistance, and uneven processing does not occur in the thermographic material.

[0048] Now, attention is given to Fig. 5, which is a sectional view of another embodiment of a thermal processor according to the present invention and which comprise backing rollers 27 being substantially thicker than the driving rollers 25-26.

As shown in Figs. 2, 3, 4 and 5, a processor according to the present invention further comprises means for driving said first and said second belt 21, 22 having at least one backing roller 27 for each of said belts.

[0049] In a further preferred embodiment, the processor comprises means for driving said first and said second belt 21, 22 having at least two driving rollers 26 and at least one backing roller 27 for at least one of said belts.

Preferably, said means for driving 50 said first and said second belt comprises a cascade free drive 51, meaning that each roller 25-26 is separately driven, directly from a motor 52 and not from another roller. By this, possible errors in one of the rollers are not transmitted to other rollers. Thus, e.g. possible speed differences are not multiplied, vibrations

or shocks are not carried over from one roller to another roller. As an example, Fig. 6 shows a worm 55 driving several wormwheels 56, each mounted on one of the driving rollers 25-26. It will be clear that transmission 53, being illustrated as a flat belt between the motor 52 and a pulley 54, might be replaced by any other transmission (e.g. a V-shaped belt) which does not introduce any speed or vibration errors.

5 **[0050]** Having disclosed the driving system of the processor, attention has to be focussed on the heating system of the processor. In particular, reference is made to Figs. 2 and 8.

According to a further embodiment of the present invention, a means for heating 17 said processing chamber preferably comprises an electrically resistant heating element 31, shown in Fig. 8, and means for transmitting 34, 35 heat from said heating element to one of said belts, as shown in Fig. 2.

10 Preferably, at least two means for heating are disposed for heating the thermal chamber 12, one heating means in the lower part of the chamber 14 and one heating means in the upper part of the chamber 15.

[0051] Moreover, in a processor according to the present invention said heating means comprises at least two independently controlled temperature zones. More preferably, both the heating elements of the lower part of the chamber 14 as well as the heating elements of the upper part of the chamber 15 each comprise three independently controlled temperature zones, indicated by ref. nrs. 41, 42, 43; ref. nr.49 indicate the electrical connections to a heating element or to a zone of the heating element. The temperature of each heater, and/or the temperature of each zone can be controlled by means of a suitable temperature sensor (not shown) and a temperature regulating controller (not shown) which affects the heat amount given to the thermographic material 1.

15 **[0052]** Preferably said electrically resistant heating element 31 has a power density ranging between 0.1 and 10 W/Cm², more preferably between 0.5 and 2 W/Cm².

[0053] In a preferred embodiment of the present invention, said heating elements comprise so-called flexible heaters, based on a silicone rubber, as available e.g. from WATLOW™. The thickness of these flexible heaters preferably is in a range between 0.5 and 1.5 mm.

20 **[0054]** The temperature of the heating and the time for which thermal processing is to be performed are not limited to any particular values and may be determined as appropriate for the material to be used. The time of thermal processing may be adjusted by altering the transport speed of the material, generally by controlling the number of revolutions pro time of electromotor 52.

[0055] According to a further embodiment of the present invention, said processor 10 further comprises auxiliary means for heating 32 said processing chamber 12 and auxiliary means for transmitting 36 heat from said heating means to one of said belts, preventing any loss of energy by incorporating suitable isolation means 33. The auxiliary means for heating 32 comprises e.g. an electrically resistant heating element, or a bank of thermostatically controlled infrared heaters. Also this auxiliary means for heating 32 may comprise e.g. three independently controlled temperature zones (not shown separately).

25 **[0056]** The means for heating 17 and the auxiliary heating element 32 are not limited to any particular type. Possible heating means include a nichrome wire for resistive heating, a light source such as a halogen lamp or an infrared lamp, and a means for heating by electric induction in a plate or a roller.

[0057] In a particularly preferred embodiment, said at least one backing roller is heated, indirectly or directly. Indirect heating of the backing roller is e.g. carried out by an electrically resistant heating element 31 and by means for transmitting 35 heat (see Figs. 2, 4 and 5). In another embodiment (not illustrated for the sake of conciseness), direct heating of the backing roller may be carried out e.g. by a separate heating of the backing roller, e.g. by means of an infrared lamp intended for radiation heating or an electrical coil mounted within or nearby the backing roller intended for induction heating.

In another embodiment, said means for heating 17 said processing chamber comprises both an electrically resistant heating element and an electrical heat radiator.

30 **[0058]** In an alternative embodiment (not shown) of a processor according to the present invention, some of said at least two driving rollers are not heated, e.g. some driving rollers near to the exit of the processor. A processor zone with at least two driving rollers which are not heated may fit several purposes, e.g. cooling a thermographic material after thermal processing.

[0059] A thermal processor according to the present invention preferably also comprises measuring means (not shown) for measuring the temperature of the heating chamber 12 in at least one place, preferably in the neighbourhood of a belt, more preferably in the neighbourhood of the thermographic material (not shown). In addition, the measured temperatures are converted into control signal for activating the heating means.

35 **[0060]** In order not to disturb the thermal balance within the processor, e.g. by any prohibitive air flow from the outside of the apparatus, thermal sealing at the input side and at the exit side of said processor is present. This sealing may be carried out by a first sealing means 38 and a second sealing means 39, e.g. four cushions of polyamide 100% Nylvelours™, being thermally resistant (e.g. up to temperatures of 150 °C during at least 10 hours).

40 **[0061]** The processor illustrated in Fig. 2, further may comprise a density control. Such density control incorporates a densitometer for measuring the optical density of the thermographic material m, preferably before thermal processing

(hence, measuring the base density and possible fog; see ref. nr. 126 in Fig. 15) and after thermal processing (hence, measuring the print, see ref. nr. 127 in Fig. 15). More preferably, also an electronic feedback system in order to control these densities may be advantageous (not shown).

[0062] If dust or other foreign matter enters between the thermographic material 1 and one of the belts 21, 22, the thermographic material "floats" during thermal processing microscopically and the efficiency of heat transfer in the affected area decreases. As a result, the quantity of heat being imparted to the thermographic material by thermal processing varies from place to place and uneven densities occur due to unevenness in thermal processing.

[0063] Therefor, for sake of highest reliability and print-quality, even under severe conditions (such as high processing speed, huge volumes of prints, etc.) the processor also may comprise automatic cleaning means 61-62 for the respective belts 21-22 (see Fig. 9).

[0064] The cleaning means may include a cleaning brush, optionally a cleaning brush capable of rotating while contacting a belt. A scraper device may alternatively be used as the cleaning means.

In another embodiment, said cleaning means 61, 62 comprise cleaning materials as available from e.g. TEKNEK™ . Herein, a contact cleaner preferably comprises an elastomer rubber roller (called transfer roller; not shown) which touches the belt to be cleaned and picks up debris which then transfers to an adhesive roll (called cleaning roller; not shown) which captures the debris from the elastomer roller. The cleaning roller is in rolling contact with said transfer roller. The tackiness or adhesiveness of the surface of the cleaning roller is substantially greater than the tackiness of the surface of said transfer rollers. Periodically the adhesive film or paper wound around in the cleaning roller is taken away from the processor 10 for renewal.

[0065] In order to remove residual particles which adhere to the surface of a belt 21, 22, another cleaning system 31 may include a corona generating device and a brush. First, the remaining particles are brought under the influence of the corona generating device to neutralise the electrostatic charge remaining on the belt and that of the residual particles. Thereafter, the neutralised particles are removed by the rotatably mounted brush.

[0066] Now, attention is given again to the above mentioned Fig. 5, but also to Fig 6. This Fig. 6 is a fragmentary sectional view of another embodiment of a thermal processor according to the present invention and comprises backing rollers and stationary shoes.

[0067] In a processor according to the present invention, the radius r_D of a driving roller and the radius r_B of a backing roller are in a range defined by following equations

$$0,5 \cdot r_{Dj} < r_{Bj} < 5 \cdot r_{Dj} \quad [\text{eq.1}]$$

$$r_{Bj} \geq \frac{E \cdot f}{2 \cdot \sigma_y} - t_{Bj} \quad [\text{eq.2}]$$

$$r_{Dj} \geq \frac{E \cdot f}{2 \cdot \sigma_y} - t_{Bj} \quad [\text{eq.3}]$$

wherein

E is the modulus of elasticity of the support layer of the thermographic material, σ_y is the yield strength of the support layer of the thermographic material, f is the thickness of the thermographic material (e.g. film), j = 1 for the lower part 71 of the processing chamber 12, and j = 2 for the upper part 72 of the processing chamber 12; so, e.g. r_{B1} and t_{B1} relate to a backing roller and to the belt of the lower part, whereas r_{B2} and t_{B2} relate to a backing roller and to the belt of the upper part. In some embodiments, it may be that $r_{B1} = r_{B2}$ and/or $t_{B1} = t_{B2}$. Preferably, E, σ_y and f are measured at processing temperature t_p .

[0068] For sake of good understanding, it is mentioned that the numerical value of σ_y , generally called the 'yield strength' of the thermographic material, preferably is measured in accordance to the standards ASTM D 638 and ASTM D 882. More precisely, σ_y means the 'offset yield strength' of the thermographic material. Most preferably, the present specification relates to a polyester material exhibiting in the initial part of the stress-strain curve a region with a linear proportionality of stress to strain and σ_y indicates the '2 % yield strength' or 'yield strength at 2 % offset'. According to ASTM D 638, the 2 % yield strength is the stress at which the strain exceeds by 2 % (being 'the offset') an extension of the initial proportional portion of the stress-strain curve. It may be determined experimentally by suitable test equipment, as e.g. a tensile testing machine available from INSTRON™. The resulting numerical value is expressed in force per unit area, e.g. in megapascals (Mpa), or optionally in pounds-force per square inch (psi).

[0069] In a further preferred embodiment, following relations between the radius r_D of the driving rollers, the thickness

tB of a belt and a horizontal centre-distance dH are satisfied

$$(r_{D_1} + r_{D_2} + t_{b1} + t_{b2}) > d_H > 1,05 \cdot r_{D_1} \quad [\text{eq. 4a}]$$

and also

$$(r_{D_1} + r_{D_2} + t_{b1} + t_{b2}) > d_H > 1,05 \cdot r_{D_2} \quad [\text{eq. 4b}]$$

wherein j = 1 for the lower part 71 of the processing chamber 12, and j = 2 for the upper part 72 of the processing chamber 12; so, R_{d1} relates to a driving roller of the lower part 71 of the processing chamber 12.

[0070] Moreover, preferably dH < 25 mm. This equation dH < 25 mm applies in particular for a thermographic material based on a PET-film.

[0071] In a further preferred embodiment, following equation applies to the driving rollers

$$\sqrt{(r_{D_1} + r_{D_2} + t_{b1} + t_{b2})^2 + d_H^2} < d_v < (r_{D_1} + r_{D_2} + t_{b1} + t_{b2}) \quad [\text{eq. 5}]$$

[0072] As an example, one embodiment of the present invention applies: E = 1 GPa for a 0.175 mm PET-based film at about 393 K (or +120 °C); with a $\sigma_y = 10$ MPa at 393 K, a thickness tB common for both belts with tB = 1.5 mm, resulting in r_D and r_B both being at least ≥ 7.25 mm.

[0073] In another preferred embodiment, said first belt and said second belt have a volumetric heat capacity below 2.5 kJ/K.dm³.

Herein, volumetric heat capacity is calculated as being the product of material density (e.g. in kg/dm³) and specific heat capacity (e.g. in kJ/kg.K).

Suitable materials comprise e.g. elastomers of the kind ethylene/propylene/diene terpolymers EPDM.

[0074] Preferably, said first belt and said second belt have a heat conductivity or conductance lower than 0.3 W/K m.

Suitable materials comprise again e.g. elastomers of the kind ethylene/propylene/diene terpolymers EPDM.

[0075] In a processor according to the invention, said driving rollers 25, 26 have a ratio (ϕ/Lr) of the maximum diameter ϕ of the roller to the length Lr thereof being sufficient stiff to avoid wrinkling of the thermographic material.

[0076] Next, said driving rollers 25-26 and said backing rollers 27 are made of a material having an elasticity above 60 GPa, e.g. comprising steel or stainless steel.

[0077] It may be evident for the people skilled in the art that in a processor according to the present invention said first belt and said second belt follow at least partly a sinuous path. Indeed, as seen e.g. in Fig. 2 or Fig. 4, each of said belts may follow a partly linear path (especially between a driving roller 26 and a backing roller 27), and a partly circular path (e.g. a semicircle around a driving roller 26 or around a backing roller 27).

[0078] It has to be emphasised that many properties (such as thermal conductivity and thermal capacity) of both belts preferably should be isotrope or quasi-isotrope both in the transport-direction Y and in the transversal-direction X. Further, it is highly preferred that in each point, having arbitrary co-ordinates X and Y on each belt, which could be in contact with the thermographic material should have equal or quasi-equal properties (such as thermal resistance) in the vertical direction Z.

[0079] In a highly preferred embodiment of the present invention, each belt is operated under a prestretch caused by an enforced expansion of the belt in a range between 1 and 5 %, preferably about 2% of its nominal length. This can be carried out e.g. by displacement of a bending part, e.g. by displacement of the edge rollers 29.

[0080] In a thermal processor according to the present invention, the belts are preferably formed of a material selected from silicone rubber such as Silicon R (trade mark of Wacker) or Silopren (trade mark of Bayer), polyurethane (PUR) such as 'Esband' (available from Max Schlaterer GmbH, D 59542 Herbrechtingen, Germany), acrylat-elastomere ACM such as Cyanacryl (trade mark of Cyanamid), ethylene/propylene polymers EPM and ethylene/propylene/diene terpolymers EPDM such as Epcar (trade mark of Goodrich) or Keltan (trade mark of DSM), nitrile-butyl rubber NBR such as Butacril (trade mark of Ugine Kuhlmann) or Perbunan (trade mark of Bayer), and fluor rubber such as Viton (trade mark of Du Pont) or Technoflon (™ of Montedison).

[0081] Other materials suitable for the belts, comprise e.g. some kinds of textile (e.g. Nomex, trade mark of Du Pont), or some specific materials selected from stainless steel, non-ferrous alloys (as aluminium, copper), nickel, titanium and composites thereof ...

[0082] In a preferred embodiment of the present invention, the belts 21 and 22 comprise "Esband EPDM GRUEN", with a thickness tB of 2 mm.

[0083] Belt guidance is, for example, carried out by the use of crowned rollers 29, having a greater diameter in the middle than at the edges (see Fig. 10). Preferably, at least some of the backing rollers 27 are crowned rollers. Moreover, backing rollers 26 may be idler rollers, i.c. not driven, or they may be driven. Also some of the edge rollers 29 may be idle and/or crowned. Further, belt guidance may be sustained by means of flanges (57) at one or two ends of some rollers.

[0084] In a processor according to the present invention, said first belt and said second belt have an average surface finish better than $3.2 \mu\text{m Ra}$ or CLA, preferably better than $0.8 \mu\text{m}$.

[0085] In alternative embodiments, a belt comprising inherent means for guiding may be used, as illustrated in Figs. 23.1-23.3. Fig. 23.1 is a perspective partial view of a flexible belt which is ridged, said view taken at an arbitrary moment during processing and omitting (for sake of clarity) all redundant components of the apparatus. Fig. 23.2 is a partial lateral view of the same belt, said view taken along the X-direction. Fig. 23.3 is a partial cross-sectional view of the same belt, said view taken along the transport direction Y. Herein a ridged belt 23 has a ridge 24, or a cam which fits into a groove (not shown) of the frame of the processor.

[0086] Optionally, the material 1 that ends the thermal processing may be separated from the belts e.g. by separation means, such as a stripping finger or a peeling-off blade (not shown). Then, the detached thermographic material emerges from the processor 10 to appear on the tray 9 as a hard copy having a reproduced image.

[0087] Although most of the drawings have been described with regard to the use of at least one belt being an endless belt, also embodiments with at least one belt being a well applied finite belt (see ref. nr 60 in Fig. 11) are enclosed within the present invention. Ref. nr. 63 is an unroll drum, ref. nr. 64 is a round-up drum.

[0088] It has to be remarked that in some embodiments of a thermal processor according to the present invention, the lower and the upper part of the chamber 12 are nearly symmetric (see e.g. Figs. 2, 3,, 5, 6, 9, 12). Yet, in other embodiments the lower and the upper part of the chamber 12 are substantially non-symmetric (see e.g. Figs. 4, 11, 13).

[0089] For people skilled in the art, it might be clear that the teaching of the present invention also comprises modifications wherein at least one of said first belt 21 and said second belt 22 is replaced by at least two other belts. As a non-restrictive example, Fig. 12 illustrates an embodiment applying a plurality of first belts (indicated as 211, 212, 213, etc. having transport directions Y11, Y12, Y13, etc.) and a plurality of second belts (indicated as 221, 222, 223, etc. having transport directions Y21, Y22, Y23, etc.)

[0090] By an analogue reasoning, it also might be clear that the teaching of the present invention comprises modifications wherein at least one of said first belt 21 and said second belt 22 is replaced by at least one other belt and one contacting roller. As a non-restrictive example, Fig. 13 illustrates an embodiment applying a first belt 21 as before, but replacing the second belt by at least another belt 221 and a contacting roller 24.

[0091] Within the same spirit, further variations and combinations are enclosed.

[0092] For sake of clarity, although all drawings of the present invention illustrate a generally horizontal path, a vertical path, an oblique path or an arcuate path is also possible (but not shown).

[0093] In order to achieve an error-free processing of the material within the thermal processor (e.g. no wrinkles, no slippage, no smearing or material transfer...), the distance and the angle of the upper part 15 of the chamber 12 preferably is adjusted relative to the lower part 14 of the chamber 12. In a preferred embodiment, this levelling is realised by means of three controlling mechanisms, e.g. comprising 3 studs or screws (not shown).

[0094] In a next preferred embodiment, the processor 10 comprises an internal imager 96 for exposing an image on a photothermographic material 1.

[0095] The present invention further comprises an image recording system 99 incorporating an imager for exposing an image on a photothermographic material 1 and a thermal processor 10 according to any one of the embodiments as disclosed hereabove.

(iii) Preferred embodiments of a method according to the present invention

[0096] For a detailed description of preferred embodiments, comprising Figs. 14 and 15, of a method for thermally processing according to the present invention, more information can be found in co-ending application entitled "Thermal recording method with a sinuous-beltprocessor", filed on a same date and incorporated herein by reference.

(iv) Photothermographic applicability of the present invention

[0097] The present invention can be applied advantageously in so-called photothermography.

[0098] Thermally processable silver-containing materials for producing images by means of imagewise exposing followed by uniform heating are generally known. A typical composition of such thermographically imaging elements includes photosensitive silver halide in combination with an oxidation-reduction combination of, for example, an organic silver salt and a reducing agent therefor.

[0099] Fig. 16 (not to scale) shows a cross-section of a composition of a photothermographic material m suitable for

application within the present invention. The material of the thermographic imaging element 3 comprises a polyethylene terephthalate (PET) support 65 of about 60 to 180 @ (e.g. 175 @), optionally carrying a subbing layer 66 of about 0.1 to 1 @ (e.g. 0.2 @) thickness, at least one emulsion layer 67 (comprising a photo-addressable thermosensitive element) of about 7 to 25 @ (e.g. 20 @) thickness, and a protective layer 68 of about 2 to 6 pm (e.g. 4 @) thickness (sometimes called top-layer TL). Optionally, on the other side of the PET support 65 one or more backing layers 69 is/are provided.

[0100] The photo-addressable thermosensitive element in layer 67 comprises a substantially light-insensitive organic silver salt, an organic reducing agent for the substantially light-insensitive organic silver salt in thermal working relationship therewith, photosensitive silver halide in catalytic association with the substantially light insensitive organic silver salt and a binder. The outermost backside layer 69 may comprise a matting agent (or roughening agent, or spacing agent, terms that often are used as synonyms) to prevent sticking, e.g. polymeric beads, an antihalation dye to increase image sharpness, and / or an antistatic species to prevent the build-up of charge due to triboelectric contact.

[0101] Further details about the composition of such (indirect) thermophotographic material m may be read in EP 0 810 467 (in the name of Agfa-Gevaert).

(v) Direct-thermographic and laserthermographic applicability of the present invention

[0102] From the preceding it might be clear, that the present invention also can be applied advantageously in so-called laserthermography.

[0103] Fig. 16 (not to scale) shows a cross-section of a composition of a thermographic material m suitable for application within the present invention. The material of the thermographic imaging element 3 comprises a polyethylene terephthalate (PET) support 65 of about 60 to 180 μm (e.g. 175 μm), carrying a subbing layer or substrate 66 of about 0,1 to 1 (e.g. 0.2 μm) thickness, an emulsion layer 67 of 5 about 7 to 25 (e.g. 20 μm) thickness, and a protective layer 68 of about 2 to 6 μm (e.g. 4 μm) thickness (sometimes called top-layer TL). Optionally, on the other side of the PET support 65 a backing layer 69 is provided containing an antistatic and/or a matting agent (or roughening agent, or spacing agent, terms that often are used as synonyms) to prevent sticking. Further details about the composition of such thermographic material m may be read in EP 0 692 733 (in the name of Agfa-Gevaert). The thermographic material can also contain one or more light-to-heat converting agents, preferably in layer 66, 67 or 68. This light-to-heat converting agent is often an infrared absorbing component and maybe added to the thermographic material in any form, e.g. as a solid particle dispersion or a solution of an infrared absorbing dye.

(vi) Imager integrated applicability of the present invention

[0104] Next paragraphs describe an image recording system comprising a thermal processor according to the present invention and an integrated imager. The description has three sections: (i) first, at a general systems-level, functional block diagrams, (ii) second, at an apparatus-level, a cross-section of a thermal processor comprising internal imaging means, (iii) third, at a detailed level, an evolution over time of the temperature of the thermographic material.

[0105] Fig. 17 is a functional block diagram of an image recording system 99 comprising a thermographic material 1, an external imager 95, a thermal processor 10 according to the present invention, and a control equipment 97. More specific, Fig. 18 is a functional block diagram of another image recording system 99 comprising a thermographic material 1, an internal imager 96, a thermal processor 10 according to the present invention, and a control equipment 97.

[0106] In some applications it can be wise to integrate (not shown) both an external imager 95 and an internal imager 96 within a same thermal processor 10. Herein, as a non-restrictive example, one imager can record desired image-information, while another imager can record auxiliary information (such as the name of the patient in medical radiography, or the exact type of colouring in graphical printing business, or the identification of relevant algorithms in desk-top-publishing).

[0107] Fig. 9 is a schematically cross-section of a further preferred embodiment of a thermal processor 10 according to the present invention and comprising cleaning means 61, 62 (not discussed in this paragraph) and internal imaging means (indicated by ref. nrs. 93 and 94). In practice, ref. nr. 93 is e.g. a flying spot laser, a Laser Emitting Diode LED, a laser diode array, and/or a mirror or a digital micromirror device DMD, or a Charged Coupled Device CCD-array. Ref. nr. 94 preferably is a thermal head or a transparent thermal head, or a flying spot laser, a LED, a laser diode, a mirror, a digital micromirror device, etc. In order to avoid possible thermal drift in the output of said imaging means 93 and 94, optionally fibres may be introduced, or self-focusing fibres (often called 'selffocs'), or other suitable means.

[0108] More information about digital micromirror devices DMD can be found e.g. in EP 0 620 676 (in the names of Agfa-Gevaert N.V. and Texas Instruments Inc.). More information about different embodiments of a transparent thermal head and about different methods using a transparent thermal head can be found in pending applications EP-A 99.204.069.1 and EP-A-99.204.070.9, (of Agfa-Gevaert N.V.). More information about the use of a laser diode array can be found in WO 99/21719 array (of Agfa-Gevaert AG), the shortened abstract reading: "The invention relates to a device for inscribing thermographic material. The inventive device comprises a heating means with which the ther-

mographic material is preheated to a temperature being lower than a writing temperature ... The thermographic material can be inscribed with a writing means which is distanced from the thermographic material ... having a plurality of individually controllable point sources. The thermographic material can be inscribed in a point-by-point manner with said point sources."

5 **[0109]** As to a further detailed description of an imager integrated within a processor according to the present invention, reference is made to Figs. 19.1-19.3 which show evolutions over time of the temperature of 5 the thermographic material m, relating to photothermography, to Figs. 20.1-20.3 which show evolutions over time of the temperature T_I, of an imaging element I_e being part of the thermographic material m, relating to direct thermography or to laserthermography, and to Fig. 21 which shows the temperature of a resistive print head heating element during an activation pulse.

10 **[0110]** For a detailed description of preferred embodiments, more information can be found in co-pending application entitled "Thermal recording method with a sinuous-belt-processor", filed on a same date and incorporated herein by reference.

15 **[0111]** To illustrate a possibility of compensation in the transversal direction X, Fig. 24.1 shows a hardware possibility comprising three different installed powers P₁-P₃ in a heating element 31. Of course, more or less than three heating zones can be used, with or without symmetrical heating.

20 **[0112]** Fig. 24.2 shows an embodiment of a heating element 31 in which various powers (see P_{1,1} - P_{1,2} - P_{1,3} up to and including P_{m,n}) can be switched on by hardware both in the transversal direction X as in the transport direction Y of the thermographic material (see terminals M_{ij} - N_{ij}).

(vii) Comparative experiments on processed thermographic materials

25 **[0113]** As mentioned in the background section of the present invention, thermal development of photothermographic image-forming materials often causes a plastic film support to deform irregularly, thus losing flatness. According to the instant object, the present invention discloses thermally processing a thermographic material with improved dimensional stability.

30 **[0114]** Comparative experiments, conducted by the inventors, sustain this object. More information about comparative experiments and test results -- comprising Figs. 22, 25, and 26.1-26.3 -- on thermal processing method according to the present invention can be found in co-pending application entitled "Thermal recording method with a sinuous-belt-processor", filed on a same date and incorporated herein by reference.

(viii) Further applicability of the present invention

35 **[0115]** It may be clear that an apparatus or a method according to the present invention can be used in photothermography, in direct thermography, and in laserthermography, especially comprising so-called monosheet thermographic materials.

[0116] Having described in detail preferred embodiments of the current invention, it will now be apparent to those skilled in the art that numerous modifications can be made therein without departing from the scope of the invention as defined in the appending claims.

40 **[0117]** For example, although not shown, a cooling chamber can be positioned adjacent exit of processor to quickly lower the temperature of the processed sheet for subsequent handling to allow an operator to hold the processed sheet while examining the developed image.

Parts list

45 **[0118]**

- 1 thermographic material m
- 2 imaging element I_e
- 50 3 material path
- 4 sinuous way
- 5 an image
- 6 a first side of a thermographic material
- 7 a second side of a thermographic material
- 55 8 input tray
- 9 exit tray
- 10 thermal processor
- 12 processing chamber

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13	exit section
14	first part of the processing chamber
15	second part of the processing chamber
16	means for supplying
5 17	means for heating
19	means for exporting
21	first belt
211, 212, 213	other lower belts
22	second belt
10 221, 222, 223	other upper belts
23	ridge of a belt
24	contacting roller
25	lower driving roller
26	upper driving roller
15 27	backing roller
28	edge rollers
29	crowned roller
30	heating
31	heating element
20 32	auxiliary heating element
33	heat isolation means
34	first heat transmission means
35	second heat transmission means
36	third heat transmission means
25 37	thermally insulated walls
38	first sealing means
39	second sealing means
41	first temperature zone
42	second temperature zone
30 43	third temperature zone
46	activation pulse
47	temperature evolution TI@ of a print head heating element
49	connections to the heating element
50	means for driving
35 51	cascade-free drive
52	electromotor
53	transmission
54	pulley
55	worm
40 56	wormwheel
57	flange
58	shoes
59	upper exporting means
60	finite belt
45 61	first cleaning unit
62	second cleaning unit
63	unroll drum
64	round-up drum
65	support
50 66	subbing layer
67	emulsion layer
68	protective layer
69	backing layer
84	cover
55 85	handle
86	hinge
87	piston mechanism
88	lower frame

89	upper frame
91	processing temperature T_p
92	processing speed v ,
93	first integrated imaging means
5 94	second integrated imaging means
95	external imager
96	internal imager
97	controlling equipment
10 99	image recording system
100-130	several steps of a method according to the invention
140	test equipment for flatness
141	plane table
142	illumination sources
15 143	apertured sight
144	angle of sight
145	incoming beam
146	outgoing beam
147	aperture
20 150	plane table
151	template for flatness
152	holes for air evacuation
153	reference lines
154	thermographic material with unacceptable nonflatness
25 155	thermographic material with acceptable nonflatness

Symbols:

[0119]

30	D	optical density
	ϕ	diameter of a roller
	dH	horizontal distance
	dV	vertical distance
35	E	modulus of elasticity
	Ex	exposure
	f	thickness of a film
	F, G	Fbl, Fov, Finv comparative films
40	G	gap between two belts
	le	imaging element
	m	thermographic material
	n	normal
	Lr	length of a roller
	Lf	length of a film
45	Lt	length of a table
	Mij, Nij	electric terminals
	P	power (e.g. P _{1,1} - P _{m,n} ...)
	rB, rB1, rB2	radius of backing rollers
	rD, rD1, rD2	radius of driving rollers
50	tB, tB1, tB2	thickness of a belt
	Ta	ambient temperature
	Tc	threshold temperature
	T _{ie}	temperature of imaging element
	Tm	temperature of a thermographic material
55	Tp	processing temperature
	TM	trade mark
	tw	time of exposure
	vP	processing speed

	W	width
	Wf	width of a film
	Wt	width of a table
	X	transversal direction
5	Y	transport direction of a thermographic material
	Z	vertical direction
	Y1	transport direction of the lower belt
	Y2	transport direction of the upper belt
	Y11 Y12 Y13	transport direction of lower belts
10	Y21 Y22 Y23	transport direction of upper belts
	Y, M, C, K	yellow, magenta, cyan and black colour selection

	α	angle of incidence
	β	angle of refraction
15	σ_y	yield strength

Claims

20 1. A thermal processor (10) for thermal processing a thermographic material having an imaging element le, said thermal processor comprising:

- means for supplying (16) said thermographic material to said thermal processor,
- a processing chamber (12),
- 25 - means for heating (17) said processing chamber,
- means for transporting said thermographic material through said processing chamber,
- means for exporting (19) said thermographic material out of said thermal processor,

30 **characterised in that** said means for transporting comprise a first belt (21) and a second belt (22) arranged with respect to said first belt so that transporting said thermographic material through said processing chamber is carried out in a sinuous way (4).

35 2. The processor according to the preceding claim, wherein said first belt (21) is conveying said thermographic material at a first side (6) and wherein said second belt (22) is conveying said thermographic material at a second side (7).

40 3. The processor according to claim 1 or 2, wherein said means for heating (17) said processing chamber comprises an electrically resistant heating element (31) and means for transmitting (34, 35) heat from said heating element to one of said belts.

4. The processor according to any one of the claims 1-3, further comprising means for driving said first and said second belt (21, 22) having at least one backing roller (27) for each of said belts.

45 5. The processor according to any one of the claims 1-4, further comprising means for driving said first and said second belt (21, 22) having at least one driving roller (25, 26) for each of said belts.

6. The processor according to the preceding claim, wherein the radius rD of a driving roller and the radius rB of a backing roller are in a range defined by following equations

50
$$0,5 \cdot r_{Dj} < r_{Bj} < 5 \cdot r_{Dj} \quad [\text{eq. 1}]$$

55
$$r_{Bj} > \frac{E \cdot f}{2 \cdot \sigma_y} \cdot t_{Bj} \quad [\text{eq. 2}]$$

$$r_{Dj} \geq \frac{E \cdot f}{2 \cdot \sigma_y} \cdot t_{Bj} \quad [\text{eq.3}]$$

5 wherein E = modulus of elasticity of the thermographic material σ_y is the yield strength of the thermographic material, j = 1 for the lower part of the processing chamber (14), and j = 2 for the upper part of the processing chamber (15).

10 7. The processor according to any one of the claims 5-6, wherein for said driving rollers, following equation applies

$$\sqrt{(r_{D_1} + r_{D_2} + t_{b1} + t_{v2} + f)^2 - d_H^2} < d_V < (r_{D_1} + r_{D_2} + t_{b1} + t_{b2}) \quad [\text{eq.5}]$$

15 8. The processor according to any one of the preceding claims, wherein said first belt and said second belt have a volumetric heat capacity below 2.5 kJ/K dM³

9. The processor according to any one of the claims 1-7, wherein said first belt and said second belt have a heat conductivity lower than 0.3 W/K m .

20 10. The processor according to any one of the preceding claims, wherein said processor further comprises an internal imager (96) for recording an image on a thermographic material (1).

25 11. An image recording system comprising an external imager (95) or an internal imager (96) for recording an image on a thermographic material (1) and a thermal processor (10) according to any one of the preceding claims.

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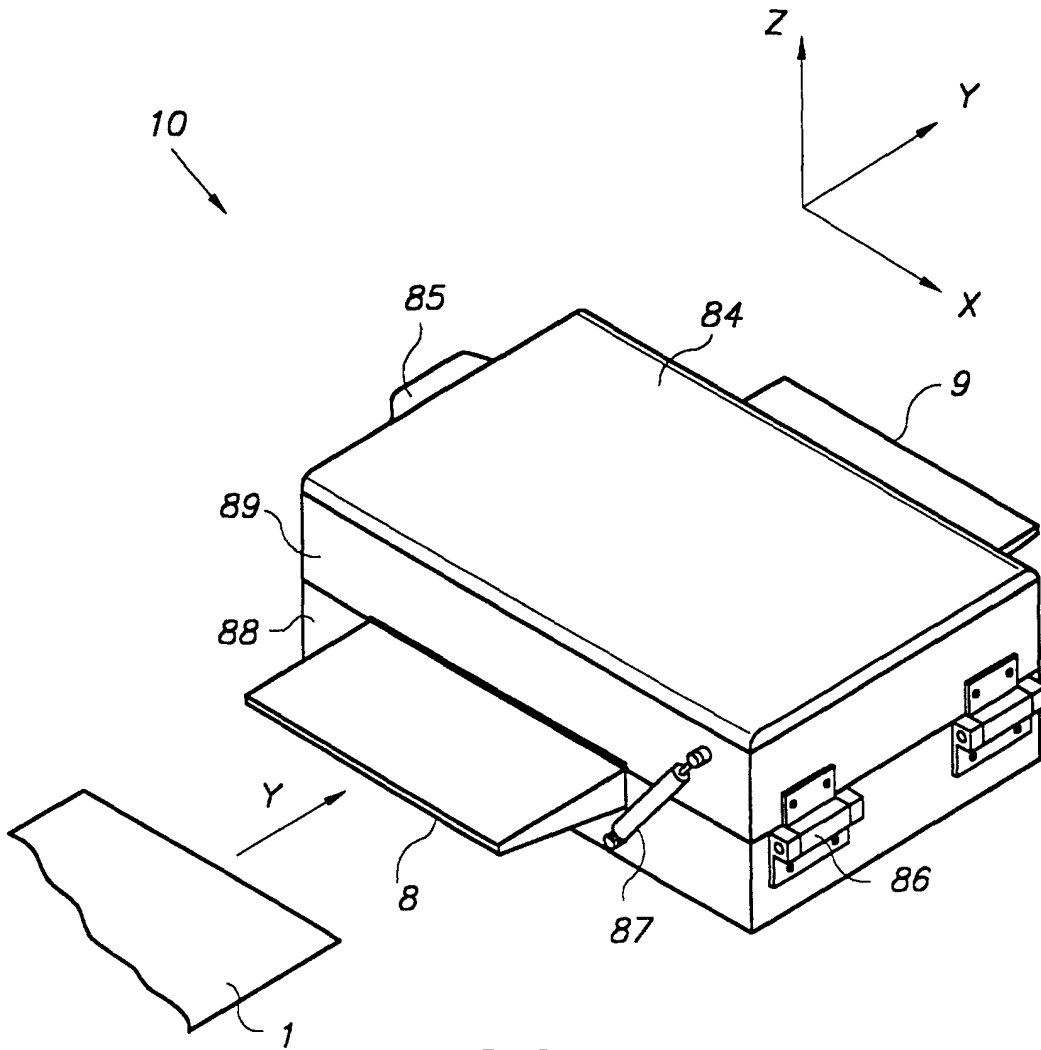


FIG. 1

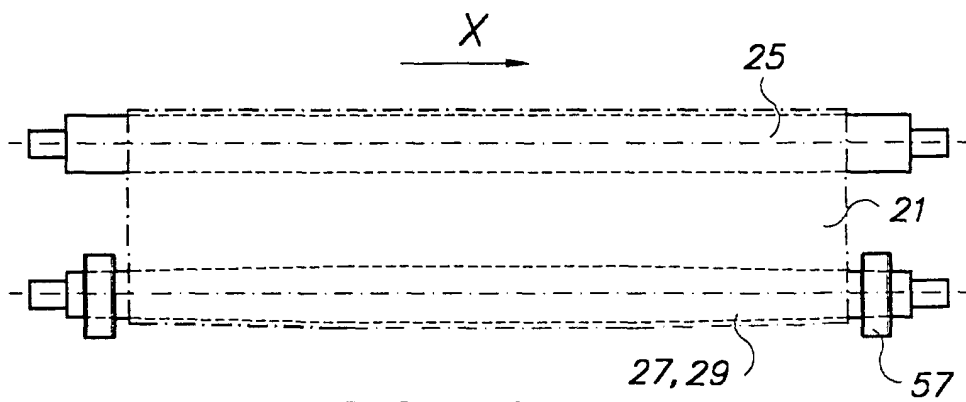


FIG. 10

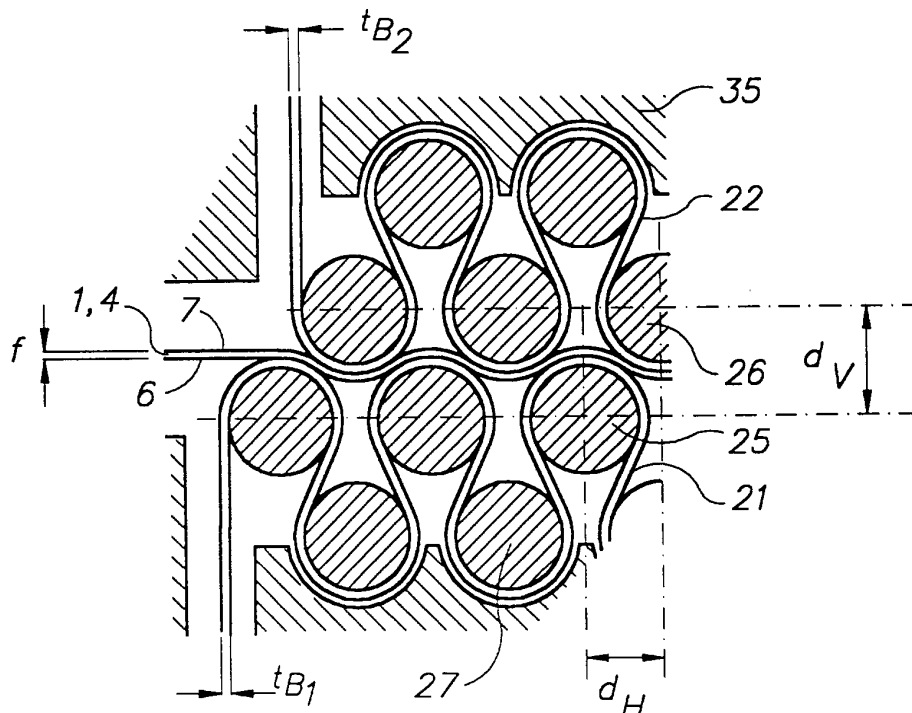


FIG. 3

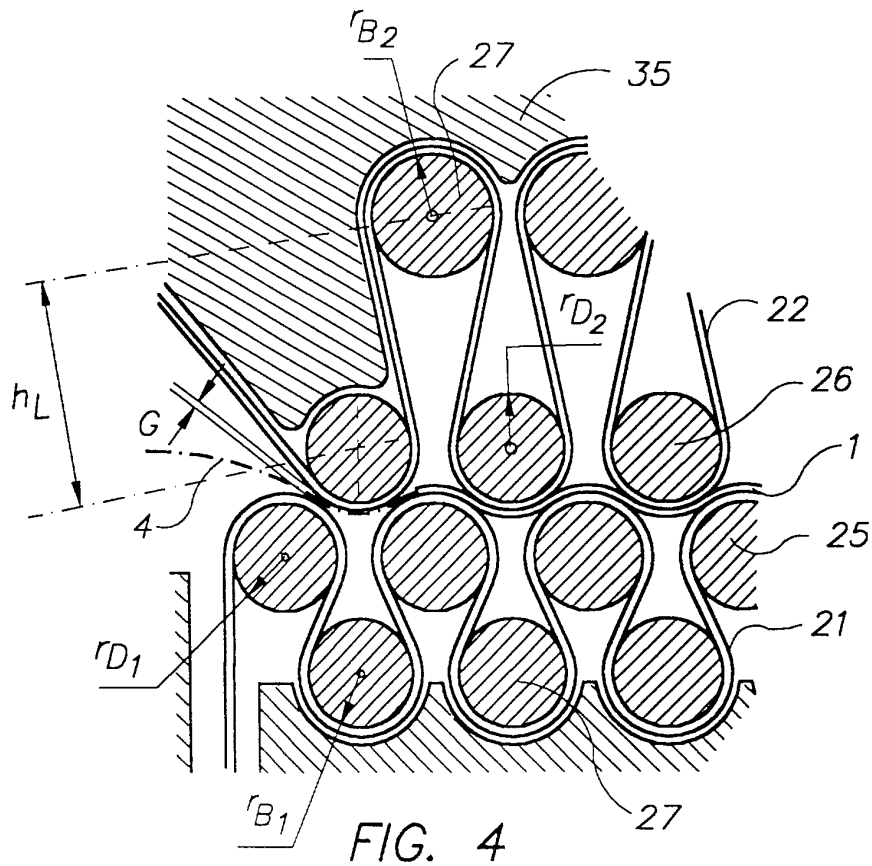
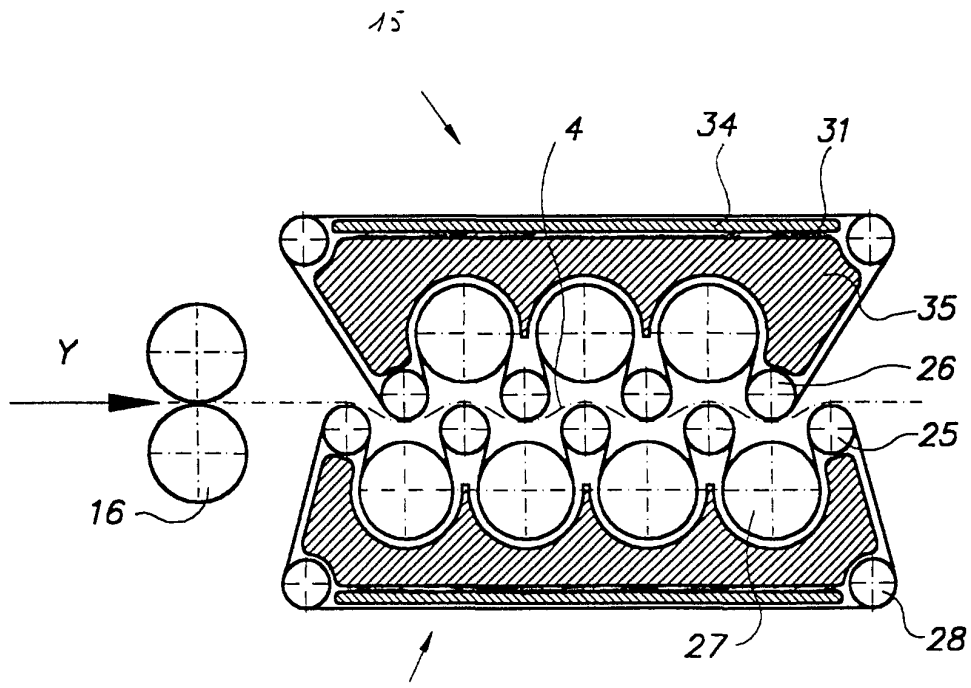
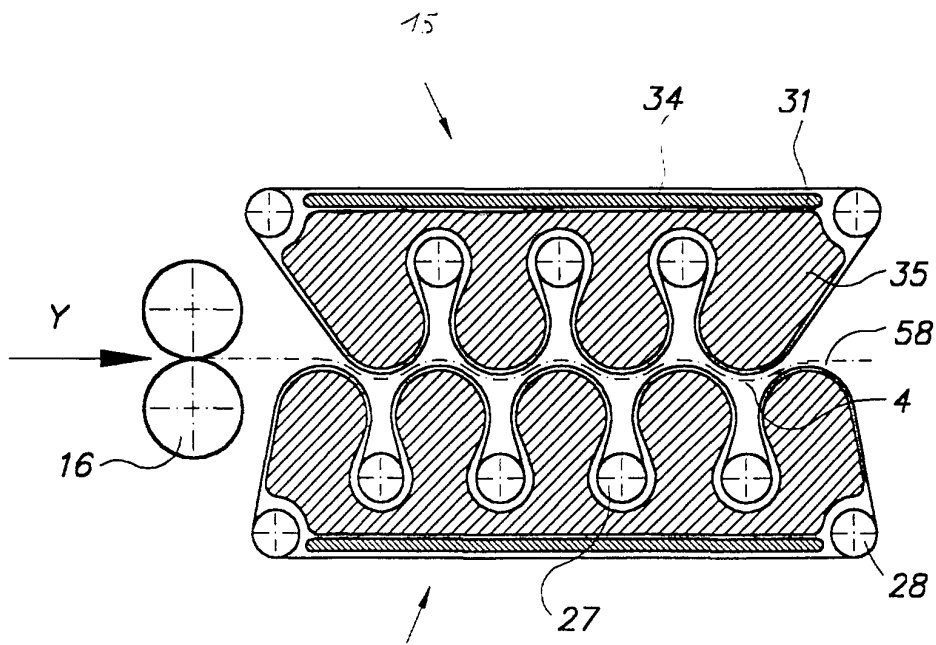


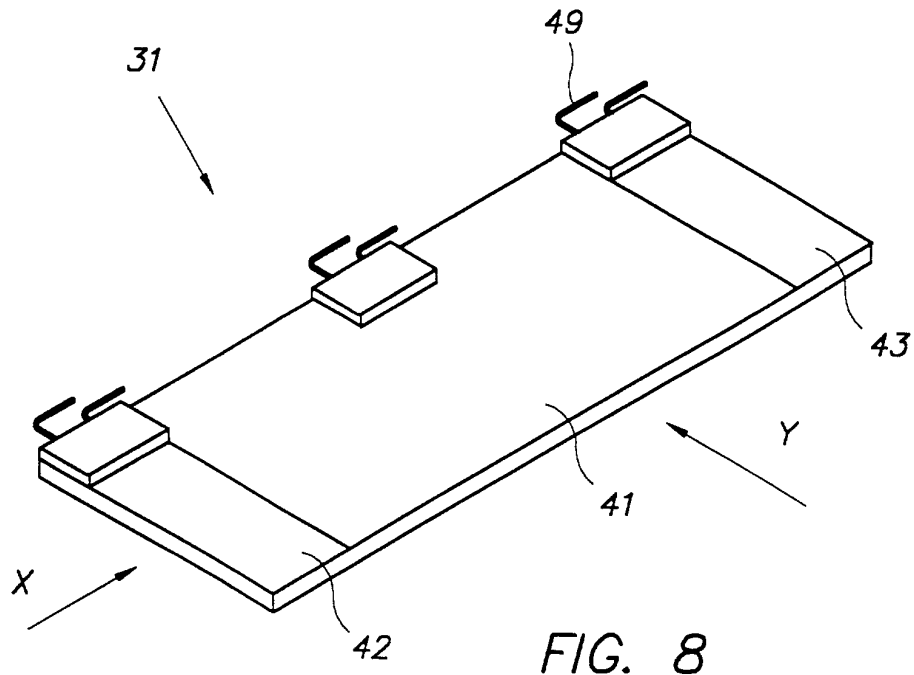
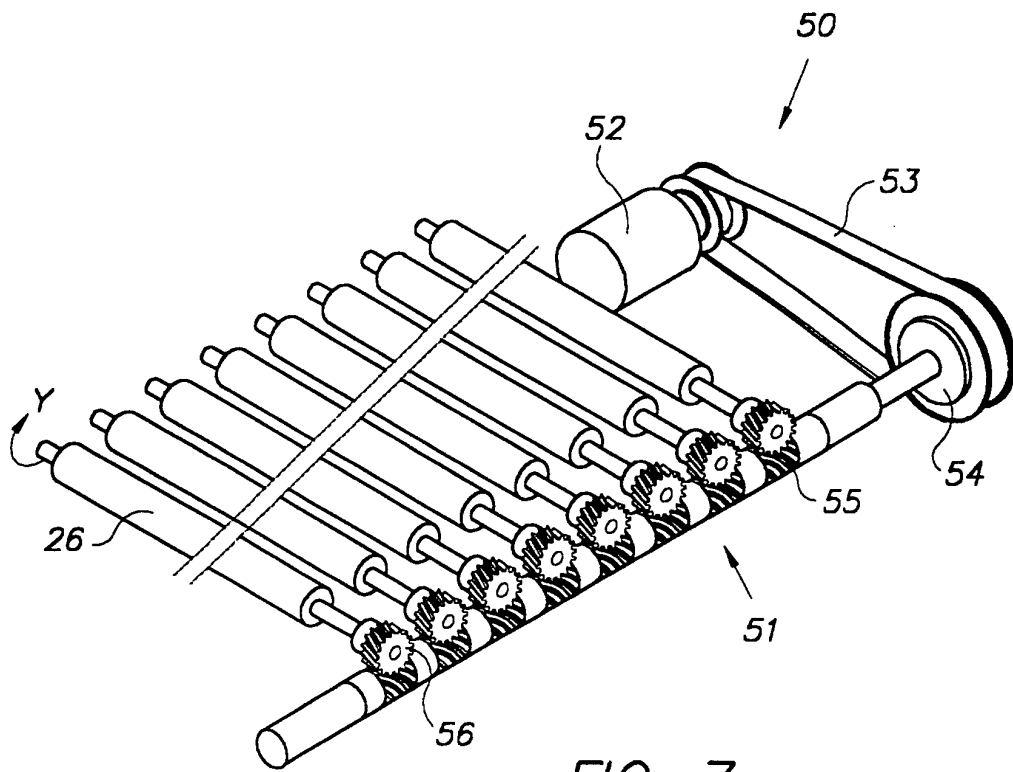
FIG. 4



14 FIG. 5



14 FIG. 6



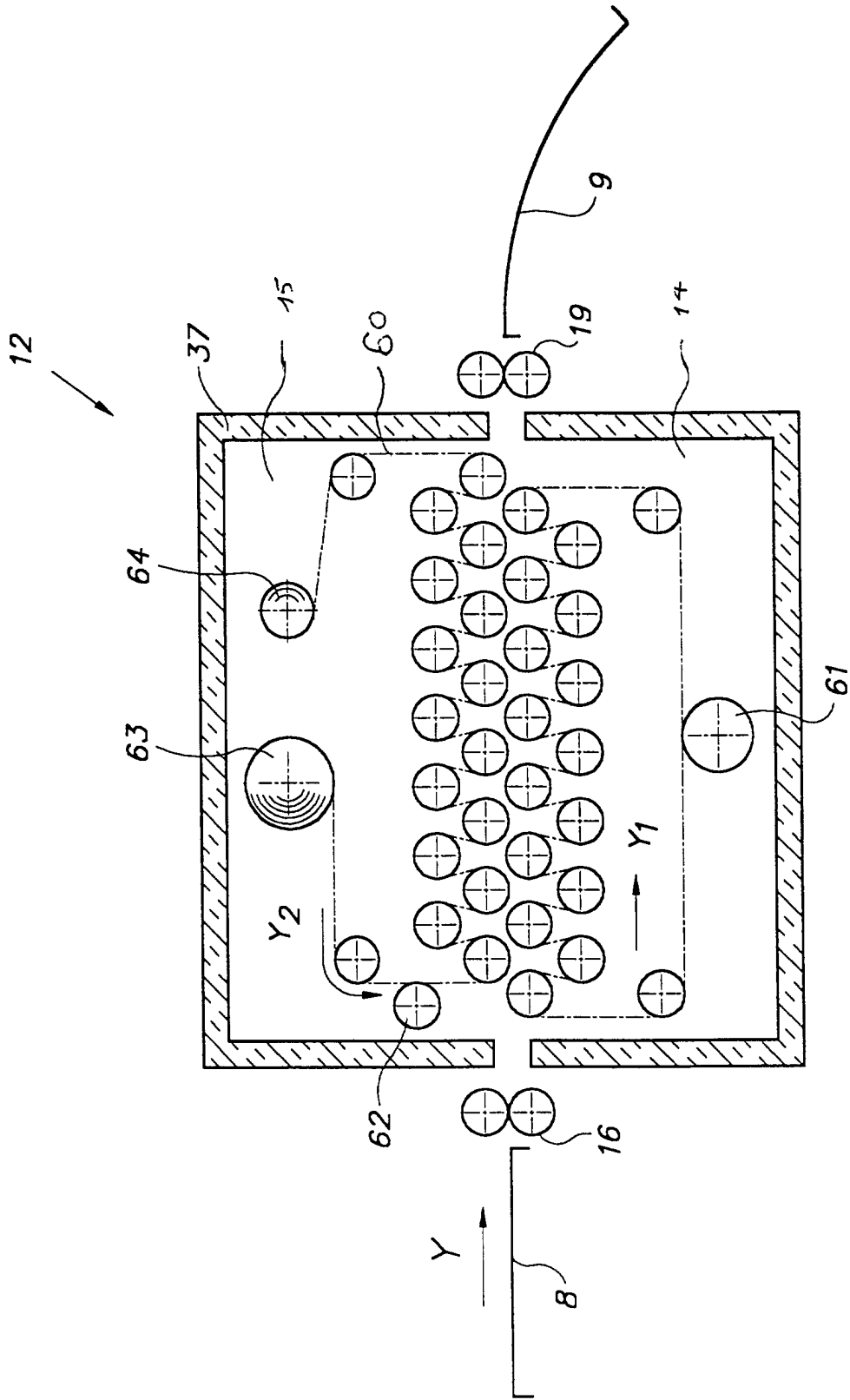


FIG. 11

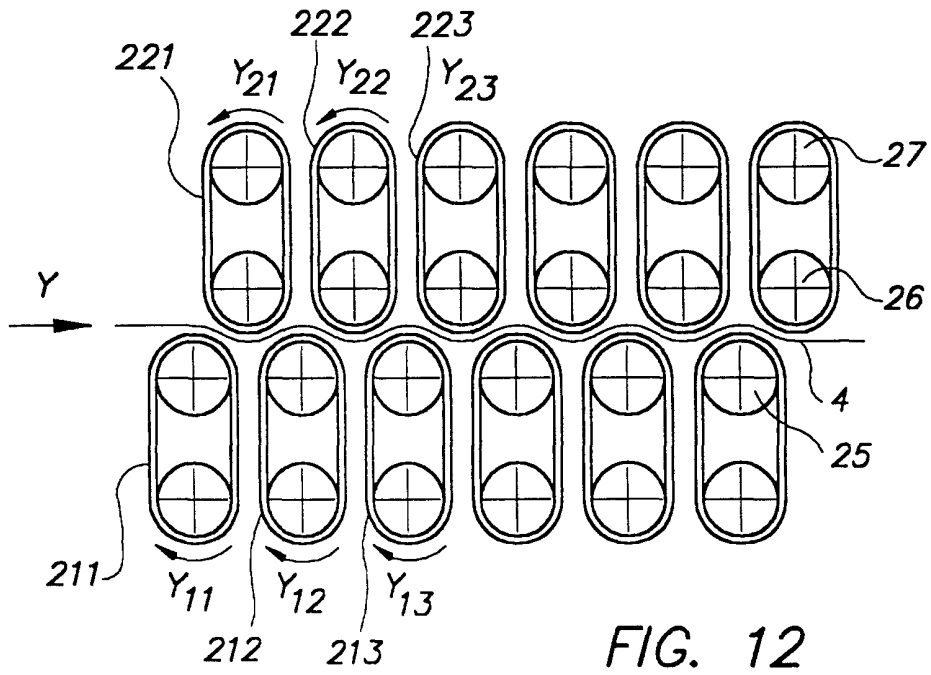


FIG. 12

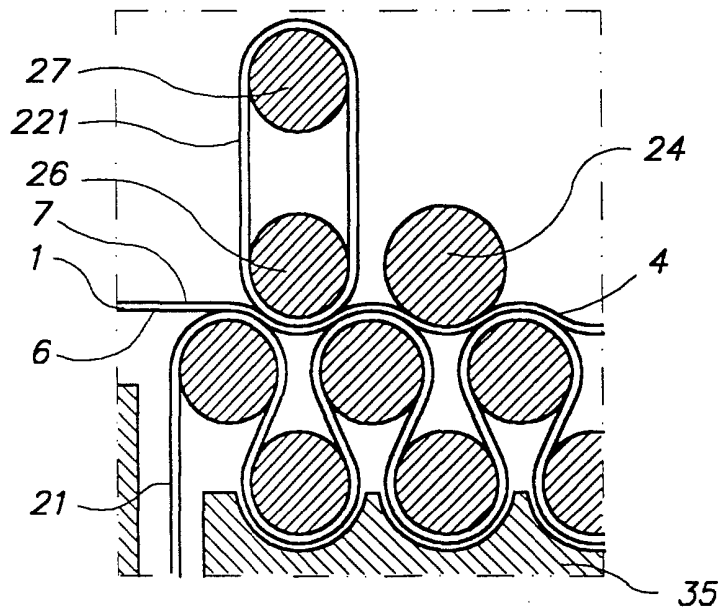


FIG. 13

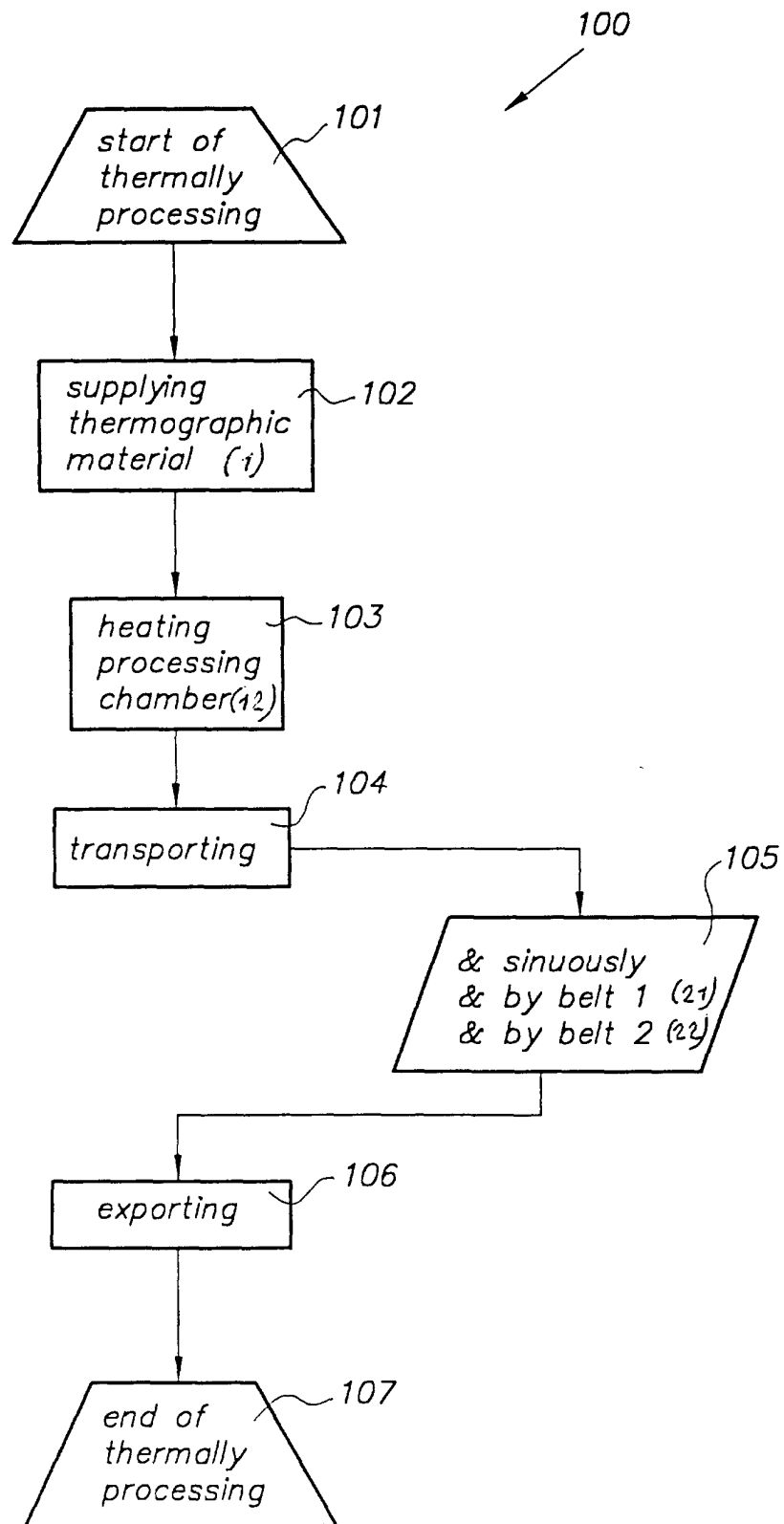


FIG. 14

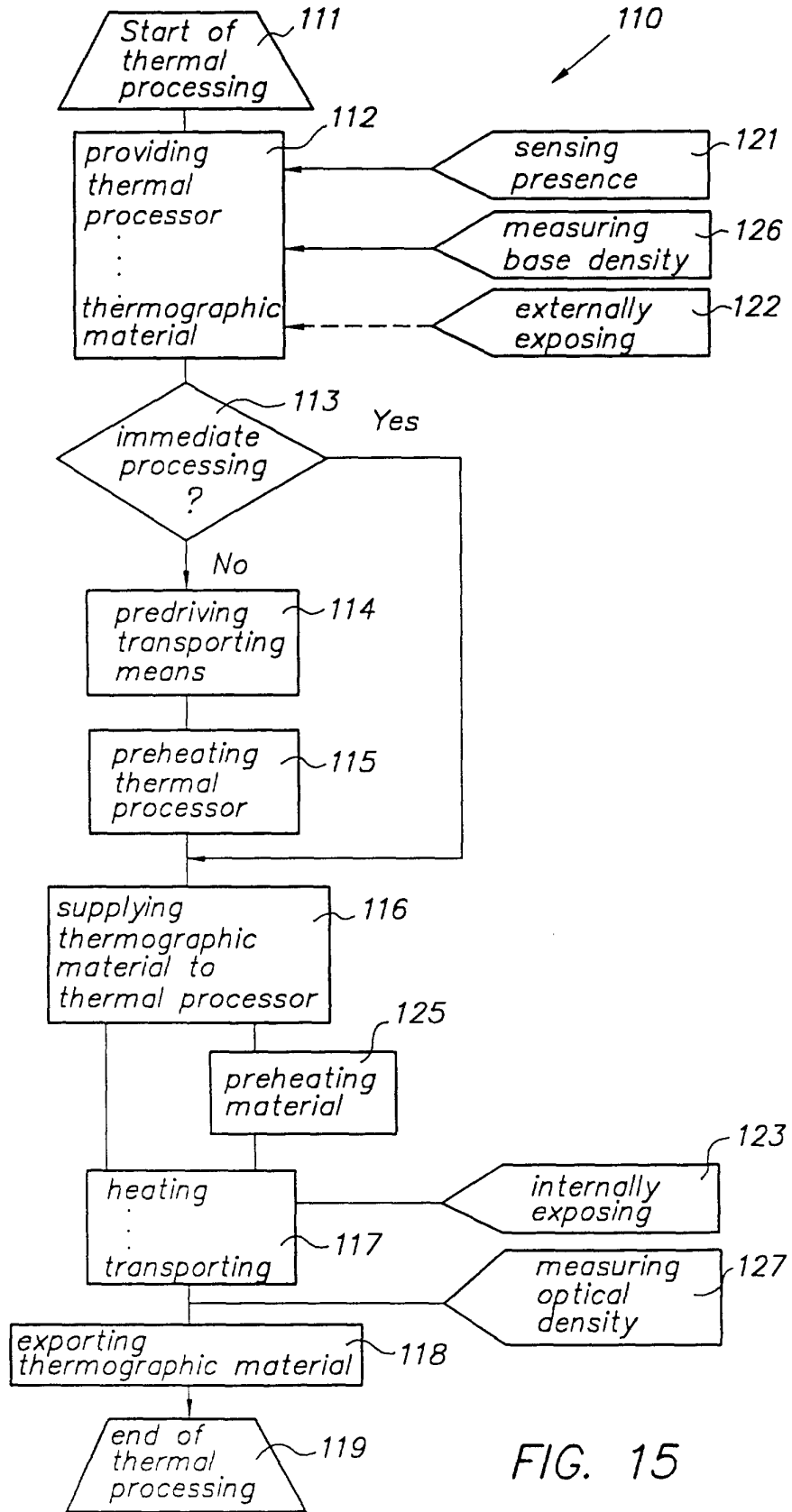


FIG. 15

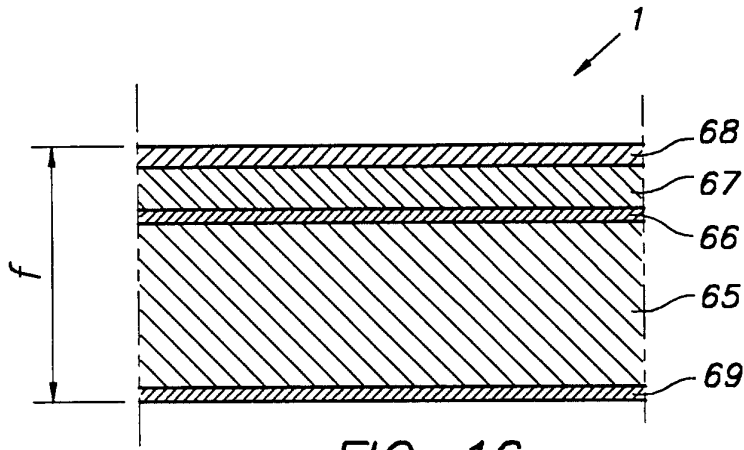


FIG. 16

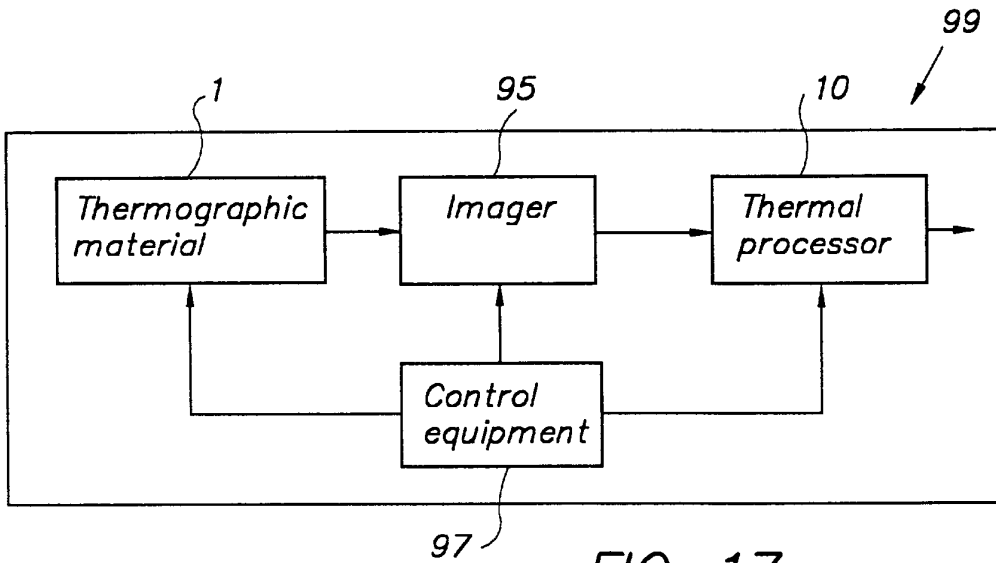


FIG. 17

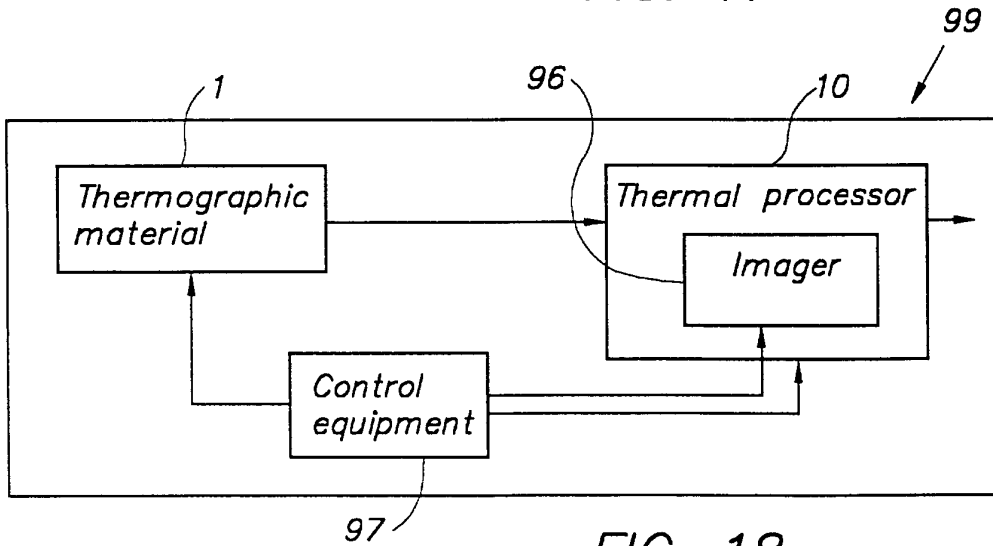


FIG. 18

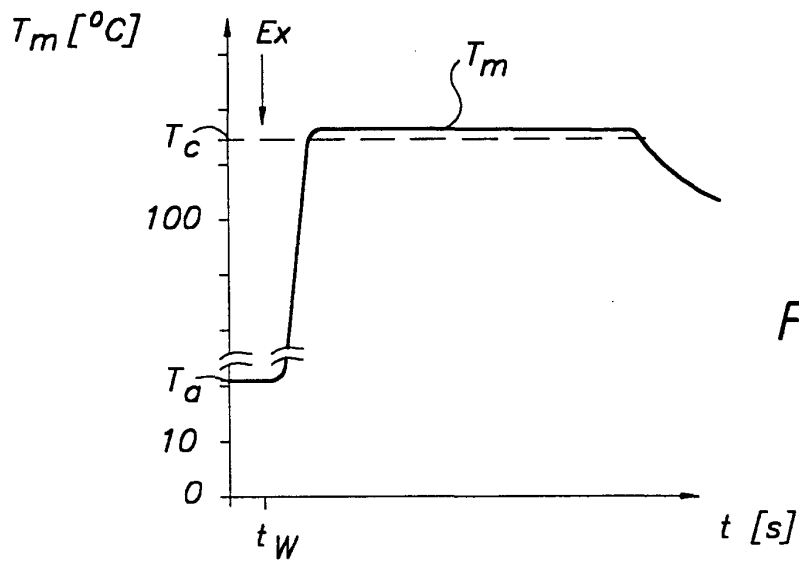


FIG. 19.1

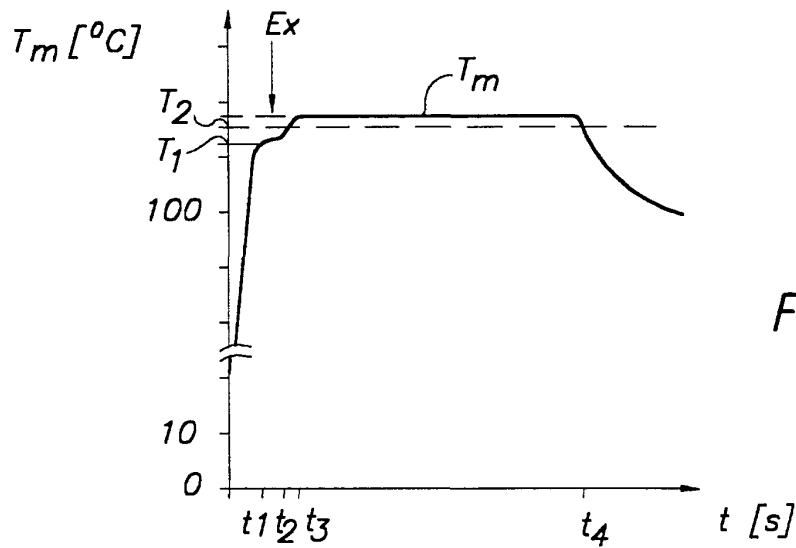


FIG. 19.2

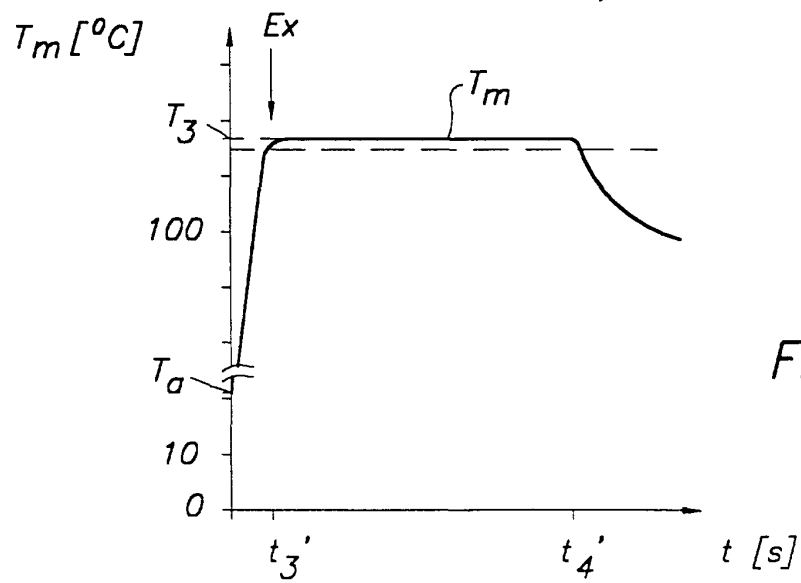


FIG. 19.3

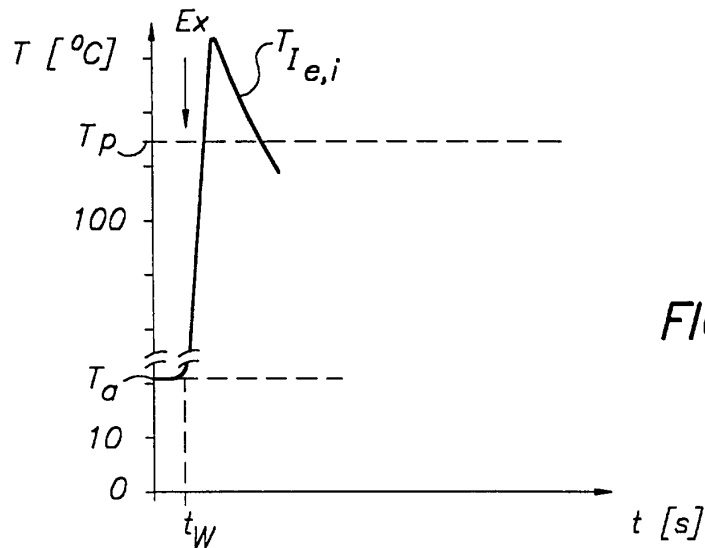


FIG. 20.1

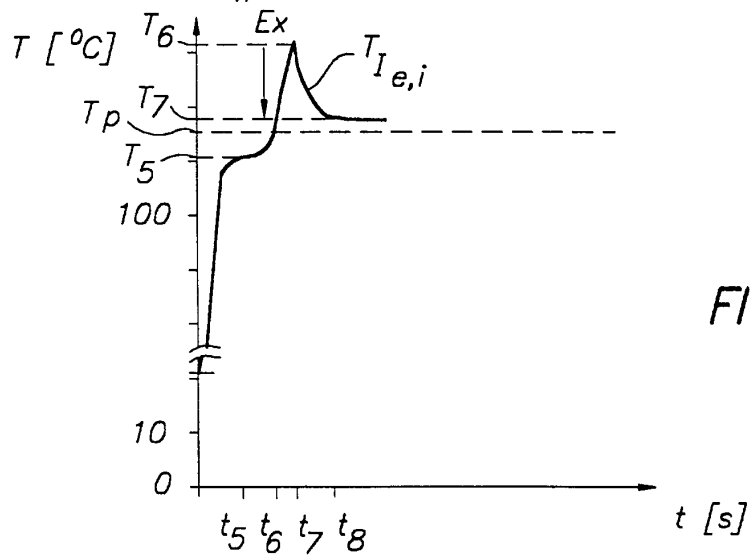


FIG. 20.2

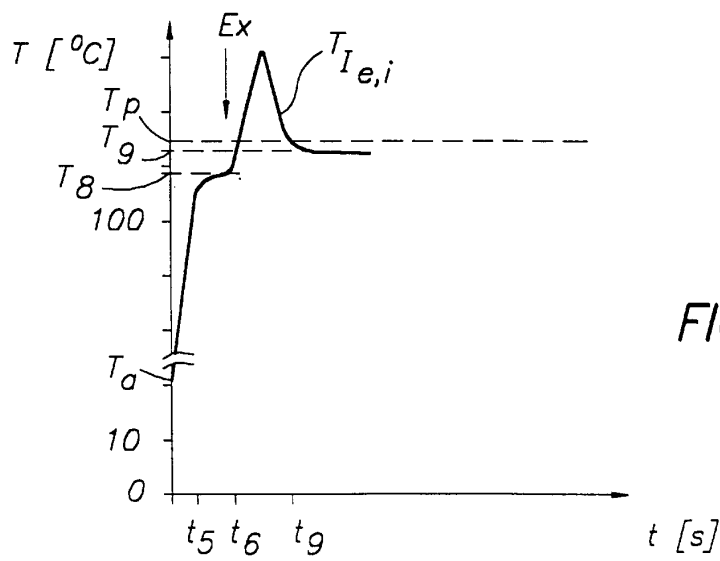


FIG. 20.3

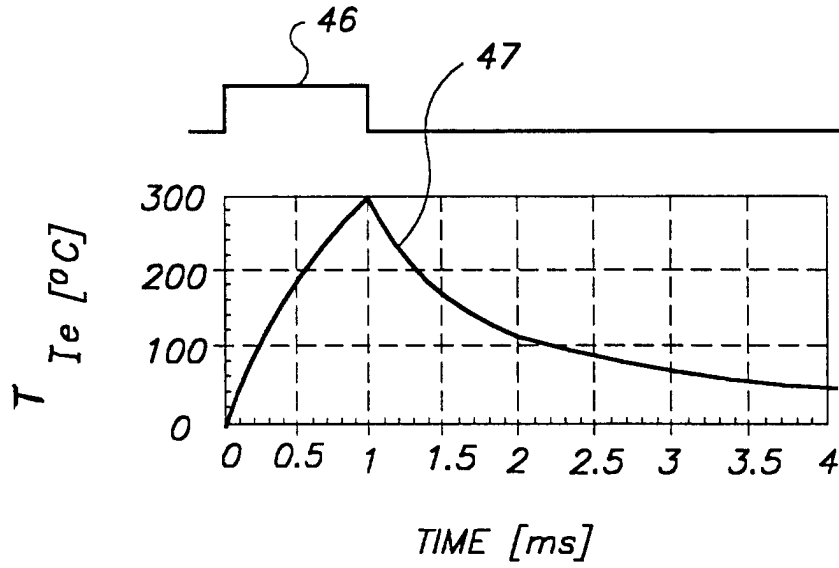


FIG. 21

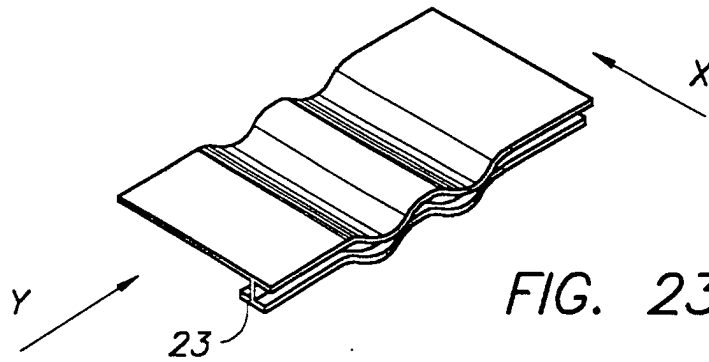


FIG. 23.1

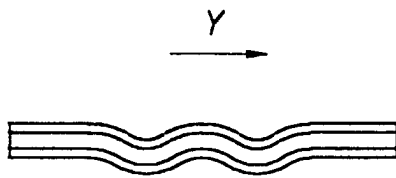


FIG. 23.2

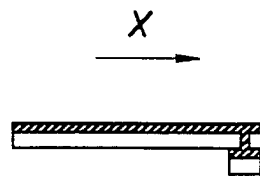
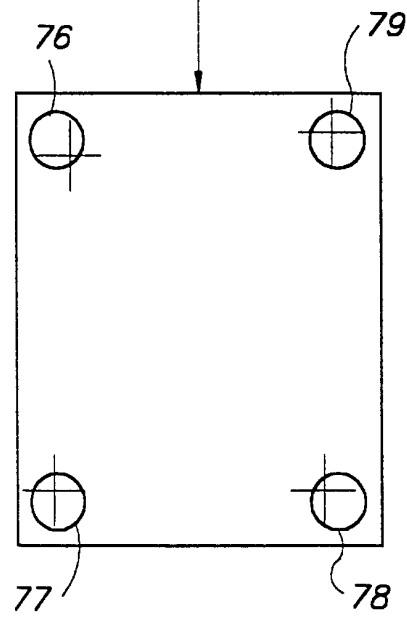
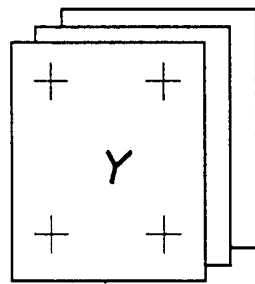
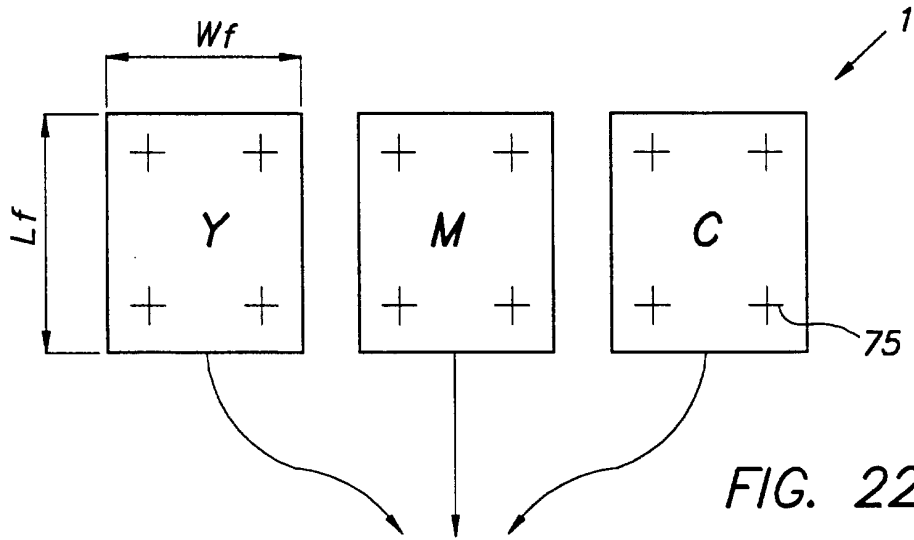


FIG. 23.3



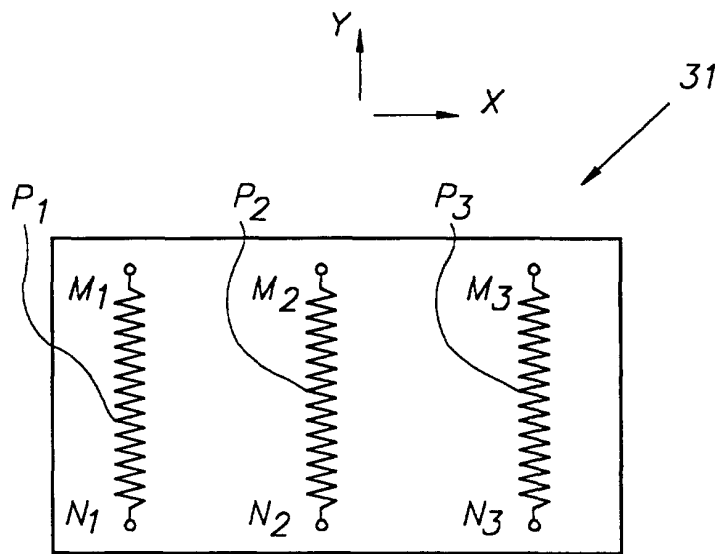


FIG. 24.1

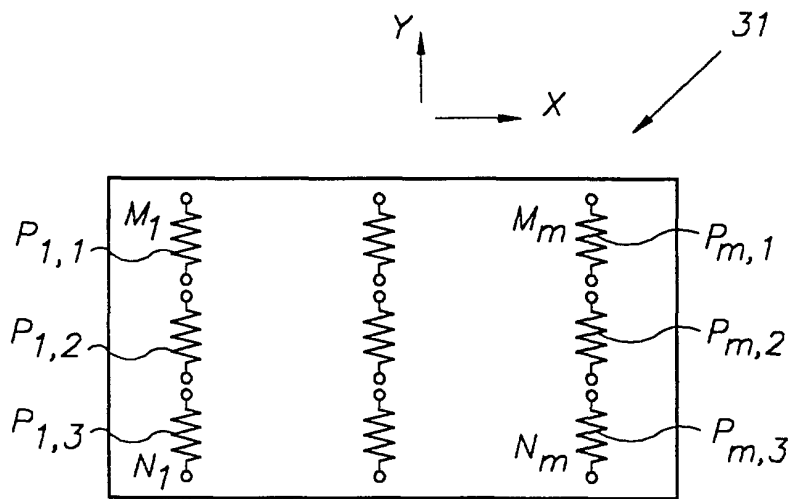
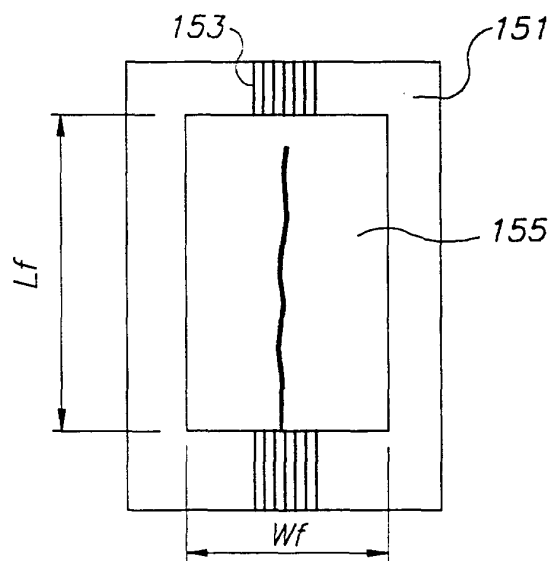
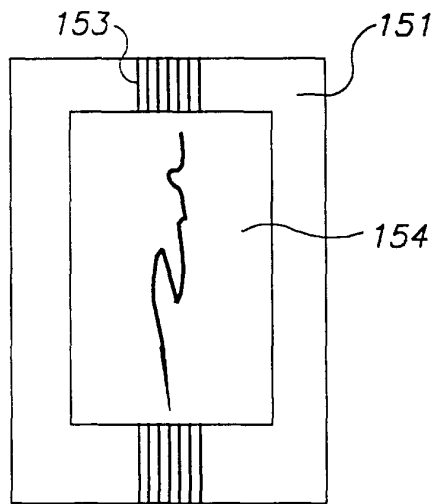
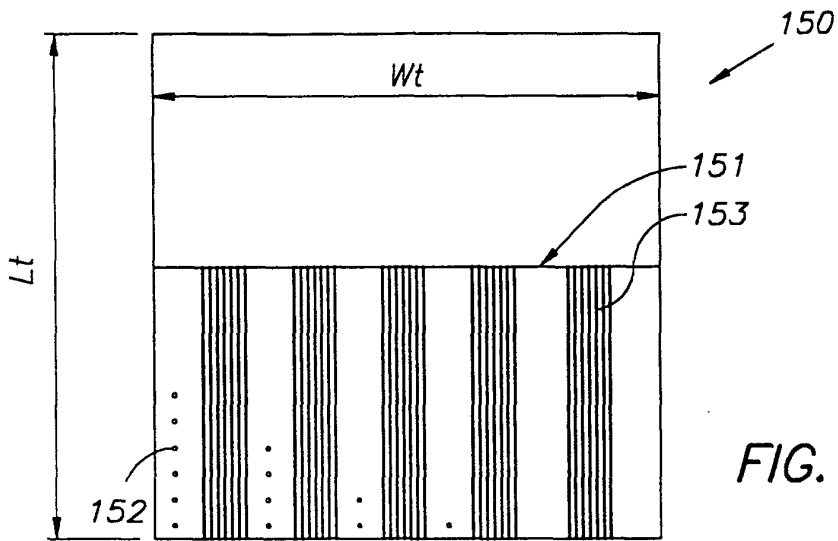


FIG. 24.2





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.CI.7)
Y	PATENT ABSTRACTS OF JAPAN vol. 0151, no. 53 (P-1191), 17 April 1991 (1991-04-17) & JP 03 023446 A (KONICA CORP.), 31 January 1991 (1991-01-31) * abstract *	1-3,5	G03D13/00
Y	--- PATENT ABSTRACTS OF JAPAN vol. 0122, no. 98 (P-744), 15 August 1988 (1988-08-15) & JP 63 071848 A (KONICA CORP.), 1 April 1988 (1988-04-01) * abstract *	1-3,5	
A	---	10,11	
D,Y	--- US 5 869 806 A (K.R.STRUBLE) 9 February 1999 (1999-02-09) * column 5 - column 12; figures 1-5 * -----	1,3	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.CI.7)
			G03D
Place of search	Date of completion of the search	Examiner	
THE HAGUE	2 January 2001	Boeykens, J	
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ON EUROPEAN PATENT APPLICATION NO.**

EP 00 20 2682

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02-01-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 03023446 A	31-01-1991	NONE	
JP 63071848 A	01-04-1988	NONE	
US 5869806 A	09-02-1999	AU 1572997 A EP 1012669 A WO 9728489 A	22-08-1997 28-06-2000 07-08-1997

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