

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 86306300.4

(51) Int. Cl.⁴: **B 41 F 23/04**

(22) Date of filing: 14.08.86

(30) Priority: 14.08.85 GB 8520367

(43) Date of publication of application:
11.03.87 Bulletin 87/11

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

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(54) **Improvements in ink drying apparatus.**

(57) The invention relates to improvements in ink drying apparatus of the type in which a conveyor belt (1) on which a printed substrate may be placed passes beneath an infra red radiation emitting surface (3) to convey the substrate from one end of the radiation emitting surface (3) to the opposite end of the radiation emitting surface (3) in which the radiation emitting surface (3) comprises a plurality of discrete radiation units.

In a first aspect of the invention which is applicable with particular advantage to drying plasticised inks, the radiation emitting surface (3) is arranged such that, said one end of the radiation emitting surface (3) there is situated a bank (7) of radiation units (4) arranged contiguously, the number of radiation units in the bank (7) being sufficient to heat the printed ink but to a temperature above its triggering temperature, and adjacent the bank (7) in a direction from said one end to the other a gap (8) of a length sufficient to allow the rate of temperature rise to be slowed down, and adjacent said gap (8) further radiation units (9) to maintain the temperature of the ink and substrate.

A second aspect of the invention is applicable equally to water-based inks and white spirit emulsion-based inks and with this apparatus the radiation emitting surface includes at said one end a first radiation zone (4A) comprising at least one radiation unit arranged to emit infra red radiation predomi-

nantly with a wavelength of less than 3.5 μm and in the peak absorption range of the substrate, and a second radiation zone (4B) spaced from the first radiation zone (4A) in a direction from said one end to the other end, the second radiation zone (4B) including at least two discrete radiation units (10 and 11) separated by a gap (12) each unit within said second zone (4B) being arranged to emit infra red radiation predominantly of a wavelength greater than 3.5 μm and within the peak absorption range of the ink.

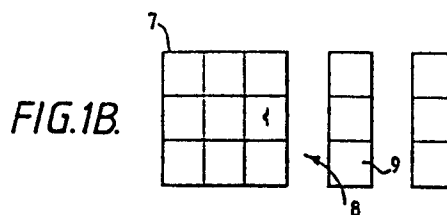
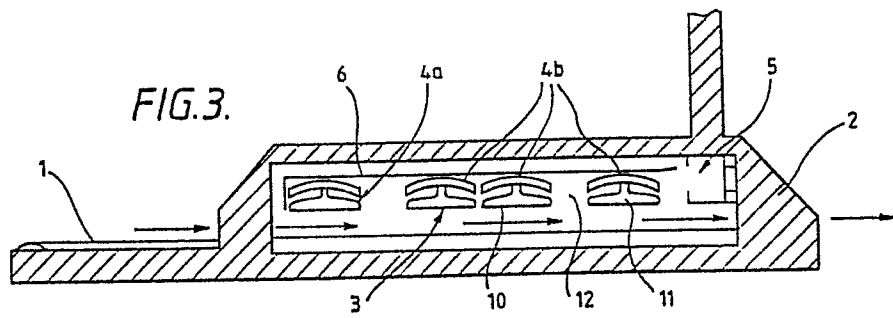


FIG.3.



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IMPROVEMENTS IN INK DRYING APPARATUSField of the Invention

5 The invention relates to improvements in ink drying apparatus and in particular to apparatus where a substrate printed with ink travels on a conveyor belt past a heating surface which emits infra red radiation to cure and dry the ink.

10 One example of such apparatus is described in published UK Patent Application No 2 141 072. The apparatus described therein was designed specifically for drying printed ink on a woven fabric although it is applicable equally to drying printed ink on other forms of substrate. The infra red emitters advantageously are ceramic radiation elements. The invention will be described with particular reference to the apparatus described in UK Patent Application No 2 141 072 but is applicable
15 equally to any apparatus in which an object comprising a substrate printed with ink to be cured is past in the path of an infra red emitting surface comprising a series of discrete infra red radiation units.

20 In the following specification the conveyer will be described as travelling beneath the infra red emitting surface. This will be taken to mean that the conveyor runs parallel to the surface and brings the object into a position where its printed surface lies in the path of the infra red radiation emitted by the surface. In many cases the conveyor will be, in fact,

vertically beneath the emitting surface.

5 As an object printed with ink (the substrate) is moved along the conveyor belt from one end of the infra red emitting surface to the other, the temperature of the ink rises exponentially until it has reached a given drying temperature whereupon the required physical/chemical reactions start to occur. The temperature will be referred to as the "triggering temperature". It will be understood that the triggering temperature for each different type of ink will be different.

10 In order for the drying and curing of the ink to continue, the object at this point must still pass beneath more units of the infra red emitting surface, and so the temperature of the ink will continue to rise. Apart from the fact that this temperature rise is not necessary and, therefore wastes
15 power, in many cases this can be deleterious to the ink and/or the substrate.

It has been found that the peak absorption of a substrate which is a textile is in the range of 0.5 - 3 μm radiation. The peak absorption point in the infra red spectrum for most
20 inks whether water based or plasticised lies in the range 4 - 5 μm . Thus in the apparatus of the type described in published UK Patent Application No 2 141 072 the infra red emitters are arranged to emit their infra red radiation in the peak absorption range of the inks and not the substrates.
25 However even using this system the printed substrate still has to be heated and the temperature rise is still damaging to the substrate therefore scorching, charring or shrinkage of the substrate can occur.

30 The object of both aspects of the invention is to provide improved ink drying apparatus to try to reduce the risk of substrate and/or ink degradation.

Summary of the Invention

According to a first aspect of the invention there is provided an ink drying apparatus for drying ink printed on a substrate, comprising a conveyor belt on which the printed substrate may be placed, the conveyor belt passing beneath an infra red radiation emitting surface to convey the substrate from one end of the radiation emitting surface to the opposite end of the radiation emitting surface, the radiation emitting surface comprising a plurality of discrete radiation units, the ink drying apparatus being characterised in that, the radiation emitting surface is arranged such that, at said one end of the radiation emitting surface there is situated a bank of radiation units arranged contiguously, the number of radiation units in the bank being sufficient to heat the printed ink to a temperature above its triggering temperature, and adjacent the bank in the direction from said one end to the other, a gap of a length sufficient to allow the rate of temperature rise to be slowed down, and adjacent said gap a further radiation unit to maintain the temperature of the ink and substrate.

It is preferred that adjacent the further radiation unit there is at least a second further radiation unit spaced from its adjacent unit by a further gap. When the substrate passes beneath a gap between radiation units, there is no extra radiation being emitted to the ink but there is a residual effect on the ink and its temperature continues to rise, albeit at a much slower rate than during its passage beneath the bank of radiation units. When the substrate then passes through a further discrete radiation unit, the temperature of the ink is prevented from falling again to below its triggering temperature and so air and drying of the ink continues.

Thus the ink drying apparatus can work at a greater efficiency since to work the conveyor at the same speed through the apparatus, fewer radiation units than hitherto are required.

More importantly, although the temperature of the ink has been kept above its triggering temperature, its exponential rise in temperature is interrupted and the highest temperature reached by the ink in the apparatus is considerably reduced. Thus the danger of heat degradation of the ink or the substrate is also considerably reduced.

This improvement in the curing of inks is applicable to all inks commonly used including water-based inks, white spirit emulsion based inks and plasticised inks. However an important advantageous effect is noticed when the apparatus is used to dry plasticised inks.

This is described in the following paragraph.

By the introduction of the gaps between some of the discrete radiation units of the radiation emitting surface, the total length of the radiation emitting surface for a given number of radiation units can be substantially increased and there is therefore to be expected an increase in the speed at which the conveyor may pass the substrate beneath the surface. However it has been found that in the ink drying apparatus the speeds may be remarkably increased, for example up to speeds equal to 160% of the speeds used in conventional ink drying apparatus which means that the alternate cooling and heating of the ink by the introduction of the gaps serves to decrease the curing time required to dry the ink. This was a very unexpected result.

The length of the series of gaps and in the series of discrete radiation units which separate the gaps do not have to be equal. However in order to achieve a constant heating effect, the total lengths of all the gaps must equal the total length of all the separate discrete radiation units or their effective radiation zones.

The infra red heating units may be infra red bars, rods, black body radiation pads or lamps but it is preferred that the

heating units are ceramic radiation tiles. A typical tile measures 125 mm (5 inches) square.

5 In the case where the radiation unit is a ceramic radiation tile it has been found that an effective apparatus is created where each gap has length equal to the length of a ceramic radiation tile. In a preferred arrangement the radiation emitting surface comprises a bank of three contiguous ceramic tiles adjacent a gap of one tile length adjacent a further single tile adjacent a second gap of length equal to a tile adjacent 10 a final ceramic tile. This gives an arrangement which is extremely effective especially for drying inks which have been silk screened onto woven fabrics.

15 Most types of ink have a similar triggering temperature in the region of 135°C and have similar heating curves. In this case spacing and positioning of the radiation units can stay fixed.

20 However in some cases where extremely different types of ink are to be used, it is preferred that the radiation units are mounted so that they can be easily moved about the surface.

25 In the case where the radiation units are ceramic tiles it is preferred that the tiles are mounted in pairs upon stainless steel reflectors which are, in turn, mounted upon supporting rails. The tiles can then be moved about on the supporting rails so that their spacing may be changed if required.

It has been found that the most efficient arrangement is produced if the percentage of the total length of the heating surface occupied by the solid set of heater units at one end of the surface is between 30% and 60%.

30 As has already been outlined, the apparatus in accordance with the first embodiment of the invention gives a remarkable

increase in the speed at which the conveyor may travel if the ink to be cured is a plasticised ink. Although the danger of heat degradation of the substrate is reduced in other types of ink such as water-based and white spirit based inks, these
5 do not give the same speed increases. The object of the second aspect of the invention is to produce apparatus which will give increased speeds with different types of inks.

According to a second aspect of the invention there is provided ink drying apparatus for drying ink printed on a substrate,
10 comprising a conveyor belt on which the printed substrate may be placed, the conveyor belt passing beneath an infra red radiation emitting surface to convey the substrate from one end of the radiation emitting surface to the opposite end of the radiation emitting surface, characterised in that the
15 radiation emitting surface includes at said one end a first radiation zone comprising at least one radiation unit arranged to emit infra red radiation predominantly with a wavelength of less than $3.5 \mu\text{m}$, and in the peak absorption range of the substrate, and a second radiation zone spaced from the
20 first radiation zone in a direction from said one end to the other end, the second radiation zone including at least two discrete radiation units separated by a gap, each unit within said second zone being arranged to emit infra red radiation predominantly of a wavelength greater than $3.5 \mu\text{m}$ and within
25 the peak absorption range of the ink.

This apparatus operates by heating the substrate up quickly by irradiating it first at the first radiation zone with infra red of a wavelength which heats up the substrate quickly. This consequently raises the temperature of the ink quickly.
30 In the second zone the ink curing is taken over by the radiation elements which act predominantly on the ink rather than the substrate. Within the second zone there is at least one gap which serves as in the first aspect of the invention to control the temperature rise within the ink. This ensures
35 that the temperature within the ink is raised quickly to its triggering temperature and then is maintained at a temperature above the triggering temperature without allowing it to get

so high that it can be deleterious to the substrate.

5 The invention is applicable with particular advantage to the printing of inks on fabrics. Fabrics are much more easily and speedily heated by a radiation with infra red of wavelength 1 - 3.5 μm . In a garment silk screened with ink, the ink will form a less than .1% component of the total weight and therefore the quickest way to heat the ink will be to heat the garment. This is done by irradiating the garment for a short time duration with infra red of short wavelength. 10 This can heat the ink and substrates to a temperature of around 80°C which is not yet the triggering temperature for most inks.

15 Preferably the spacing of the second zone from the first zone is sufficient to allow the rate of temperature rise to be slowed down considerably before the garment passes under the second radiation zone.

20 The first radiation zone may comprise infra red radiation elements which are different from the infra red radiation elements in the second radiation zone. Typically the first radiation zone elements may be quartz glass infra red lamps but preferably the radiation units in each of the zones comprise ceramic radiation elements.

25 In ceramic radiation elements the higher the temperature to which the element is heated the lower the wavelength of the infra red radiation it emits. A preferred configuration is produced in which the first radiation zone is one ceramic unit in length which is heated to about 540°C to emit radiation of a wavelength of 3.5 microns. The second radiation zone consists of a first block two ceramic units in length spaced from the second block one ceramic unit in length. The second ceramic unit of the first block i.e. that closest to the second block is connected to a thermostat and heat is supplied to all three units. The second ceramic unit is maintained at 30 a temperature of 370°C which means that it emits radiation

of wavelength 4.6 μm . Because the first ceramic unit of the first block of the second radiation unit is closest to the first radiation zone, it will be heated up slightly by the hottest ceramic unit and so will be hotter than the second thermostated element and will be in a temperature of around 440°C which will emit radiation of around 4.1 μm . The third ceramic unit forming the second block will be at a lower temperature of around 350°C emitting a radiation of 4.8 μm .

It has been found that the best configuration is produced if the gap between the first and second zones is equal to the gap between the first and second blocks within the second zone.

Preferably this gap is equal to 58 mm.

It is found that the speed at which the conveyor belt may move the printed substrate through the apparatus in accordance with the second aspect of the invention can be increased by up to 60% with plasticised inks but also with water-based and white spirit emulsion-based inks. To achieve this, up to 25% power consumption increase is required to heat the first row of ceramic elements to a higher temperature.

The radiation unit may, as in the first aspect of the invention, be mounted for movement to help vary the spacing between the various elements.

Brief Description of the Drawings

Examples of apparatus in accordance with the first and second aspects of the invention will now be described and contrasted with the prior art, with reference to the accompanying drawings, in which:-

Figure 1A is a schematic view of a radiation emitting surface of apparatus : of a prior art;

Figure 1B is a schematic view of the radiation emitting surface of a first apparatus in accordance with the first aspect of the invention;

5 Figure 1C is a schematic view of the radiation emitting surface of a second apparatus in accordance with the second aspect of the invention;

Figure 2 is a front sectional elevation of the second apparatus;

Figure 3 is a side sectional elevation of the second apparatus.

10 Figure 4 is a simplified graph showing temperature rise against length of apparatus of the prior art and of the first and second apparatus;

15 Figure 5 is a simplified graph showing temperature against corrected time base of a printed substrate passing through apparatus of the prior art and the first and second apparatus; and,

Figure 6 is a schematic view of the first apparatus identifying the units used in the formula.

Description of the Preferred Embodiment

20 The apparatus of the prior art and according to the invention is of the general type described in published Patent Specification No 2 141 072.

25 The apparatus shown in Figures 2 and 3 is the second apparatus of the prior art and the first apparatus are both of a similar structure apart from the arrangement of the ceramic elements on the radiation emitting surface.

In each apparatus a flat bed conveyor belt 1 is passing the printed substrate from a loading apron into a drying housing 2. The conveyor belt 1 is an open weave glassfibre Polytetra-

fluoroethane (PTFE) coated belt with an anti-static additive such as that available from Fothergill Tygaflor of Manchester England. The conveyor belt 1 is driven to pass the object from one end of the housing 2 to the opposite end. The belt is driven by a motor which is a variable speed motor which is a single phase input to DC thyristor controlled engine, such as that sold as Model 118 WS by Parvalux Motors Limited of Bournemouth England.

The conveyor belt 1 passes the printed substrate which in this case is preferably a fabric such as a T-shirt silk screened with ink beneath a infra red radiation emitting surface 3. The infra red radiation emitting surface is made up of a plurality of discrete radiation units 4A, 4B.

A low power fan 5 is provided to move the air across the material being dried and thereby to promote uniform ink curing. The fan 5 provides a positive fresh air flow into the dryer across the surface of the substrate. The effect of this is to remove the vapour produced from the evaporating solvent from the surface of the substrate thus promoting further evaporation and drying of the print. The toxic vapours are also prevented from escaping from the dryer into the surrounding work space.

A cover 6 surrounds the ceramic units 4A, 4B to provide a heat shield around them.

The conveyor belt 1 is supported the length of the heated chamber by suitably reinforced and stiffened plate, advantageously manufactured in galvanised steel sheeting which functions also to seal the heated chamber and to ensure that the air flow is positively away from the printed substrate, and all the exhaust gases and noxious fumes are thoroughly exhausted.

The radiant ceramic tiles 4 measure 125 mm square and are mounted in pairs on a stainless steel reflector (not shown) which is in turn mounted upon a supporting rail formed by

extruding a complex shape in Duralumin. The pairs of tiles 2 can be mounted on this rail to form heating strips 250mm 500 mm, 750 mm and 1,000 mm in length. At least one tile 4 is thermostated.

5 In apparatus of the prior art, as shown in Figure 1A, there is a radiation emitting surface which is 500 mm in length, which is equivalent to four tiles 4. The effectiveness of the apparatus of the prior art will be contrasted with that of both aspects of the invention by comparing the heating curve of a yard stick ink which, in this case, is sold under the trade mark TEXICAL by Sericol Limited of Parsons Green 10 London. The belt speed to cure this ink is $8\frac{1}{2}$ - 9 ft per minute (2.59 m - 2.74 m per minute). Tests using heat sensitive markers and pyrometers show that the temperature build-up on the ink surface is a rising exponential as shown in 15 Figures 4 and 5.

Since most of the ink is cured by a process of clearing the solvent vehicle then cross-linking the polymeric particles, overheating (achieving temperatures in excess of the triggering 20 temperature of around 135°C) degrades the ink film and is deleterious to the appearance and mechanical strength of the print and/or substrate. In this case it can be seen from Figure 5 that after the third ceramic tile the temperature of the ink has gone above the optimum 135°C and this therefore has a deleterious effect on the ink. 25

The apparatus in accordance with the first aspect of the invention is arranged such that at said one end there is a bank 7 of radiation elements 4 arranged contiguously, the number of radiation units in the bank 7 being sufficient to heat the printed ink to a temperature above its triggering temperature. 30 Adjacent the bank in the direction from said one end to the other is a gap 8 of a length sufficient to allow the rate of temperature rise to be slowed down and adjacent said gap 8 is a further radiation unit 9 to maintain the temperature of the ink and substrate. In this case the bank of units 35

includes three ceramic radiation units 4 and there are two gaps 8 one unit in length, and two separate discrete units 9, each one ceramic unit in length.

5 The heating effect on the ink used as a comparison is shown in Figures 4 and 5. The temperature still rises exponentially but the rate of rise is slowed down by the inclusion of the gap 8. Whilst the substrate is passing beneath the gap 8, there is a residual effect on the ink and its temperature does continue to rise but at a much slower rate. This slows down
10 the overall rate of increase to ensure that the temperature of the ink and substrate never rises as high as it would do in a standard dryer and so there is a much decreased risk of fabric degradation occurring.

15 In this particular example, as compared with the prior art, the overall length of the radiation emitting surface 3 has increased by 75%. The installed power in the radiation surface has only increased by 25% since in the apparatus shown in Figure 1B, there are fifteen ceramic tiles as opposed to twelve.

20 It is to be expected that if the length of the radiation surface is increased, that there would be an increase in the belt speed required to achieve curing perhaps by as much as 50%. However tests using the ink use the comparison cured at belt speeds up to 14 ft per minute (4.27 m per minute) which gave a totally unexpected increase of 60% in the belt speed.
25 Thus the curing of the ink is much more efficient and is speeded up by this alternate heating and cooling effect. The efficiency of the heating surface, when taking into account the speed of the curing produced for a unit of installed power, is increased by 100% plus.

30 The tiles are arranged 67 mm from the belt which runs flat on a galvanised support tray and the temperature is accurately controlled by a variably set closed looped temperature controller giving plus or minus 2°C accuracy.

It has been found that the most efficient results are achieved if the following formula is satisfied:

$$30 < \frac{SR}{1} \times 100 < 60$$

Where SR equals the length of the set of heater units 7 and 1 is the overall length of the heating surface. It will also be appreciated that for the most effective heating and cooling effect, the following formula must be satisfied:

$$\int S = \int G$$

where

$$\int G = G_1 + G_2 + \dots + G_n$$

Where G_1 equals the length of the first gap; G_2 equals the length of the second gap; G_n equals length of nth gap; and:

$$\int S = S_1 + S_2 + \dots + S_n$$

Where S_1 equals the length of the first discrete separate heater unit 9 and S_2 equals the length of the second discrete heater unit 9; and S_n equals the length of the nth discrete heater unit 9.

The results obtained with the first apparatus were obtained using plasticised inks such as the yard stick ink. With inks which are water-based or white spirit emulsion-based, although the first apparatus can be used to decrease the risk of scorching or damage of the fabric substrate, there is no marked improvement in the speed of the conveyor belt and therefore not the same efficiency obtained.

The second apparatus however, in accordance with the second aspect of the invention, works with equal effectiveness with all types of ink including water-based inks such as that sold under the trade mark TEXISCREEN by Sericol Limited of Parsons Green London.

In the second apparatus the radiation emitting surface 3 includes at one end where the substrate enters the drying zone, first zone,

5 4A which comprises one radiation unit which is arranged to emit infra red radiation predominantly with a wavelength of less than $3.5 \mu\text{m}$, and in the peak absorption rate of the substrate. And a second radiation zone 4B spaced from the first radiation zone 4A in a direction from said one end to the other end, the second radiation zone including two blocks 10 and 11 separated by a gap 12, each unit within the second zone being arranged to emit infra red radiation predominantly of a wavelength greater than $3.5 \mu\text{m}$ and within the peak absorption range of the ink.

15 As is shown in Figure 1C the first radiation zone is of length equal to one ceramic tile. The first block of the second radiation zone is two ceramic tiles in length with the second block 11 being one ceramic tile in length. The first radiation zone 4A is spaced from the second zone by a gap 13 which is equal to 58 mm which is the same length as gap 12 between the two blocks 10 and 11 of the second radiation zone.

20 The second row of ceramic units 14 of the first block of the second radiation zone is thermostated and its temperature is therefore controlled at all times. The row of ceramic elements in the first radiation zone are heated to a temperature of around 540°C which causes them to emit infra red radiation of a wavelength less than $3.5 \mu\text{m}$. This corresponds to the peak absorption range of the fabric substrate which means that as the substrate is passed beneath the first radiation zone the substrate is heated rapidly which therefore heats the inks printed thereon rapidly. The thermostated tile 14 is controlled to be at a temperature of 370°C which means that it emits radiation of wavelength $4.6 \mu\text{m}$. The row of ceramic elements 15 lies in between the thermostated element and the first radiation zone and picks up some of the heat from the hottest tile and so is at a higher temperature of around 35 440°C and it will emit radiation of around $4.1 \mu\text{m}$. The tile

11 has a lower temperature than the thermostated tiles 14 and will be at a temperature of around 350°C which means that they will emit infra red radiation of around 4.8 μm . This arrangement is such that the ink is rapidly heated via the substrate in the first radiation zone and then the temperature rise is arrested by the gap 13 to slow down the rate of the temperature rise. The ceramic elements in the second radiation zone all emit infra red radiation on a wavelength within the peak absorption range of the ink, and so the ink is heated from then on rather than the substrate. This helps to reduce the possibility of heat damage to the fabric substrate. The extra gap 12 also helps slow down the temperature rise and in some cases it is possible to maintain the temperature at a level once it has reached the triggering temperature.

The graph showing the temperature rise within the second apparatus is shown in Figures 4 and 5 and it can be seen that in the second apparatus the inks reach their triggering temperature much quicker than in the apparatus of the prior art or of the first apparatus whilst the temperature is not allowed to go so high as to be able to damage the fabric and/or the ink.

Figure 4 is a graph showing the temperature rise across the length of the infra red radiation surface. The first vertical line 16 represents the length of the radiation surface of the apparatus of the prior art and the heating curve of the ink printed on a substrate being passed through apparatus of the prior art is represented in chain line 17. As can be seen the heating curve is an exponential rise which rises above triggering temperature represented by the horizontal line 18 to start the curing of the ink on the substrate. The temperature then rises in the length of the radiation surface to a higher temperature represented by line 19 where there is an increased risk of fabric degradation. Clearly this is undesirable.

The length of the first apparatus is represented by vertical

line 20 and it can be seen that this is much longer than apparatus of the prior art. The heating curve of the ink as it passes beneath the heating surface of the first apparatus is represented by a chain dotted line 21. As can be seen, the temperature rises first exponentially and then slows down due to the presence of the gap 8 in the radiation surface. The temperature rises to above the triggering temperature 18 but is prevented from rising as high as it did in the apparatus of the prior art.

The length of the second apparatus is represented by vertical line 22 and it can be seen that, although it increases the length of the apparatus of the prior art, it is by no means as long as the first apparatus. The heating curve of an ink passing beneath the radiation surface of the second apparatus is represented by solid line 23. It can be seen that the temperature rise in the second apparatus is initially very steep due to the heat emitted by the first radiation zone so that the heating curve is a steeper rise up to the triggering temperature 18. However the presence of the gaps 13, 12 mean that this rate of rise decreases rapidly to prevent the temperature from reaching the same heights as they do in apparatus of the prior art.

Figure 5 is a similar graph showing the temperature rise over a corrected time base. Lines 18 and 19 again represent the triggering temperature and a non-specific temperature at which fabric degradation may occur. The temperature rise in apparatus of the prior art is represented by curve 24, that of apparatus 1 is represented by line 25 and that of apparatus 2 is represented by line 26.

CLAIMS

1. An ink drying apparatus for drying ink printed on a substrate comprising a conveyor belt (1) on which the printed substrate may be placed, the conveyor belt (1) passing beneath an infra red radiation emitting surface (3) to convey the substrate from one end of the radiation emitting surface (3) to the opposite end of the radiation emitting surface (3), the radiation emitting surface (3) comprising a plurality of discrete radiation units (4), the ink drying apparatus being characterised in that the radiation emitting surface (3) is arranged such that, at said one end of the radiation emitting surface (3) there is situated a bank (7) of radiation units (4) arranged contiguously, the number of radiation units in the bank (7) being sufficient to heat the printed ink to a temperature above its triggering temperature, and adjacent the bank (7) in a direction from said one end to the other a gap (8) of a length sufficient to allow the rate of temperature rise to be slowed down, and adjacent said gap (8) a further radiation unit (9) to maintain the temperature of the ink and substrate.

2. Apparatus according to Claim 1 in which the radiation emitting surface (3) includes at least a second further radiation unit (9) spaced from its adjacent unit by a further gap (8).

3. Apparatus according to Claim 1 or Claim 2 further characterised in that each radiation emitting unit (4) comprises a radiant ceramic tile.

4. Apparatus according to Claims 2 and 3 further characterised in that the bank (7) of the radiation units (4) is three ceramic tiles in length; the gap adjacent the bank is a length equal to the length of the ceramic tile and adjacent the further radiation unit there is a further gap of length equal to the length of a tile and a second radiation unit.

5. Apparatus according to any one of the preceding claims further characterised in that it is adapted to dry plasticised inks.

5 6. Apparatus in accordance with Claim 2 or any one of Claims 3 - 5 when dependant upon Claim 2 in which the total length of all the gaps (8) in the radiation emitting surface (3) is equal to the total length of all the further radiation units (9) separated from the bank (7).

10 7. An ink drying apparatus for drying ink printed on a substrate, comprising a conveyor belt (1) on which the printed substrate may be placed, the conveyor belt (1) passing beneath an infra red radiation emitting surface (3) to convey the substrate from one end of the radiation emitting surface (3) to the opposite end of the radiation emitting surface (3)
15 characterised in that the radiation emitting surface (3) includes at said one end a first radiation zone (4A) comprising at least one radiation unit arranged to emit infra red radiation predominantly with a wavelength of less than $3.5 \mu\text{m}$, and in the peak absorption range of the substrate, and a second radiation zone (4B) spaced from the first radiation zone 4A in
20 a direction from said one end to the other end, the second radiation zone (4B) including at least two discrete radiation units (10 and 11) separated by a gap (12), each unit (10 and 11) within said second zone (4B) being arranged to emit
25 infra red radiation predominantly of a wavelength greater than $3.5 \mu\text{m}$ and within the peak absorption range of the ink.

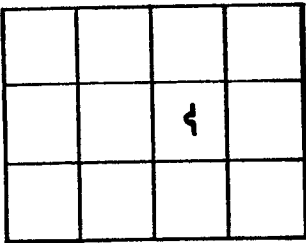
8. Apparatus in accordance with Claim 7 and further characterised in that each radiation emitting unit of the radiation emitting surface (3) comprises a radiant ceramic tile,
30 the ceramic tiles in the first radiation zone being heated to a higher temperature than the temperature to which the tiles of the second radiation zone are heated.

9. Apparatus according to Claim 8, further characterised in that the length of the gap between the first and second

radiation zones is equal to the length of the gap between the two discrete units of the second radiation zone.

10. Apparatus in accordance with any one of the preceding claims further characterised in that the radiation units are ceramic tiles which are mounted in pairs upon stainless steel reflectors which are, in turn, mounted upon supporting rails to allow movement of the tiles along the supporting rails to change the spacing if required.

FIG.1A.



PRIOR ART

FIG.1B.

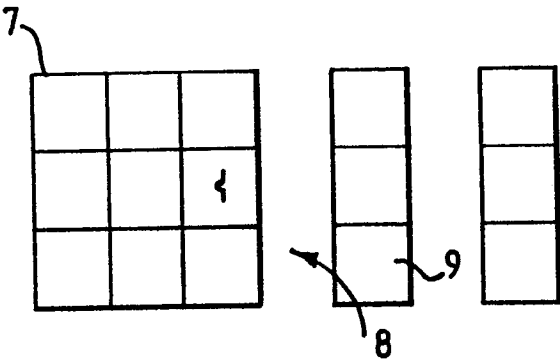
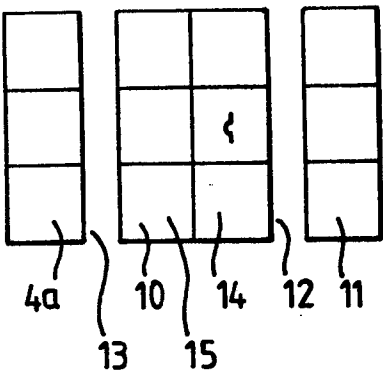


FIG.1C.



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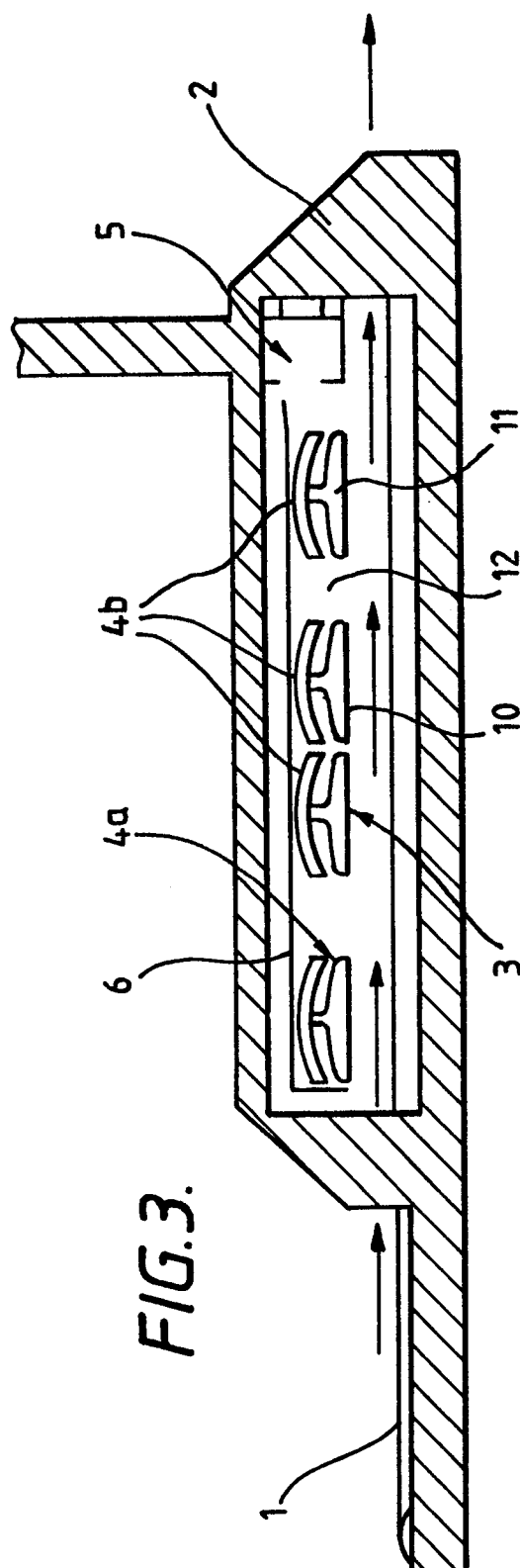
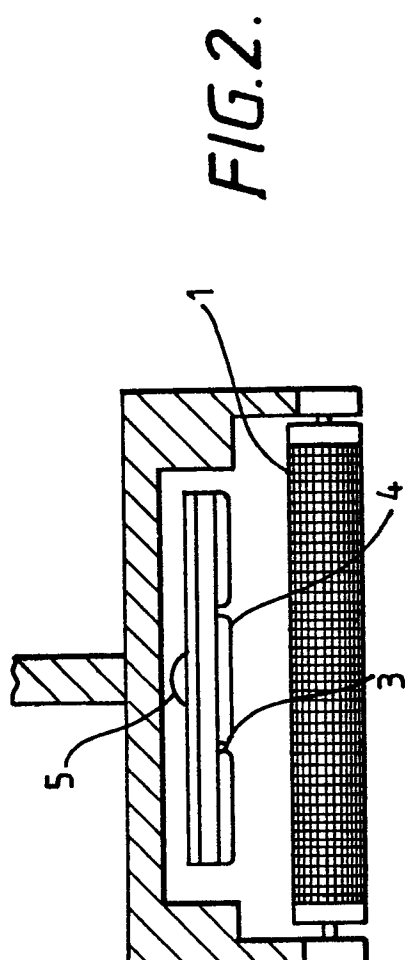


FIG. 4.

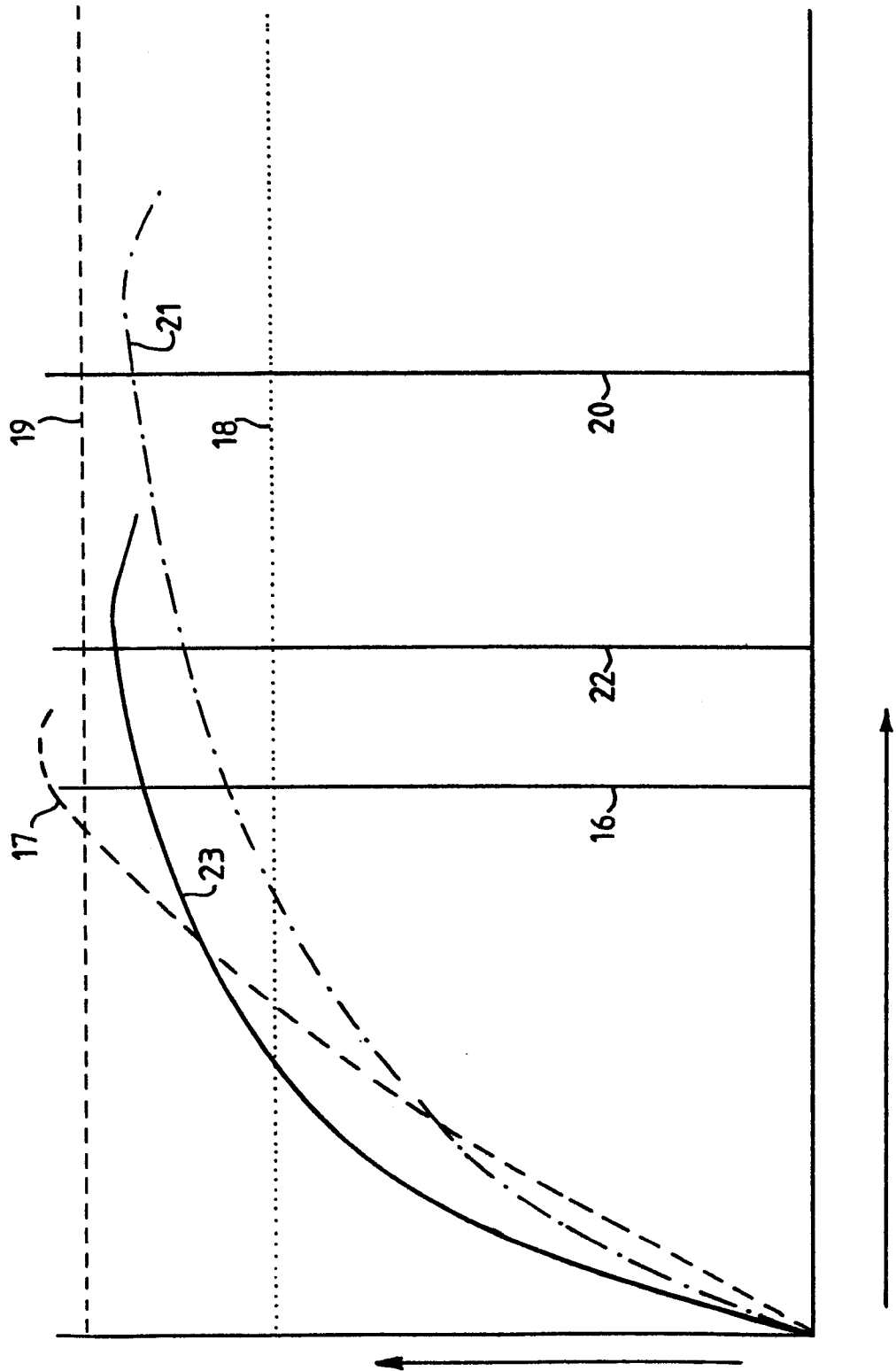
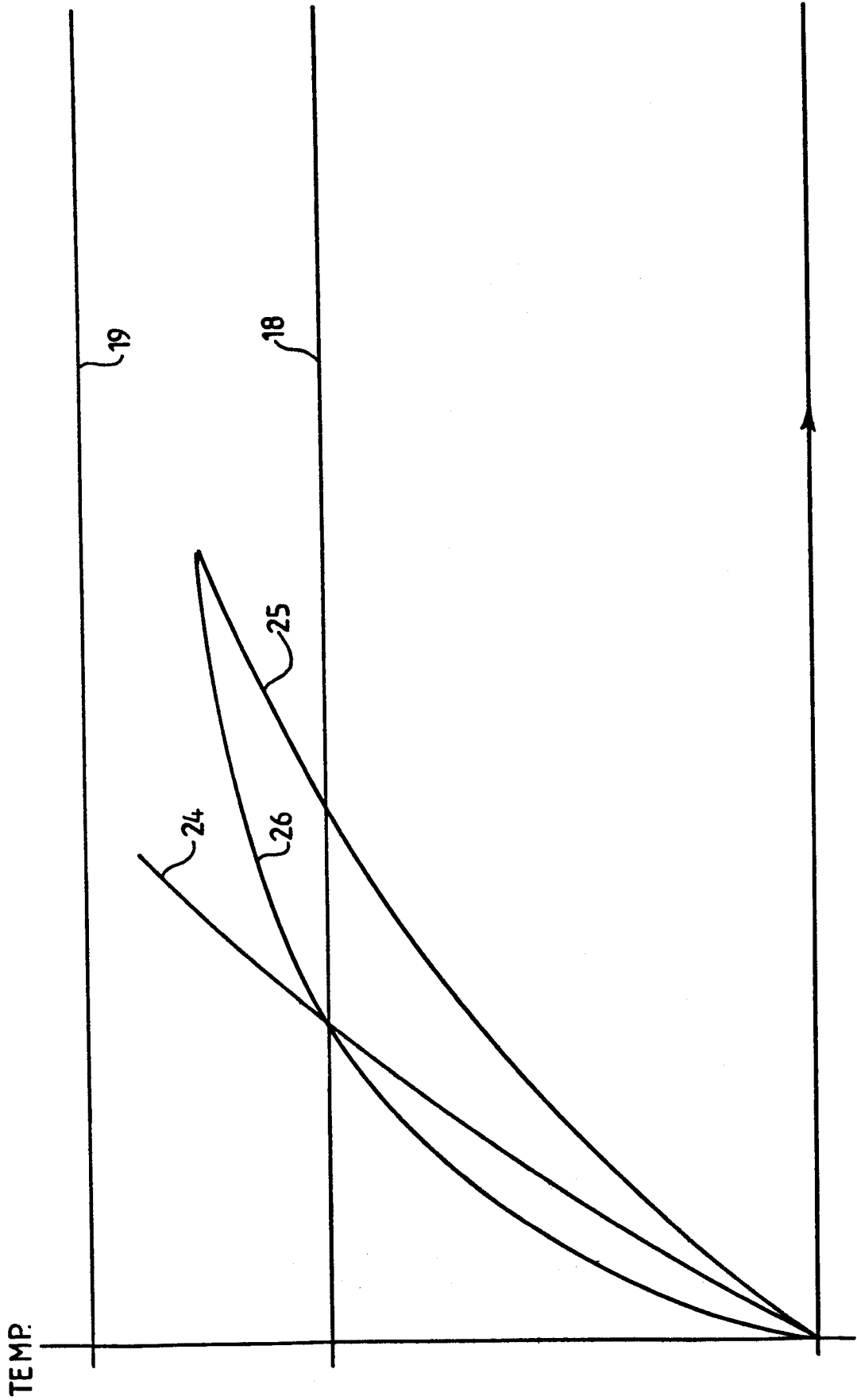


FIG. 5.



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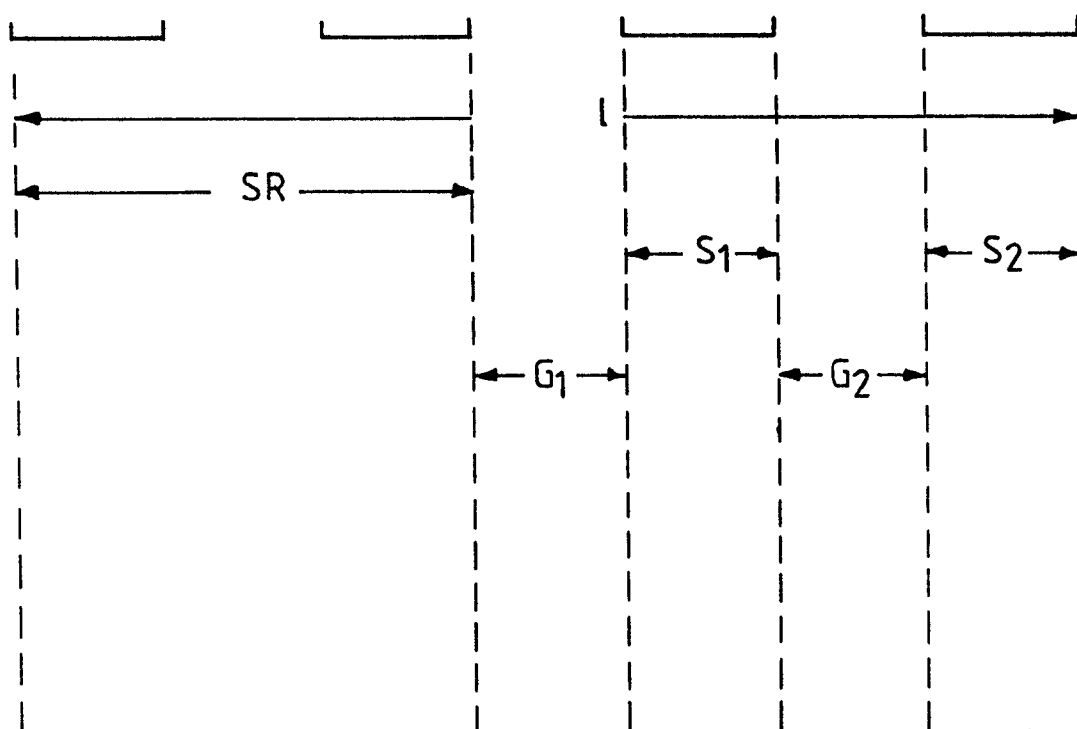


FIG. 6.