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(54) A thermal image-recording apparatus with a dancer roller for controlling the donor ribbon tension.

(57) A thermal image-recording apparatus which comprises a print head (18), a rotatably mounted print drum (14), rotatably mounted supply (31) and take-up spools (32) for a dye-bearing ribbon (17), a first motor (40) for rotating said print drum and a second motor (41) for rotating said take-up spool, and control means for controlling the winding tension of the take-up spool, which comprises a dancer roller (34) at a position between the print head and the take-up spool, and a control circuit (26,45,46) for controlling said second motor (41) in response to the position taken by said dancer roller so that during printing the rotational speed of said second motor (41) is increased as said dancer roller (34) reaches its lowest position, and the rotational speed of said second motor is decreased as said dancer roller reaches its highest position.

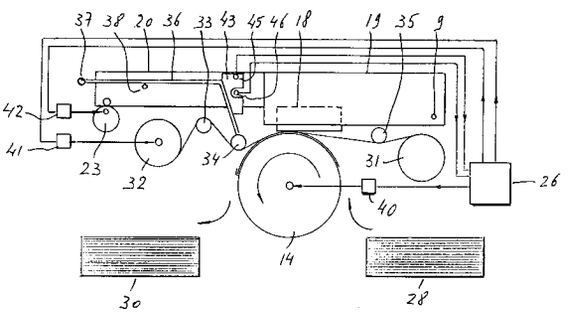

Fig. 5

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BACKGROUND OF THE INVENTION

Field of the invention.

The present invention relates to a thermal image recording apparatus which comprises a thermal print head.

Description of the prior art.

In the thermal printing process, a dye-bearing donor ribbon is brought into contact with a dye-receiving print sheet at a print zone. Thermal printing is effected by contacting the donor ribbon with a multi-element print head which spans the ribbon in a direction transverse to the direction of ribbon travel. The print head typically comprises a linear array of closely spaced resistive heating elements, each being independently dressable by an applied voltage to heat that portion of the donor ribbon directly opposite and thereby cause dye to transfer from the ribbon to the print sheet. To maintain intimate contact between ribbon and print sheet during this printing operation, the donor ribbon and print sheet are partially wrapped over the surface of a rotatably driven print drum. The print drum is usually driven by a precision stepper motor to maintain precise synchronisation between with the printing of information lines on the print media. Most often, the take-up spool is rotatably driven by a far less-expensive DC motor, since its function is simply to accumulate expended donor ribbon. The donor ribbon is supplied by a rotatably mounted supply spool, and a clutching arrangement is used to control the drag on the ribbon by the supply spool so as to prevent free-wheeling of the supply spool under the influence of the take-up spool motor.

In thermal printing apparatus of the above type it has been observed that the print quality is influenced considerably by the tension in the donor ribbon during printing. When ribbon tension varies during printing, an artifact known as "banding" appears in the thermal print. This artifact is particularly noticeable when the nominal donor ribbon tension is high, as is ordinarily the case when the take-up spool has not yet accumulated a significant amount of donor ribbon and, hence, the diameter of the wound-up web spool is small. It is difficult to achieve a relatively constant web tension, especially when relatively low-cost drive motors are used to effect take-up spool rotation. Ribbon tension is also known to vary with the load applied by the print head, and the drag action of the ribbon supply spool. Also, the relative diameters of the supply and take-up spools have a variable effect on ribbon tension. As prints are being made, these spool diameters change, thereby altering the ribbon tension.

It has been proposed to eliminate the variable ribbon-tension-produced artifacts in thermal printing by reducing the tension in the donor ribbon produced by a rotatably driven take-up spool to zero during the printing operation. This technique is disclosed in US-A-5 117 241 and the tensionless condition is achieved by rotating the take-up spool at a rate slower than the rate at which the donor ribbon is paid out from the print zone. To eliminate the ribbon slack which inherently results from rotating the take-up spool at a rate which is insufficient to accumulate the ribbon paid out from the print zone, the take-up spool is rotated at a relatively high rotational rate during the intervals between printing cycles when the thermal print head is spaced from the donor ribbon.

A disadvantage of this technique is the ribbon slack whereby the position of a certain length of ribbon is absolutely uncontrolled what may lead to undesired contact of the ribbon with adjacent parts of the apparatus under the influence of air displacements caused by ventilator means for cooling the print head, of static charges of the ribbon, etc. Also, in the case of jam at a moment a ribbon slack is produced, removal of a cassette containing the supply and take-up spool for the ribbon may cause the ribbon slack to touch the apparatus. It should be pointed out that the ribbon is very thin, in the order of magnitude of 10 micrometer, and that wrinkling of the ribbon or even finger contact can damage the ribbon intolerably. Furthermore, rotation of the take-up spool at a relatively high rate during the invervals to eliminate all ribbon slack between printing cycles requires careful control to avoid overtensioning of the ribbon as it becomes taut.

A further point with ribbon tension is that a high tension is detrimental to the accuracy of coincidence of the distinct part images in colour printing. Since printing causes the donor ribbon to adhere to the print sheet, and since the print sheet itself usually is only fixed at its leading edge to the print drum, it will be understood that pull of the ribbon will endeavour to lift the print sheet from the print drum, resulting in the register accuracy going down. If a small ribbon tension is used registering does not raise problems but, on the contrary, high demands are put on the ribbon winding motor since it must be capable to operate at small torques. A D.C. motor is inherently unsuited for operation at small torques so that more expensive motor types have to be envisaged.

SUMMARY OF THE INVENTION

Object of the invention

An object of this invention is to eliminate the variable ribbon-tension-produced artifacts in prints produced by thermal printing apparatus of the above described type. More in particular, the invention aims to provide a ribbon tension control that maintains the ribbon tension exerted by the take-up spool uniform through the printing cycle, and this without the use of high-cost drive motors.

Statement of the invention

In accordance with the present invention, a thermal image-recording apparatus which comprises a print head, a rotatably mounted print drum, rotatably mounted supply and take-up spools for a dye-bearing donor ribbon, first motor means for rotating said print drum and second motor means for rotating said take-up spool, and means for controlling the winding tension of the take-up spool, is characterised thereby that said winding tension controlling means comprises dancer roller means at a position between the print head and the take-up spool, and means for controlling said second motor means in response to the position taken by said dancer roller means to that during printing the rotational speed of said second motor means is increased as said dancer roller means reaches its lowest position and the rotational speed of said second motor means is decreased as said dancer roller means reaches its highest position.

The term "dancer roller means" stands for one or a plurality of vertically displaceable idler rollers about which the dye-bearing ribbon is angularly wrapped and which are lifted by the longitudinal tension of the ribbon. The downwardly acting force of said roller(s) stems from gravity, from spring means biasing said rollers, or the like.

According to a suitable embodiment of the invention, the rotational speed of said second motor means is reduced to zero as said dancer roller means has reached its highest operative position. This allows the use of an ordinary low-cost one-speed D.C. motor for said second motor.

The term "operative positions" for the dancer roller means stands for all those positions of the dancer roller means which still cause a noticeable angular wrapping of the donor ribbon about the print drum, thereby to perform thermal printing under optimal circumstances.

The dancer roller means may suitably be formed by an idler roller supported between two arms that are pivotable about an axis parallel to that of the print drum and bearing a member the position of which is detectable by two vertically spaced stationary sensors.

According to a preferred embodiment of the invention, the print head is arranged for pivotation towards and away from the print drum, and said dancer roller means has means whereby it is mechanically coupled with the mechanism controlling the position of said print head so that displacement of the print head away from the print drum entails automatically the displacement of said dancer roller means from its operative into its inoperative position.

The term "inoperative position" of the dancer roller stands for a position which is so high that a ribbon tensioned in a straight path over a guide roller downstream of said dancer roller means and a guide roller determining the path of the ribbon towards the print drum does no longer touch the periphery of the drum. This is important for the free movement of the ribbon as a next colour patch is advanced between two successive printing operations, and for the print drum to take a start position for a next printing cycle.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described hereinafter by way of example with reference to the accompanying drawings wherein :

- Fig. 1 is a diagrammatic representation of one embodiment of a thermal image recording apparatus according to the present invention, the print head being in the operative position and a dancer roller taking its lowest position,
- Fig. 2 shows the apparatus according to Fig. 1, the dancer roller taking its highest position,
- Fig. 3 shows the apparatus according to Figs. 1 and 2 with the print head in the inoperative position,
- Fig. 4 shows the apparatus according to Figs. 1 to 3 with the lid opened, and
- Fig. 5 shows the electric control of the apparatus.

Detailed description of the invention.

Figs. 1 to 4 show a diagrammatic representation of one embodiment of a thermal image-recording apparatus according to the present invention.

The apparatus is mounted in a housing having a base 11 and a lid 12 hinged to the base at 13, and generally comprises a cylindrical print drum 14 which functions to support and transport a print-receiver sheet 15 through a print zone 16 where it receives thermally printed information.

Thermal printing is effected by advancing a dye-bearing donor ribbon 17 through the print zone between the print-receiver sheet 15 and a thermal print head 18.

The print head is shown in broken lines and is mounted in a subhousing 19 mounted in lid 12 pivotably about a pin 9. The subhousing has two arms 20 spaced in parallel, which are interconnected by a rod 21. Rod 21 rests on a cam 23 mounted on shaft 24 equally mounted with its driving motor (not shown) in lid 12. Rotation of the cam brings the print head from its print position in which it presses against the print drum and the media therebetween (see Fig. 1), into a non-printing position in which the print head is spaced from the print drum (see Fig. 3).

More details about the mounting of print head in subhousing 19 can be found in our co-pending application no. .... entitled : "Thermal image recording apparatus with detent means for holding a print head", filed on even day herewith, whereas details about the cooling of the print head can be found in our co-pending application no. ... entitled "A thermal image recording apparatus", also filed on even day herewith.

The details of both subjects are not relevant for the understanding of the present embodiment of the invention, and therefore no further details are given about these subjects.

Print head 18 spans the print drum and comprises a linear array 25 (see Fig. 4) of closely spaced resistive elements, each being independently addressable with image information by an applied voltage supplied by a microprocessor 26. As each resistive element is addressed, it heats that portion of the donor web directly opposite, thereby causing dye to transfer from the donor ribbon to the print-receiver sheet. In colour thermal printers, the donor web usually comprises patches of cyan, yellow and magenta dyes in a repeating series, and the print-receiving sheet is rotated three times through the print zone to receive a full-colour image. The print receiver sheets are fed to the drum from a sheet supply 28 and are clamped to the drum by a suitable clamping mechanism 29. Upon receiving the thermal image, the clamping mechanism releases the print-receiver sheet allowing it to enter an output tray 30, which has been illustrated within the housing but which may be located in front of the apparatus as well. Print drum 14 is rotatably driven by a precision stepper motor, which in turn is controlled by microprocessor 26. The microprocessor also functions to control the position of the subhousing via cam 23 so as to move printing head 18 to its non-printing position to allow passage of the clamping mechanism through the print zone.

The dye-bearing donor ribbon 17 is fed from a supply spool 31 to a take-up spool 32 driven by a suitable motor. Both spools can be fitted in a disposable cassette for ease of handling, as known in the art.

Fig. 4 shows the apparatus with lid 12 opened. In this position the printing head is brought into its non-printing position by appropriate rotation of cam 23. This figure also shows that ribbon guide rollers 34 and 35 controlling the path of the dye-donor ribbon move together with lid 12, whereas guide roller 33 remains in the base part. In practice, roller 33 makes part of the cassette, which houses spools 31 and 32.

Roller 34 is in fact a dancer roller, which is supported between two laterally spaced angled arms 36 fixed to shaft 37, which is pivotable in lid 12.

Arms 36 are located within the arms 20 of subhousing 19 and lean in their lowest position on a rod 38 interconnecting arms 20. The bias produced by roller 34 on the ribbon stems from its own mass only, there being not provided spring means or the like for increasing the bias of said roller.

The purpose of dancer roller 34 is to control the tension of ribbon 17 downstream of the printing zone 16 as will be described hereinafter with reference to Fig. 5.

Referring to Fig. 5, print drum 14 is driven by a precision stepper motor 40 which in turn is controlled by the output of microprocessor 26.

Rotation of take-up spool 32 is effected by a low cost D.C. motor 41, whereas the position of cam 23 is controlled by a motor 42, both motors being connected to the output of microprocessor 26.

One of arms 36 carries a flag 43 with a slotlike opening capable of setting free optical sensors 45, resp. 46 each comprising a light emitter and a light sensor between which the flag can move. The output of the both sensors is fed to the input of microprocessor 26.

The printing operation of a given image starts with the apparatus in a position as shown in Fig. 1. During printing, the donor ribbon is advanced through the printing zone by movement of the print drum and by the frictional engagement between said ribbon and the moving print-receiver sheet clamped to the drum. Movement of the donor ribbon is assisted by a small tension on the ribbon produced by dancer roller 34. This tension is produced by the fact that the peripheral velocity of spool 32 is slightly higher than that of drum 14 so that immediately after the start of a printing cycle, represented by the Fig. 1 situation, dancer roller 34 will become slowly but continuously lifted. After some time, which may vary between 1 and a plurality of seconds, dancer roller has come to a position as shown in Fig. 2 whereby flag 43 fitted to its arm 36 uncovers sensor 45. The signal of 45 makes controller 26 to stop the rotation of motor 41. Printing still continues but since spool 39 no

longer takes-up, dancer roller 34 progressively lowers. Sensor 45 becomes covered again by the flag but motor 41 is kept de-energised until sensor 44 is uncovered whereby rotation of spool 32 is re-started. Since the diameter of spool 32 increases as ribbon is being wound up, the periods of rising and lowering of the dancer roller become shorter but this does not influence in any way the satisfactory operation of the system.

As soon as printing is completed, motor 42 is controlled by microprocessor 26 to rotate cam 23 to the position shown in Fig. 3 whereby print head 18 is removed from the print drum. The upward displacement of rod 38 causes arms 31 to become correspondingly pivoted whereby dancer roller 34 is swung out of the path of the ribbon. A short activation of motor 41 causes the ribbon to become taut over the distance separating rollers 33 and 35 so that the ribbon comes free from the print drum and the print-receiver sheet clamped thereon.

Motor 40 is now energised to rotate print drum 14 into its initial position, clamp 29 being free to pass unhindered below the print head, and motor 41 causes spool 32 to rotate to pull the ribbon until an appropriate mark on a margin of the ribbon signals the correct position of the next colour patch of the ribbon for printing the next part image on the receiver sheet. The operation is repeated once more for the third colour patch after which clamp 29 is opened and sheet 15 becomes ejected in tray 30.

It was noted that dancer roller 34 produced a remarkable satisfactory control of the ribbon tension during printing. The up- and downward movements of this roller did not alter the tension on the ribbon and the final print was completely free from the artifacts known in the art and described hereinbefore. Occasional ribbon jam or any other defect necessitating opening of the lid did not cause any problem as to the ribbon, whether such opening had to occur during a printing cycle or after a finished printing cycle.

The invention is not limited to the described embodiment.

Measurement of the position of the dancer roller can also occur by means of capacitive or inductive sensors, or the like.

The dancer roller may be spring-biased or loaded by extra masses if higher ribbon tensions are desired.

The displacement of the dancer roller into its inoperative position can also occur by a separate motor under the control of microprocessor 26.

The supply and take-up rolls for the dye-donor ribbon need not be arranged in a disposable cassette, but can also be supported in a dedicated cassette or frame which is loaded by the operator with dye ribbon outside of the apparatus. Suchlike arrangement is disclosed in EP application N° 92 203 247.9 entitled "A dye ribbon package for use with a thermal printer and a method of loading the reloadable cassette of a thermal printer with a dye ribbon from a dye ribbon package", filed 22.10.92.

Claims

1. A thermal image- recording apparatus which comprises a print head (18), a rotatably mounted print drum (14), rotatably mounted supply (31) and take-up spools (32) for a dye-bearing ribbon (17), first motor means (40) for rotating said print drum and second motor means (41) for rotating said take-up spool, and means for controlling the winding tension of the take-up spool, characterised in that said winding tension controlling means comprises dancer roller means (34) at a position between the print head and the take-up spool, and means (43, 45, 46) for controlling said second motor means in response to the position taken by said dancer roller means so that during printing the rotational speed of said second motor means is increased as said dancer roller means reaches its lowest position and the rotational speed of said second motor means is decreased as said dancer roller means reaches its highest position.

2. A thermal image-recording apparatus according to claim 1, wherein the rotational speed of said second motor means (41) is reduced to zero as said dancer roller means (34) has reached its highest operative position.

3. A thermal image-recording apparatus according to claims 1 or 2, wherein said second motor (41) is a one-speed D.C. motor.

4. A thermal image-recording apparatus according to claim 1, wherein said dancer roller means is formed by an idler roller (34) supported between two arms (36) that are pivotable about an axis (37) parallel to that of the print drum.

5. A thermal image-recording apparatus according to claim 4, which comprises two bodily spaced stationary sensors (45, 46) and a member (43) mounted on the dancer roller mechanism, the vertical position of which member being detectable by said sensors.

6. A thermal image-recording apparatus according to claim 5, wherein said member is a flag and said sensors are optical sensors.

7. A thermal image-recording apparatus according to any of claims 1 to 6, wherein said print head (18) is arranged for pivotation towards and away from the print drum (14), and wherein said dancer roller means (38) has means whereby it is mechanically coupled with the mechanism (20) controlling the position of said print head so that displacement of the print head away from the print drum entails automatically the displacement of said dancer roller means from its operative into its inoperative position.

8. A thermal image-recording apparatus according to any of claims 1 to 7, wherein said supply and take-up spools are mounted in a reloadable cassette.

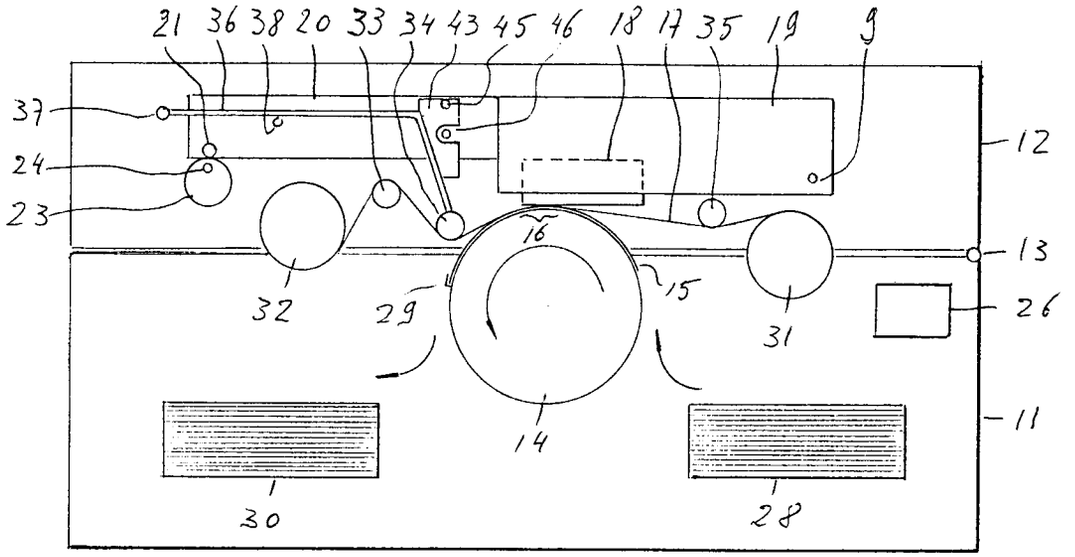
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Fig. 1

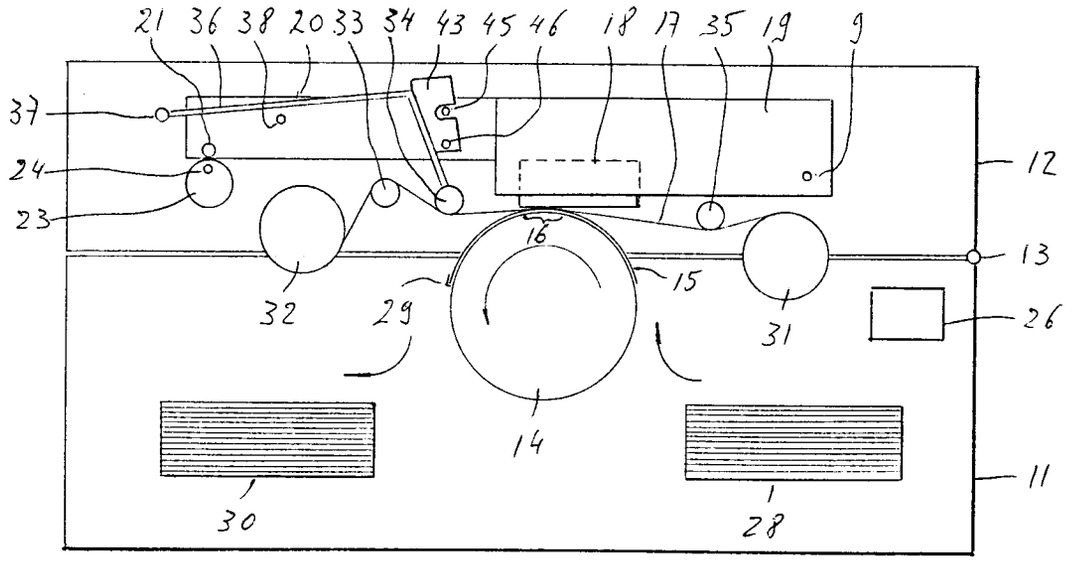
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Fig. 2

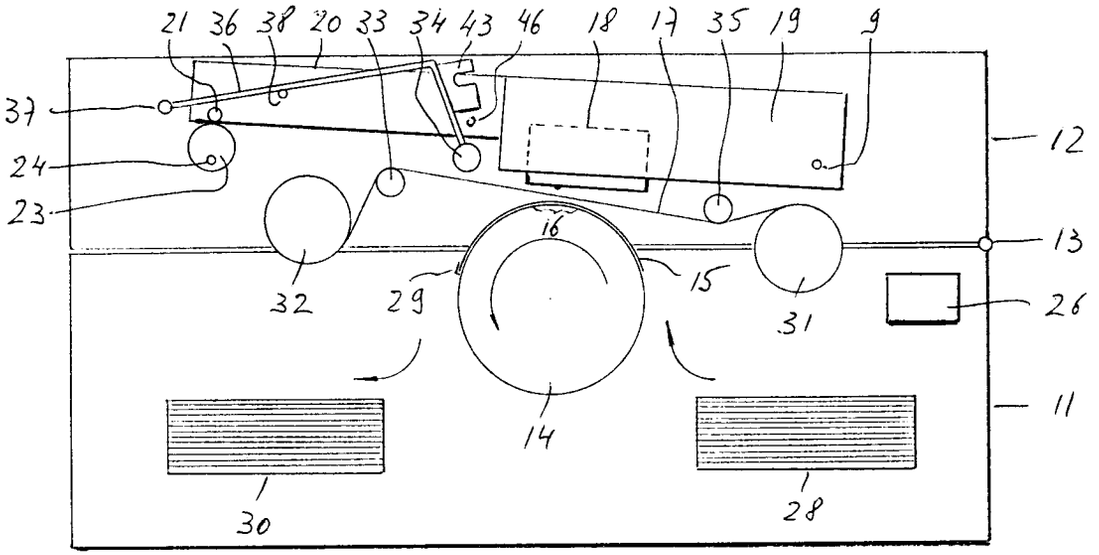
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Fig. 3

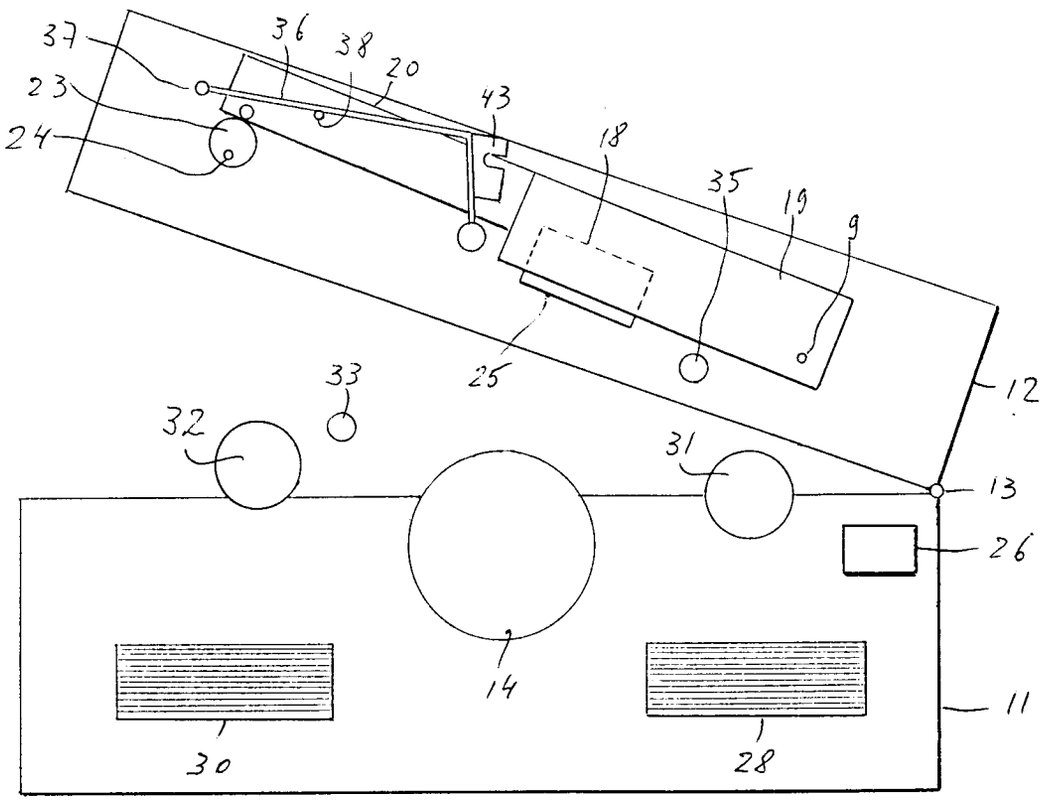
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Fig. 4

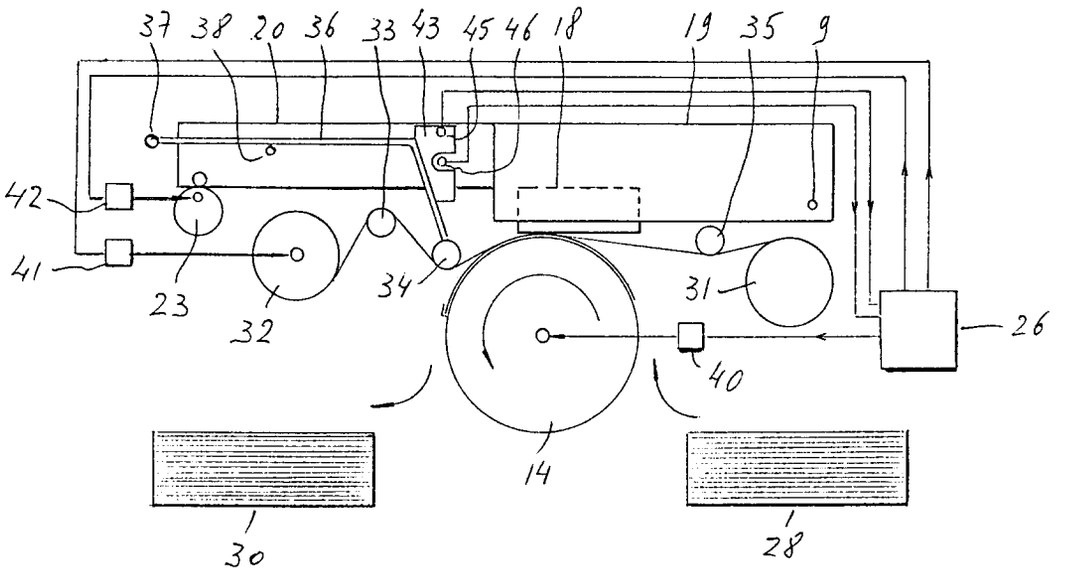

Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 92 20 3893

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,Y	US-A-5 117 241 (STEPHENSON) * the whole document * ---	1-8	B41J17/24
Y	US-A-4 464 916 (GREW ET AL..) * the whole document * ---	1-8	
A	EP-A-0 086 661 (K.K. TOSHIBA) * page 10, paragraph 1 * ---	5,6	
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 222 (M-712)(3069) 24 June 1988 & JP-A-63 19 274 (HITACHI LTD) 27 January 1988 * abstract * -----	7	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B41J
B65H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 AUGUST 1993	JOOSTING T.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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