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(54) Thermal dye diffusion printer and method for its use

(57) The printer comprises drive means, including a variable speed drive motor (18), for passing a dye carrier (12) and a receiver material (11) adjacent a print head (16). Heating energy is fed to the print head (16) in response to image data to transfer a dye image to the receiver material (11). In a standard quality operating mode the drive motor (18) is driven at a relatively high speed and in at least one premium quality operating mode the drive motor (18) is driven at a relatively slow speed. Automatic change-over means (41) switch the printer between the operating modes. The quality of the printed image is at a desired level according to the prevailing circumstances. The necessary adjustments which need to be made to the printer by the operator in order to change operating modes are minimised.

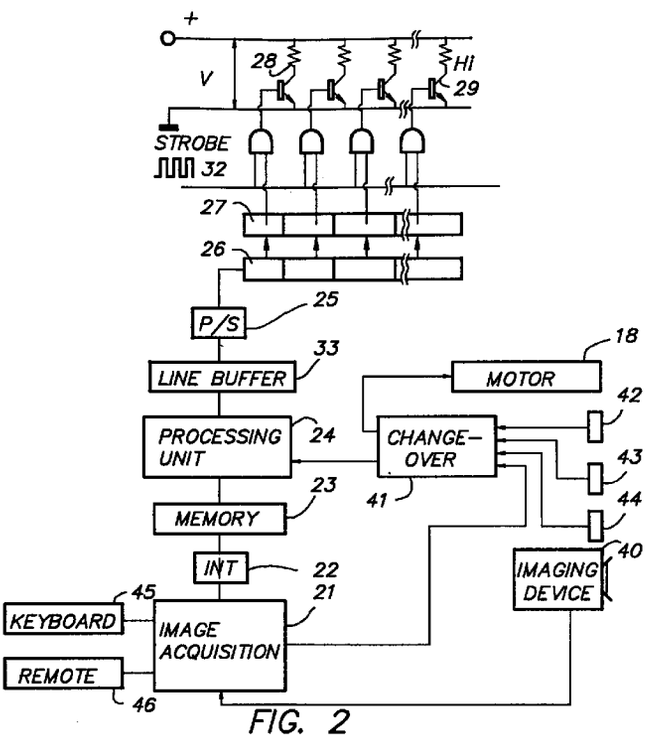

FIG. 2

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Description

Field of the invention

The present invention relates to a thermal dye diffusion printer and to a method of operating such a printer. In particular, this invention relates to a method of representing an image of the human body obtained during medical imaging and most particularly to a printer intended for printing medical image picture data received from a medical imaging device.

Background of the invention

Thermal dye diffusion printing, also known as sublimation printing, uses a dye transfer process in which a carrier containing a dye is disposed between a receiver material, such as a transparent material or paper, in sheet or web form, and a print head formed of a plurality of individual heat producing elements. The receiver material is mounted on a rotatable drum. The carrier and the receiver material are generally moved relative to the print head which is fixed. When a particular heating element is energised, it is heated and causes dye to transfer, e.g. by diffusion or sublimation, from the carrier to an image pixel (or picture element") in the receiver material. The density of the printed dye is a function of the temperature of the heating element and time the carrier is heated. In other words, the heat delivered from the heating element to the carrier causes dye to transfer to the receiver material to make thereon an image related to the amount of heat.

Thermal dye transfer printing apparatus offer the advantage of true "continuous tone" dye density transfer. By varying the heat applied by each heating element to the carrier, a variable density image pixel is formed in the receiver material.

It may be desirable to modify the conditions under which the printer operates, for example to change from a standard quality operating mode to a higher or premium quality operating mode. For example, in the premium quality mode one or more of the following changes may be desirable:

(a) an increase in D_{max} while D_{min} remains constant, i.e. an enlarged dynamic density range;

(b) a greater number of perceptible density levels in the final print; and

(c) fewer image errors (e.g. contouring).

It is a disadvantage of the thermal dye diffusion printers known in the art that the quality of the printed image may not be as high as may be desired in certain circumstances and also that most such printers cannot easily be modified to change operating mode, or if such modifications are possible they must be made by the operator.

Summary of the invention

It is an object of the present invention to provide a thermal dye diffusion printer in which the quality of the printed image is at a desired level according to the prevailing circumstances and also in which, in order to modify the conditions under which an image is printed, the necessary adjustments which need to be made to the printer by the operator are minimised.

We have now discovered that this object can be achieved by the provision of automatic change-over means for switching the printer between operating modes.

According to a first aspect of the invention there is provided a thermal dye diffusion printer comprising: a print head; control means for receiving image data; drive means for passing a dye carrier and a receiver material adjacent the print head, the drive means including a variable speed drive motor; and heating energy feed means for feeding heating energy to the print head in response to the image data to transfer a dye image to the receiver material, the heating energy and the speed of the drive motor being controlled in accordance with a predetermined print quality, wherein the printer is capable of operating in at least two modes, including a standard quality operating mode in which the drive motor is driven at a relatively high speed and at least one premium quality operating mode in which the drive motor is driven at a relatively slow speed, characterised by automatic change-over means for switching the printer between operating modes.

According to another aspect of the invention there is provided a method of operating a thermal dye diffusion printer comprising: passing a dye carrier and a receiver material adjacent a print head, with the dye carrier between the print head and the receiver material, by means of a variable speed drive motor; feeding heating energy to the print head in accordance with image data to transfer a dye image to the receiver material; and controlling the heating energy and the speed of the drive motor in accordance with the predetermined print quality, characterised by automatically switching the printer between at least two operating modes including a standard quality operating mode in which the drive motor is driven at a relatively high speed and a premium quality operating mode in which the drive motor is driven at a relatively slow speed.

The print head used in the printer according to the invention may take a number of different forms.

Thus, the print head may comprise a thermal print head for image-wise heating the dye carrier, comprising individually energisable juxtaposed heating elements. Thermal print heads that can be used to transfer dye from dye carriers to a receiving material sheet are commercially available and include the Fujitsu Head FTP-040 MCS001, the TDK Thermal Head F415 HH7-1089 and the Rohm Thermal Head KE 2008-F3.

Other possible embodiments of the print head include those based on laser technology or based on resistive ribbon technology.

A laser induced dye thermal transfer apparatus is described in European patent specification EP-A-0343443 (Agfa-Gevaert NV).

In resistive ribbon technology, a support member of the dye carrier is an electrically resistive ribbon which consists for example of a multi-layered structure of a carbon-loaded polycarbonate coated with a thin aluminium film. Current is injected into the resistive ribbon by electrically addressing one of a plurality of print head electrodes, thus resulting in highly localised heating of the ribbon beneath the relevant electrode.

Although line-type printing heads having a one dimensional array have been referred to here, the present invention can also make use of two dimensionally arranged printing head arrays.

The present invention is equally applicable to thermal wax printing.

In one embodiment of the invention, the automatic changeover means operates in response to predetermined quality signals included in the image data fed to the printer. The method according to this embodiment of the invention thus preferably includes automatically switching between the operating modes in response to these predetermined quality signals. The predetermined quality signals may be included in the data fed to the printer in a number of ways, for example (i) within the image data (i.e. part of the "bit-map" and read, for example by optical character recognition or (ii) aside from the image data in a so-called "header". Examples of such data may included the type of medical apparatus involved, the name of the operator or specialist, the name of the patient and the patient's medical history.

Thermal imaging can be used for production of both transparencies and reflection-type prints. In the hard copy field, recording materials based on an opaque, usually white, base are used, whereas in the medical diagnostic field monochrome, usually black, images on a transparent base find wide application, since such prints can conveniently be viewed by means of a light box.

In an alternative embodiment, the printer may further comprise a sensor for generating a signal indicative of the nature of the dye carrier, wherein the automatic change-over means operates in response to the dye carrier nature signals. The method according to this embodiment of the invention thus preferably further comprises automatically switching between the operating modes in response to the dye carrier nature signals. For example, this sensor may be capable of distinguishing between a dye carrier carrying monochrome (e.g. black) dye and a dye carrier carrying a plurality of coloured dyes. A suitable sensor for this purpose is a high efficiency light emitting diode such as Wustlich type WU-SHR-37C or WU-SY-37C or a photodiode such as Siemens type BPX 90.

In a further alternative embodiment, the printer may further comprise a sensor for generating a signal indicative of the type of the receiver material, wherein the automatic change-over means operates in response to the receiver material type signals. The method according to this embodiment of the invention thus preferably further comprises automatically switching between the operating modes in response to the receiver material type signals. A suitable sensor for this purpose is a so-called slotted optical switch such as Sharp type GP 1A 17.

In a still further alternative embodiment, the printer may further comprise a sensor for generating a signal indicative of the quality of the printed image, wherein the automatic change-over means operates in response to the printed image quality signals. The method according to this embodiment of the invention thus preferably further comprises automatically switching between the operating modes in response to the printed image quality signals. The calibration of this control may involve the making and examination of a test print. A suitable sensor for this purpose is an opto-electronic sensor with a high dynamic range such as Texas Instruments type TLS 230.

The image data may be in the form of medical image picture data received from a medical imaging device, especially a scanning medical image camera. The image data may include additional data alpha/numeric data, Such additional data alpha/numeric data may, for example, be related to the subject of the medical image picture. Alternatively or additionally, such additional data alpha/numeric data may, for example, be indicative of technical information related to conditions under which the medical image picture was taken. Ultrasound doppler technology provides colour images for which a lower density print may be more appropriate, whereas in computer thermographic imaging and in magnetic resonance imaging generally black and white images of high density are preferred. The additional alpha/numeric data included in the image data, may relate to these requirements. The method according to the invention preferably includes automatically switching between the operating modes in response to predetermined quality signals included in this additional data.

Preferred embodiments of the invention

The invention will now be further described, purely by way of example, by reference to the accompanying drawings in which:

Figure 1 schematically shows the basic functions of a thermal diffusion printer;

Figure 2 shows an electronic circuit for use with the printer generally illustrated in Figure 1; and

Figure 3 shows the current pulses applied to a single heating element of the circuit shown in Figure 2.

Referring to Figure 1, the printer is capable of printing a line of pixels at a time on a receiver material or acceptor member 11 from dyes transferred from a carrier or dye-donor element 12. The receiver material 11 is in the form of a sheet while the carrier 12 is in the form of a web fed from a supply roller 13 onto a take-up roller 14. The receiver material 11 is held against a rotatable drum or platen 15, driven by a drive mechanism which includes a variable speed stepper drive motor 18, which advances the drum 15 and the receiver material sheet 11 past a stationary print head 16. The print head 16 presses the carrier 12 against the receiver material 11. The print head 16 includes a plurality of heating elements 28, for example equal in number to the number of pixels in the image data in a line memory. The image-wise heating of the carrier is performed on a line by line basis, with the heating resistors geometrically juxtaposed each along another and with gradual construction of the output density as described, for example, in European Patent Application 91201608.6 (Agfa-Gevaert). Each of the resistors is capable of being energised by heating pulses, the energy of which is controlled in accordance with the required density of the corresponding picture element. As the image input data values increase, the output energy increases and so the optical density of the hardcopy image 17 on the receiving sheet 11 increases. On the other hand as the image input data values fall, the output energy falls and so the optical density of the hardcopy image 17 on the receiving sheet 11 decreases.

The supply roller 13 and the take-up roller 14 are also driven by the variable speed motor 18 via a slipping coupling mechanism (not shown). In an alternative embodiment, the supply roll 13 is not driven, but is freely rotatably mounted and is provided with a braking mechanism to maintain a predetermined tension in the web of the carrier 12.

The activation of the heating elements in this embodiment of the invention is executed pulse-wise by digital electronics as explained further below with reference to Figure 2.

The printer is capable of operating in at least two modes, including a standard quality operating mode in which the drive motor 18 is driven at a relatively high speed and a premium quality operating mode in which the drive motor 18 is driven at a relatively slow speed.

A carrier sensor 42 positioned adjacent the carrier material path generates a signal indicative of the nature of the dye carrier 12. The sensor 42 is capable of distinguishing between a dye carrier carrying only black dye and a carrier carrying a plurality of coloured dyes.

A further sensor 43, positioned adjacent the receiver material path, upstream of the print head 16, generates a signal indicative of the type of the receiver material 11.

A still further sensor 44, positioned adjacent the receiver material path, downstream of the print head 16, generates a signal indicative of the quality of the printed image.

Referring to Figure 2, the different processing steps up to the activation of the heating elements are illustrated. First a digital signal representation is obtained in an image acquisition apparatus 21, for example from an X-ray camera 40. The image data includes not only picture data, but also additional alpha/numeric data related to the subject of the X-ray picture and indicative of technical information related to conditions under which the X-ray picture was taken, this additional data being supplied from a keyboard 45 or a remote control device 46. The image acquisition apparatus 21 serves to separate out picture data from the alpha/numeric data contained in the image data, such as by optical character recognition (often indicated by "OCR") of the alpha/numeric data.

Then, the picture data signal is applied via a digital interface 22 and a first storage means (MEMORY) 23 to a data processor 24, which assigns a pulse width and number and the heating energy applied to a given heating element 28. After processing, the digital image signals are fed via a line buffer 33 to a parallel to serial converter 25 of which an advantageous embodiment is disclosed in European Patent Application 91201608.6 (referred to above) to produce a stream of serial data of bits representing the next line of data to be printed which is passed to a second storage means in the form of a shift register 26. Thereafter, under controlled conditions, these data bits are supplied in parallel to the associated inputs of a latch register 27. Once the bits of data from the shift register 26 are stored in the latch register 27, another line of bits can be subsequently clocked into the shift register 26.

The upper terminals 30 of the heating elements 28 are connected to a positive voltage source V, while the lower terminals 31 of the heating elements are respectively connected to the collectors of drive transistors 29, whose emitters are grounded. These transistors 29 are selectively turned on by a high state signal, indicated as an ANDed STROBE signal supplied on line 32 applied to the bases of the transistors 29 to allow energy to flow through the associated heating elements 28.

In this way a thermal sublimation hardcopy 17 of the electrical image data is recorded.

Automatic change-over means 41, mainly comprising a dedicated software program in addition to the above mentioned sensors and user preferences, are provided for switching the printer between the operating modes.

The change-over means 41 receives signals from the carrier sensor 42, the receiving material sensor 43 and the output sensor 44 indicative of the nature of the dye carrier 12, the nature of the receiving material 11 and the quality of the printed image respectively. The change-over means 41 also receives alpha/numeric data separated from the image signal by the image

acquisition apparatus 21. The change-over means 41 operates in response to predetermined quality signals included in the image data, the dye carrier nature signal from the sensor 42, the receiver material type from the sensor 43 and the printed image quality signals from the sensor 44, to adjust the speed of the variable speed motor 18 and to change the criteria applied by the processing unit 24, in particular to change one or more of pulse width, pulse number and heating energy.

The heating energy and the speed of the drive motor 18 is thereby controlled in accordance with the predetermined print quality.

In a preferred embodiment according to European Patent Application 92203816.1 (Agfa-Gevaert NV) the activation of the heating elements in executed pulsewise in a manner referred to as "duty cycled pulsing", which is illustrated in the accompanying Figure 3, showing the current pulses applied to a single heating element (reference 28 in Figure 2).

The repetition strobe period (t_s) consists of one heating cycle (t_{son}) and one cooling cycle (t_s - t_{son}) as indicated in Figure 3. The strobe pulse width (t_{son}) is the time during which an enable strobe signal is on. The strobe duty cycle of a heating element is the ratio of the pulse width (t_{son}) to the repetition strobe period (t_s).

Supposing that the maximum number of obtainable density values attains N levels, the line time (t_l) is divided by the number (N) of strobe pulses each with a repetition strobe period t_s as indicated in Figure 3. In the case of for example 1024 density values, according to a 10 bits format of the corresponding electrical image signal values, the maximum diffusion time would be reached after 1024 sequential strobe periods.

Claims

1. A thermal dye diffusion printer comprising:
   a print head (16); control means (21) for receiving image data; drive means for passing a dye carrier (12) and a receiver material (11) adjacent said print head (16), said drive means including a variable speed drive motor (18); and heating energy feed means (24, 33, 25) for feeding heating energy to said print head (16) in response to said image data to transfer a dye image to said receiver material (11), said heating energy and the speed of said drive motor (18) being controlled in accordance with a predetermined print quality,
   wherein said printer is capable of operating in at least two modes, including a standard quality operating mode in which said drive motor (18) is driven at a relatively high speed and at least one premium quality operating mode in which said drive motor (18) is driven at a relatively slow speed, characterised by automatic changeover means (41) for switching said printer between said operating modes.

2. A printer according to claim 1, wherein said automatic change-over means (41) operates in response to signals included in said image data.

3. A printer according to claim 1, further comprising a sensor (42) for generating a signal indicative of the nature of said dye carrier (12), wherein said automatic change-over means (41) operates in response to said dye carrier nature signal.

4. A printer according to claim 3, wherein said sensor (42) is capable of distinguishing between a dye carrier carrying monochrome dye and a dye carrier carrying a plurality of coloured dyes.

5. A printer according to claim 1, further comprising a sensor (43) for generating a signal indicative of the type of said receiver material (11), wherein said automatic change-over means (41) operates in response to said printed receiver material (11) type signals.

6. A printer according to claim 1, further comprising a sensor (44) for generating a signal indicative of the quality of said printed image, wherein said automatic change-over means (41) operates in response to said printed image quality signals.

7. A printer according to any preceding claim, wherein said printer head comprises a plurality of individually energisable printing elements.

8. A printer according to claim 7, wherein said printer head is a thermal printer head.

9. A printer according to claim 7, wherein said printer head is based on resistive ribbon technology.

10. A printer according to any one of claims 1 to 6, wherein said printer head is selected from printer heads based on induced thermal transfer technology.

11. A printer according to any one of claims 1 to 6, wherein said printer head is selected from printer heads based on laser technology.

12. A method of operating a thermal dye diffusion printer comprising: passing a dye carrier (12) and a receiver material (11) adjacent a print head (16), with said dye carrier (12) between said print head (16) and said receiver material (11), by means of a variable speed drive motor (18); feeding heating energy to said print head (16) in accordance with image data to transfer a dye image to said receiver material (11); and controlling said heating energy and the speed of said drive motor (18) in accordance with predetermined print quality, characterised by automatically switching said printer

between at least two operating modes including a standard quality operating mode in which said drive motor (18) is driven at a relatively high speed and a premium quality operating mode in which said drive motor (18) is driven at a relatively slow speed.

13. A method according to claim 12, including automatically switching between said operating modes in response to predetermined quality signals included in said image data.

14. A method according to claim 12, further comprising generating a signal indicative of said nature of said dye carrier (12) and automatically switching between said operating modes in response to said dye carrier (12) nature signals.

15. A method according to claim 14, wherein said dye carrier nature signals distinguish between a dye carrier carrying monochrome dye and a dye carrier carrying a plurality of coloured dyes.

16. A method according claim 14, further comprising generating a signal indicative of said quality of said printed image and automatically switching between said operating modes in response to said quality signals.

17. A method according to claim 14, which is a medical imaging method, wherein said image data is in said form of medical image picture data received from a medical image camera (40).

18. A method according to claim 17, wherein said image data includes additional alpha/numeric data related to said subject of said medical image picture.

19. A method according to claim 17 or 18, wherein said image data includes additional alpha/numeric data indicative of technical information related to conditions under which said medical image picture was taken.

20. A method according to claim 18 or 19, including automatically switching between said operating modes in response to predetermined quality signals included in said additional data.

21. A method according to any one of claims 17 to 20, in which said medical image picture data comprises X-ray picture data received from an X-ray camera.

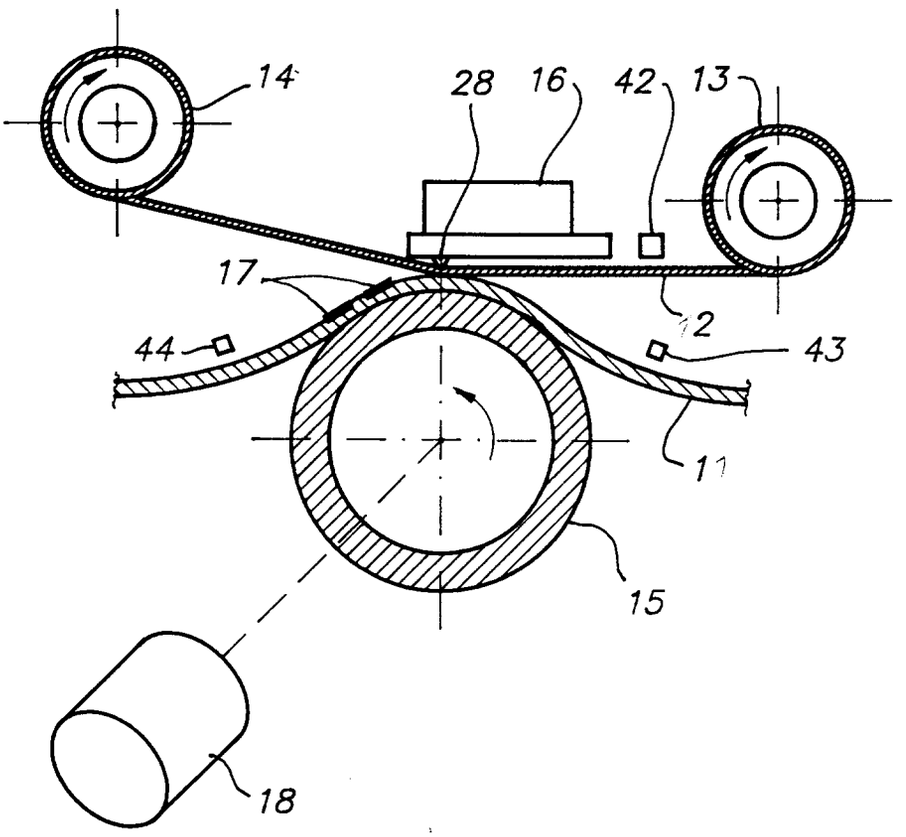
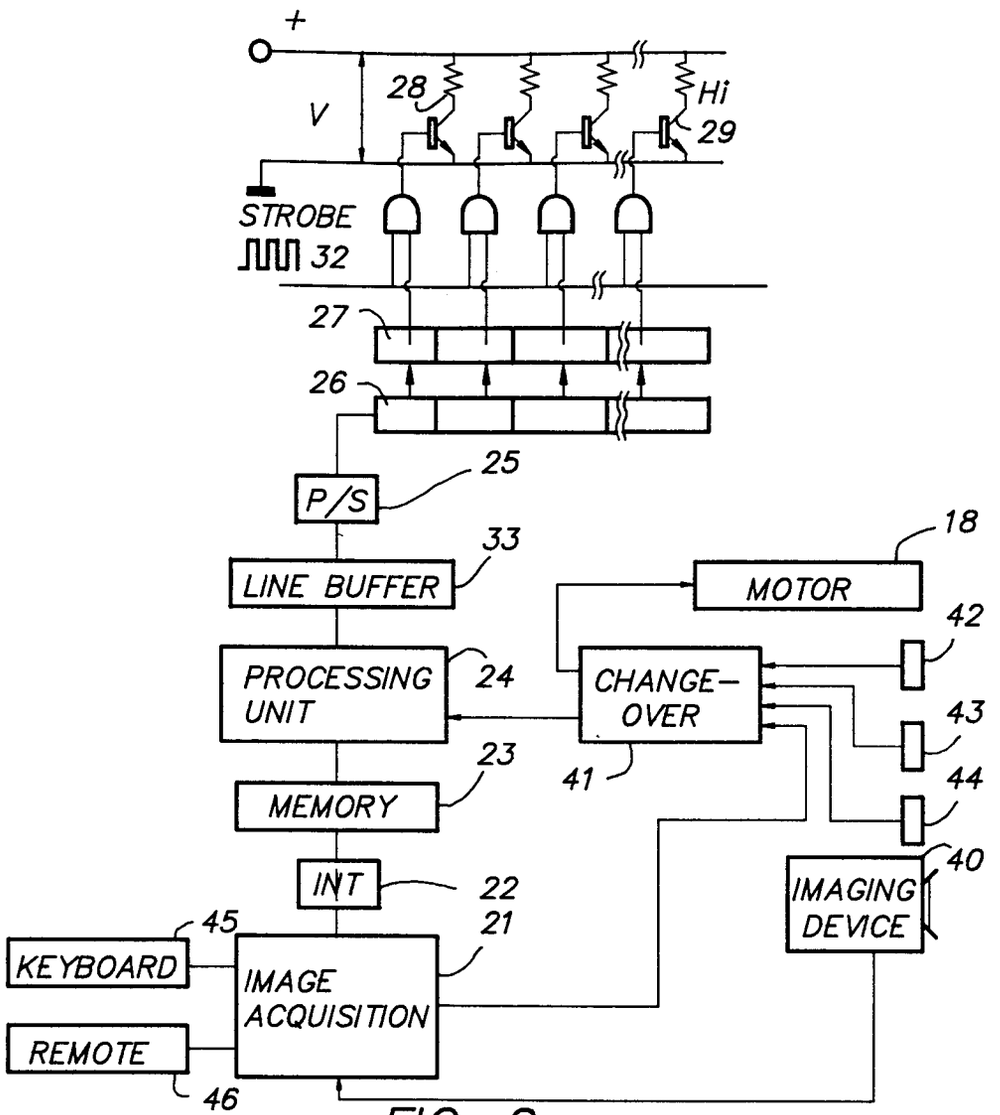


FIG. 1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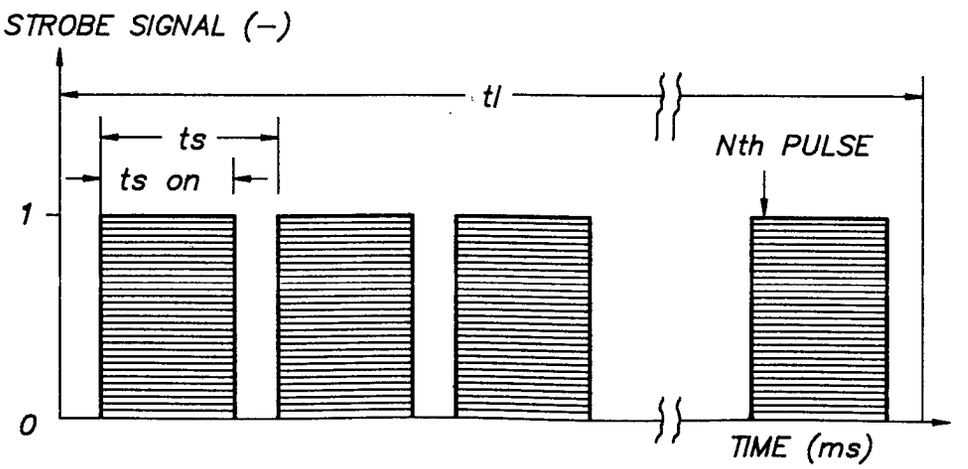
P/S
33
LINE BUFFER
18
MOTOR
42
PROCESSING UNIT
24
CHANGE-OVER
43
41
23
MEMORY
44
INT
22
40
IMAGING DEVICE
45
21
KEYBOARD
IMAGE ACQUISITION
REMOTE
46

FIG. 2


STROBE SIGNAL (–)
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Nth PULSE
1
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TIME (ms)

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 20 0236

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.6)
Y	EP-A-0 517 625 (EASTMAN KODAK COMPANY) * column 2, line 45 - line 55 * * column 5, line 51 - column 7, line 40; figure 1 *	1,2,7,8, 12,13	B41J2/325
Y	US-A-4 528 572 (SASAKI ET AL.) * column 1, line 19 - line 37 * * column 1, line 59 - column 4, line 41; figures 1-8 *	1,2,7,8, 12,13	
A	US-A-4 578 689 (SPENCER ET AL.) * column 2, line 3 - line 28 * * column 15, line 40 - column 16, line 19; figures 6A-6B *	1,11,12	
A	US-A-4 667 208 (SHIRAKI ET AL.) * column 2, line 13 - line 29 * * column 4, line 1 - line 48; figures 1-5 *	1,10,12	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	EP-A-0 257 633 (HITACHI, LTD.) * page 2, line 39 - line 51 * * column 11, line 15 - line 44; figure 10 *	1,12	B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 June 1995	Rivero, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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