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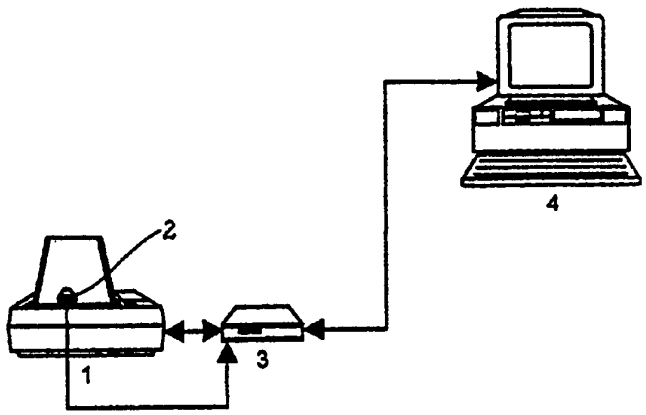

1 INKJET PRINTER
2 CCD IMAGE SENSOR
3 ADD-ON CIRCUIT BOX
4 HOST COMPUTER

(57) Abstract

By exchanging the print head cartridge of an inkjet (bubble jet) printer (1) with a CCD image sensor (2), an apparatus capable of scanning and digitising optical images - the reverse process of printing - is provided. While a document is fed into the printer (1), the printer (1) is commanded to "print" by a host computer (4), passing the print head platform which holds the CCD image sensor (2) across the document horizontally and feeding the document vertically. As the CCD image sensor (2) is scanning the document, images on the document are digitised and fed to the host computer (4). The CCD image sensor (2) and its support circuitry are in a similar housing as the print head cartridge, making it easily exchangeable. The printer (1) recovers its normal function when the print head cartridge is put back.

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SCANNER

The present invention relates to image scanners of the type which scan an image and convert it to a form which may be inputted to a computer. More particularly, the invention relates to a scanner which uses a known printer carriage to transport the scanning device.

It is known to use printer carriages to transport scanner devices, however, these devices only provide a line by line scan and thus are slow compared to dedicated scanners and provide reduced resolution. Further with dot matrix and daisy wheel printers, the actual printing mechanism is incorporated into the printer carriage as only the ribbon need be readily replaceable. This leads to complexity when disabling or replacing the printer mechanism so that the printer may act as a scanner as well as difficulty in mounting the scanning device.

According to the present invention, there is provided a scanning apparatus for use with a computer comprising:

an ink jet printer having a print head platform laterally displaceable relative to a paperfeed mechanism carrying an image bearing medium;

said printer including a cartridge mounting means for mounting interchangeably an ink jet printer cartridge or a scanning array cartridge;

said scanning array cartridge including a scanner array for sequentially converting portions of the image bearing medium into digital signals;

logic circuitry interconnecting the scanning array, an I/O port of a computer and an I/O port of said printer;

said logic circuitry responsive to signals from said computer and said printer to produce control signals to cause said print head platform to scan said image bearing medium and to couple digital signals produced by said scanning array to said computer through said computer I/O port.

The present invention uses an inkjet printer with a changeable print head cartridge instead of a dot matrix (impact) printer with a print head having actuatable pins and a ribbon. The image sensor can be housed in a module similar to the inkjet head and can face the document in a similar manner to the print head. The image sensor can also be inserted and removed with ease, in the same fashion as the replaceable print head module.

The present invention uses a CCD image array scanning device which, typically, can sample 128 dots at a time, making it much faster and more accurate than known systems which use a single optical sensor. For example, to scan 128 lines, a single sensor has to make 128 passes, making it extremely slow. The scanner of the present invention needs to make only one pass. The

vertical resolution of the known system is restricted to the smallest line feed the printer can make, whereas the scanner of the present invention has no such restriction.

The present invention does not use the "Strobe" signal from the printer to trigger the sampling process, thus it can have higher horizontal resolution than the printer. When the "Strobe" signal is used to trigger each sampling operation, the scanner can only have horizontal resolution as high as the printer.

One form of the present invention uses the printer port of the host computer as both the interface for the printer and the scanner, making it more economical and still useful even when the host computer (such as a portable computer) cannot accommodate any more add-on cards.

The present invention also provides the ability to do colour scanning.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a pictorial representation of the configuration of the present invention;

Figure 2 shows a circuit block diagram of the present invention;

Figure 3 shows a circuit block diagram of an alternate embodiment of the present invention;

Figure 4 shows a flow chart of the operation

sequence of mono scanning;

Figure 5 shows a flow chart of the operation sequence of colour scanning;

Figure 6 shows a diagram of an optical system of the CCD image sensor (90 degree); and

Figure 7 shows a diagram of further embodiment of the optical system of the CCD image sensor (parallel).

One form of the current invention is an add-on device for an inkjet printer as shown in Figure 1. The printer 1 can be used as an image scanner for a host computer 4 when the add-on circuit box 3 is plugged into the printer port 11 of the printer and the printer cable is plugged into the other end of the add-on box 3. A printer port 41 of the host computer 4 is connected with the printer cable. The print head cartridge is replaced by a CCD image sensor 2 having a similar housing to the print cartridge. The CCD image sensor 2 is connected to the add-on box 3 by a flexible cable (not shown). The cable is arranged so that it will not obstruct the movement of the print head platform.

Another implementation of the present invention is to house the circuitry for scanning inside the printer 1. Extra contacts and wirings are provided on the print head platform for the CCD image sensor inserted.

In operation, the document to be scanned is first fed to the printer 1. Then the host computer 4 sends

carriage movement commands to the printer. The printer starts "printing" although nothing is printed because there is no print head. When the printer moves its print head platform from one end to the other, a synchronisation signal from the print head platform is intercepted and fed to the scanner circuit 3. Once the host computer 4 detects this signal, it sends a command through the printer port 41 to the scanner control circuit 34, telling it to sample. The sampled image signal of analogue form is coupled to an amplifier 31 and then to a A/D converter 32. Brightness and contrast can be adjusted at this stage. The digitised image is then sent to the host computer 4 via the printer port 41.

For black and white or greyscale scanning, each pass is followed by one line feed. The light source 22 remains the same during the whole process.

For colour scanning, three passes are needed for every line feed, red, green and blue light sources are used, one for each of the three passes.

In one particular embodiment, in order to save adding an interface card to the host computer (PC) 4, the printer port 41 is used to input the digitised image data to the PC as well as to control the printer 1. The scanner box 3 sits between the PC printer port 41 and the printer 1. One output line of the printer port (from the PC's point of view) - the least useful one - is nominated to set the scanner box 3 to "scan

mode" or "print mode". In print mode, the scanner box bypasses all the active signals using electronic switch 35 so that the PC can send commands to the printer as usual. In scan mode, the printer is isolated from the printer port using switch 35, the input and output lines being used by the scanner to receive commands and to send data to the PC.

Interfacing

The widest input register in an IBM PC printer port (or compatible) is 5-bit. To read each 8-bit image data from the scanner to the host PC, two input operations are needed. The speed of this input process must catch up with the scanning process because the printer moves its print head platform at a set speed. In other words, all the data generated by the A/D converter 32 must be transferred to the computer during each pass unless a buffer is implemented in the scanner.

One solution to transfer an 8-bit number through the 5-bit input register is described as follows. For an 8-bit number of XXXXYYYY, the higher nibble XXXX is shifted 4 times to the right and "1" is added to the 5th bit, making one 5-bit number 1XXXX. Another 5-bit number 0YYYY is made of the lower nibble YYYY and an "0" being set to the 5th bit. These 5-bit numbers are presented to the input port, first the "1" leaders then the "0" leaders, one after the other. The PC running

the scanner driver program reads all these 5-bit numbers into a memory buffer, separates the higher nibbles and the lower nibbles according to the 5th bit ("0" or "1"), and reconstructs the 8-bit numbers to be stored as the image data. The scanner presents each 5-bit number to the input port in a period of time that is slightly greater than a read cycle of the PC so that all 5-bit numbers can be read in, although some redundant numbers are also read.

The redundant numbers can be filtered out by checking the 5th bit. For example, there can be a sequence of numbers as "1TTTT, 0UUUU, 1VVVV, 1WWWW, 1YYYY, 0ZZZZ", after decoding and filtering input data of "TTTTUUUU, VVVVXXXX, YYYYZZZZ" will be obtained.

Although the normal interfacing method such as handshaking can be used, the one described above has been found faster. The reason is that, for hand-shaking, several slow I/O operations are needed for each 5-bit compared to the 1 to 2 operations needed for each 5-bit in the described method. The overhead of filtering is minute due to the fast nature of mathematic operations.

Referring to Figure 3, a second interfacing method which may be used employs a memory buffer 36 of size m*n, where n is the number of elements of the CCD imaging array, and m is the maximum number of horizontal pixels. For each pass, data of m*n pixels is generated and stored in the memory buffer 36.

Because the memory buffer 36 is located in the circuit box 3, the speed of this storing process can easily be matched to the speed of the scanning process. Data in the buffer 36 is transferred to the host computer 4 using conventional methods (e.g. handshaking) via the printer port 41 during the scanning period and during the carriage return. The reason a slower interfacing method may be used is that more time is allowed to transfer the m*n pixel data. In fact, there is no time constraint at all.

A third interfacing method which may be used for 1-bit depth scanning is to shift four bits to a nibble before transferring it to the host computer. That way one I/O operation can transfer four pixels.

For serial printers, computers with a parallel port can still interface to the scanner while communicating with the printer using the serial port. When there is no conventional parallel printer port on the host computer, another interface port such as the SCSI port, bidirectional printer port or PCMCIA slot may be used. Higher interfacing speed can be achieved through these ports as they normally provide 8 bit or wider transfer ability.

Synchronisation

The scanning process must synchronise with the movement of the print head platform as it holds the CCD

image sensor 21. The position of the print head platform has to be known by the scanner circuitry 3 and the host PC 4.

First, the host computer 4 sends commands to the printer 1, asking it to print continuously from left to right. After the printer 1 has moved its print head platform to the beginning position, it sends high voltage pulses through to the print head platform. These pulses are normally sent to the print head cartridge to eject ink, but in the scanning mode the print head is removed, so nothing is printed. Instead, the first few pulses are intercepted by the scanner circuitry 3 and sent to the host computer 4. The host computer 4, knowing the position of the print head platform, starts the scanning process. As the constant speed of the print head platform is known by the host computer 4, it can calculate the position of each digitised pixel and stop scanning when the print head platform reaches to the end of a scan pass. The carriage is returned. For colour scanning, the light source 22 is changed twice and the above process repeated twice. If the CCD imaging array 21 has n elements, and it samples m times in one pass, this pass will scan an area of m*n pixels.

After m*n pixels are sent to the host computer 4, the printer 1 will do a line feed of n pixels high. The above scanning process is repeated for another m*n area.

Reducing from 128 to <128 pixels

A CCD imaging array 21 has a fixed number of elements n, for example 128. If m is the number of horizontal pixels to achieve a certain resolution, m*n pixels will have to be sent to the host computer 4 for each pass. Without buffering, this has to be done within the time of a one-way pass of the print head platform. For a fast printer/slow computer combination, this is impossible. The solution is to reduce the number of vertical pixels per pass to k, with k<=n, so that m*k pixels can be sent to the host computer 4 during the pass. k is calculated and set by the host computer 4 after obtaining the speed of the printer 1 and the host computer 4.

It is known that for an n-element CCD imaging array 21, n+d readout clock pulses must be applied in a 1-line readout period (d is the number of dummy elements). In the preferred embodiment of the present invention, two clock speeds are used, one normal, one very fast. For each 1-line readout, the clock pulse of normal speed is fed k times, followed by n+d-k times of fast clock pulse. k is adjusted so that m times of 1-line readout can be accomplished with one pass.

CCD Image Sensor

One form of the image sensor is made up of a reduction type CCD imaging array 21, a lens 23 and a lamp 22. As shown in Figure 6, the axial lamp 22 provides a uniform light source. The lens 23 and the CCD array 21 are arranged to construct a reduction focusing system, forming the image of the document irradiated by the light source 22 on the CCD sensing element surface.

In the situation where the optical system cannot be placed vertically to the surface of the document due to the structure of the print head platform, a mirror 24 can be used to change the focusing direction as shown in Figure 7.

In the case of colour scanning, three light sources of blue, red and green are used.

Other kinds of light source 22 can be light emitting diode (LED) and fluorescent lamp.

A contact type sensor can also be used. One pass colour scanning can be achieved when using a contact type sensor with colour filters built in.

It will be appreciated that further embodiments and exemplifications of the invention are possible without departing from the spirit or scope of the invention described.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A scanning apparatus for use with a computer comprising:

an ink jet printer having a print head platform laterally displaceable relative to a paperfeed mechanism carrying an image bearing medium;

said printer including a cartridge mounting means for mounting interchangeably an ink jet printer cartridge or a scanning array cartridge;

said scanning array cartridge including a scanner array for sequentially converting portions of the image bearing medium into digital signals;

logic circuitry interconnecting the scanning array, an I/O port of said computer and an I/O port of said printer;

said logic circuitry responsive to signals from said computer and said printer to produce control signals to cause said print head platform to scan said image bearing medium and to couple digital signals produced by said scanning array to said computer through said computer I/O port.

2. A scanning apparatus according to claim wherein said logic circuitry is responsive to a signal indicative of movement of said print head platform to commence scanning of said image bearing medium.

3. A scanning apparatus according to claim 1 or claim 2 wherein said digital signals comprise a series of 8-bit words and said words are divided by said logic

circuitry into a first 5 bit portion containing a control character and the four higher order bits of said 8-bit word and a second 5 bit portion containing a further control character and the four lower order bits of said 8-bit word, said first and second portions of each 8-bit word being sent sequentially to said I/O port of the computer, said computer responsive to said control characters to reform the two 5 bit portions into said eight bit word.

4. A scanning apparatus according to claim 1 or claim 2 including memory buffer means located between said scanner array and said I/O port of the computer, said memory buffer means being m*n bits in size, where n is the number of elements of the scanner array and m is the maximum number of horizontal pixels to be scanned, data representing of m*nth pixel of said image bearing medium being stored in a corresponding bit location in said memory buffer means.

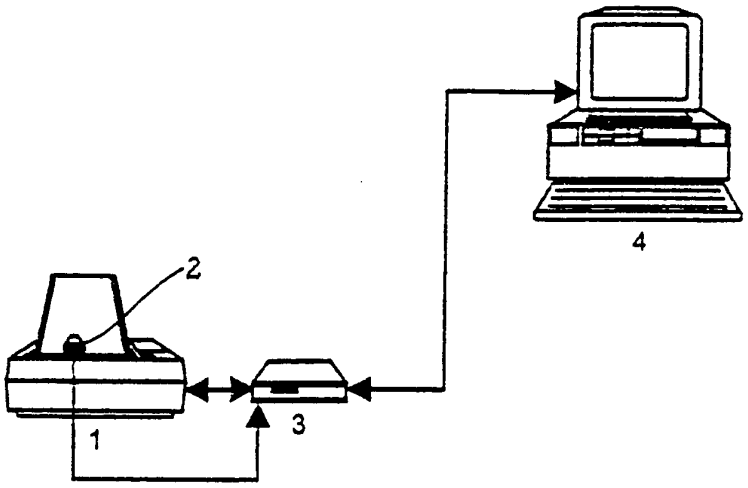
5. A scanning apparatus according to any one of the preceding claims wherein said scanner array is a charge coupled device.

6. A scanning apparatus according to any one of the preceding claims including a switch means selectively operable to bypass said logic circuitry and connect said printer I/O port directly to said computer I/O port.

7. A scanning apparatus according to any one of the preceding claims further including a light source to illuminate said portion of the image bearing medium.

8. A scanning apparatus according to any one of claims 1 to 6 for colour scanning including red, green and blue light sources operable to sequentially illuminate said portion of the image bearing medium and said print head platform being operable in response to control signals from said logic circuitry to scan said portion of the image bearing portion sequentially during illumination by each of said red, green and blue light sources.

9. A scanning apparatus substantially as hereinbefore described with reference to Figures 1 and 2 or Figures 1 and 3 of the accompanying drawings.



1 INKJET PRINTER
2 CCD IMAGE SENSOR
3 ADD-ON CIRCUIT BOX
4 HOST COMPUTER

FIGURE 1

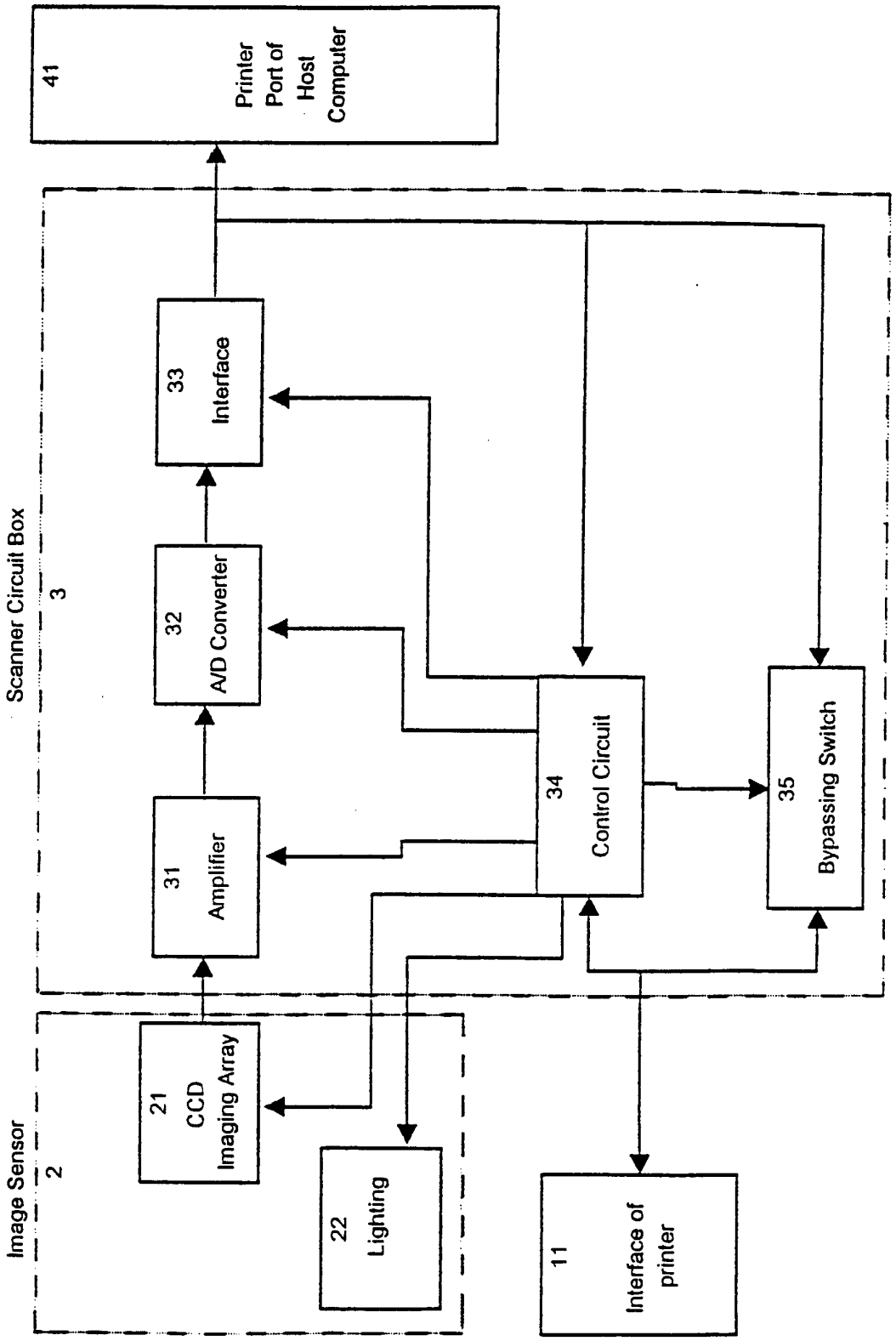

41
Printer Port of Host Computer
Scanner Circuit Box
3
33
Interface
32
A/D Converter
31
Amplifier
34
Control Circuit
35
Bypassing Switch
Image Sensor
2
21
CCD Imaging Array
22
Lighting
11
Interface of printer

FIGURE 2

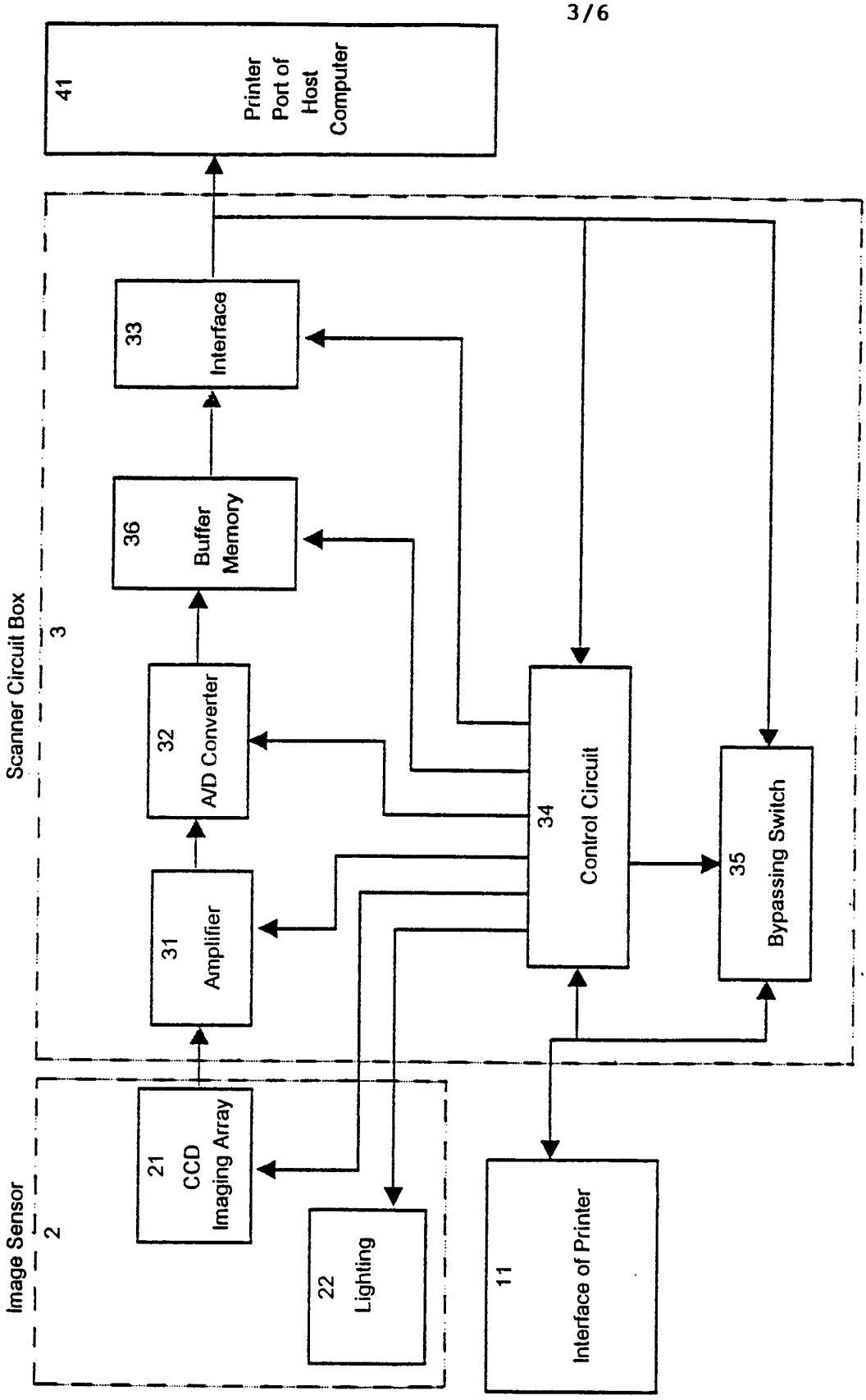

41
Printer Port of Host Computer
Scanner Circuit Box
3
33
Interface
36
Buffer Memory
32
A/D Converter
31
Amplifier
34
Control Circuit
35
Bypassing Switch
Image Sensor
2
21
CCD Imaging Array
22
Lighting
11
Interface of Printer

FIGURE 3

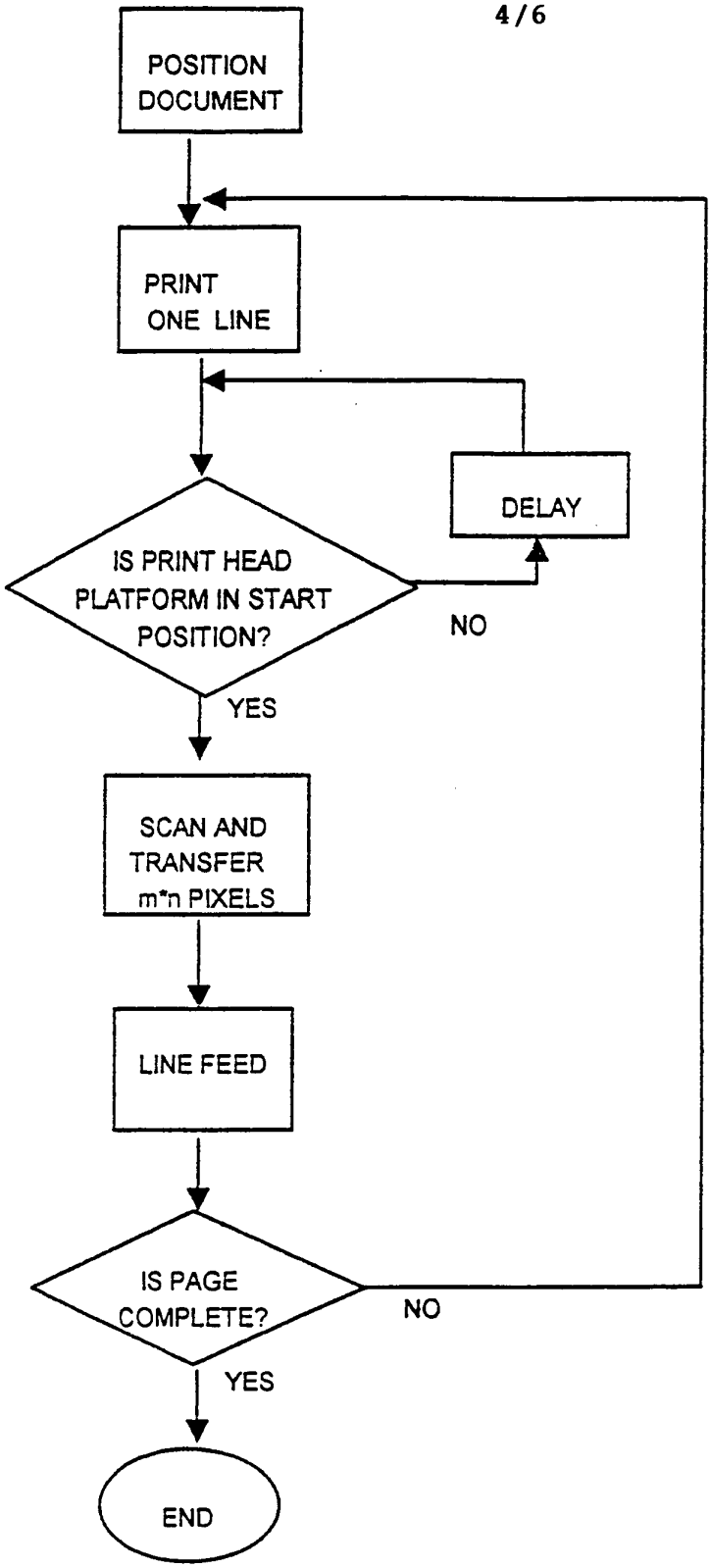

POSITION DOCUMENT
PRINT ONE LINE
DELAY
IS PRINT HEAD PLATFORM IN START POSITION?
NO
YES
SCAN AND TRANSFER m*n PIXELS
LINE FEED
IS PAGE COMPLETE?
NO
YES
END

FIGURE 4

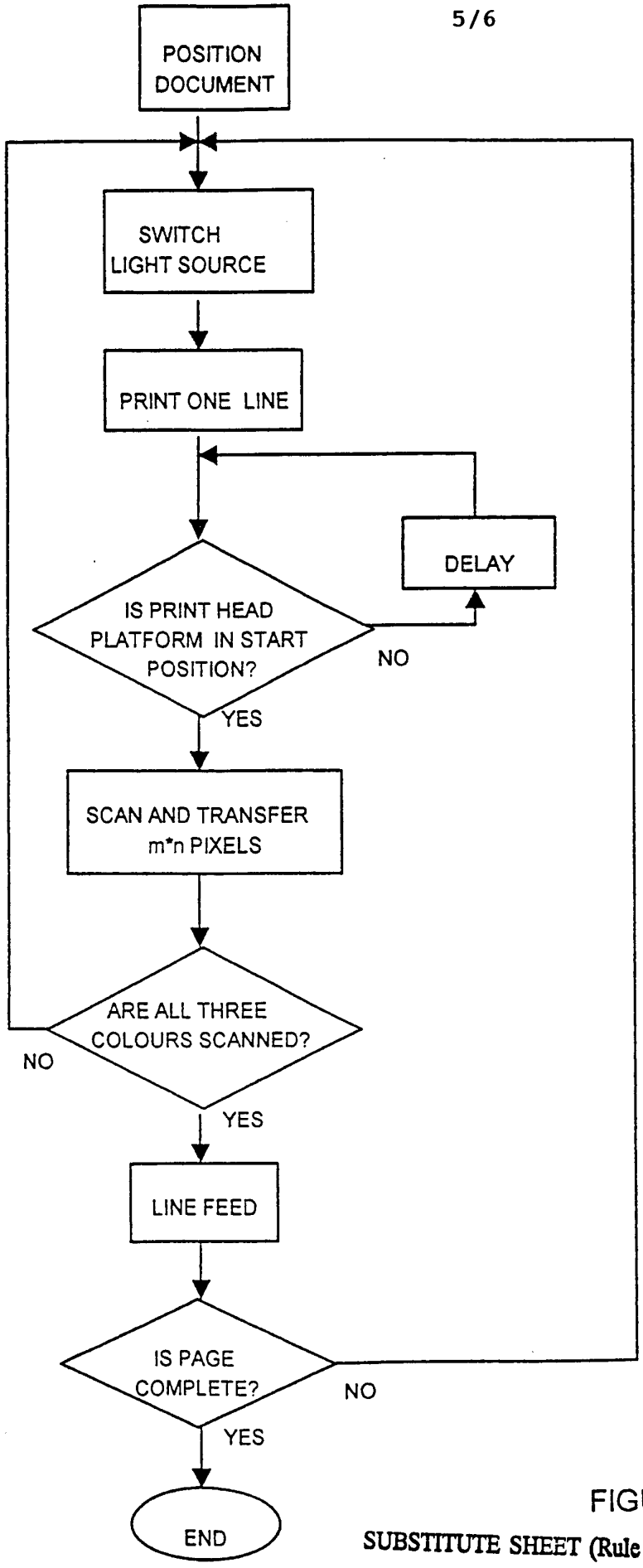

POSITION DOCUMENT
SWITCH LIGHT SOURCE
PRINT ONE LINE
DELAY
IS PRINT HEAD PLATFORM IN START POSITION?
NO
YES
SCAN AND TRANSFER m*n PIXELS
ARE ALL THREE COLOURS SCANNED?
NO
YES
LINE FEED
IS PAGE COMPLETE?
NO
YES
END

FIGURE 5

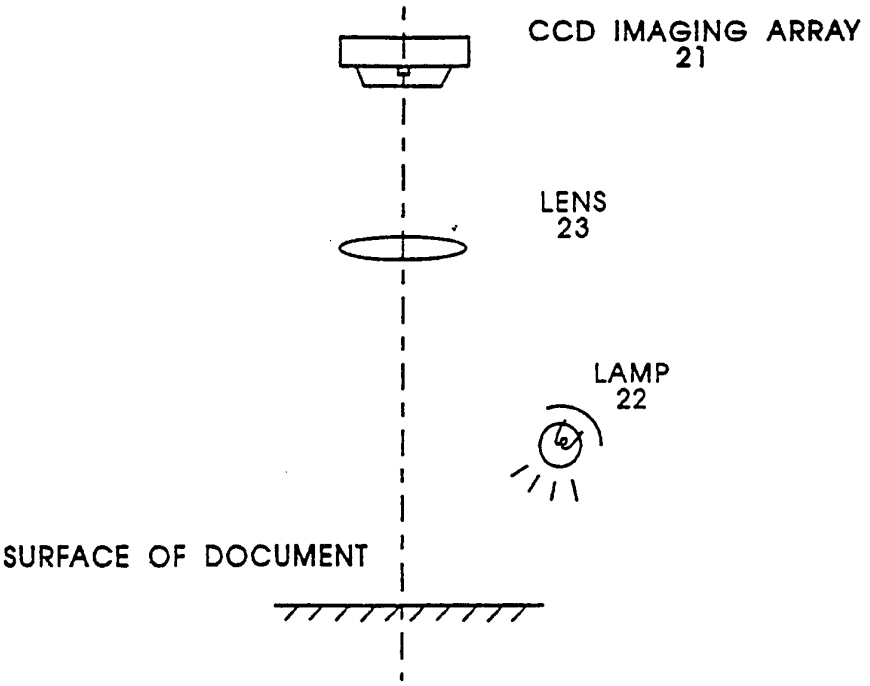


FIGURE 6

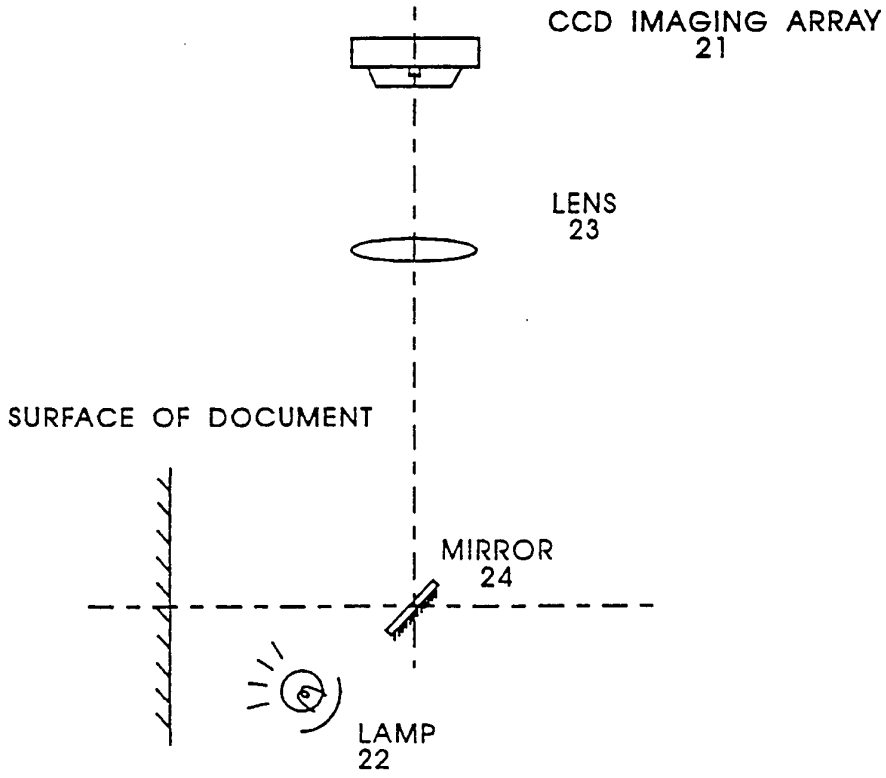


FIGURE 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 95/00170

A. **CLASSIFICATION OF SUBJECT MATTER**
Int. Cl.[6] H04N 1/028, 1/03, 1/19, 1/40, 1/48; G06K 9/28

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

B. **FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC H04N 1/024, 1/028 1/03, 1/19, 1/40; G06K 9/20, 9/28

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

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

C. **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
P,X	EP,A, 641115 (HEWLETT-PACKARD, COMPANY) 01 March 1995. See entire document	1-9
P,X	EP,A, 641114 (HEWLETT-PACKARD, COMPANY) 01 March 1995, see entire document	1-9
X	US,A, 4851925 (YAMASAKI et al) 25 July 1989, see entire document	1-9
X	AU,A, 43505/85 (WRIGHT) 05 December 1985, see entire document	1-9

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
20 June 1995

Date of mailing of the international search report
6 JULY 1995 (06.07.95)

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Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	GB,A, 2152326 (CASIO COMPUTER CO, LTD.) 31 July 1985, see entire document	1-9
Y	GB,A, 1368483 (THE MEAD CORPORATION) 25 September 1974, see entire document	1-9

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	641115	JP	7107245				
EP	641114	JP	7107246				
US	4851925	JP	62112472	JP	62113594	JP	62113595
AU	43505/85	EP	181889	WO	8505520		
GB	2152326	DE JP	3446933 4003707	GB US	8431201 4788587	JP JP	60136471 60139066
GB	1368483	CA JP	957010 54034289	DE US	2157098 3689693	FR	2114015

END OF ANNEX