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(54) Method and system for determining usage of a print solution for a print operation

(57) A method for determining a usage of a print solution for a printing operation comprises the steps of determining a number of drops of the solution consumed during the printing operation, and determining the usage based on at least the number of drops and a volume per drop of the solution.

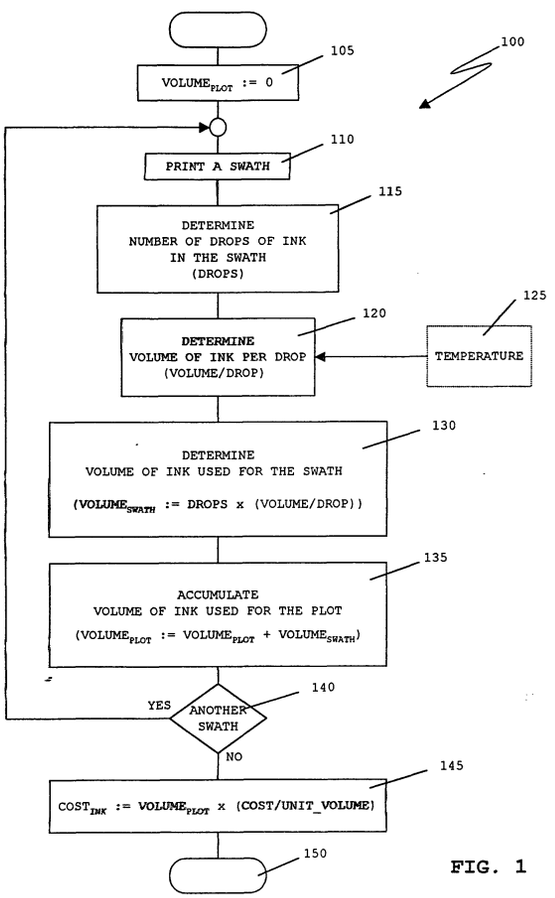

FIG. 1

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Description

FIELD OF THE INVENTION

[0001] This invention relates generally to printing devices and, more particularly, to a determination of a quantity of a print solution, e.g., ink, consumed during a printing operation.

BACKGROUND OF THE INVENTION

[0002] Inkjet printing mechanisms are used in a variety of different printing devices, such as plotters, facsimile machines and inkjet printers. Such printing devices print images using a print solution or a colorant, referred to generally herein as "ink." These inkjet printing mechanisms use inkjet cartridges, often called "pens," to shoot drops of ink onto a page or a sheet of print media.

[0003] Some inkjet print mechanisms carry an ink cartridge with an entire supply of ink, back and forth, across the sheet. Other inkjet print mechanisms, known as "off-axis" systems, propel a printhead carriage with only a small ink supply across a printzone, and store a main ink supply in a stationary reservoir, which is located "off-axis" from the path of printhead travel. Typically, in the off-axis systems, a flexible conduit or tubing is used to convey the ink from the off-axis main reservoir to the printhead cartridge.

[0004] In a multi-color cartridge, several printheads and reservoirs are combined into a single unit, with each reservoir/printhead combination for a given color also being referred to herein as a "pen". Each pen has a printhead that includes very small nozzles through which ink drops are fired.

[0005] A particular ink ejection mechanism within the printhead may take on a variety of different forms known to those skilled in the art, such as by using piezo-electric or thermal printhead technology. For example, two thermal ink ejection mechanisms are shown in U.S. Patent Nos. 5,278,584 and 4,683,481. In a thermal system, a barrier layer containing ink channels and vaporization chambers is located between a nozzle orifice plate and a substrate layer. This substrate layer typically contains linear arrays of heater elements, such as resistors, which are energized to heat ink within the vaporization chambers. Upon heating, an ink droplet is ejected from a nozzle associated with the energized resistor.

[0006] To print an image, the printhead is scanned back and forth across a printzone above a sheet of print media. A pen in the printhead shoots drops of ink as the printhead moves. By selectively energizing the resistors as the printhead moves across the sheet, the ink is expelled in a pattern on the print media to form the image, e.g., a picture, a chart or text.

[0007] The nozzles are typically arranged in one or more linear arrays. In an arrangement of more than one linear array, the arrays are located side-by-side on the printhead, parallel to one another, and substantially perpendicular to the scanning direction. Thus, the length of the nozzle array defines a print swath or band. That is, if all the nozzles of one array were continually fired as the printhead made one complete traverse through the printzone, a band or swath of ink would appear on the sheet. The height of this band is known as the "swath height" of the pen, the maximum pattern of ink that can be laid down in a single pass.

[0008] Conventional printing devices do not typically report a quantity of ink used for a printing operation. Consequently, a user wishing to determine an amount of ink used for a printing operation would need to measure the amount of ink in an ink distribution system before and after the printing operation, and find a difference in the two measured values. Such measurements usually require removal, weighing, and reinstallation of the ink distribution system, including supplies, pens, and/or tubes. Accordingly, some external equipment, such as a scale or other measuring device, is also required. This is clearly an undesirable method for determining a quantity of ink used, or consumed, during a printing operation.

OBJECTS OF THE INVENTION

[0009] It is a first object of this invention to provide an improved method for determining an amount of ink used by a printer device for a printing operation.

[0010] It is a second object of this invention to provide such a method that does not involve a removal of hardware from the device or a use of external measuring equipment.

[0011] It is a further object of this invention to provide such a method that also determines a cost of the ink used for the printing operation.

SUMMARY OF THE INVENTION

[0012] In accordance with the present invention, a method is provided for determining a usage of a print solution for a printing operation. The method comprises the steps of determining a number of drops of the solution consumed during the printing operation, and determining the usage based on at least the number of drops and a volume per drop of the solution.

[0013] In accordance with a first embodiment of the present invention, a system is provided for determining a usage of a print solution for a printing operation. The system comprises a first unit for determining a number of drops of the solution consumed during the printing operation, and a second unit for determining the usage based on at least the number of drops and a volume per drop of the solution.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The above set forth and other features of the invention are made more apparent in the ensuing De-

tailed Description of the Invention when read in conjunction with the attached Drawings, wherein:

Fig. 1 is a flowchart of a method for determining a usage of a print solution for a printing operation in accordance with the present invention; and

Fig. 2 is a block diagram of a system for determining a usage of a print solution for a printing operation in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The present invention relates generally to printing devices and, more particularly, to a determination of a quantity of ink consumed during a printing operation. The invention is described herein, by way of example, in the context of a plotter. However, the invention is not limited to use with any particular type of printing device, and may be employed in other devices such as facsimile machines and inkjet printers.

[0016] A large format printer is a printing device used for the production of large printed articles such as, for example, posters or banners. The amount of ink consumed during the production of a large printed article may represent a considerable portion of its production cost. The present invention calculates the amount of ink consumed to produce a plot from a plotter. It is particularly suited for a "pay-per-print" application in which the specific cost for producing a printed image is charged to a customer for whom the image is printed.

[0017] Fig. 1 is a flowchart of a method 100 for determining a usage of a print solution, e.g., ink, for a printing operation. Method 100 includes steps for determining a number of drops of the solution consumed during the printing operation, and determining the usage based on at least the number of drops and a volume per drop of the solution. As used herein, a "printing operation" can be any printing activity of interest including printing of a pixel, a dot, a line, a swath, a page, a banner, or a plurality of such activities. The printing operation can also be itemized by color; that is, by the amount of ink used for each of one or more colors. In the following example, the printing operation is a printing of a plot on a sheet of print media, and accordingly, the method is employed to determine the amount of ink used to print the plot. The method begins with step 105.

[0018] In step 105, the method initializes a variable that is used to accumulate the total volume of ink consumed by the plot.

$$VOLUME_{PLOT} := 0$$

The method then advances to step 110.

[0019] In step 110, the method prints a portion of the plot, such as a swath. The method then advances to step 115.

[0020] In step 115, the method determines the number of drops of ink discharged by a pen during the printing of the swath in step 110. That is, the method counts the number of drops of ink fired during the printing of the swath.

DROPS = number of drops of ink in the swath

[0021] Accordingly, step 115 can be performed concurrently with step 110. The method contemplates the use of any convenient technique for counting the drops of ink. For example, if a signal is issued to the pen to cause a discharge of a drop of ink, the occurrences of that signal can be counted.

[0022] Another technique for counting the drops of ink can be employed in a system that prepares a bit map of an image to be printed. The bit map includes bits that correspond to points or pixels of the image. The state of each bit indicates whether its corresponding point or pixel will be printed or left blank. Such a bit map is created for each color per swath. The number of drops of ink can be determined from the number of bits set in a bit map.

[0023] In practice, a nozzle of a print head is susceptible to obstruction by dry ink, a particle of paper or a particle of some other debris. The obstruction can cause a problem such as a misdirection of ink from the nozzle or a total blockage of the nozzle. In most systems, a service routine is periodically performed on the nozzle during a printing operation to ensure a proper flow of ink through the nozzle. Such a service routine may consume one or more drops of ink. The preferred technique of determining the number of drops of ink discharged is the technique of counting the signals issued to the pen to cause the discharge. This is because this technique counts the number of drops effectively fired during the printing of the swath, which may include drops fired during a service routine, but not required by the bit map.

[0024] In a multi-color system, the method may itemize ink usage by each of the individual colors of ink. After step 115, the method then advances to step 120.

[0025] In step 120, the method determines the volume of ink per drop for the pen.

VOLUME/DROP = volume of ink per drop

[0026] The value for the volume/drop may be a predetermined constant, such as an average volume/drop for a pen. The average volume/drop can be found by discharging a predetermined number of drops into a container, measuring the cumulative volume of ink in the container, and finding the quotient of cumulative volume divided by the number of drops.

[0027] The average can be that of a sample population of pens, but preferably, each individual pen is characterized during the manufacturing of the pen. Data representing the characterization of the pen can be written

to a machine readable storage media integrated into the pen assembly. The method would then include reading this data from the storage media.

[0028] The volume/drop of ink has a tendency to vary with temperature. Accordingly, a full characterization of the pen includes the volume/drop as a function of the temperature of the ink. Preferably, the method considers this variation due to temperature when determining the volume/drop in step 120. Thus, given the temperature, in step 120, the method determines volume/drop as a function of temperature. Accordingly, the resultant volume/drop is found from a standard volume per drop ($VOLUME/DROP_{STD}$), e.g., the average volume/drop as discussed earlier, adjusted by a temperature-dependent constant (C_T). If the temperature varies over a large range, the temperature-dependent constant (C_T) can be refined by an exponential operator (N).

$$VOLUME/DROP = (VOLUME/DROP_{STD}) + C_T^{\ N}$$

[0029] In the case where the temperature variation is not great, N = 1, yielding a simplified equation.

$$VOLUME/DROP = (VOLUME/DROP_{STD}) + C_T$$

[0030] The temperature-dependent constant (C_T) can be determined from an empirical evaluation of the volume/drop over a temperature range of interest. Preferably, each different ink color has its own temperature-dependent constant.

[0031] In step 125, the method determines the temperature of the ink and provides this data for use in the calculation performed by step 120. The temperature can be obtained, for example, from a temperature sensor located in the printhead of the printing device. Generally, a more accurate temperature measurement yields a more accurate determination of the volume. In a preferred implementation, an average temperature is determined from temperature readings taken as the printhead moves from the beginning to the end of the swath.

[0032] The determination of the volume of the drop may also consider other variables that have a potential to affect the volume. Such variables include, but are not limited to, (a) the age of the printhead, (b) the size of the orifice through which the ink is discharged, (c) the viscosity of the ink, and (d) the density of the ink.

[0033] After completion of step 120, the method advances to step 130.

[0034] In step 130, the method determines the volume of the ink used for the swath. The volume for the swath is found from the product of the number of drops in the swath and the volume per drop.

$$VOLUME_{SWATH} := DROPS \times (VOLUME/DROP)$$

[0035] After completion of step 130, the method advances to step 135.

[0036] In step 135, the method accumulates the volume of ink used for the plot by adding the volume from the current swath to the previously stored volume for the **plot.**

$$VOLUME_{PLOT} := VOLUME_{PLOT} + VOLUME_{SWATH}$$

[0037] For the first pass of method 100, as only one swath has been printed, after the execution of step 135, $VOLUME_{PLOT}$ will be equal to $VOLUME_{SWATH}$. During the second pass of method 100, after the execution of step 135, $VOLUME_{PLOT}$ will represent the sum of the volume from the first swath and the volume from the second swath. During subsequent passes, the volumes of the subsequent swaths will be added. Upon completion of step 135, the method advances to step 140.

[0038] In step 140, the method determines whether there is another swath to be printed. If there are one or more additional swaths to be printed, then the method loops back to step 110 to print the next swath. If there are no more swaths to be printed, then the method advances to step 145.

[0039] In step 145, the method determines the cost of the ink consumed in the production of the plot. The cost of the ink consumed is found from the product of the volume of ink used for the plot, as found in step 135, and the cost of the ink per unit volume.

$$COST_{INK} := VOLUME_{PLOT} \times (COST/UNIT\_VOLUME)$$

[0040] The cost per unit volume may be a predetermined constant. Alternatively, it may be based one or more variable parameters such as, for example, (a) the manufacturer of the ink, (b) the quality of the ink, or (c) the color of the ink. The cost per unit volume and other parameters could be written and obtained from a storage media integrated into the printhead in a manner similar to that described above for step 120.

[0041] The cost of the ink consumed is only one component of the total cost a printed item. Other components influencing the total cost can include, for example, the type of print media used, the size of the print media, and the time required to produce the printed item. Additional costs can include factors such as lamination of the printed item and image enhancement. After step 145, the method advances to step 150.

[0042] In step 150, method 100 terminates.

[0043] Fig. 2 is a block diagram of a system 200 for determining a usage of a print solution for a printing operation in accordance with the present invention. The principal components of system 200 are a printer 215 and a user interface 205. System 200 also includes a processor 210 with an associated memory 225, which are shown in Fig. 1 as being embedded within printer

215. However, processor 215 and memory 225 may be located external to printer 215.

[0044] User interface 205 enables a user to input data to, and receive data from, system 200. User interface 205 may be any conventional input/output subsystem that includes a keyboard, a mouse or a similar pointing device, and a display. User interface 200 sends data to, and receives data from, processor 210. The user of system 200 may be a customer that makes a request, via user interface 205, for the printing of an image by printer 215.

[0045] Printer 215 is a printing device. Examples of conventional printing devices include a printer, a plotter, a facsimile machine or an inkjet printer. However, for purposes of the present invention, printer 215 may be any device that discharges a liquid solution onto a surface of a carrier. Exemplary liquid solutions include, ink, paint, adhesive, and molten material. The carrier can be a print media such as, for example, a sheet of paper, a banner of paper, which is typically provided on a roll, or it can be a non-paper material, such as a fabric, a plastic or a metal. In its preferred embodiment, printer 215 includes a temperature sensor 220 that senses a temperature of the solution, and reports the temperature to processor 210.

[0046] Memory 225 contains data and instructions for controlling the operation of processor 210. More particularly, it includes instructions 230 that enable processor 210 to perform the method for determining a usage of a print solution for a printing operation, as described above in association with Fig. 1.

[0047] Processor 210 reads data from, and writes data to, memory 225 and user interface 205. Processor 210 obtains instructions 230 from memory 225 that enable it to determine a number of drops of ink consumed during a printing operation by printer 215, and to determine the usage of the ink based on at least the number of drops and a volume per drop of the ink. Techniques for determining the number of drops were described earlier.

[0048] Processor 210 determines the usage from a product of the number of drops and the volume per drop. It also determines the volume per drop of the ink. It can obtain the volume per drop from a storage media that is integrated into a printhead (not shown) in printer 215. Preferably, processor 210 also considers the temperature of the ink, which it obtains from temperature sensor 220, and uses the temperature to more accurately determine the volume of each drop of ink.

[0049] After determining the volume of ink consumed by the printing operation, processor 210 determines the cost of the ink, and charges the customer for the printing operation based on the amount of ink consumed. The total charge may include other costs, as described earlier. System 200 reports this charge to the customer via user interface 205.

[0050] In the preferred embodiment, the amount of ink consumed by the printing operation may include the ink consumed by the servicing of the printhead, e.g., by performing conventional servicing tasks such as spitting, wiping and/or priming, which can occur before and/or after printing an image.

[0051] Although system 200 is described herein as having the instructions for the method of the present invention installed into memory 225, the instructions can reside on an external storage media 235 for subsequent loading into memory 225. Storage media 235 can be any conventional storage media, including, but not limited to, a floppy disk, a compact disk, a magnetic tape, a read only memory, or an optical storage media. Storage media 235 could also be a random access memory, or other type of electronic storage, located on a remote storage system and coupled to memory 225.

[0052] While the invention has been particularly shown and described with respect to preferred embodiments thereof, it will be understood by those skilled in the art that changes in form and details may be made therein without departing from the invention. Accordingly, the present invention is intended to embrace all such alternatives, modifications and variances that fall within the scope of the appended claims.

Claims

1. A method for determining a usage of a print solution for a printing operation, comprising:

   determining a number of drops of said solution consumed during said printing operation; and
   determining said usage based on at least said number of drops and a volume per drop of said solution.

2. The method of claim 1, wherein said step of determining said usage applies a formula:

   usage = number of drops x volume per drop.

3. The method of claim 1, wherein said volume per drop is a predetermined value.

4. The method of claim 1, further comprising, before said step of determining said usage, the step of determining said volume per drop based on at least one variable having a potential to affect said volume.

5. The method of claim 4, wherein said at least one variable includes a temperature of said solution.

6. The method of claim 1, further comprising determining a cost of said solution for said printing operation based on said usage.

7. The method of claim 1, further comprising charging a customer for said printing operation based on said cost.

8. A system for determining a usage by an inkjet printing device for a printing operation, comprising:

means for determining a number of drops of said solution consumed during said printing operation; and
means for determining said usage based on at least said number of drops and a volume per drop of said solution.

9. The system of claim 8, wherein said means for determining said usage applies a formula:

usage = number of drops x volume per drop.

10. The system of claim 8, wherein said volume per drop is a predetermined value.

11. The system of claim 8, further comprising means for determining said volume per drop based on at least one variable having a potential to affect said volume.

12. The system of claim 11, wherein said at least one variable includes a temperature of said solution.

13. The system of claim 8, further comprising means for determining a cost of said solution for said printing operation based on said usage.

14. The system of claim 8, further comprising means for charging a customer for said printing operation based on said cost.

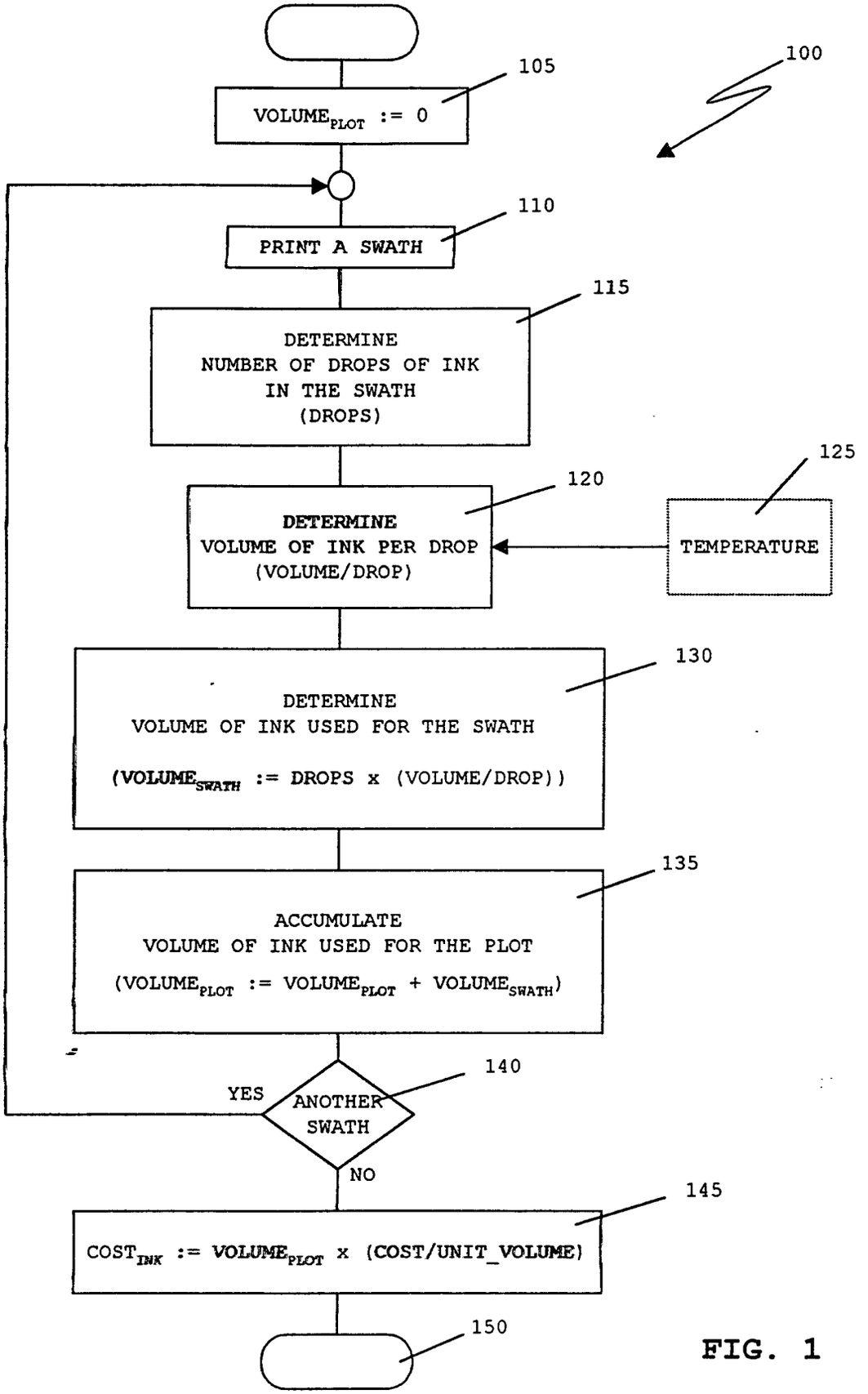
100
105
VOLUME$_{PLOT}$:= 0
110
PRINT A SWATH
115
DETERMINE
NUMBER OF DROPS OF INK
IN THE SWATH
(DROPS)
125
120
DETERMINE
VOLUME OF INK PER DROP
(VOLUME/DROP)
TEMPERATURE
130
DETERMINE
VOLUME OF INK USED FOR THE SWATH
(VOLUME$_{SWATH}$:= DROPS x (VOLUME/DROP))
135
ACCUMULATE
VOLUME OF INK USED FOR THE PLOT
(VOLUME$_{PLOT}$:= VOLUME$_{PLOT}$ + VOLUME$_{SWATH}$)
140
YES
ANOTHER
SWATH
NO
145
COST$_{INK}$:= VOLUME$_{PLOT}$ x (COST/UNIT_VOLUME)
150

FIG. 1

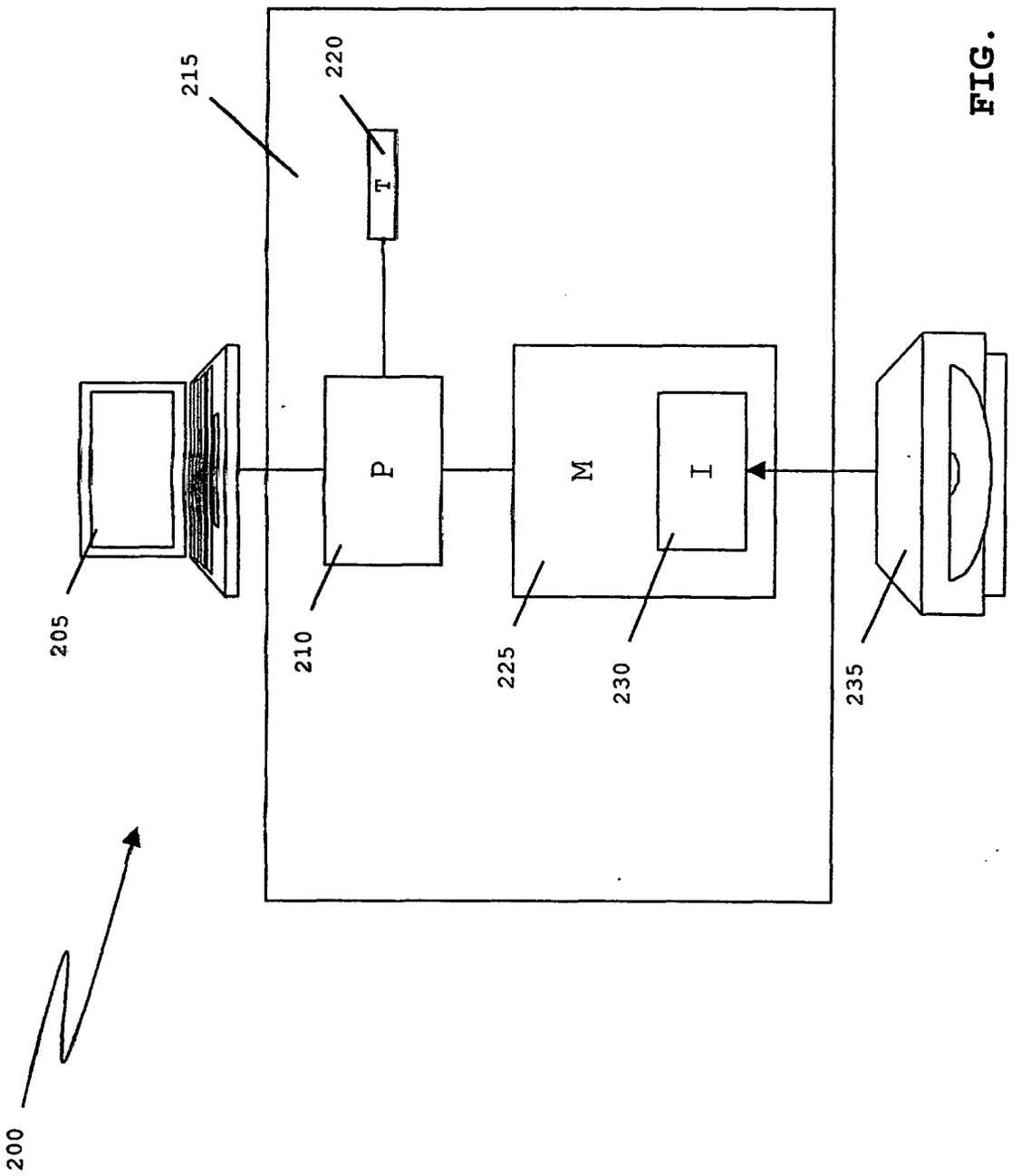

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	20 November 2001	Bridge, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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