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(54) Self-configuring ink jet printer

(57) A method is provided for optimizing ink jet printing system operation. A computer is used for interactive control of an ink jet printing system, and ink jet characteristics are stored in the computer memory. The computer can then access and matrix the stored ink jet characteristics. The matrix is interpreted to optimize operation of the ink jet printing system.

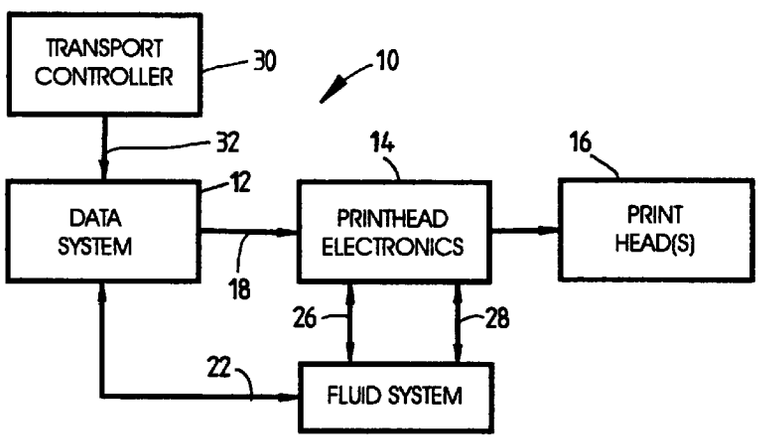

FIG. 1

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Description

Technical Field

The present invention relates to ink jet printing and, more particularly, to computer optimized ink jet control and operation.

Background Art

In continuous ink jet printing, ink is supplied under pressure to a manifold region that distributes the ink to a plurality of orifices, typically arranged in a linear array(s). The ink discharges from the orifices in filaments which break into droplet streams. The approach for printing with these droplet streams is to selectively charge and deflect certain drops from their normal trajectories. Graphic reproduction is accomplished by selectively charging and deflecting drops from the drop streams and depositing at least some of the drops on a print receiving medium while other of the drops strike a drop catcher device. The continuous stream ink jet printing process is described, for example, in U.S. Pat. Nos. 4,255,754; 4,698,123 and 4,751,517, the disclosures of each of which are totally incorporated herein by reference.

As ink jet printer systems grow increasingly more complex and the types, colors and variety of inks used in such systems increase, the control and configuration of the electro-mechanical systems of the ink jet printer for particular applications grows more difficult.

It is seen then that there is a need for a control technique which optimizes ink jet printing operation for different applications of ink jet control and different ink characteristics.

Summary of the Invention

This need is met by the control technique of the present invention which provides optimal operating parameters for a plurality of configurations for different applications of ink jet control and different ink jet characteristics.

In accordance with one aspect of the present invention, a method is provided for optimizing ink jet printing system operation. A computer is used for interactive control of an ink jet printing system, and ink jet characteristics are stored in the computer memory. The computer can then access and matrix the stored ink jet characteristics. The matrix is interpreted to optimize operation of the ink jet printing system.

It is an object of the present invention to optimize ink jet printer control and operation. It is an advantage of the present invention that the computer configures the various inputs in an optimal manner to support customised operation or installation.

Other objects and advantages of the invention will be apparent from the following description and the appended claims.

Brief Description of the Drawings

Fig. 1 is a block diagram of the main components of an ink jet printing system capable of employing the optimized configuration of the present invention;

Fig. 2 is a side view of a continuous ink jet system of the type suitable for use with the optimized operation concept of the present invention;

Fig. 3 is a flow chart block diagram illustrating the automatic reading and implementation of functions and features for optimized ink jet printer operation, in accordance with the present invention; and

Fig. 4 is an illustration of non-inclusive contents of a machine initialization file, of the type used in the optimized configuration concept of the present invention.

Detailed Description of the Invention

Printing systems using ink jet technology produce images on a web, usually paper. The system employs any of a variety of sized printheads, such as, for example, 4.27 inches (10.8 centimeters), 9.06 inches (23.1 centimeters), (10.7 inches (27.1 centimeters), or 13.3 inches (33.8 centimeters) wide. The printing system can print anywhere on a document, using a variety of type styles, point sizes, ink colors, and special effects.

Images are formed on the web by individual drops of ink released by a printhead at a density of 120 drops per inch or 240 drops per inch. The printing system uses continuous jet technology, in which the printhead releases a continuous stream of ink drops. Drops that are needed to form an image fall onto the web, while drops that are not needed receive an electric charge and are deflected into a catcher, for recirculation.

Imaging can be accomplished using multiple and independent printheads, and each head may image a different colors. The printheads are of the binary, continuous ink jet type, and employ planar charging technology known in the art.

Referring to the drawings, Fig. 1 is a block diagram of the main components of an ink jet printing system 10. A data system or raster image processor (RIP) 12 receives and provides information to the various components of the ink jet printing system. A printhead electronics block 14 controls printhead(s) 16. Print data and control bits from the data system 12 to the printhead electronics 14 are sent over a data and control interface 18. Control and status of the printhead electronics 14 are sent over the printhead control and status interface 20. A fluid system control and status interface 22 connects a fluid system 24 and the data system 12. A printhead control and status interface 26 and a synchronizing and control interface 28 provide data between the printhead electronics 14 and the fluid system 24. Finally, a transport controller 30 sends data via

a transport controller interface 32 to the data system 12.

The present invention relates to the type of continuous ink jet system illustrated in Fig. 2. A plurality of jets is created at high spatial resolution by a drop generator, which stimulates the natural break-up of jets into uniform streams of droplets. A plurality of conducting elements, or charge leads 32, are located on a planar charge plate 34. A plurality of streams of drops 36 are supplied by drop generator 38. A plurality of independently switchable sources 40 of electrostatic potential are supplied to the plurality of charge leads 32. A catcher 42 intercepts the slightly deflected streams of drops. The plurality of streams of drops impacting on the catcher forms a film of ink 46, which in turn forms a flow of ink 44, sucked away from the face of the catcher by a vacuum. Reference number 48 represents the area on the catcher at which the deflected drops impact the catcher and merge together to form a film of ink on the catcher face. The undeflected ink drops then print the image on substrate 50.

As ink jet printer systems grow increasingly more complex and the types, colors and variety of inks used in such systems increase, the control and configuration of the electro-mechanical systems of the ink jet printer for particular applications grows more difficult. The present invention addresses these difficulties by permitting automatic and self-configuration of ink jet printers to optimize ink jet printing for various operating conditions. As will be obvious to those skilled in the art, most of the customization is necessitated by the type and the particular application of inks, but the automatic self-configuration concept can be applied to achieve the customization.

Referring now to Fig. 3, there is illustrated a flow chart block diagram of computer 52 showing automatic reading and implementation of functions and features for optimized ink jet printer operation, in accordance with the present invention. The computer 52, for interactive control of an ink jet printing system 10, receives a whole host of inputs, including but not limited to various files 54, 56, 58 and 60; operator inputs and interfaces 62; hardware installation checks; fluid handling system characteristics, ink characteristics and descriptor files, machine descriptor files, sensor calibration files, machine sequencing files, application information, ink jet control strategies, etc. These ink jet characteristics are stored in the computer memory, to be accessed for customized operation and configuration. If, for example, the operator changes the ink in the system, the operator indicates this to the computer. The ink jet characteristics stored in the computer are then accessed and matrixed at block 64 to optimize a whole new set of ink jet operating parameters at block 66, based on the new ink. The computer, rather than the operator, causes printer timing, ink pressures, temperature compensations, and any other operating parameters to be changed to optimize the printer operation. Hence, the computer interprets the matrixed information to optimize operation of the ink jet printing system.

Continuing with Fig. 3, block 68 comprises an array of printer sequences, i.e., a consecutive series of machine states, printer states, and/or running condition of valves, motors, pumps, etc. The computer selects the sequences (states) appropriate for the configuration of the printer. Block 70 allows for operator selected printer functions, such as choice of printer function, printhead cleaning, or making the system ready to print. The computer control of the printer automatically adapts or configures itself to carry out the operator commands in the optimal manner.

Current hardware configuration information is available to the computer, relating to printhead and presently installed ink. Computer 52, as part of its initialization procedure, reads multiple configuration files which are stored on its media storage device, such as a hard drive or similar device. These files contain guide information for the computer 52.

In a preferred embodiment of the present invention, the ink jet characteristics are stored in ASCII or similar files, although it will be obvious to those skilled in the art that multiple other formats can be used, including but not limited to a double byte format. The ink jet characteristics files, in whatever suitable format, are accessed by the computer controlling the printer operation. These files are interpreted and matrixed into a fluid station control scheme. The structure of the files preferably allows for verification of the integrity of the printer configuration. Corrupted (or correct) control files can be easily identified using a word processor. This also quickens engineering development time, since the designer can quickly test printer performance as printer operating parameters are varied. Such file structures also allow for customization of printer operation and/or operator interface.

In the present embodiment, for purposes of illustration only, and not to be considered as limiting the scope of the invention, there are two ASCII type configuration files. One file is an ink data file, such as block 56 of Fig. 3, with data shown below.

```
#6001002=0,220
#6001002=1,160
#6001004=2,255
#6003600=3,130
```

This file provides a list of the tabulated ink part order number, along with their matrix number. The matrix number is arbitrarily assigned, and indicates a matrix row pointer in the ink matrix. The matrix is stored, for the sake of convenience, as the first block in the machine initialization file. For example, an ink order number is 6001002. This references the ink to customer catalog part numbers. The next number, 0 in line 1, indicates the ink matrix number. This number is used by the computer 52 to configure the computer. The last number in this example, 220, indicates the resistivity of the ink. This

number is used by the computer 52 to control ink characteristics. Other data can be attached to each of the data entries. The list of ink order numbers is accessible by the printer operator for ink changeovers.

The second ASCII type file is a machine initialization file, illustrated as Fig. 4. This file provides the computer with the look up tables for the plurality of configurations for the printer. The files contain several sections. The first section contains a reference to the ink matrix, and is labeled [boot]. The machine initialization file is an abbreviated representation of an actual file. The [boot] section of the file lists the available matrices. If a matrix number 0 is specified in the ink data file (for a particular ink), the mx00 row is selected in the machine initialization file [boot] section. Each number of the selected row sets the configuration of a particular function of the printer. The actual order of the functions in the rows of the ink matrix is not significant. The functions merely have to be ordered consistently throughout.

Continuing with Fig. 4, once the row is selected, the first number in the row (in this example) indicates what type of printhead is permitted to be used with the selected row. This is a printer interlock check, in that if the printer hardware configuration does not match this numerical value, the configuration is halted and a fatal error condition is created.

The second number in the row determines which sequence type is to be used by the printer. The printer is required to be brought to a certain operating condition for printing or maintenance. If the sequence type number is 0, then all of the sequences are of the 0 type. This number is used to find the defined sequence type in the [sequences] section of Fig. 4. The sequence 0, 1, 2, 3, etc., of type 0 causes the computer 52 to look for and use sequences which have the coding s000, s010, s020, s030, etc., respectively, since it is logical to assign sequences in a numerical order, not necessarily related to the function of the sequence. The assignment is fixed by the operator. If the exact type is not found in the list, then the default sequence type "x" is used. It should be noted that Fig. 4 is only representative of a typical application, for purposes of illustration only, and there are usually many more sequences required for an operation of the printer. The number of sequence types increases with inks which have significant formulation differences.

The third number in the selected row determines which set (from files of block 60) of printer states are to be used by the printer. A state is the operational condition of the printer, such as a certain ink pressure, vacuum level, charge voltage level, time duration, etc. A sequence uses a series of states cascaded together. The state numbers are shown in the [sequences] section. For example, Fig. 4 shows that sequence s01 consists of cascaded state 2, state 3, state 16, state 0. State 0 is an "all off" condition and is used as a system stop in case of a sequence malfunction. The representation of particular printer states are stored in files for the convenience of this implementation. Obviously, a section in the machine initialization file can be created to represent the printer states in subsequent implementations, in ASCII or other format.

The fourth and fifth numbers in the selected row are similar in their application. The type number is used to point to a row of information. The type number represents a pointer to temperature compensation coefficients used to vary respectively the stimulation magnitude and the charge voltage magnitude, shown in Fig. 4 as sections [stimcomp] and [cvtcomp]. The sections contain the coefficients of a power series. The numbers are used in a programmable power series equation which models the required magnitude changes as a function of temperature.

The sixth number of the selected row provides a pointer to stimulation magnitude adjustment. The type number points to a percentage adjustment of the stimulation magnitude output, shown as [stimmag] in Fig. 4. This factor is typically required by different inks which have significant formulation differences.

The last section of the machine initialization file of Fig. 4, [maindisplay], controls features of the display. This section allows the display to enable or disable information on the operator's display. The value 1, for example, enables the item to be displayed on the operator's interface screen, while the value 0 disables the item.

The present invention provides for a compactly and orderly method for describing ink jet characteristics as contrasted to the computer storage for a full set of printer operating characteristics for every function of every ink formulation. The technique of the present invention provides for compact storage of the machine configuration, versus the brute force storage of all configurations. The matrix feature of the present invention condenses all of the printer operating characteristics for all applications in a compact orderly configuration.

Industrial Applicability and Advantages

The present invention is useful in the field of ink jet printing, and has the advantage of optimizing ink jet printer control and operation. It is a further advantage of the present invention that the computer configures the various inputs in an optimal manner to support customized operation or installation. It is yet another advantage of the present invention that it allows for increased complexity of printer configurations while simplifying the intervention of the operator or the printer installer.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that modifications and variations can be effected within the spirit and scope of the invention.

Claims

1. A method for optimizing ink jet printing system

operation comprising the steps of:

using a computer for interactive control of an ink jet printing system;
storing ink jet characteristics in a computer memory;
accessing the stored ink jet characteristics with the computer;
matrixing the stored ink jet characteristics;
interpreting the matrix to optimize operation of the ink jet printing system.

2. A method for optimizing ink jet printing system operation as claimed in claim 1 wherein the step of matrixing the stored ink jet characteristics further comprises the step of comparing ink jet characteristics with printer operating characteristics for every function of every ink formulation.

3. A method for optimizing ink jet printing system operation as claimed in claim 1 wherein the step of matrixing the stored ink jet characteristics further comprises the step of condensing all of the ink jet characteristics and printer operating characteristics for every function of every ink formulation.

4. A method for optimizing ink jet printing system operation as claimed in claim 1 wherein the step of storing ink jet characteristics in a computer memory further comprises the step of storing the ink jet characteristics in formatted files.

5. A method for optimizing ink jet printing system operation as claimed in claim 4 wherein the formatted files are accessed by the computer controlling printer operation.

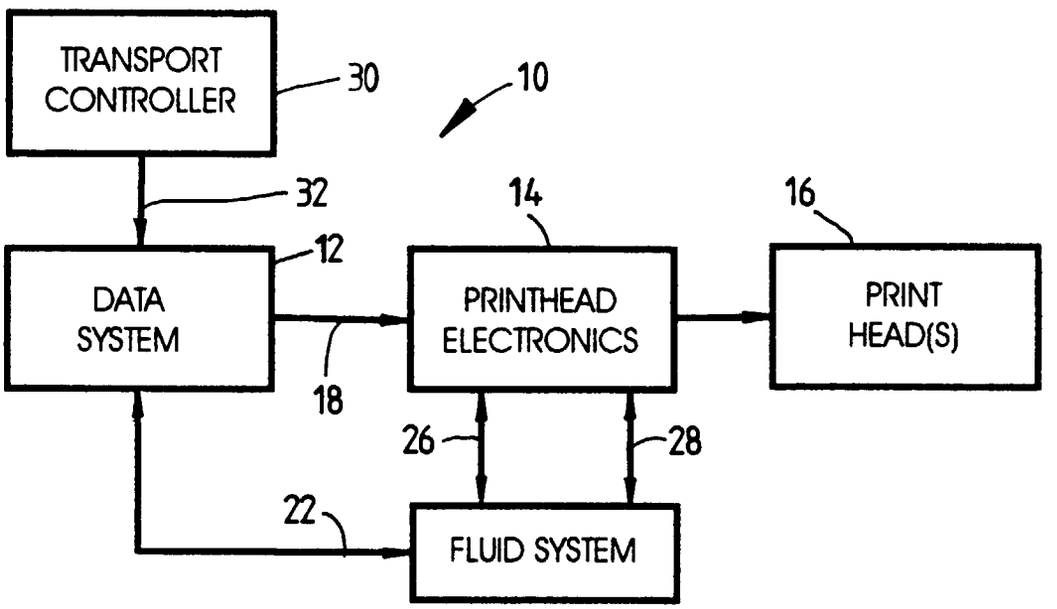
TRANSPORT CONTROLLER
30
10
32
14
16
12
DATA SYSTEM
PRINTHEAD ELECTRONICS
PRINT HEAD(S)
18
26
28
22
FLUID SYSTEM

FIG. 1

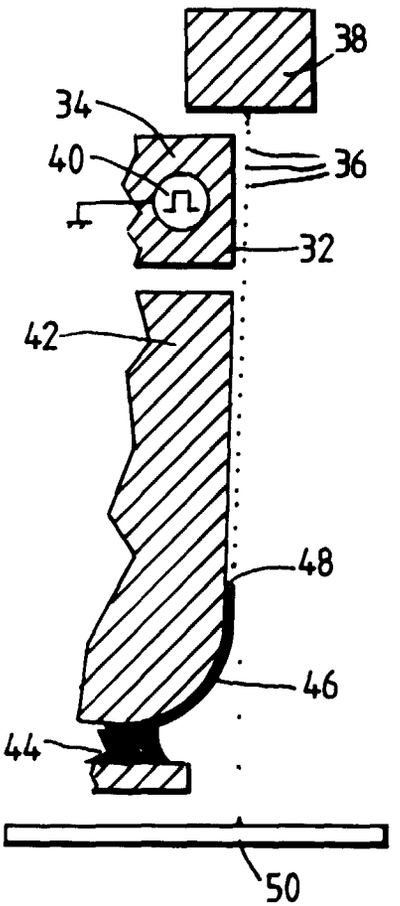

FIG .2

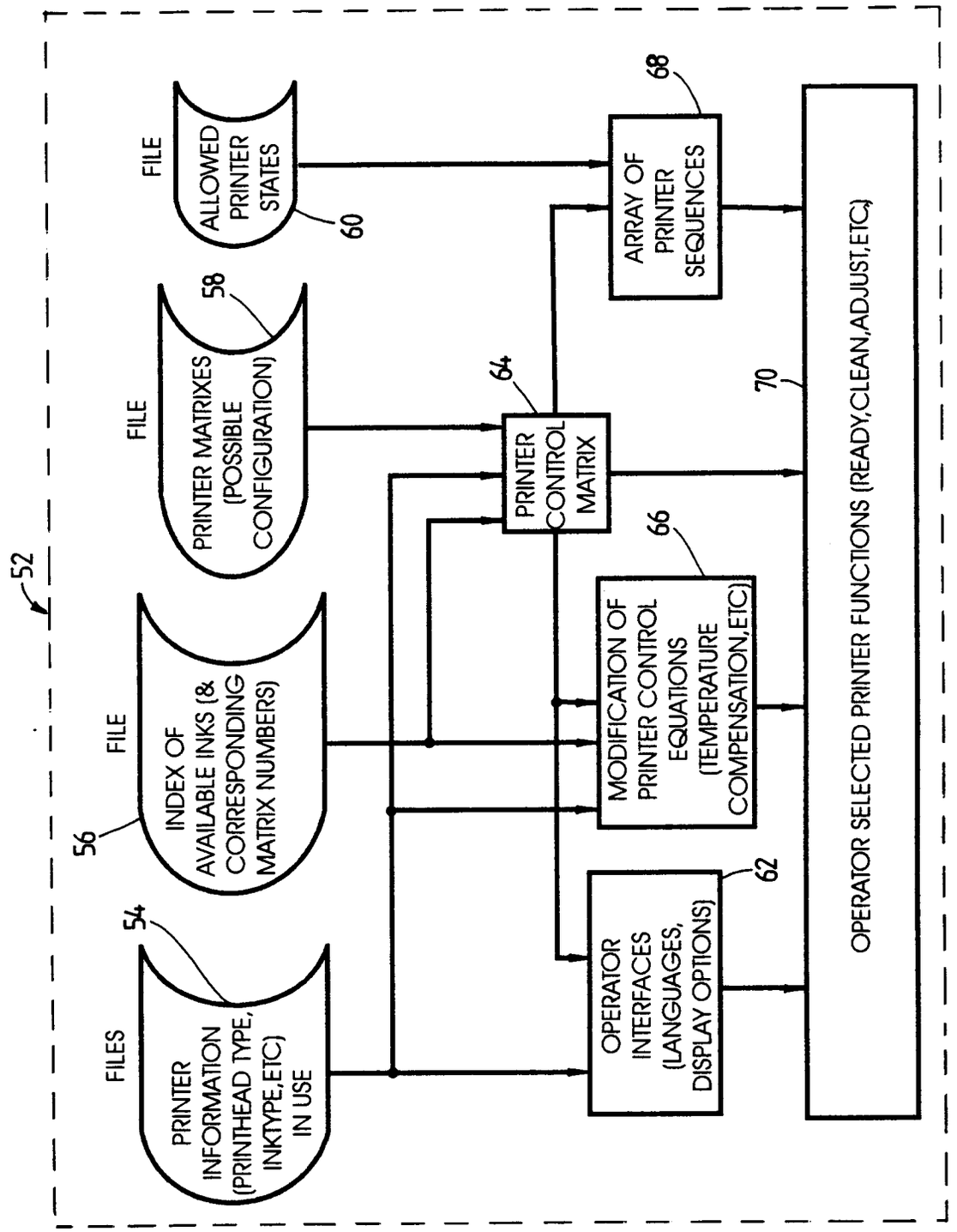
52
FILES
PRINTER INFORMATION (PRINTHEAD TYPE, INKTYPE,ETC) IN USE
54
FILE
INDEX OF AVAILABLE INKS (& CORRESPONDING MATRIX NUMBERS)
56
FILE
PRINTER MATRIXES (POSSIBLE CONFIGURATION)
58
FILE
ALLOWED PRINTER STATES
60
OPERATOR INTERFACES (LANGUAGES, DISPLAY OPTIONS)
62
MODIFICATION OF PRINTER CONTROL EQUATIONS (TEMPERATURE COMPENSATION,ETC)
66
PRINTER CONTROL MATRIX
64
ARRAY OF PRINTER SEQUENCES
68
70
OPERATOR SELECTED PRINTER FUNCTIONS (READY,CLEAN,ADJUST,ETC)

FIG. 3

```
[boot]
mx00=0,0,0,0,0,0
mx01=1,1,1,1,1,1
mx02=1,2,2,1,1,1
mx03=1,1,1,1,1,2


[sequences]
s000=23,12,32,13,12,32,13,12,32,33,20,6,46,9,8,10,11,0
s001=23,12,32,13,12,32,13,12,32,33,20,6,46,9,8,10,11,0
s002=23,12,32,13,12,32,13,12,32,33,34,35,36,6,46,9,8,10,11,0
s00x=23,12,32,13,12,32,13,12,32,33,20,6,46,9,8,10,11,0
s01x=2,3,16,0
s02x=24,25,14,14,2,3,1,16,0
s06x=0

[stimtcomp]
smtc0=1200,-8,0
smtcl=1572,-29,245
smtcx=1572,-29,245

[cvtcomp]
cvtc0=-64,256,0
cvtc1=-64.256,0
cvtcx=-64,256,0

[stimmag]
smag0=100
smag1=100
smag2=115
smagx=100

[maindisplay]
inkservo=0
vacservo=0
phstatus=0
stimstatus=0
phtime=1
```

FIG. 4