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(54) **INFORMATION PROCESSING APPARATUS, INFORMATION PROCESSING METHOD, AND STORAGE MEDIUM**

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(57) **ABSTRACT**

Apparatus and method is provided for simulating behavior of a flexible medium for a plurality of times under different conditions. A component inside the conveyance path is displayed together with a plurality of locations in which abnormal behavior of the flexible medium has occurred based on a result of the simulation.

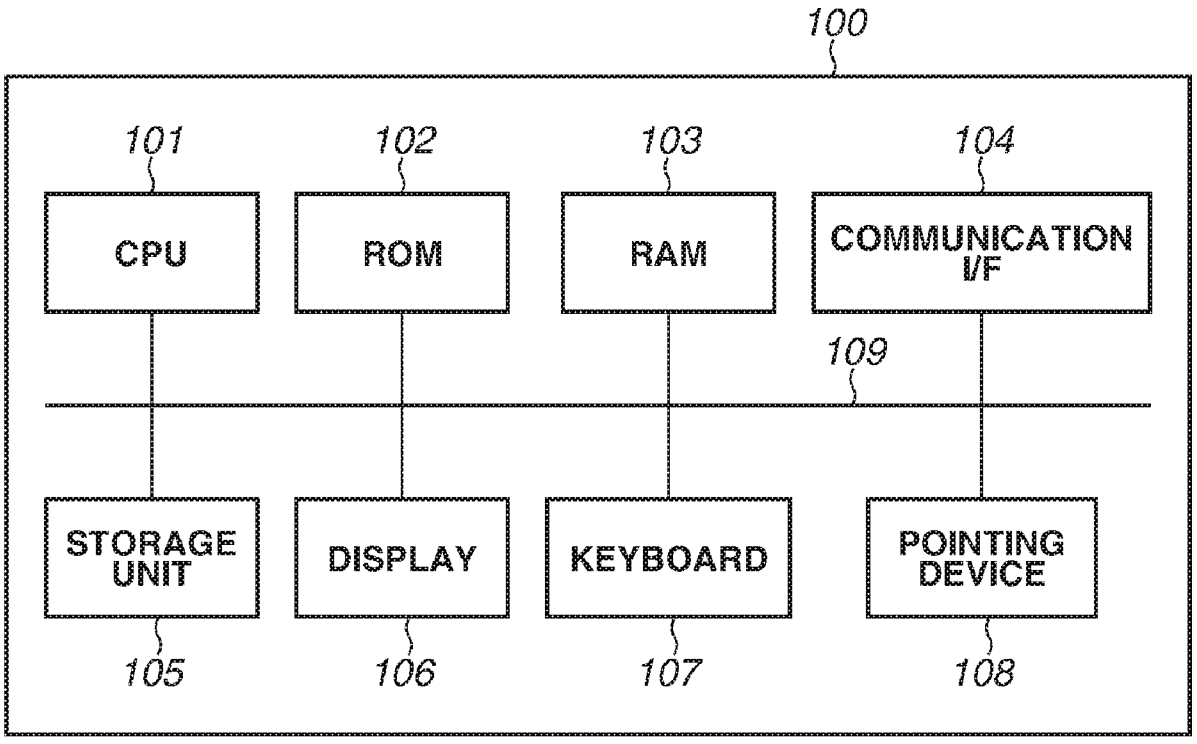


FIG.1

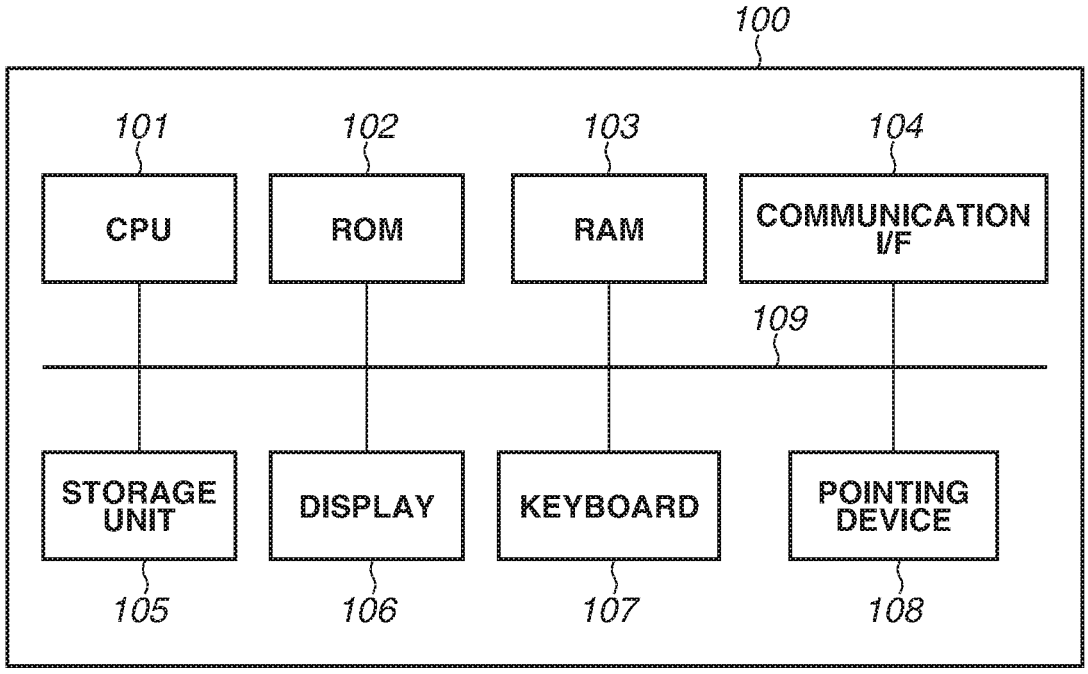

100
101
102
103
104
CPU
ROM
RAM
COMMUNICATION I/F
109
STORAGE UNIT
DISPLAY
KEYBOARD
POINTING DEVICE
105
106
107
108

FIG.2

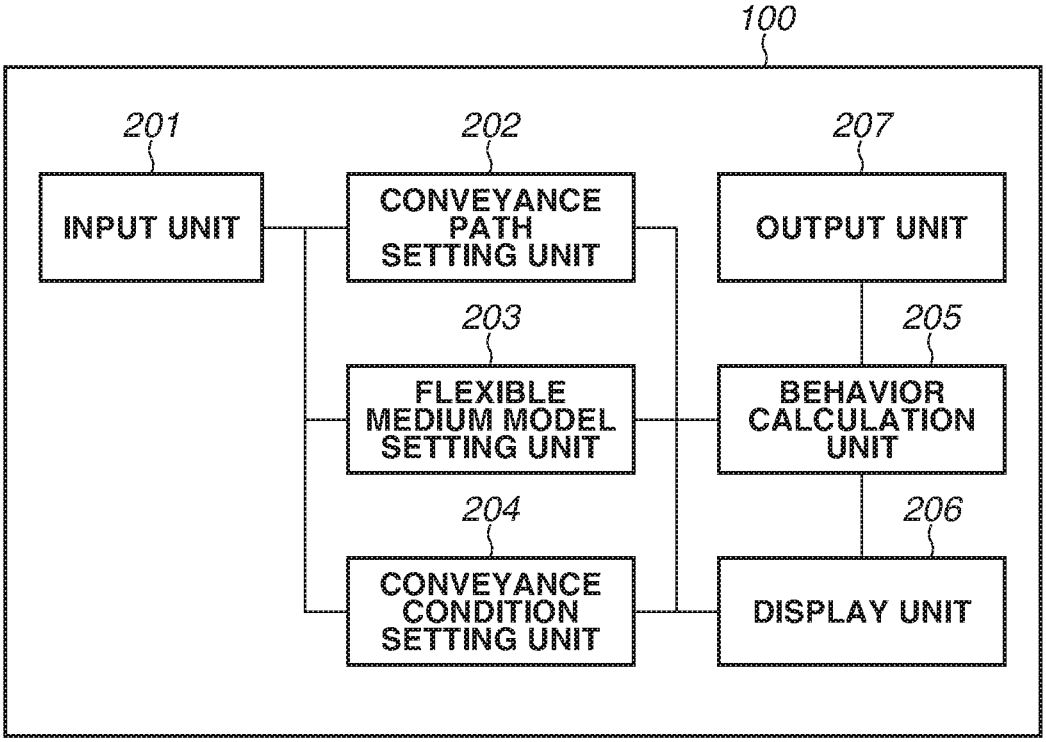

100
201
INPUT UNIT
202
CONVEYANCE PATH SETTING UNIT
203
FLEXIBLE MEDIUM MODEL SETTING UNIT
204
CONVEYANCE CONDITION SETTING UNIT
207
OUTPUT UNIT
205
BEHAVIOR CALCULATION UNIT
206
DISPLAY UNIT

FIG.3

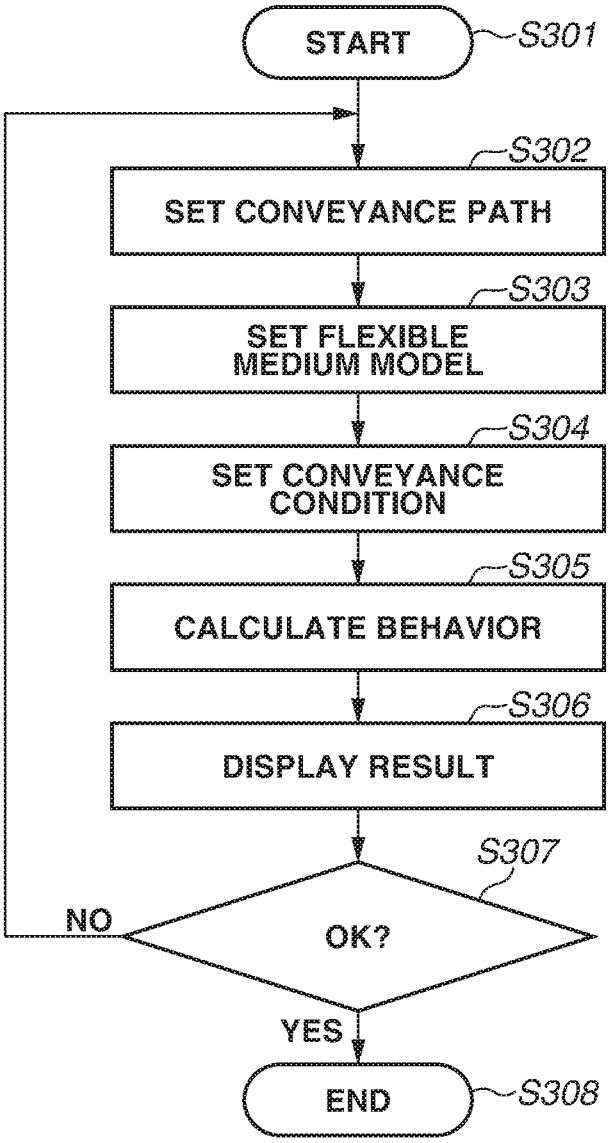

START
S301
S302
SET CONVEYANCE PATH
S303
SET FLEXIBLE MEDIUM MODEL
S304
SET CONVEYANCE CONDITION
S305
CALCULATE BEHAVIOR
S306
DISPLAY RESULT
S307
OK?
NO
YES
END
S308

FIG.4

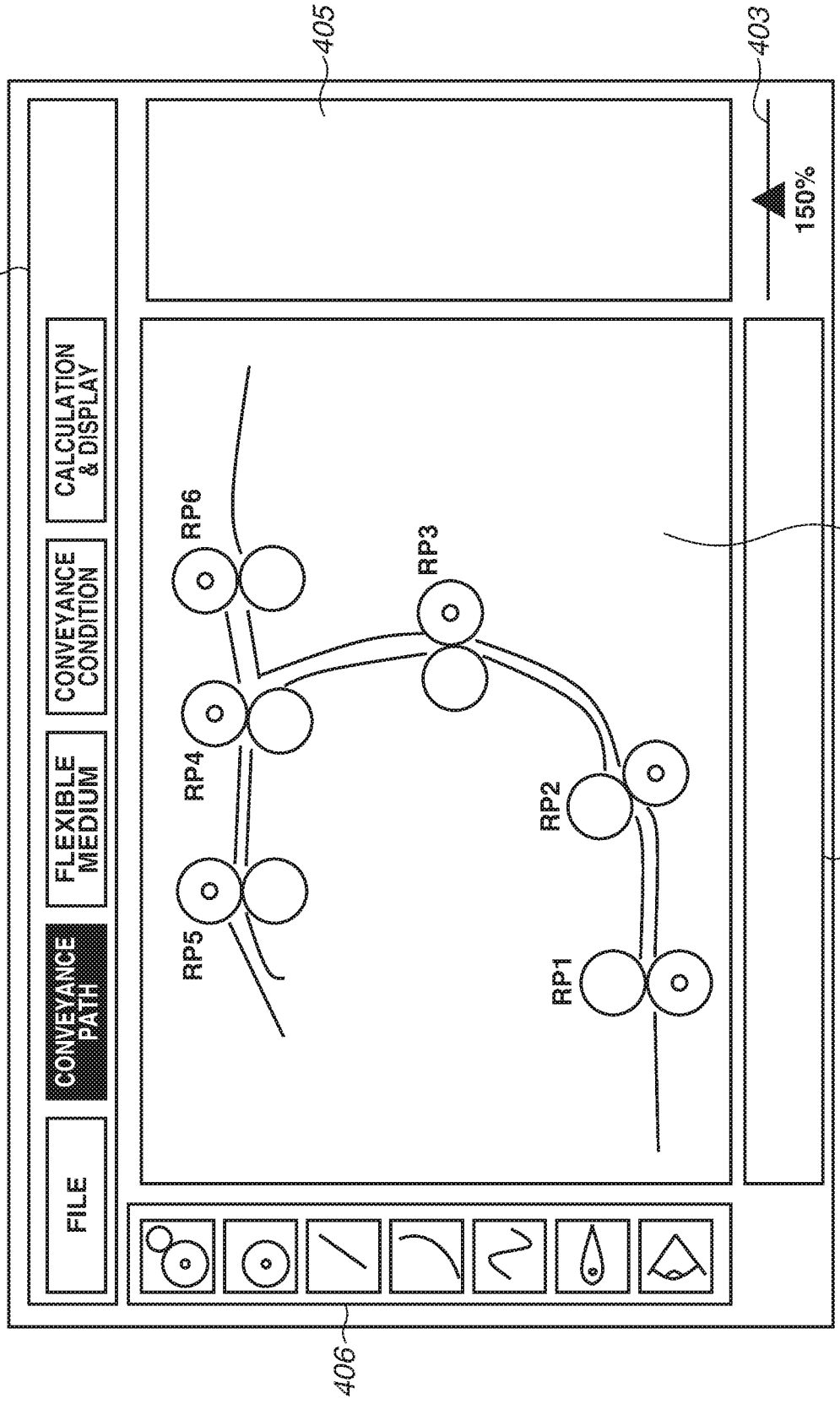

402
405
403
150%
FILE
CONVEYANCE PATH
FLEXIBLE MEDIUM
CONVEYANCE CONDITION
CALCULATION & DISPLAY
RP6
RP3
RP4
RP2
RP5
RP1
401
404
406

FIG.5

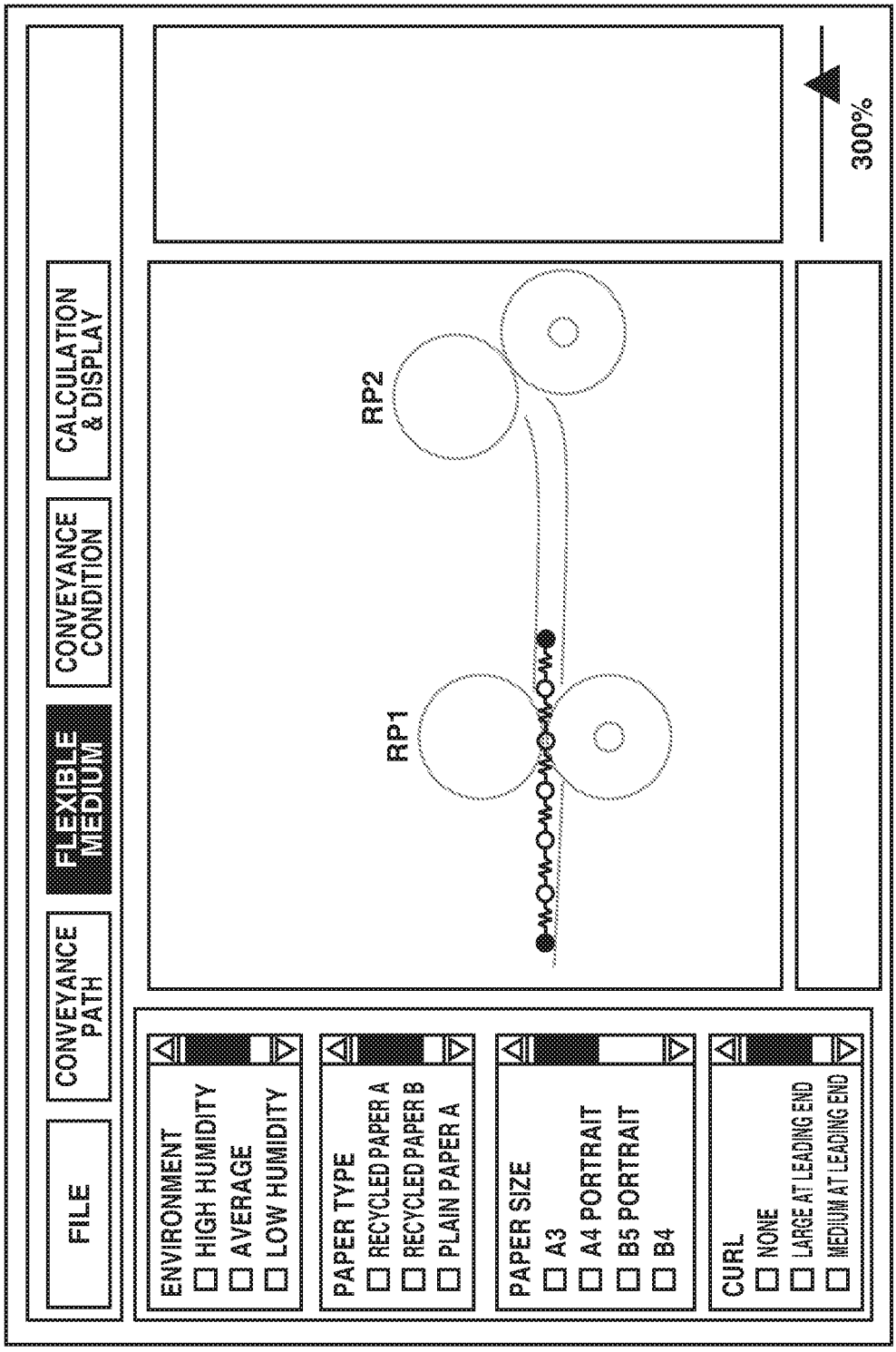

FILE
CONVEYANCE PATH
FLEXIBLE MEDIUM
CONVEYANCE CONDITION
CALCULATION & DISPLAY
ENVIRONMENT
HIGH HUMIDITY
AVERAGE
LOW HUMIDITY
PAPER TYPE
RECYCLED PAPER A
RECYCLED PAPER B
PLAIN PAPER A
PAPER SIZE
A3
A4 PORTRAIT
B5 PORTRAIT
B4
CURL
NONE
LARGE AT LEADING END
MEDIUM AT LEADING END
RP1
RP2
300%

FIG.6

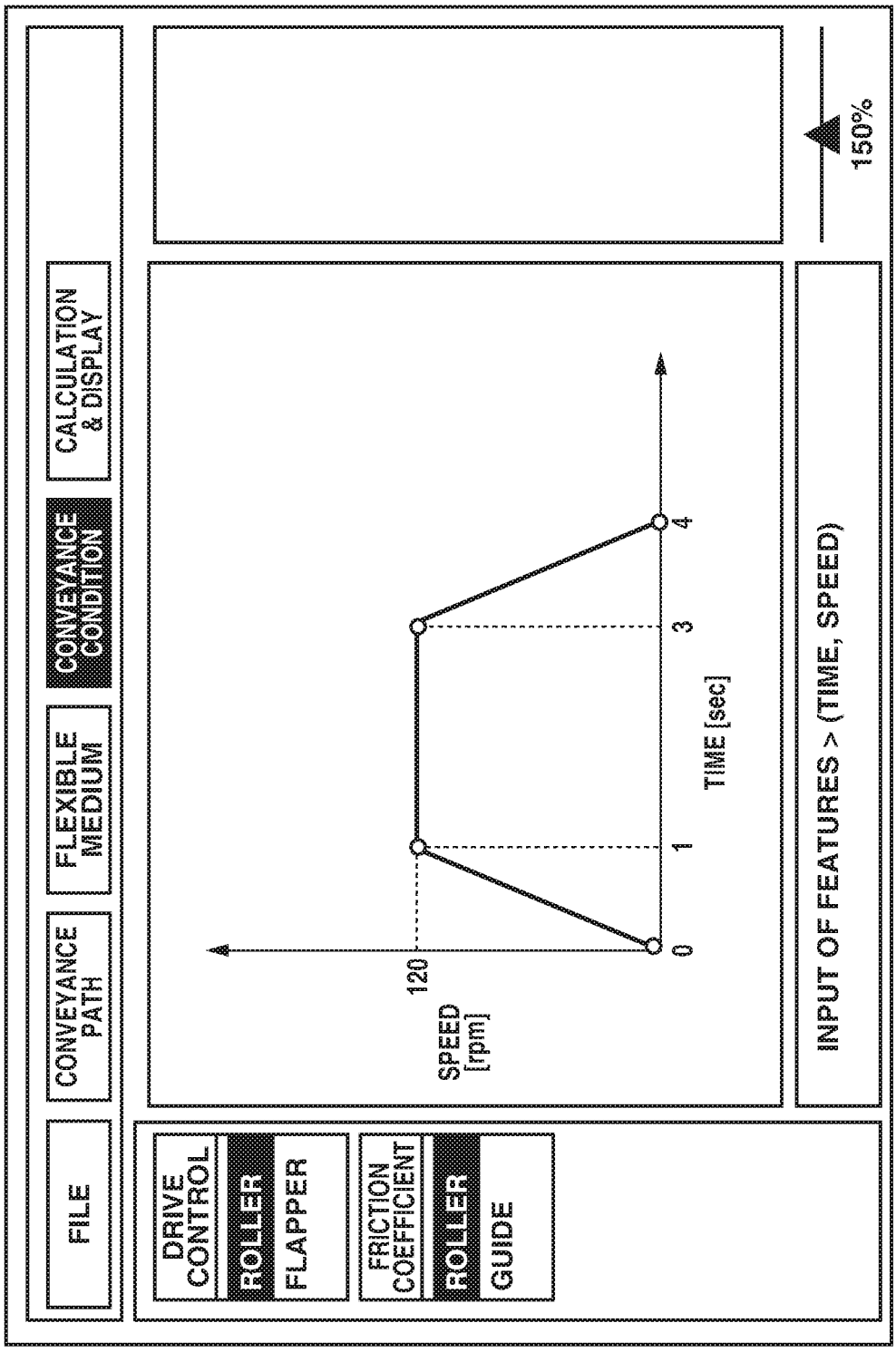

FILE
CONVEYANCE PATH
FLEXIBLE MEDIUM
CONVEYANCE CONDITION
CALCULATION & DISPLAY
DRIVE CONTROL
ROLLER
FLAPPER
FRICTION COEFFICIENT
ROLLER
GUIDE
SPEED [rpm]
120
0
1
3
4
TIME [sec]
INPUT OF FEATURES > (TIME, SPEED)
150%

FIG.7

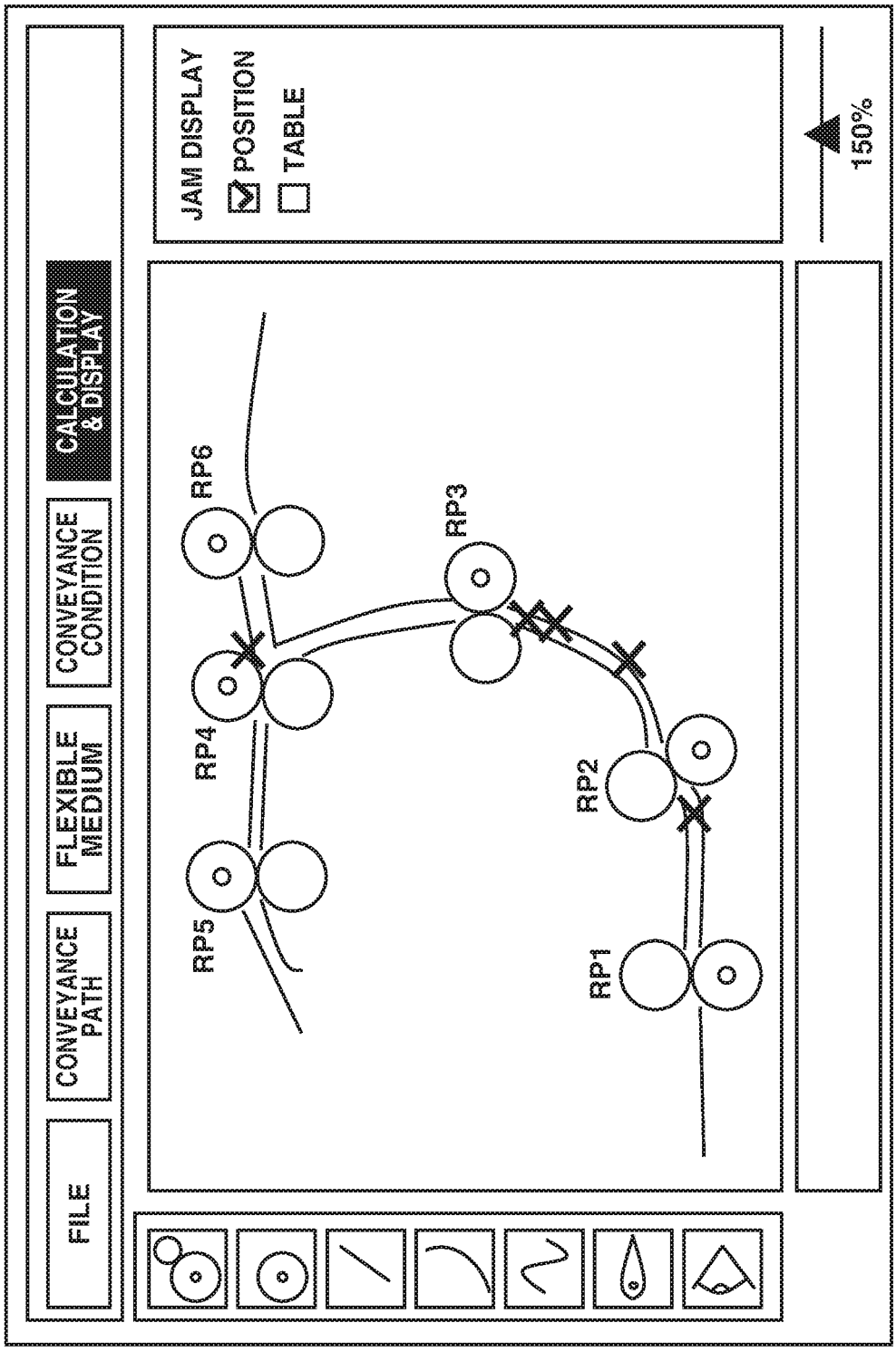

FILE
CONVEYANCE PATH
FLEXIBLE MEDIUM
CONVEYANCE CONDITION
CALCULATION & DISPLAY
JAM DISPLAY
POSITION
TABLE
150%
RP1
RP2
RP3
RP4
RP5
RP6

FIG.8

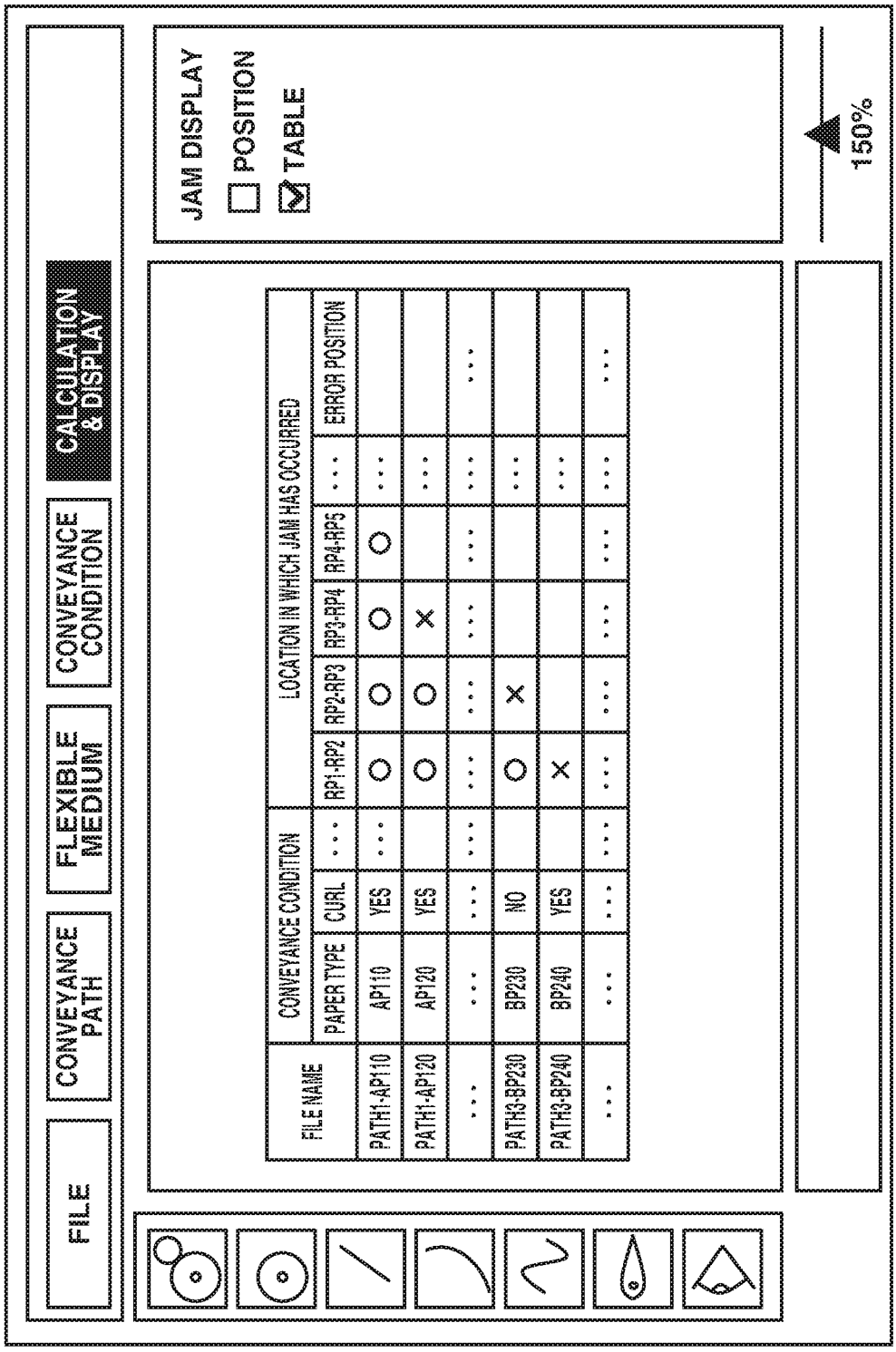

FILE
CONVEYANCE PATH
FLEXIBLE MEDIUM
CONVEYANCE CONDITION
CALCULATION & DISPLAY
JAM DISPLAY
POSITION
TABLE
150%
FILE NAME
CONVEYANCE CONDITION
PAPER TYPE
CURL
...
LOCATION IN WHICH JAM HAS OCCURRED
RP1-RP2
RP2-RP3
RP3-RP4
RP4-RP5
...
ERROR POSITION
PATH1-AP110 AP110 YES ... ○ ○ ○ ○ ... ...
PATH1-AP120 AP120 YES ○ ○ × ... ...
... ...
PATH3-BP230 BP230 NO ○ × ... ...
PATH3-BP240 BP240 YES × ... ...
... ...

FIG.9

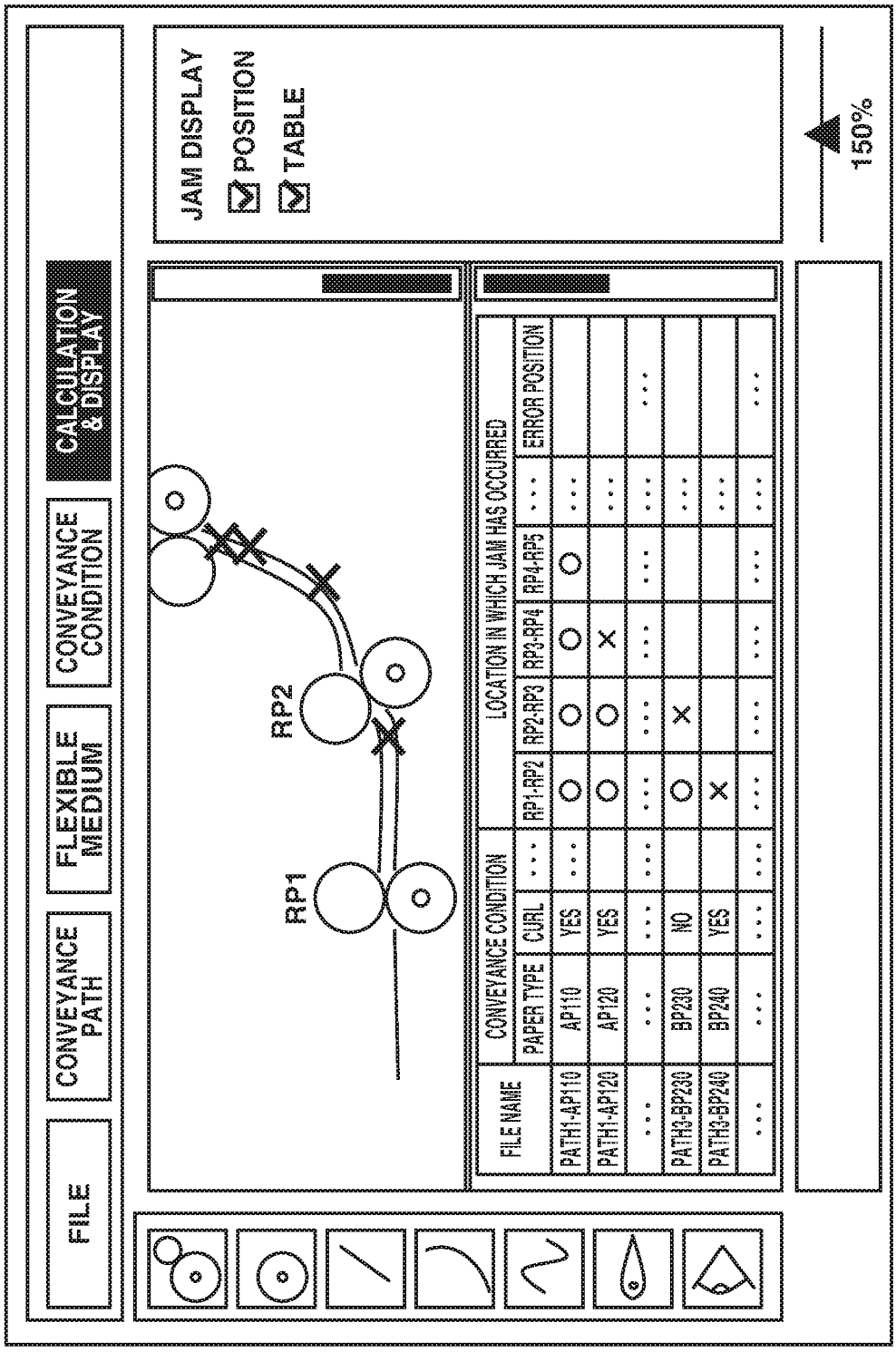
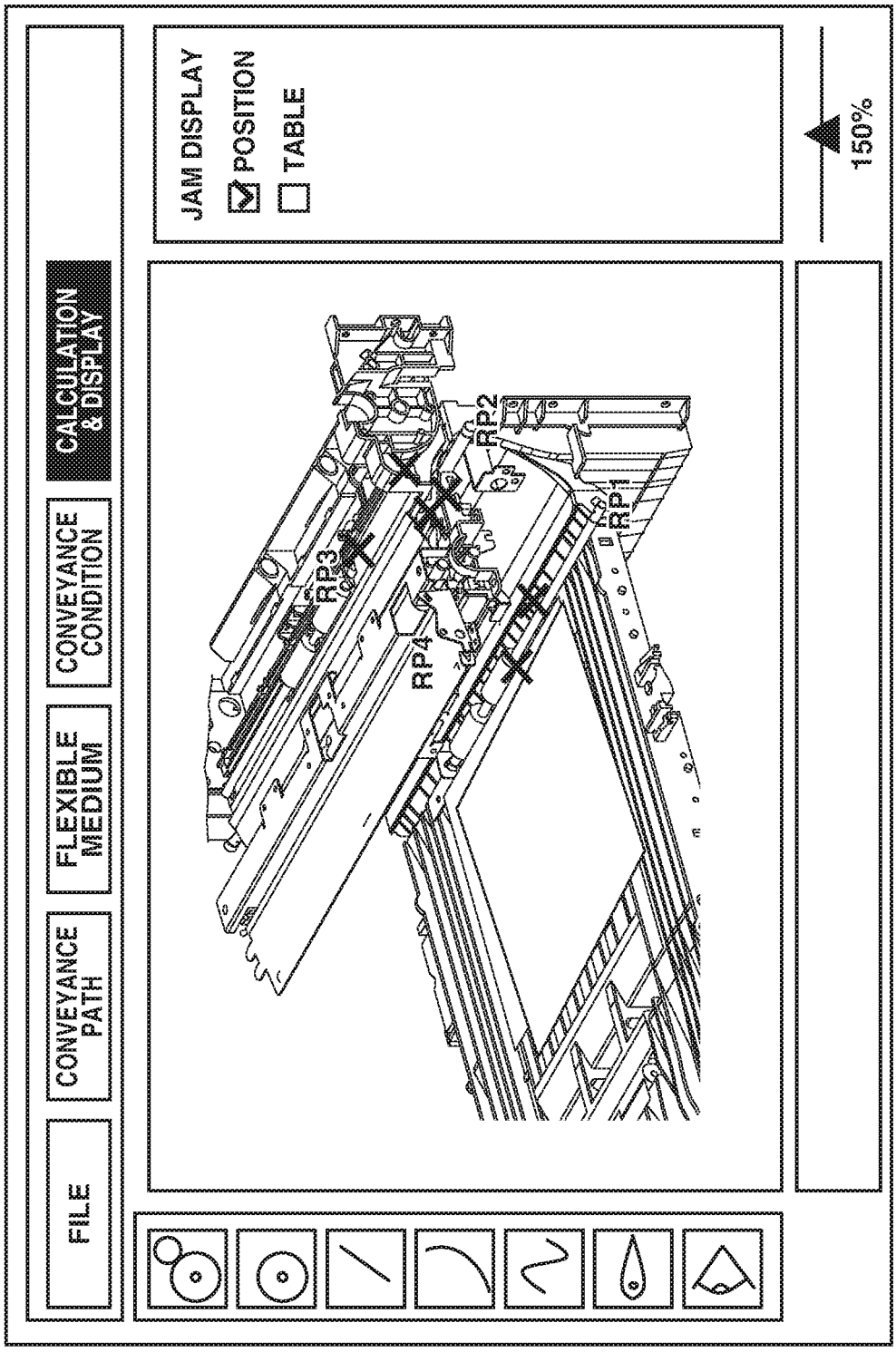

FILE
CONVEYANCE PATH
FLEXIBLE MEDIUM
CONVEYANCE CONDITION
CALCULATION & DISPLAY
JAM DISPLAY
POSITION
TABLE
RP1
RP2
150%
FILE NAME
CONVEYANCE CONDITION
PAPER TYPE
CURL
LOCATION IN WHICH JAM HAS OCCURRED
RP1-RP2
RP2-RP3
RP3-RP4
RP4-RP5
ERROR POSITION
PATH1-AP110 AP110 YES ○ ○ ○ ○
PATH1-AP120 AP120 YES ○ ○ × ×
PATH3-BP230 BP230 NO ○ × ×
PATH3-BP240 BP240 YES × ×

FIG.10


FILE
CONVEYANCE PATH
FLEXIBLE MEDIUM
CONVEYANCE CONDITION
CALCULATION & DISPLAY
JAM DISPLAY
POSITION
TABLE
150%
RP1
RP2
RP3
RP4

INFORMATION PROCESSING APPARATUS, INFORMATION PROCESSING METHOD, AND STORAGE MEDIUM

BACKGROUND

Field

[0001] The present disclosure relates to an information processing apparatus that simulates behavior of a sheet-shaped flexible medium that moves inside a conveyance path.

Description of the Related Art

[0002] When designing a conveyance path in an image forming apparatus such as a copier and a laser beam printer, functions of a designed object are studied under various conditions before the object is actually created. Such study can reduce not only the man-hours necessary for prototype manufacturing and prototype testing, but also a development period and a cost. For such purposes, behavior of a sheet-shaped flexible medium (e.g., paper and a sheet) that moves inside a conveyance path in an image forming apparatus is analyzed by computer simulation so that the design of the conveyance path can be studied based on the analysis result.

[0003] Conventionally, a design assisting system (Japanese Patent Application Laid-Open No. H11-195052) has been discussed as a technique for simulating behavior of a flexible medium. The design assisting system expresses a flexible medium in a finite element based on the finite element method, determines contact between the flexible medium and a guide or a roller inside the conveyance path, and numerically solves an equation of motion, thereby evaluating a conveyance resistance or a contact angle between the flexible medium and the guide.

[0004] To understand the motion of the flexible medium, an equation of motion of the flexible medium discretely represented in a finite element or a mass-spring system is formulated, and an analysis target time is divided into time steps (steps of time) having a finite width. Then, acceleration, speed, and displacement of unknown quantities are sequentially determined for each step from a time 0, and the resultant numeric values are time-integrated, so that behavior of the flexible medium can be expressed. Such an analysis method includes Newmark β method, Wilson θ method, Euler method, and Kutta-Merson method are known.

[0005] However, the related-art simulation apparatus identifies a location in which an abnormality has occurred under one condition per simulation. Consequently, if simulations are to be performed under a plurality of conditions, a user needs to set a condition, perform a simulation, and check a result on a simulation basis. Moreover, the user can only review the result of one simulation at a time.

SUMMARY

[0006] According to an aspect of the present disclosure, an information processing apparatus that simulates behavior of a sheet-shaped flexible medium that moves inside a conveyance path includes a simulation unit configured to simulate behavior of the flexible medium for a plurality of times under a plurality of different conditions, and a display unit configured to display a component inside the conveyance path together with a plurality of locations in which abnormal behavior of the flexible medium has occurred based on a result of the simulation.

[0007] Further features of the present disclosure will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a block diagram illustrating a hardware configuration of an information processing apparatus.

[0009] FIG. **2** is a block diagram illustrating a functional configuration of the information processing apparatus.

[0010] FIG. **3** is a flowchart illustrating an information processing method.

[0011] FIG. **4** is a display screen to be displayed when a conveyance path is set.

[0012] FIG. **5** is a display screen to be displayed when a flexible medium is set.

[0013] FIG. **6** is a display screen to be displayed when a conveyance condition is set.

[0014] FIG. **7** is a display screen of a simulation result.

[0015] FIG. **8** is a display screen of a simulation result.

[0016] FIG. **9** is a display screen of a simulation result.

[0017] FIG. **10** is a display screen of a simulation result.

DESCRIPTION OF THE EMBODIMENTS

<Hardware>

[0018] FIG. **1** is a diagram illustrating one example of hardware of an information processing apparatus **100** that functions as a simulator according to the present exemplary embodiment.

[0019] The information processing apparatus **100** is, for example, an apparatus such as a personal computer (PC) having a communication function. The information processing apparatus **100** includes a central processing unit (CPU) **101**, a read only memory (ROM) **102**, a random access memory (RAM) **103**, a communication interface (I/F) **104**, a storage unit **105** such as a hard disk drive (HDD) and a solid state drive (SSD), and a display **106**. Moreover, the information processing apparatus **100** includes a keyboard **107**, a pointing device **108**, and a system bus **109**. The CPU **101** uses the RAM **103** as a work memory to execute an operating system (OS) or various programs stored in a memory such as the ROM **102** and the storage unit **105**. Moreover, the CPU **101** controls each component via the system bus **109**. The CPU **101** loads a program code stored in a memory such as the ROM **102** and the storage unit **105** into the RAM **103** to execute processing that will be described below with reference to a flowchart. The communication I/F **104** is connected to an external apparatus via a wireless/wired module. The display **106** displays various screens for running a simulation. Each of the keyboard **107** and the pointing device **108** receives an input from a user.

<Functional Block Diagram>

[0020] FIG. **2** is a block diagram illustrating a functional configuration of the information processing apparatus **100**. The CPU **101** of the information processing apparatus **100** uses the RAM **103** as a work memory to execute a program stored in the ROM **102**, thereby providing various functions illustrated in FIG. **2**. The CPU **101** does not necessarily have to execute the entire processing described below. The infor-

mation processing apparatus **100** can be configured such that the processing is partially or entirely executed by one or a plurality of processing circuits other than the CPU **101**.

[0021] The information processing apparatus **100** includes functional blocks such as an input unit **201**, a conveyance path setting unit **202**, a flexible medium model setting unit **203**, a conveyance condition setting unit **204**, a behavior calculation unit **205**, a display unit **206**, and an output unit **207**.

[0022] The input unit **201** is realized by, for example, the keyboard **107**, the pointing device **108**, and the communication I/F **104**. The display unit **206** is realized by, for example, the display **106**.

[0023] FIG. **3** is a flowchart illustrating processing related to simulation of behavior of a flexible medium. The processing program is stored as a program for design assist and simulation in a storage device (the storage unit **105**), and is executed by the CPU **101**. Each of the aforementioned components of the information processing apparatus **100** is provided by execution of the processing program stored in the storage unit **105** by the CPU **101**.

[0024] Hereinafter, the processing according to the present exemplary embodiment will be described with reference to the functional block diagram illustrated in FIG. **2** and the flowchart illustrated in FIG. **3**.

[0025] In step S**301**, the CPU **101** stars processing.

[0026] In step S**302**, the conveyance path setting unit **202** sets a conveyance path.

[0027] FIG. **4** is a display screen displayed by the display unit **206** when a conveyance path is set. A main area **401** is an area in which various settings such as a conveyance path setting and a result such as a simulation result are displayed. A menu area **402** is a display area for navigation of an operation change and a file operation. A slide bar **403** is used to determine a scale ratio of the main area **401**. A message area **404** is a display area in which various messages are displayed. A setting area **405** is a display area in which attribution information is set. A component selection area **406** is a display area in which each component (e.g., a roller, a conveyance path, and a friction coefficient μ) in setting of the conveyance path is selected. A user operates the input unit **201** to set a conveyance path.

[0028] In step S**303**, the flexible medium model setting unit **203** sets a flexible medium model.

[0029] FIG. **5** is a display screen to be displayed by the display unit **206** when a flexible medium model is set. In the present exemplary embodiment, a flexible medium is defined as a mass-point-spring system elastic model divided into n. Parameters necessary for simulation of a flexible medium behavior include Young's modulus, a density, a thickness, a size, and a curl state of a flexible medium. These parameters can correspond to a flexible medium type (e.g., a paper type). The user operates the input unit **201** to set conditions such as an environment, a paper size, a medium, a curl position, and an initial position via the display screen illustrated in FIG. **5**. For example, if the user performs simulations under conditions of "A3", "A4 portrait", and "B5 landscape", the user places checkmarks in checkboxes of the respective items.

[0030] The simulations are performed for all of the combinations of the conditions of respective items selected by the user. For example, if two environments, eight paper sizes, 30 media, and three curl states of conditions are selected, simulations are executed for 1440 times based on 2×8×30×3=1440. Conventionally, a user has set a combination of conditions on a one-by-one basis, and then perform simulations for all of the combinations of the conditions. Thus, the workload of the user has been very high. According to the present exemplary embodiment, since the combinations of the conditions can be automatically set, the workload of the user can be markedly reduced.

[0031] In step S**304**, the conveyance condition setting unit **204** sets a conveyance condition.

[0032] FIG. **6** is a display screen to be displayed by the display unit **206** when a conveyance condition is set. FIG. **6** illustrates an input example of drive control of a conveyance roller.

[0033] In step S**305**, the behavior calculation unit **205** simulates behavior of the flexible medium for a plurality of times under a plurality of different conditions based on an instruction from the user. After starting the simulation, the behavior calculation unit **205** calculates a state (e.g., a position and shape) of the flexible medium on a time step basis to calculate behavior of the flexible medium. Herein, the behavior calculation unit **205** also calculates whether the flexible medium indicates abnormal behavior. The term "abnormal behavior" used herein includes the following states.

[0034] A shape of the flexible medium becomes abnormal (e.g., a paper jam state)

[0035] Stress that exceeds anticipated stress occurs in a mass-point-spring system

[0036] The flexible medium enters an unintended conveyance path

If abnormal behavior occurs, a location in which the abnormal behavior has occurred is stored in a memory such as the storage unit **105**, and then the behavior calculation unit **205** performs a simulation under a next condition.

[0037] In step S**306**, a simulation result is displayed.

[0038] FIG. **7** is a display screen that is provided when the display unit **206** displays a simulation result. A cross mark indicates a location in which abnormal behavior of a flexible medium has occurred, in an overlapping manner on a component of the conveyance path set in step S**302**. The case illustrated in FIG. **7** indicates that the abnormal behavior has occurred in one location between a roller pair (RP) **1** and a RP **2**, three locations between the RP **2** and a RP **3**, and one location near a RP **4**. The user checks such displayed areas, so that the user can readily ascertain a location in which abnormal behavior is liable to occur. Thus, design efficiency can be enhanced.

[0039] FIG. **8** is another example of a display screen that is provided when the display unit **206** displays a simulation result. Unlike the display screen illustrated in FIG. **7**, a location in which abnormal behavior has occurred is expressed in a table format. Herein, a condition is displayed in association with information (e.g., RP**1**-RP**2**) about a location in which abnormal behavior has occurred. Unlike the display screen illustrated in FIG. **7**, a condition is displayed. Thus, the use of the display screen illustrated in FIG. **8** enables the user to readily identify a cause of abnormality.

[0040] FIG. **9** is yet another example of a display screen that is provided when the display unit **206** displays a simulation result. The display screen illustrated in FIG. **9** has a combination of the display of the abnormality on the conveyance path illustrated in FIG. **7** and the display of the table illustrated in FIG. **8**. If the user identifies an error

position on the conveyance path by using, for example, a mouse, the corresponding row indicating the abnormality in the table is highlighted. Accordingly, the user can ascertain the abnormality at the time of conveyance more easily.

[0041] In step S**307**, the CPU **101** receives an input indicating whether the user is satisfied with the simulation result. If the user is satisfied with the simulation result (YES in step S**307**), the processing proceeds to step S**308** where the processing ends. On the other hand, if the user is not satisfied with the result (NO in step S**307**), the processing returns to step S**302** and the conveyance path is set again.

[0042] According to the present embodiment, therefore, a plurality of conditions can be collectively set. Moreover, listing that is used if a simulation result is checked is enhanced, so that user convenience can be enhanced.

[0043] The present exemplary embodiment has been described using an example of processing based on two-dimensional (2D) simulation. However, the present exemplary embodiment may be applied to processing based on three-dimensional (3D) simulation. FIG. **10** is an example of 3D simulation corresponding to the example illustrated in FIG. **7**.

[0044] The configuration of the above-described exemplary embodiment is not limited thereto. Any configuration may be applied as long as a function in the scope of the claims or a function of the configuration of the present exemplary embodiment can be provided. Moreover, the present exemplary embodiment may be applied to a system including a plurality of devices or a single device.

OTHER EMBODIMENTS

[0045] Embodiment(s) of the present disclosure can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a 'non-transitory computer-readable storage medium') to perform the functions of one or more of the above-described embodiment(s) and/or that includes one or more circuits (e.g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiment(s), and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiment(s) and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiment(s). The computer may comprise one or more processors (e.g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.

[0046] While the present disclosure has been described with reference to exemplary embodiments, it is to be understood that the disclosure is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

[0047] This application claims the benefit of Japanese Patent Application No. 2018-218573, filed Nov. 21, 2018, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. An information processing apparatus that simulates behavior of a sheet-shaped flexible medium that moves inside a conveyance path, the information processing apparatus comprising:

one or more memory devices storing instructions; and

one or more processors that, upon executing the stored instructions, configures the apparatus to

simulate behavior of the flexible medium for a plurality of times under a plurality of different conditions; and

display a component inside the conveyance path together with a plurality of locations in which abnormal behavior of the flexible medium has occurred based on a result of the simulation.

2. The information processing apparatus according to claim **1**, wherein the display unit displays the condition in association with information about a location in which the abnormal behavior has occurred based on a result of the simulation.

3. The information processing apparatus according to claim **2**, wherein the display unit displays the condition and the information about the location in which the abnormal behavior has occurred in a table format.

4. The information processing apparatus according to claim **1**, further comprising a condition setting unit configured to set the plurality of conditions.

5. The information processing apparatus according to claim **1**, wherein the plurality of conditions includes at least a condition concerning environment, a condition concerning a type of medium, a condition concerning a size of medium, a condition concerning an initial position of medium, and a condition concerning initial deformation of medium.

6. The information processing apparatus according to claim **4**, wherein the condition setting unit sets the plurality of conditions based on an instruction from a user.

7. The information processing apparatus according to claim **1**, wherein the abnormal behavior is at least one of an abnormal shape of the flexible medium, generation of stress that exceeds a predetermined amount, and intrusion of the flexible medium into an unintended conveyance path.

8. An information processing method for simulating behavior of a sheet-shaped flexible medium that moves inside a conveyance path, the information processing method comprising:

simulating behavior of the flexible medium for a plurality of times under a plurality of different conditions; and

displaying a component inside the conveyance path together with a plurality of locations in which abnormal behavior of the flexible medium has occurred based on a result of the simulation.

9. The information processing method according to claim **8**, wherein, in the displaying, the condition is displayed in association with information about a location in which the abnormal behavior has occurred based on a result of the simulation.

10. The information processing method according to claim **9**, wherein, in the displaying, the condition and the

information about the location in which the abnormal behavior has occurred are displayed in a table format.

11. The information processing method according to claim **8**, further comprising condition-setting for setting the plurality of conditions.

12. The information processing method according to claim **8**, the plurality of conditions includes at least a condition concerning environment, a condition concerning a type of medium, a condition concerning a size of medium, a condition concerning an initial position of medium, and a condition concerning initial deformation of medium.

13. The information processing method according to claim **11**, wherein, in the condition-setting, the plurality of conditions are set based on an instruction from a user.

14. The information processing method according to claim **8**, wherein the abnormal behavior is at least one of an abnormal shape of the flexible medium, generation of stress that exceeds a predetermined amount, and intrusion of the flexible medium into an unintended conveyance path.

15. A non-transitory storage medium storing a program causing a computer to execute an information processing method for simulating behavior of a sheet-shaped flexible medium that moves inside a conveyance path, the method comprising:

simulating behavior of the flexible medium for a plurality of times under a plurality of different conditions; and

displaying a component inside the conveyance path together with a plurality of locations in which abnormal behavior of the flexible medium has occurred based on a result of the simulation.

16. The non-transitory storage medium according to claim **15**, wherein, in the displaying, the condition is displayed in association with information about a location in which the abnormal behavior has occurred based on a result of the simulation.

17. The non-transitory storage medium according to claim **16**, wherein, in the displaying, the condition and the information about the location in which the abnormal behavior has occurred are displayed in a table format.

18. The non-transitory storage medium according to claim **15**, wherein the method further comprises condition-setting for setting the plurality of conditions.

19. The non-transitory storage medium according to claim **15**, wherein the plurality of conditions includes at least a condition concerning environment, a condition concerning a type of medium, a condition concerning a size of medium, a condition concerning an initial position of medium, and a condition concerning initial deformation of medium.

20. The non-transitory storage medium according to claim **18**, wherein, in the condition-setting, the plurality of conditions are set based on an instruction from a user.

* * * * *