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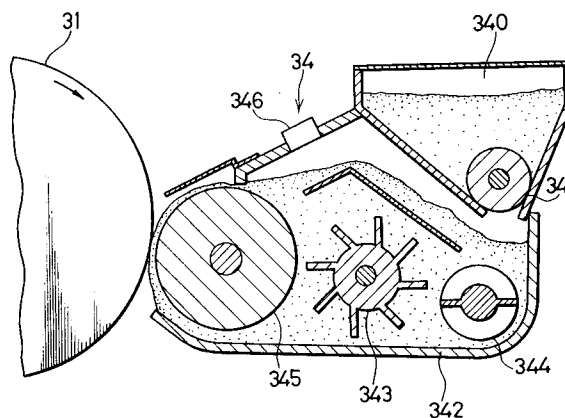
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W-8000 München 26 (DE)(54) **A developing device.**

(57) A developing device includes a container for containing toner therein, a developing unit for supplying developer including the toner and carriers to a photosensitive member, a supply roller for supplying the toner from the container to the developing unit at a low speed or a high speed, a sensor for detecting the toner density in the developing unit, a discriminator for comparing the toner density detected by the sensor with a toner supply level where the toner supply is necessary, a toner empty level where there exists almost no toner in the developing unit, and a preset intermediate level between the toner supply level and the toner empty level, and a control unit for causing the supply roller to supply the toner at the low speed when the toner density lies between the toner supply level and the intermediate level, while causing the supply roller to supply the toner at the high speed when the toner density lies between the intermediate level and the toner empty level. With thus constructed developing device, the toner density can be maintained stably at a specified level. Accordingly, copies having stable image density can be continuously made. Further even in the case where documents each having an exceedingly large black portion are copied continuously, the toner density does not continue to decrease, thus a toner empty indication can be accurately displayed.

FIG. 2

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BACKGROUND OF THE INVENTION AND RELATED ART STATEMENT

This invention relates to a developing device which detects the toner density in a developer container provided in an image forming apparatus and supplies the toner while the toner density lies between a toner supply level and a toner empty level

In an image forming apparatus such as a copying machine and a printer in which an electrostatic latent image formed on the surface of a photosensitive member is developed into a toner image by a developing device, the toner density of developer in the developing device has been maintained at a proper level by supplying the toner from a toner hopper into the developing device when the toner density falls below a toner supply level where the supply of toner is necessary.

In the above image forming apparatus, the toner density in the developing device is detected as a sensor voltage corresponding thereto by a toner sensor. The toner is supplied in such a manner that the toner density does not fall below the toner supply level by controllably driving a motor adapted to drive a means to supply the toner as indicated by a solid line A1 in Fig. 6. Specifically, when the sensor voltage becomes in excess of a voltage V1 corresponding to the toner supply level, the motor is driven to supply the toner. On the contrary, when the sensor voltage becomes below the voltage V1, the driving of the motor is stopped and accordingly the toner is not supplied.

However, in this image forming apparatus, the toner supply cannot meet the toner consumption properly, for example, in the case where a multitude of documents each having a large black portion are copied continuously. Accordingly, the toner density fluctuates greatly as indicated by a dashed line B1 in Fig. 6, which makes it difficult to stably maintain the toner density at a proper level. Further, in this case, a large amount of toner is supplied after a large amount of toner is consumed in the developing device for a short time. Thus, the toner is liable to scatter.

Further in an image forming apparatus capable of processing image data such as a digital copying machine, images may be output with a white portion and a black portion thereof reversed. In this case, the toner consumption becomes far greater than the toner supply if the black portions of the white-to-black reversed images are large. Accordingly, the toner supply falls short of the toner consumption, resulting in a continuously decreasing toner density as indicated by a phantom line C1 in Fig. 6. If the sensor voltage becomes in excess of a voltage V3 corresponding to the toner empty level where almost no toner is contained in

the developer despite the fact that there still remains toner in the toner hopper, a toner empty indication is displayed erroneously.

Japanese Unexamined Patent Publication No. 58-178381 discloses a developing device as follows. When the toner density decreases and a toner requirement signal for requiring the toner supply is issued, the toner supply is started. If the toner requirement signal is output for longer than a first specified period, the toner supply speed is increased so as to prevent a decrease in the toner density upon determination that the toner is consumed in quantity. Further, if the toner requirement signal is output for longer than a second specified period in a state where the toner supply speed is set high, the toner empty indication is displayed upon determination that the toner hopper is empty of the toner and no toner is supplied. In this way, it is accurately detected that the toner hopper is empty of the toner.

Japanese Unexamined Patent Publication No. 60-209763 discloses a developing device as follows. In the case where white-to-black reversed images are output and copied continuously, a bias voltage applied to the toner is regulated so as to restrict an amount of toner supplied to a photosensitive drum. This facilitates to maintain the toner density at a specified level even if the white-to-black reversed images have a large black portion each.

However, in the developing device disclosed in the former publication, the toner supply speed is increased regardless of the actual toner consumption when the toner requirement signal is output for longer than the first specified period. Thus, the toner density is likely to fluctuate greatly, making it difficult to maintain the toner density in a stable manner.

In the developing device disclosed in the latter publication, the toner density can be stabilized. However, since the amount of toner supplied to the photosensitive drum is restricted, the density of the overall images is low in the obtained copies.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a developing device capable of overcoming the problems existing in the prior art and of stably maintaining the toner density at a specified level.

Accordingly, a developing device of the invention comprises container means for containing toner therein; developing means for supplying developer including the toner and carriers to a photosensitive member; supply means for supplying the toner from the container means to the developing means at a low speed or a high speed; detector means for detecting the toner density in

the developing means: discriminator means for comparing the toner density detected by the detector means with a toner supply level where the toner supply is necessary, a toner empty level where there exists almost no toner in the developing means, and a preset intermediate level between the toner supply level and the toner empty level; and control means for causing the supply means to supply the toner at the low speed when the toner density lies between the toner supply level and the intermediate level, while causing the supply means to supply the toner at the high speed when the toner density lies between the intermediate level and the toner empty level.

In thus constructed developing device, the toner is supplied at the low speed when the toner density detected by the detector means lies between the toner supply level and the intermediate level, while being supplied at the high speed when the detected toner density lies between the intermediate level and the toner empty level. This allows the toner to be supplied according to the consumption of toner. Accordingly, in the case where documents each having a large black portion are continuously copied, a fluctuating range of the toner density can be made smaller and the toner density can be maintained in a stable manner. Thus, the images of the continuously made copies are stable and uniform in their density. Further, since an excessive supply of the toner is prevented, the scattering of the toner can be reduced. Moreover, even in the case where documents each having an exceedingly large black portion are continuously copied, the toner density does not continue to decrease. This prevents an error in determining that the container means is empty of the toner, thereby improving the reliability of the toner empty determination.

These and other objects, features and advantages of the present invention will become more apparent upon a reading of the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic construction diagram showing an exemplary image forming apparatus incorporating a developing device according to the invention;

Fig. 2 is a construction diagram showing the developing device;

Fig. 3 is a block diagram showing a control system of the developing device;

Fig. 4 is a flow chart showing a controlling operation of the developing device;

Fig. 5 is a chart showing a toner density control operation according to the invention; and

Fig. 6 is a chart showing a conventional toner density control operation.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT OF THE INVENTION

Fig. 1 is a schematic construction diagram showing an exemplary image forming apparatus (copying machine).

The copying machine is provided with a document holder 20 and a transparent document platen 21 at the top thereof, and is internally provided with an optical system L and an imaging assembly P. The document holder 20 is adapted for holding a document placed on the document platen 21.

The optical system L is provided with a first movable unit 25, a second movable unit 28, a lens array 29, and a mirror 30. The first movable unit 25 includes a lamp 22 such as a halogen lamp which serves as a light source, a reflector 23, and a mirror 24. The second movable unit 28 includes mirrors 26, 27. Upon start of a copying operation, the first movable unit 25 starts moving to scan a document image, and the light is projected from the lamp 22 onto the document placed on the document platen 21. The light reflected by the document is introduced to the lens array 29 through the mirrors 24, 26, and 27, and is projected onto a photosensitive drum 31 by way of the mirror 30. Thereby, the drum 31 is exposed.

The imaging assembly P includes the photosensitive drum 31, a main charger 32, a blank lamp 33, a developing device 34, a transfer charger 35, a separating charger 36, a cleaning device 37, etc. After being charged uniformly by the main charger 32, and having electric charges on an unnecessary region removed by the blank lamp 33, the surface of the photosensitive drum 31 is exposed to the light reflected by the document, thereby forming an electrostatic latent image thereon. Thus formed latent image is developed into a toner image by the developing device 34, which is in turn transferred to a copy sheet by the transfer charger 35. Then, the copy sheet bearing the toner image is separated from the surface of the photosensitive drum 31 by the separating charger 36. On the other hand, the toner residual on the surface of the photosensitive drum 31 is removed therefrom by the cleaning device 37.

Further, there are arranged cassettes 38, 39, feed rollers 40, 41, pairs of transport rollers 42, 43, and a pair of registration rollers 44 in this order from an upstream side of a sheet feeding direction. A copy sheet contained in the cassette 38 or 39 is dispensed by the feed rollers 40 or 41 and is transported to the registration rollers 44 by the pair of transport rollers 42 or 43. The copy sheet is caused to stay at the registration rollers 44 so as to

be fed to the photosensitive drum 31 as timed with the scanning of the optical system L.

Downstream of the photosensitive drum 31 are arranged a transport belt 45, a fixing device 46, a pair of discharge rollers 47, etc. in this order with respect to the sheet feeding direction. The copy sheet bearing a document image thereon which has been separated from the drum 31 is transported to the fixing device 46 by the transport belt 45. After having the image fixed thereto, the copy sheet is discharged onto a discharge tray 48 by the discharge rollers 47.

A construction of the developing device 34 will be described in detail next with reference to Fig. 2.

The developing device 34 includes a toner hopper 340, a supply roller 341, a housing 342, agitating rollers 343, 344, a developing roller 345, a toner sensor 346, and the like. The toner hopper 340 is adapted to contain toner therein, and the supply roller 341 is adapted for supplying the toner from the toner hopper 340 into the housing 342. The roller 341 supplies the toner at a specified rate by being driven by a drive motor 1 to be described later.

The agitating rollers 343, 344 mix the toner and magnetic particles, namely carriers, in the housing 342 so as to obtain uniformly mixed developer, and also cause the toner to be charged by means of frictional electrification. The developing roller 345 supplies the developer to the photosensitive drum 31, thereby developing the electrostatic latent image formed on the drum 31 into a toner image.

The toner sensor 346 includes, for example, a magnetic sensor, and is arranged in a specified position of the housing 342. The sensor 346 detects a magnetic force according to a mixing ratio of the toner to the carriers (toner density) in the housing 342, and outputs a sensor voltage corresponding to the detected toner density. It should be understood that the sensor voltage output from the sensor 346 is inversely related to the toner density. In other words, the sensor voltage decreases as the toner density increases, while increasing as the toner density decreases.

There will be described an exemplary control system for controlling the toner density next with reference to Fig. 3.

This control system includes a memory 2 and a control unit 3. The memory 2 stores preset voltage data concerning the sensor voltage, a processing program of the control unit 3, and the like. The voltage data include a voltage V1 corresponding to the toner density at a toner supply level where the toner supply is necessary, a voltage V2 ($> V1$) corresponding to the toner density at a supply speed switch level where the toner supply speed is switched, a voltage V3 ($> V2$) corresponding to the toner density at a toner empty

level where a satisfactory copy cannot be made because the toner density is exceedingly low, etc.

The control unit 3 includes a CPU, and is provided with a discriminator 4 and a drive controller 5. The discriminator 4 compares the sensor voltage V from the toner sensor 346 with the respective voltages V1, V2, and V3 stored in the memory 2. The discriminator 4 has a function of controllably switching the toner supply speed. Specifically, in the case where the sensor voltage V is in excess of the voltage V1, the discriminator 4 sends a first control signal to the drive controller 5 so as to supply the toner at a low speed. Further, in the case where the sensor voltage V is in excess of the voltage V2, the discriminator 4 sends a second control signal to the drive controller 5 so as to supply the toner at a high speed. The discriminator 4 also sends a stop signal to the drive controller 5 so as to stop the driving of the drive motor 1 in the case where the sensor voltage is equal to or higher than the voltage V1. Moreover, the discriminator 4 sends a display signal to a display unit 6 so as to cause the same to display an empty indication, and at the same time sends the stop signal to the drive controller 5 in the case where the sensor voltage V is in excess of the voltage V3.

The drive controller 5 has a function of switching the toner supply speed. Specifically, upon receipt of the first control signal from the discriminator 4, the drive controller 5 causes the drive motor 1 to rotate intermittently. For example, the drive motor 1 is stopped for 2 seconds after being driven for 1 second. Upon receipt of the second control signal from the discriminator 4, the drive controller 5 causes the drive motor 1 to rotate continuously. Further, upon receipt of the stop signal from the discriminator 4, the drive controller 5 causes the drive motor 1 to stop rotating.

A toner density controlling operation of the developing device 34 will be described next with reference to a flow chart shown in Fig. 4 and a chart shown in Fig. 5. In Fig. 5, indicated by a solid line A is a case where normal documents are copied continuously, indicated by a dashed line B is a case where documents having a relatively larger black portion are copied continuously, and indicated by a phantom line C is a case where documents each having an exceedingly large black portion, such as documents having white-to-black reversed images, are copied continuously.

First of all, in Step S1, the sensor voltage V is detected by the toner sensor 346. The detected sensor voltage V is input to the discriminator 4 in which it is discriminated whether the sensor voltage is lower than or equal to the voltage V1 in Step S2. If $V \leq V1$ (YES in Step S2), the driving of the drive motor 1 is stopped because there is no need to

supply toner in Step S3.

On the other hand, if $V > V1$ (NO in Step S2), it is discriminated whether the sensor voltage V is lower than or equal to the voltage $V2$ in Step S4. If $V \leq V2$ (YES in Step S4), the drive motor 1 is driven intermittently in Step S5, and thereby the toner is supplied from the toner hopper 340 to the housing 342 at the low speed. Accordingly, the toner is consumed relatively by the small quantity as the documents are copied continuously. As indicated by the solid line A, the toner is supplied at the low speed until the sensor voltage V decreases below the voltage $V1$, after the sensor voltage V increases in excess of the voltage $V1$. This results in a smaller fluctuating range of the toner density, compared to the case where the toner is supplied at the high speed.

On the other hand, if $V > V2$ (NO in Step S4), it is discriminated whether the sensor voltage V is lower than or equal to the voltage $V3$ in Step S6. If $V \leq V3$ (YES in Step S6), the drive motor 1 is driven continuously in Step S8. More specifically, in the case where the documents each having a large black portion are copied continuously, the toner supply falls short of the consumption thereof if the drive motor 1 is driven intermittently. Thus, the sensor voltage V increases gradually as indicated by the dashed line B or the phantom line C in Fig. 5. In view of this, the driving of the drive motor 1 is switched to the continuous driving so as to increase the toner supply speed. Thereafter, the driving of the motor 1 is switched to the intermittent driving when the sensor voltage V decreases below the voltage $V2$ due to the high speed toner supply. In other words, the intermittent driving and the continuous driving are alternately repeated so as to maintain the toner density at the one corresponding to the voltage $V2$.

If the toner hopper 340 becomes empty of the toner, the toner density in the housing 342 decreases to an exceedingly low level. When the sensor voltage V reaches the voltage $V3$ (NO in Step S6) as indicated by a right end portion of the solid line A in Fig. 5, a toner empty indication is displayed in Step S7.

As described above, when the toner consumption is low such as a case where the normal documents are copied continuously, the toner is supplied at the low speed by driving the drive motor 1 intermittently. Accordingly, the fluctuating range of the toner density can be made smaller. When the toner supply falls short of the consumption thereof such as a case where the documents each having the relatively large black portion are copied continuously, the intermittent driving and the continuous driving of the drive motor 1 are alternately repeated in a state where the toner density is slightly reduced. This makes it easier for

the toner supply to meet the toner consumption. Thus, the toner density can be stabilized, and a difference between the toner density when the first document is copied and the one when the last document is copied can be made smaller.

Further, even when the documents each having the exceedingly large black portion, such as documents having white-to-black reversed images, are copied continuously, the toner density does not continue to decrease, though fluctuating, as indicated by the phantom line C in Fig. 5. Accordingly, there can be prevented an occurrence where the toner density reaches the toner empty level despite the fact that there still remains toner in the toner hopper, and where the toner empty indication is erroneously displayed.

In the foregoing embodiment, the toner supply speed is switched by switching the driving of the drive motor 1 between the intermittent driving and the continuous driving. However, a means to switch the toner supply speed is not limited to the above. For instance, the toner supply speed may be switched by changing the driving speed of the drive motor 1. In other words, the toner is supplied at the low speed by driving the motor 1 at the low speed while being supplied at the high speed by driving the motor 1 at the high speed.

Further, an image forming apparatus to which the invention is applied is not limited to the copying machine as shown in Fig. 1, but the invention may be also applicable to a digital copying machine, a printer, etc. capable of processing image data such as white-to-black reversed image data.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be understood that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as being included therein.

Claims

1. A developing device comprising:
 container means (340) for containing toner therein;
 developing means (342 to 345) for supplying developer including the toner and carriers to a photosensitive member (31);
 detector means (346) for detecting the toner density in the developing means (342 to 345); and
 discriminator means (4) for comparing the toner density detected by the detector means (346) with a toner supply level ($V1$) where the toner supply is necessary, a toner empty level

(V3) where there exists almost no toner in the developing means, and a preset intermediate level (V2) between the toner supply level (V1) and the toner empty level (V3).

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2. A developing device as defined in claim 1, further comprising:
supply means (341) for supplying the toner from the container means (340) to the developing means (342 to 345) at a low speed or a high speed; and
control means (5) for causing the supply means (341) to supply the toner at the low speed when the toner density lies between the toner supply level (V1) and the intermediate level (V2), while causing the supply means (341) to supply the toner at the high speed when the toner density lies between the intermediate level (V2) and the toner empty level (V3).
3. A developing device as defined in claim 2, wherein the supply means (341) supplies the toner at the low speed when being driven intermittently, while supplying the toner at the high speed when being driven continuously.
4. A developing device as defined in claim 2 or 3, wherein the supply means (341) is coupled with a drive motor (1), and the low speed driving of the drive motor (1) allows the supply means (341) to supply the toner at the low speed while the high speed driving of the drive motor (1) allows the supply means to supply the toner at the high speed.

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FIG. 1

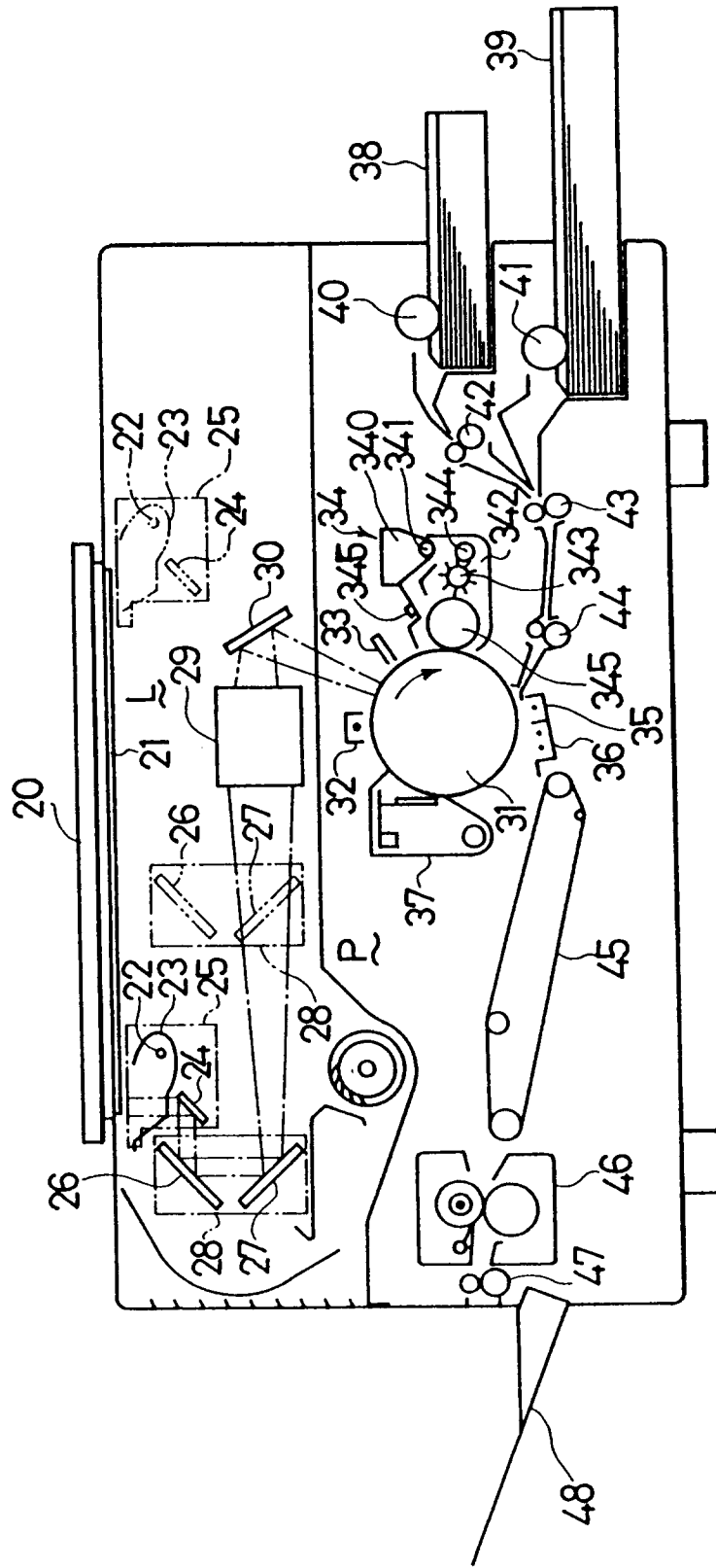


FIG. 2

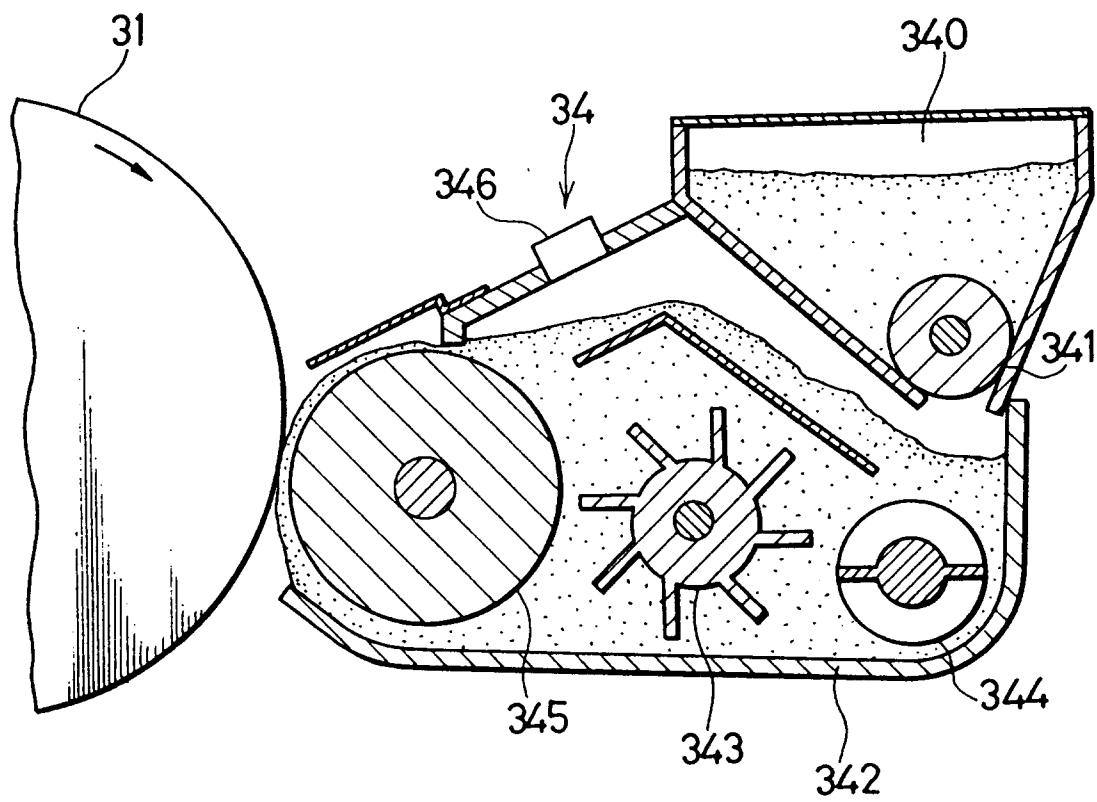


FIG. 3

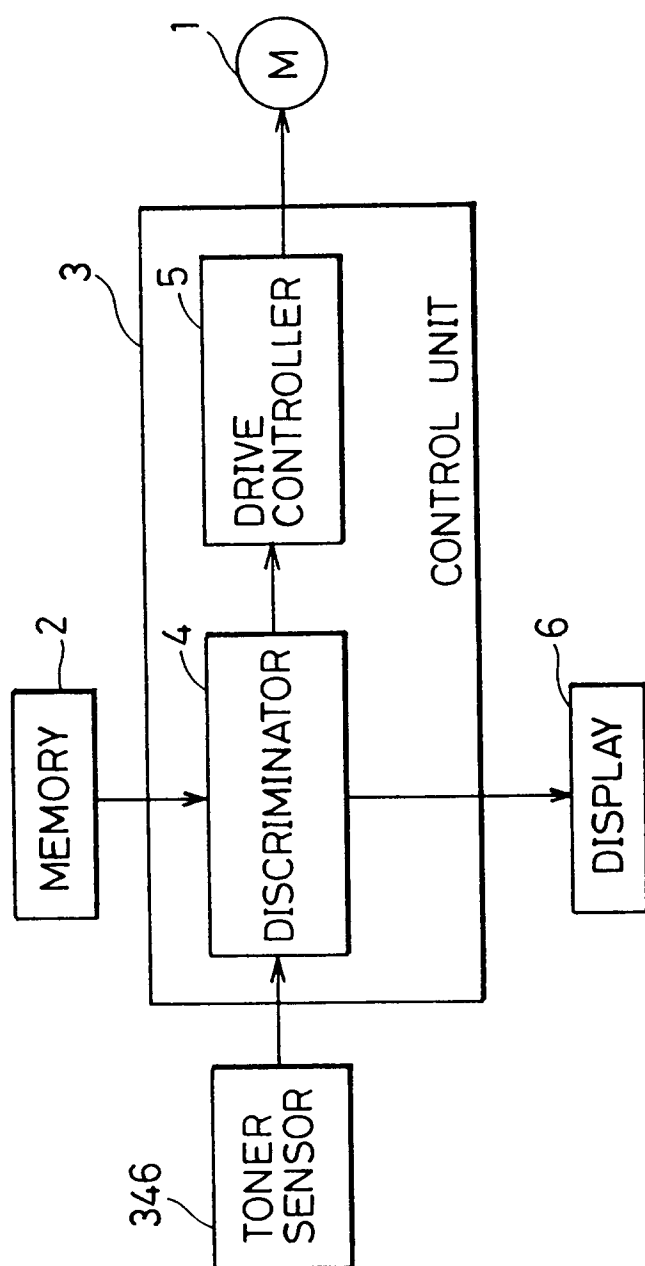


FIG. 4

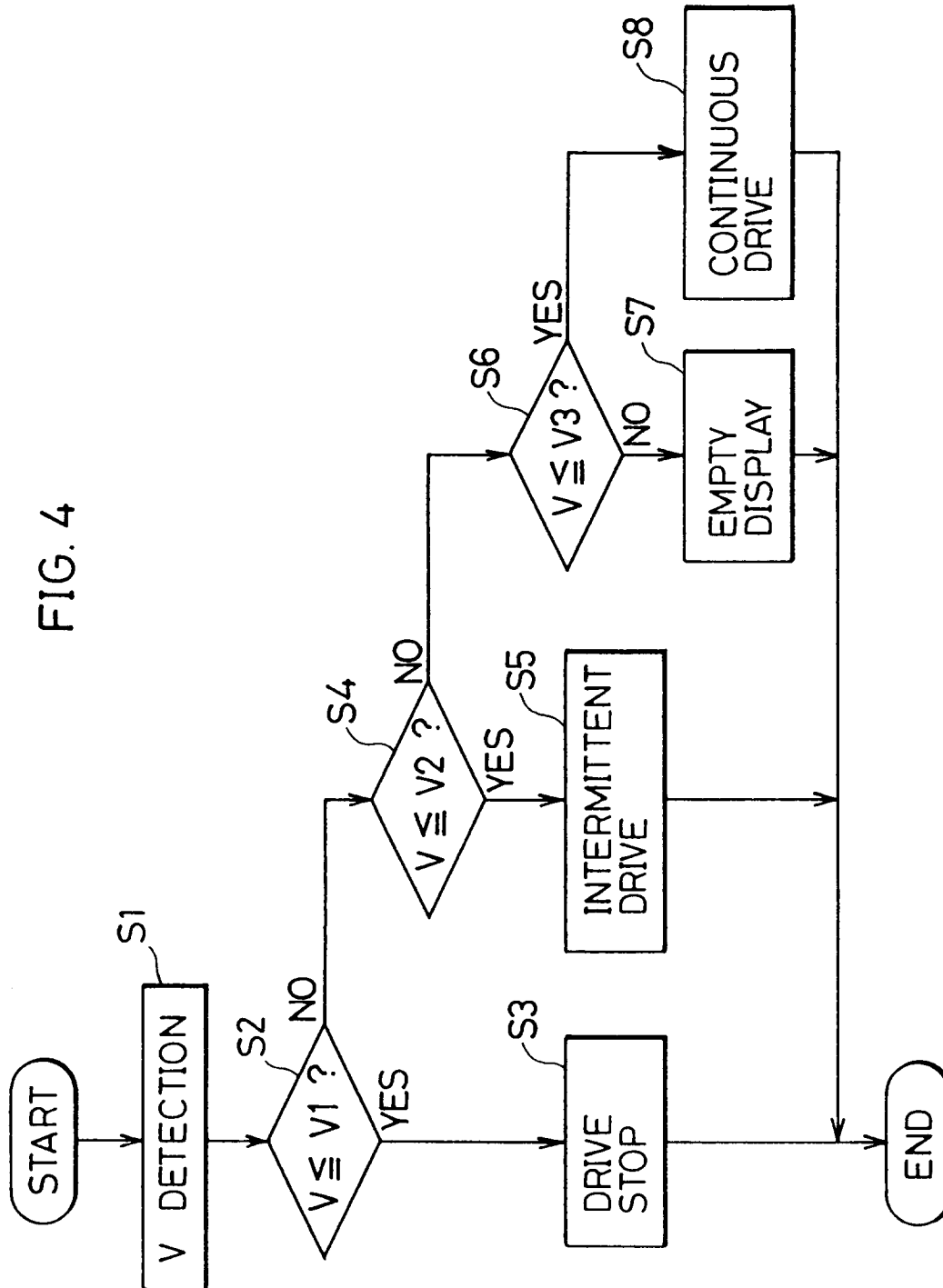


FIG. 5

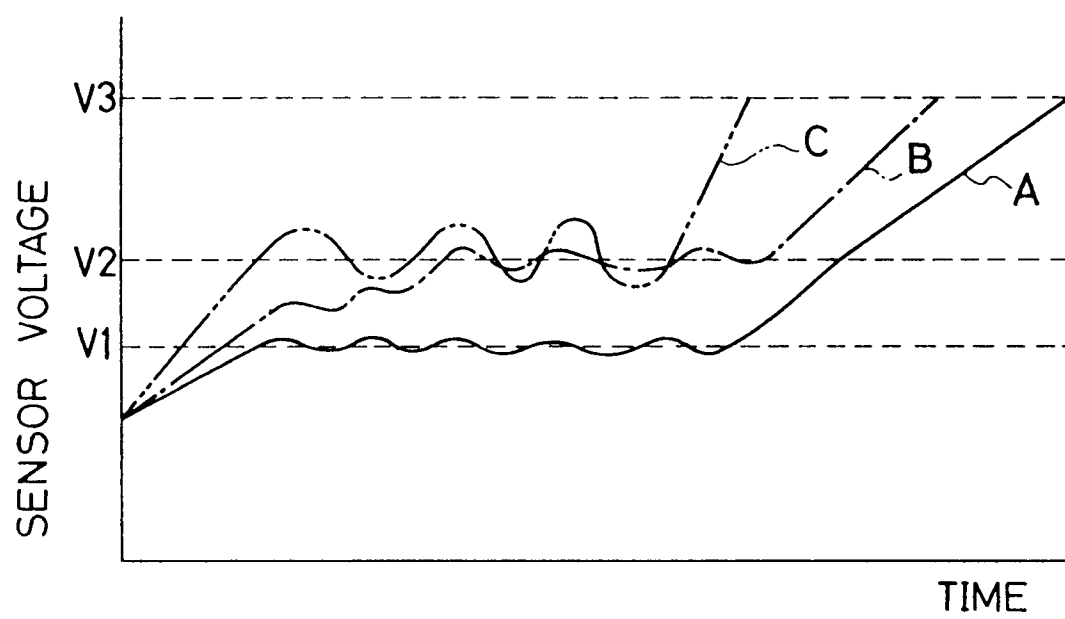


FIG. 6 PRIOR ART

