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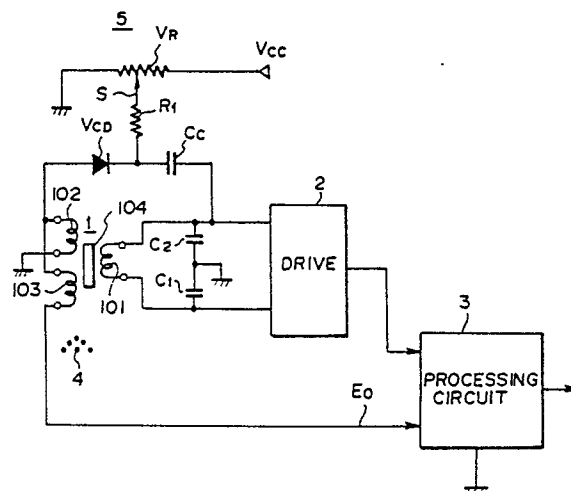
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London WC2A 1HN(GB)(54) **Toner concentration detection.**

(57) A toner concentration detecting device for detecting a toner concentration of a two component developer includes a differential transformer (1) which is connected to an oscillating drive (2) and a phase detecting circuit (3). A variable capacitance diode (V_{CD}) is connected between a primary coil (101) and the secondary coils (102, 103) and a variable resistor (V_R) is provided to supply the variable capacitance diode (V_{CD}) with a variable DC voltage thereby to select the capacitance of the diode (V_{CD}).

FIG. 1



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Toner Concentration Detection

The present invention relates to means for detecting toner concentration in a two component type developer for an electrostatic copying machine or other apparatus which is designed to produce copies in accordance with the principle of the electrostatic photography. More particularly, the present invention relates to toner concentration detecting means of a type which contain a differential transformer.

A so-called two component type developer for developing a latent image includes a carrier in the form of particles of a magnetic material and colour toner powder. To maintain the quality of the copies to be produced, it is required to maintain the concentration of the toner in the developer within a desired range. US-A-4,592,645 proposes a toner concentration controlling apparatus which uses a differential transformer. According to this proposal the differential transformer has a primary winding and a pair of secondary windings which are wound in opposite senses around a core. The primary winding and one of the secondary windings provide a detection transformer which is arranged to be placed adjacent to the developer in the developer container and produce a detection signal representing the toner concentration in the developer. The primary winding and the other of the secondary windings form a reference transformer which is arranged to provide a reference signal. The detection and reference transformers have outputs which are connected with a phase detection circuit which is arranged to detect the difference in the phase of the outputs of the detection and reference transformers. A similar toner concentration detection device is also disclosed in JP-A-60-154275.

In using the toner concentration detecting device of this type, it is required to make adjustment of the working distance after it has been mounted on the developer container so that any manufacturing tolerances are compensated for. Although not specifically illustrated, US-A-4592645 describes that an adjusting screw is provided in the magnetic gap of the reference transformer for adjusting its coupling coefficient. Another way of adjusting the coupling coefficient of a differential transformer is to provide a variable capacitor between its primary and secondary windings.

According to this invention a toner concentration detecting means including differential transformer means including primary coil means and secondary coil means for producing a differential output representing the concentration of a toner in a developer, variable capacitance means connected between the primary coil means and the secondary coil means, and drive means for applying an

oscillating signal to the differential transformer means is characterised in that the variable capacitance means comprises a variable capacitance diode and in that the detecting means also includes means for applying a voltage to the diode, and means for changing the voltage applied to the diode.

An advantage of the present invention is that the adjustment of the coupling coefficient can be readily made without any adverse effect. The means for adjusting the coupling coefficient are compact and reliable and have a high heat resistance. Also the means for adjusting the coupling coefficient of the differential transformer can be located at a readily accessible place without any problem of high frequency noise.

According to the features of the present invention, the capacitance of the diode means is controlled through an adjustment of the voltage applied to the diode so that the coupling coefficient is adjusted. There is no possibility of the phase of the voltage applied from the primary coil means to the secondary coil means being changed due to the adjustment because the voltage is changed through the adjustment of the capacitance of the diode. Further, no problem will be produced such as the setting drift as experienced in the case of using a ceramic variable capacitor. It is therefore possible to carry out a precise and accurate adjustment. It should further be noted that the means for applying the voltage to the diode can be constituted as a DC circuit so that it can be made separate from the high frequency circuit having the variable capacitance diode. Therefore, it is possible to locate the voltage adjusting means at any place which is readily accessible.

Preferred embodiments of detecting devices in accordance with the present invention will now be described and contrasted with the prior art with reference to the accompanying drawings; in which:-

Figure 1 is a schematic circuit diagram showing a toner concentration detecting device in accordance with one embodiment of the present invention;

Figure 2 is a circuit diagram similar to Figure 1 but showing another embodiment;

Figure 3 is a circuit diagram showing the details of the circuit shown in Figure 1; and,

Figure 4 is a circuit diagram showing an example of prior art.

A conventional way of adjusting the coupling coefficient of a differential transformer will now be described. Figure 4 is a circuit diagram showing an example of such arrangement. Referring to Figure 4, the conventional toner concentration detecting

device shown therein includes a differential transformer 1 including a primary winding 101, a reference secondary winding 102 and a detection secondary winding 103. The primary winding 101 has opposite ends which are connected with capacitors C_1 and C_2 . The primary winding 101 is connected with a driving circuit 2 which constitutes an oscillating circuit together with the primary winding 101 and the capacitors C_1 and C_2 . The reference secondary winding 102 has one end which is grounded. The other end of the reference secondary winding 102 is connected with one end of the detecting secondary winding 103. The other end of the detecting secondary winding 103 is connected with a processing circuit 3 which may be a phase detection circuit of a conventional type. The driving circuit 2 is also connected with the processing circuit 3 to provide the processing circuit 3 with a reference signal. The secondary windings 102 and 103 are wound around a core 104 in an opposite polarity so that a differential output E_0 is produced on the detection secondary winding 103. The processing circuit 3 functions to compare the phase of the differential output E_0 with the phase of the reference signal supplied from the driving circuit 102 to produce an output signal corresponding to the phase difference.

As shown in Figure 4, the ends of the secondary windings 102 and 103 which are connected together are also connected with one end of the primary winding 101 through a variable capacitor V_c so that the secondary windings 102 and 103 are applied with a voltage which is determined by the capacitance of the capacitor V_c . Through an adjustment of the capacitance of the variable capacitor V_c , it is possible to carry out the adjustment of the working distance.

It should however be noted that the conventional arrangement described with reference to Figure 4 has inconveniences in determining the type of the capacitor which is to be used as the variable capacitor V_c . A ceramic variable capacitor is preferable in that it is compact and has a high heat resistant property. However, it has an inherent disadvantage of a setting drift wherein the capacitance of the capacitor changes after a certain time period due to a change in the thickness of the silicon oil film which is provided between the rotor and the stator of the capacitor. Therefore, it is difficult to carry out an accurate adjustment with the use of the ceramic variable capacitor. Other types of capacitors are not preferable because they are generally bulky and do not have satisfactory heat resistance.

A further problem in using a variable capacitor is that when it is desired to locate the variable capacitor in a readily accessible position it is required to provide an extension of a high frequency

wiring. Such a high frequency wiring can cause noises which may lead to an unreliable operation of the detecting device. Therefore, it is difficult to locate the variable capacitor in a readily accessible place.

Referring now to Figure 1, there is shown a toner concentration detecting device which includes a differential transformer 1 having a primary coil 101, a reference secondary coil 102 and a detecting secondary coil 103. As in the conventional system shown in Figure 4, capacitors C_1 and C_2 are connected between the opposite ends of the primary coil 101. Further, a driving circuit 2 and a phase detecting circuit 3 are provided and connected with the differential transformer 1 as in the conventional system shown in Figure 4. The detecting coil 3 is located adjacent to a developer 4 containing a toner. The developer 4 is contained in a developer container which is not shown but may be constituted as shown in Figure 1a or 1b of the U.S. patent 4,592,645. The toner concentration detecting device comprising the differential transformer 1, the driving circuit 2 and the phase detecting circuit 3 may be positioned as shown in the above U.S. patent.

In Figure 1, it will be noted that a variable capacitance diode V_{CD} and a capacitor C_c are connected in series between the primary coil 101 and the secondary coil 102 of the differential transformer 1. There is provided a variable voltage applying circuit 5 which includes a variable resistor V_R connected at one end with a DC voltage source V_{cc} . The other end of the variable resistor V_R is grounded. A slider S of the variable resistor V_R is connected through a resistor R_1 between the diode V_{CD} and the capacitor C_c . The DC voltage is thus applied through the variable resistor V_{CD} and the resistor R_1 to determine the capacitance of the diode V_{CD} . It is therefore possible to determine the voltage applied from the primary coil 101 to the secondary coil 102.

Referring to Figure 2, there is shown another embodiment of the present invention in which the differential transformer 1 comprises a pair of primary coils 101a and 101b which are connected in an opposite polarity. The transformer 1 further includes a secondary coil 102 which is connected with the phase detecting circuit 3. Between one ends of the primary coils 101a and 101b, there are connected capacitors C_1 and C_2 . In other respects, the arrangements are the same as those in the previous embodiment. Therefore, further descriptions will be omitted by showing corresponding parts by the same reference numerals as in Figure 1.

Referring to Figure 3, there are shown details of the circuit shown in Figure 1. The driving circuit 2 is in the form of an oscillating circuit constituted

by the aforementioned capacitors C_1 and C_2 , an exclusive OR circuit 21 and a resistor R_2 . The output of the oscillating circuit is connected with the primary coil 101 of the differential transformer 1 to drive the transformer 1. Further, the oscillating circuit has an output connected with a phase detecting circuit 32 which constitute a part of the processing circuit 3. The phase detecting circuit 32 may be constituted by an exclusive OR circuit. The processing circuit 3 includes an amplifier 31 provided with a negative feedback resistor R_3 and connected through a capacitor C_4 with the detecting coil 103 of the differential transformer 1. A capacitor C_3 is further connected between the detecting coil 103 and the capacitor C_4 . The phase detecting circuit 32 has an output resistor R_4 and a smoothing capacitor C_5 . The phase of the output of the differential transformer 1 is a function of the toner concentration in the developer so that the toner concentration can be detected by detecting the change in the phase of the output of the differential transformer 1 by the phase detecting circuit 32.

Claims

1. Toner concentration detecting means including differential transformer means (1) including primary coil means (101) and secondary coil means (102, 103) for producing a differential output representing the concentration of a toner in a developer, variable capacitance means connected between the primary coil means (101) and the secondary coil means (102, 103), and drive means (2) for applying an oscillating signal to the differential transformer means (1), characterised in that the variable capacitance means comprises a variable capacitance diode (V_{CD}) and in that the detecting means also includes means (V_{CC} , R_1) for applying a voltage to the diode (V_{CD}), and means (V_R) for changing the voltage applied to the diode (V_{CD}).

2. Toner concentration detecting means in accordance with claim 1, in which the voltage applying means is means for applying a DC voltage (V_{CC}) to the diode means (V_{CD}).

3. Toner concentration detecting means in accordance with claim 1 or 2, which includes capacitor means (C_6) connected between the primary coil means (101) and the secondary coil means (102, 103) in series with the diode (V_{CD}).

4. Toner concentration detecting means in accordance with any one of the preceding claims, in which the voltage changing means includes variable resistor means (V_R).

5. Toner concentration detecting means in accordance with any one of the preceding claims, in which the differential transformer means (1) is connected with phase detecting means (3) to determine the toner concentration.

6. Toner concentration detecting means including differential transformer means including primary coil means and secondary coil means for producing a differential output representing a concentration of a toner in a developer, variable capacitance diode means connected between said primary coil means and said secondary coil means, means for applying a voltage to said diode means, and means for changing the voltage applied to the diode.

FIG. 1

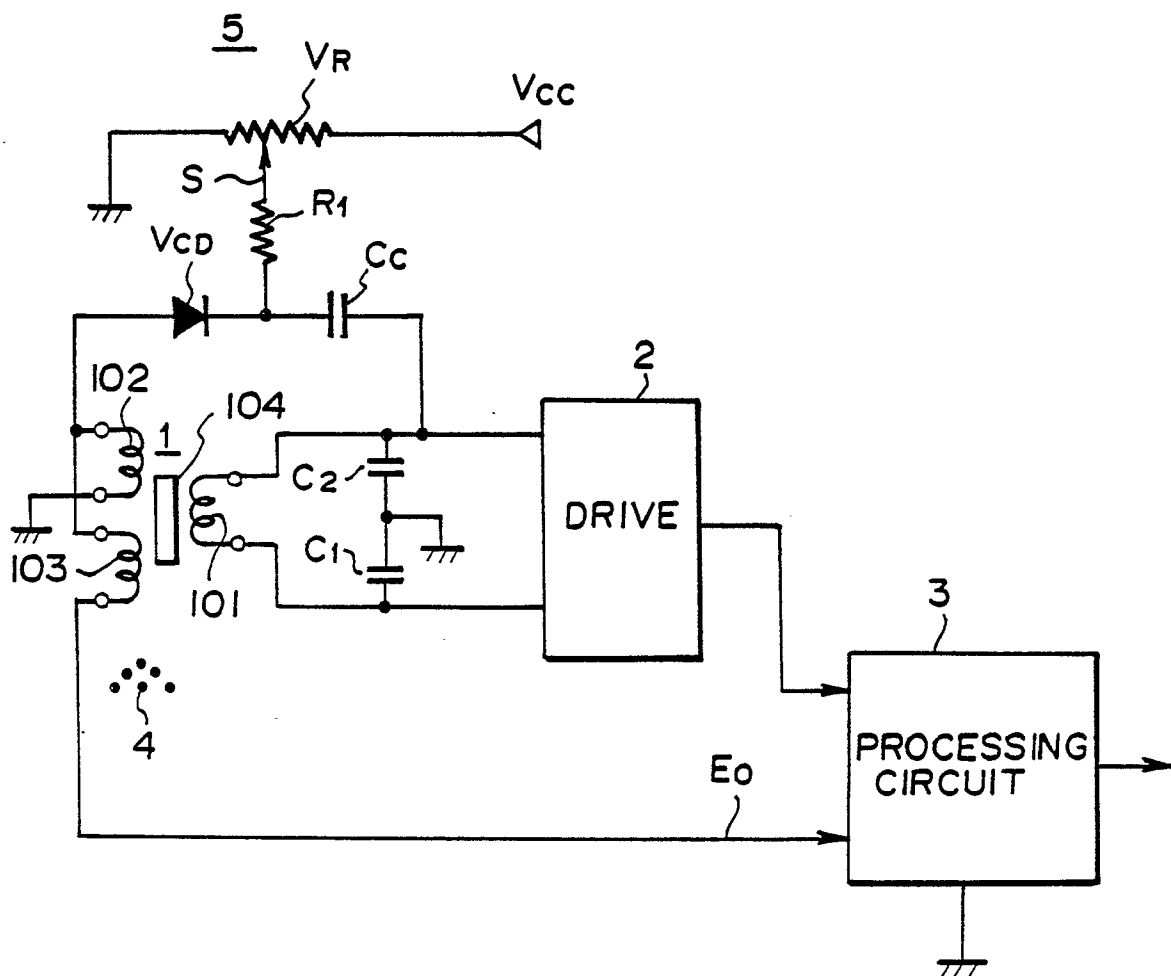


FIG. 2

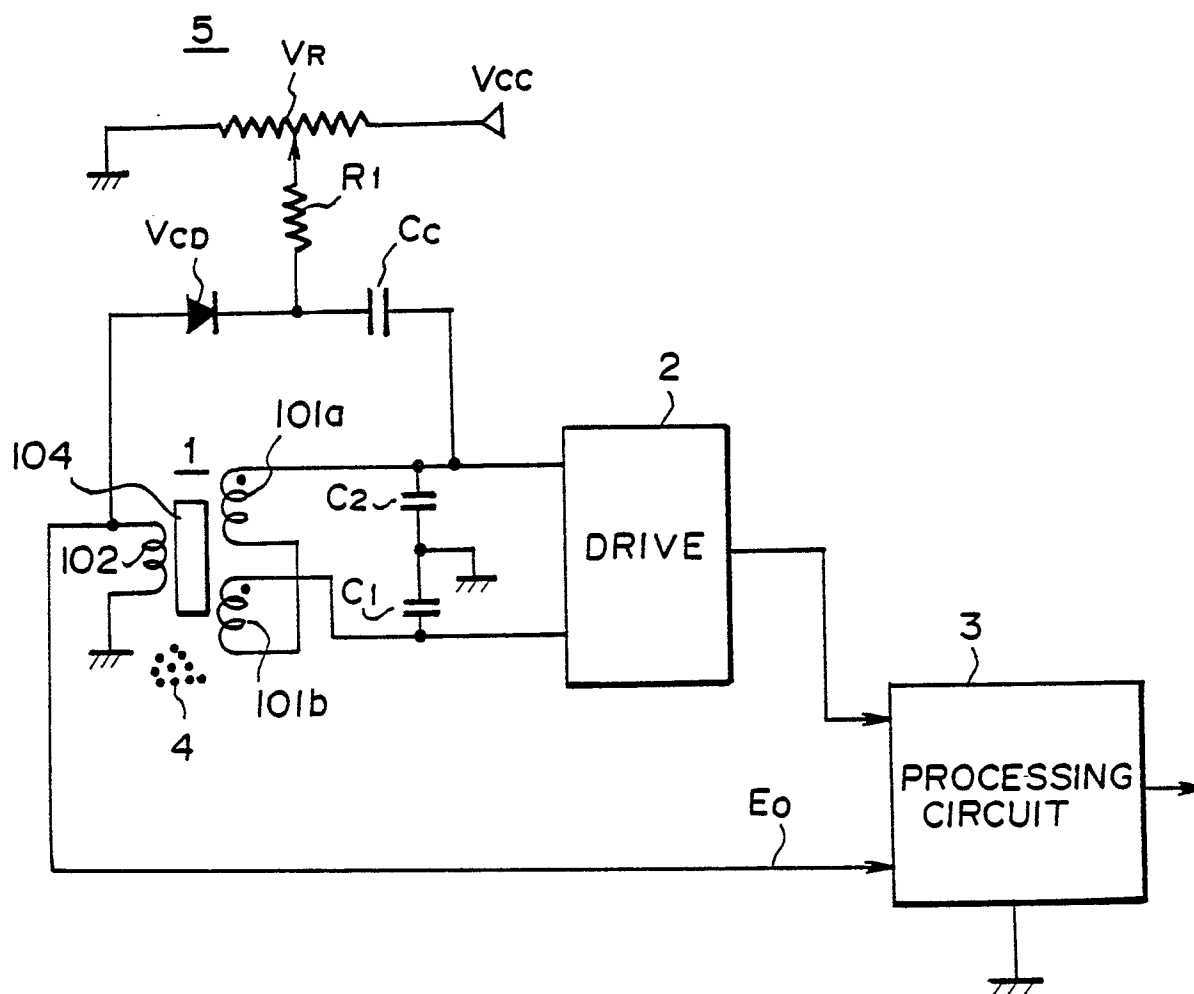


FIG. 3

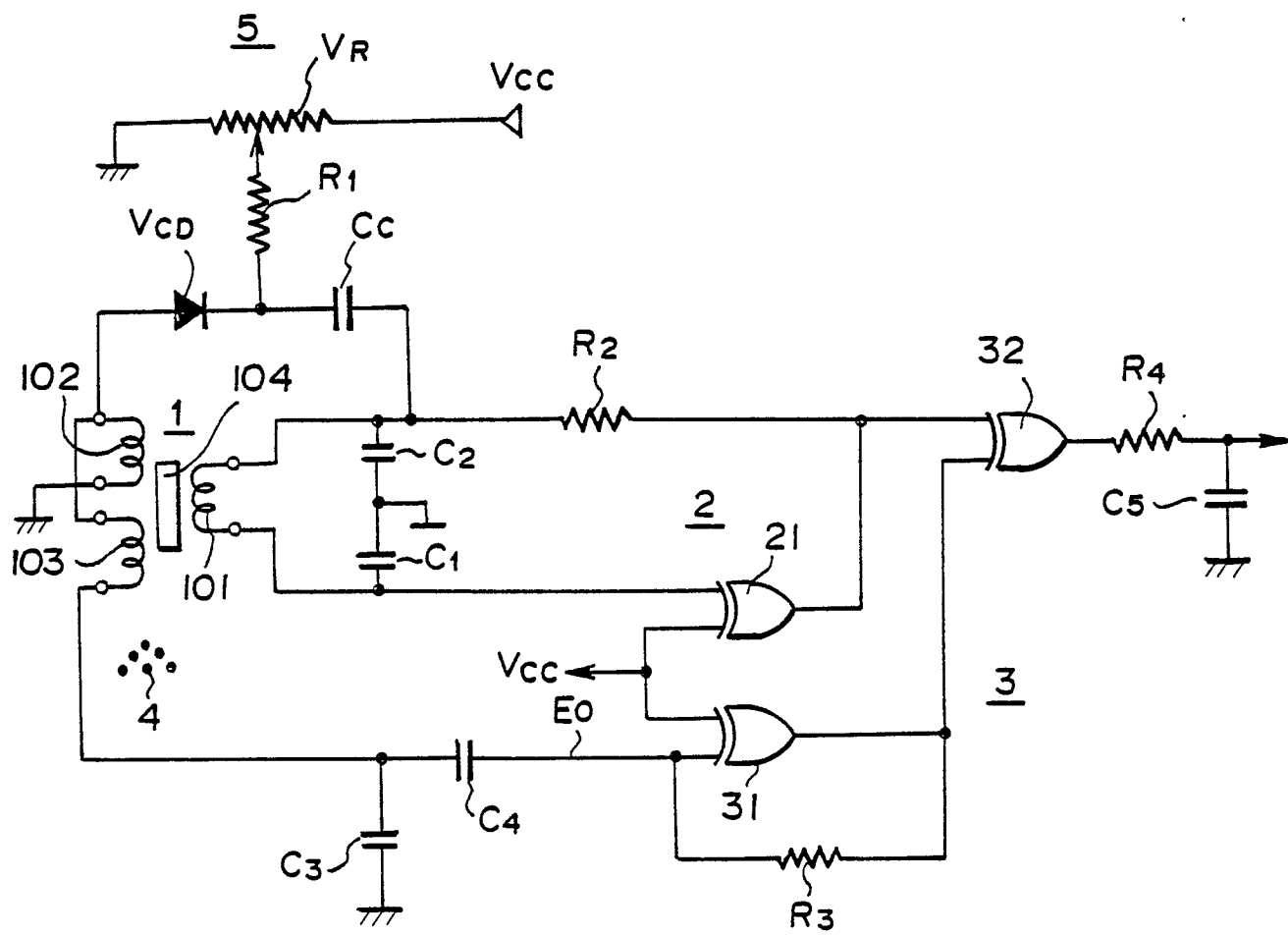


FIG. 4

