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De Mott

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[54] **FIRE DETECTING DEVICE FOR A PHOTOGRAPHIC PRINTING MACHINE**

[75] Inventor: **John C. De Mott,** Rochester, N.Y.

[73] Assignee: **Xerox Corporation,** Stamford, Conn.

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[52] **U.S. Cl.** ..... **355/133,** 219/216, 340/228 R, 355/14, 432/46, 432/59

[51] **Int. Cl.** **G03b 27/00**

[58] **Field of Search** ..... 355/11, 14, 133; 219/216, 219/388; 340/228 R; 432/46, 59

[56] **References Cited**

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Primary Examiner—Fred L. Braun

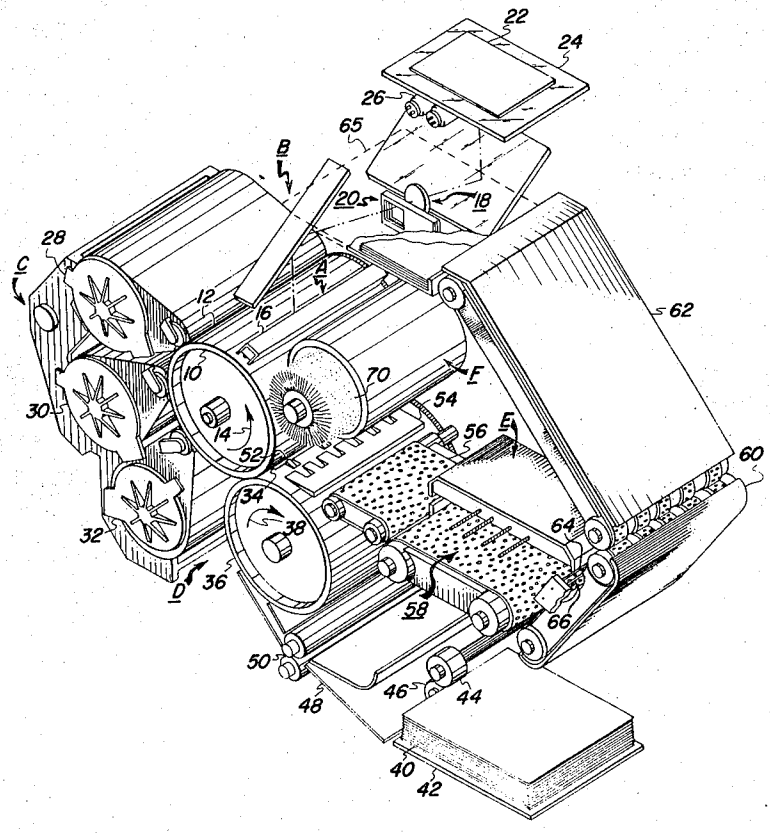
Attorney, Agent, or Firm—James J. Ralabate; Henry Fleischer

[57] **ABSTRACT**

A device in which the presence of a burning article on a moving conveyor is detected for preventing the spread of a fire therefrom. The device has at least one temperature sensitive resistance element along the conveyor path which leads from the fusing area of an electrophotographic printing machine for measuring any variation in the temperature along the path produced by a burning sheet. The resistance element is part of an electrical circuit which will generate an ouput signal in response to any variation in the temperature caused by a sheet to warn an operator of a fire in the machine.

The foregoing abstract is neither intended to define the invention disclosed in the specification nor is it intended to be limiting as to the scope of the invention in any way.

8 Claims, 3 Drawing Figures



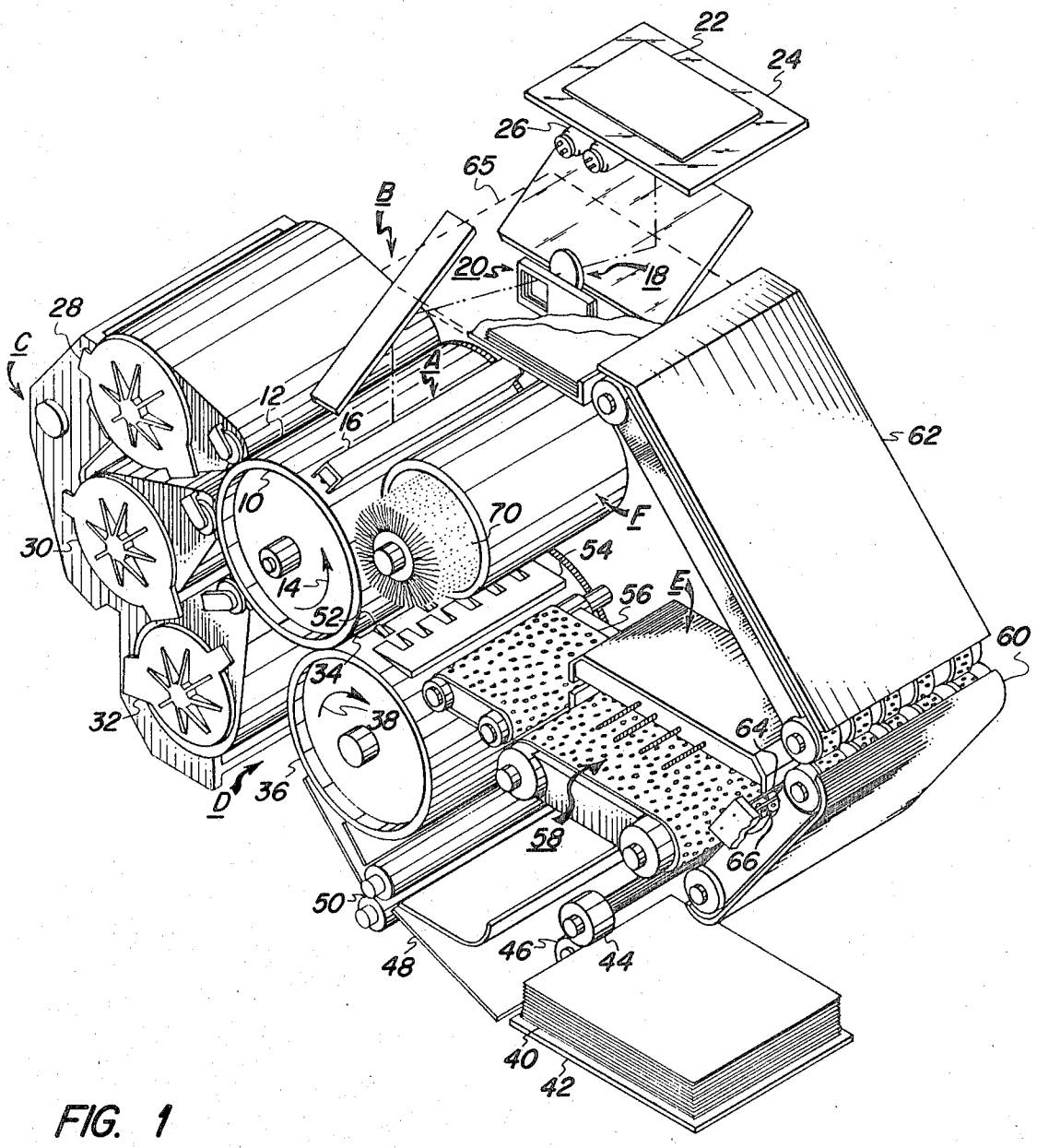

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FIG. 1

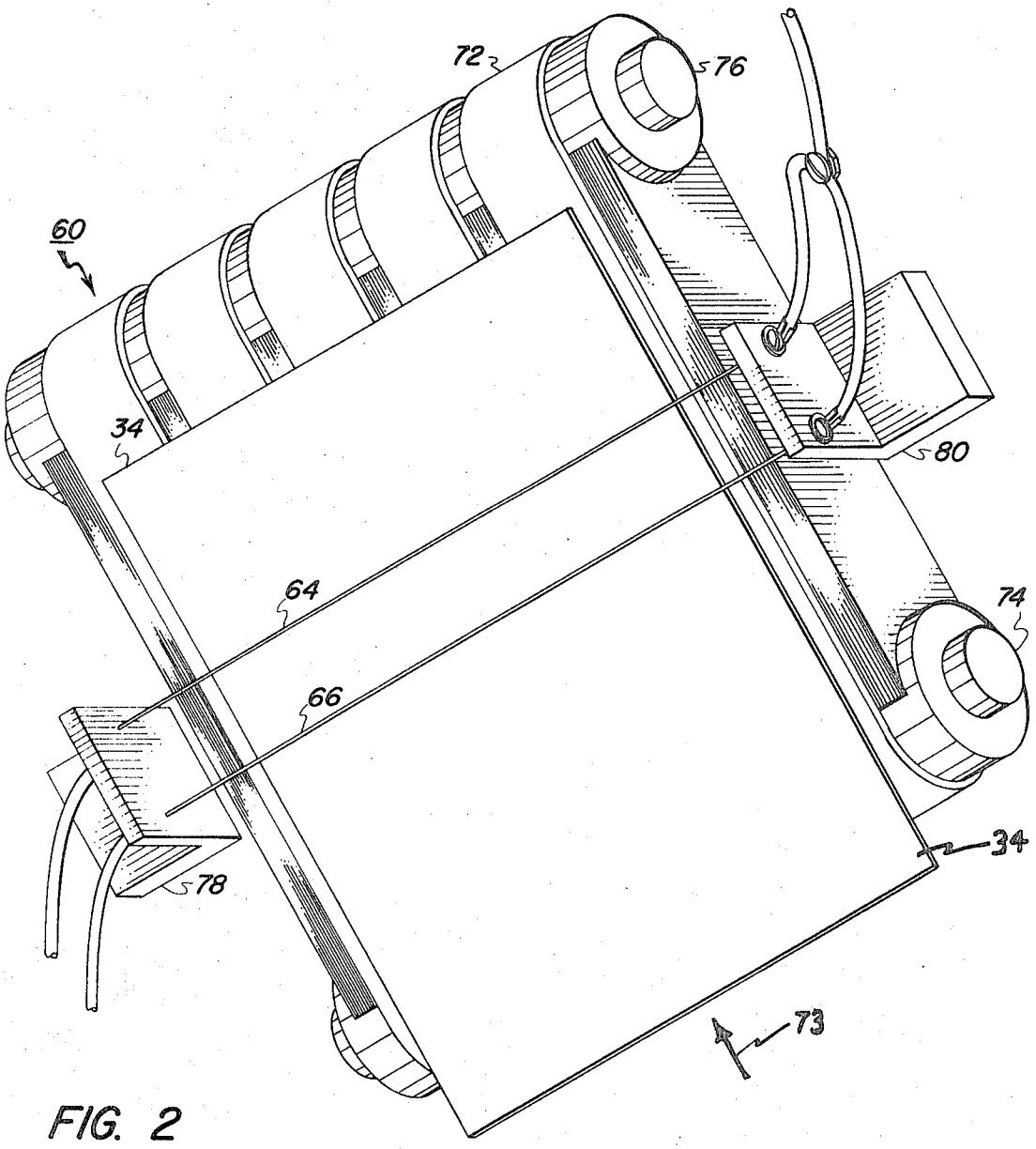

FIG. 2

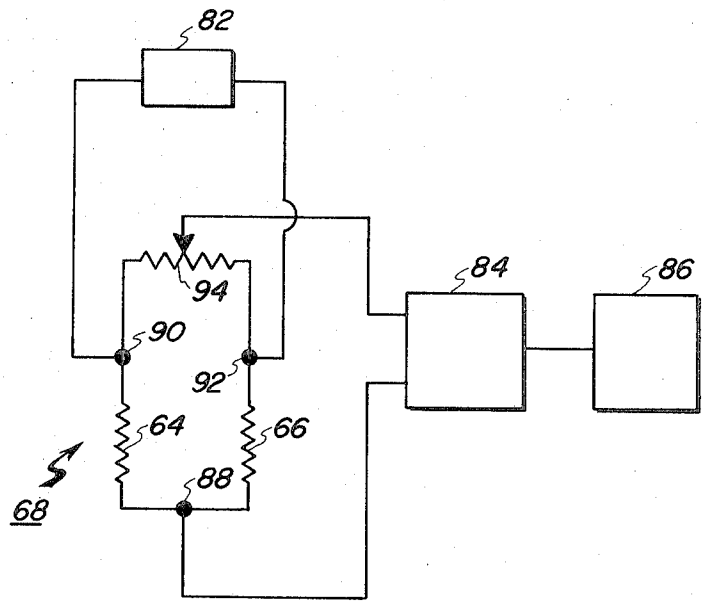

FIG. 3

FIRE DETECTING DEVICE FOR A PHOTOGRAPHIC PRINTING MACHINE

BACKGROUND OF THE INVENTION

This invention relates generally to an electrophotographic printing machine, and more particularly concerns a device for detecting the presence of a burning sheet on a conveyor utilized therein.

In the process of electrophotographic printing, a photoconductive surface is charged to a substantially uniform potential and, thereafter, selectively discharged by projecting a light image of an original document thereon. The irradiated areas on the photoconductive surface are discharged to record thereon an electrostatic latent image corresponding to the original document to be reproduced. The latent image is developed or rendered visible by depositing toner particles thereon. This toner powder image is transferred to a sheet of final support material and subsequently fused thereto. Generally, the toner particles are heat settable, colored thermoplastic powders which electrostatically adhere to the photoconductive surface and final support material. As the sheet of final support material passes through the fuser, heat of sufficient intensity is generated to permanently coalesce the toner particles in image configuration thereto.

Various types of fusers are utilized in electrophotographic printing. Typical fusers utilize radiant heating elements for raising the temperature of the toner material to the set point thereof. However, the temperature within the fuser must be controlled to insure that excess heat is not produced therein. If the temperature exceeds the kindling temperature of the support material, which is typically plain paper, a fire may occur. Thereafter, the burning sheet of paper may be advanced automatically from the fuser to a catch tray accessible to a machine operator. Potentially, this type of arrangement could be dangerous as the remainder of the electrophotographic printing machine may start to burn, or, in lieu thereof, the operator may be severely injured in attempting to remove the flaming sheet from the catch tray. This problem is common to most types of fusers utilized in electrophotographic printing.

Accordingly, it is a primary object of the present invention to improve the fire detection capability of electrophotographic printing machines.

SUMMARY OF THE INVENTION

Briefly stated, and in accordance with the present invention there is provided a device for indicating the presence of a burning article on a moving conveyor system.

This is accomplished in the present instance by at least one resistance element and signal generating means. In the preferred embodiment thereof, the resistance element is disposed adjacent the conveyor system. The resistance element has a variable effective resistance depending on thermal conditions in the region thereof. Signal generating means are provided to respond to the variation in the resistance of the resistance element. In this manner, an output signal is developed indicating the presence of the burning article on the moving conveyor system.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will become apparent upon reading the following detailed description and upon reference to the drawings, in which:

FIG. 1 is a schematic perspective view of an electrophotographic printing machine embodying the features of the present invention therein;

FIG. 2 is an enlarged perspective view of an endless belt conveyor utilized in the FIG. 1 printing machine and incorporating therein the fire detection device of the present invention; and

FIG. 3 is a schematic circuit diagram of the FIG. 2 fire detection device.

While the present invention will be described in connection with a preferred embodiment thereof, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF INVENTION

For a general understanding of the disclosed electrophotographic printing machine in which the present invention may be incorporated, continued reference is had to the drawings wherein like reference numerals have been used throughout to designate like elements. FIG. 1 schematically illustrates the various components of a printing machine for producing multi-color copies from a colored original. Although the fire detecting device of the present invention is particularly well adapted for use in an electrophotographic printing machine, it should become evident from the following discussion that it is equally well suited for use in a wide variety of applications and is not necessarily limited to the particular embodiment shown herein.

The printing machine illustrated in FIG. 1 employs a photoconductive member having a drum **10** mounted rotatably on a shaft (not shown) within the frame of the printing machine. Drum **10** includes a photoconductive surface **12** thereon, and is rotated in the direction of arrow **14** to pass sequentially through a series of processing station. The various machine operating mechanisms are driven at a predetermined speed relative to each other and drum **10** from a common drive motor (not shown), in order to synchronize the timing thereof. In this manner, the machine operations are coordinated to produce the proper sequence of events at the various processing stations.

Initially, drum **10** moves photoconductive surface **12** through charging station A. Charging station A has positioned thereat a corona generating device indicated generally at **16.** Corona generating device **16** extends in a generally transverse direction across photoconductive surface **12.** This permits corona generating device **16** to readily charge photoconductive surface **12** to a relatively high substantially uniform potential. Preferably, corona generating device **16** is of the type described in U.S. Pat. No. 2,778,946 issued to Mayo in 1957.

Thereafter, drum **10** is rotated to exposure station B where photoconductive surface **12** is exposed to a color filtered light image of the original document. A moving lens system, generally designated by the reference number **18,** and a color filter mechanism, shown generally at **20,** are located at exposure station B. One suitable type of moving lens system is disclosed in U.S. Pat. No. 3,062,108 issued to Mayo in 1962. As shown in

FIG. 1, an original document 22, such as a sheet of paper, book, or the like, is placed face down upon transparent viewing platen 24. Lamp assembly 26 and lens system 18 are moved in a timed relation with drum 10 to scan successive incremental areas of original document 22 disposed upon platen 24. This produces a flowing light image of original document 22 which is projected on charged photoconductive surface 12. During exposure, filter mechanism 20 interposes selected colored filters into the optical light path of lens 18. The color filter operates on the light rays passing through lens 18 to record an electrostatic latent image on photoconductive surface 12 corresponding to a preselected spectral region of the electromagnetic wave spectrum, hereinafter referred to as a single color electrostatic latent image.

Drum 10 next rotates to development station C where the single color electrostatic latent image recorded on photoconductive surface 12 is developed. Development station C includes thereat three individual developer units, generally indicated by the reference numerals 28, 30 and 32, respectively. A suitable development station employing a plurality of developer units is disclosed in copending application Ser. No. 255,259 filed on May 2, 1972. Preferably, the developer units are all of the type generally referred to in the art as "magnetic brush developer units." Typical magnetic brush developer units utilize a magnetizable developer mix which includes carrier granules and toner particles. Preferably, the toner particles are heat settable and adapted to be fixed or coalesced to the sheet of support material when subject to external heat. The developer mix is continually brought through a directional flux field to form a brush thereof. The electrostatic latent image recorded on photoconductive surface 12 is developed by bringing the brush of developer mix into contact therewith. Each of the respective developer units contain discretely colored toner particles corresponding to the complement of the spectral region of the wave length of light transmitted through filter 20, e.g., a green filtered electrostatic latent image is made visible by depositing green absorbing magenta toner particles thereon, blue and red latent images are developed with yellow and cyan toner particles, respectively.

Drum 10 next rotates to transfer station D where the toner powder image adhering electrostatically to photoconductive surface 12 is transferred to a sheet of final support material 34. Final support material 34 may be, amongst others, plain paper or a polysulfone thermoplastic sheet. A bias transfer roll, shown generally at 36, is disposed at transfer station D. Bias transfer roll 36 recirculates support material 34, and is electrically biased to a potential of sufficient magnitude and polarity to attract electrostatically thereto toner particles from the latent image recorded on photoconductive surface 12. A suitably electrically biased transfer roll is described in U.S. Pat. No. 3,612,677 issued to Langdon et al. in 1971. Transfer roll 36 is arranged to rotate in synchronism with drum 10 in the direction of arrow 38, i.e., roll 36 rotates at substantially the same angular velocity as drum 10. Since support material 34 is secured releasably thereon for movement in a recirculating path therewith, successive toner powder images may be transferred thereto in superimposed registration with one another. Support material 34 is advanced from a stack 40 thereof disposed on a tray 42. Feed roll 44, in operative communication with retard roll 46, advances and separates the uppermost sheet from stack 40. The advancing sheet moves into chute 48 which directs the sheet into the nip of register rolls 50. Thereafter, gripper fingers 52 mounted on transfer roll 36 secure releasably thereto support material 34 for movement in a recirculating path therewith. With continued reference to FIG. 1, after a plurality of toner powder images have been transferred to sheet 34, gripper fingers 52 release sheet 34 for separation from transfer roll 36. Stripper bar 54 separates sheet 34 from transfer roll 36 permitting it to be advanced on endless belt conveyor 56 to fixing station E. At fixing station E, a fuser, indicated generally at 58, coalesces the transferred powder image to sheet 34. Preferably, fuser 58 includes suitable radiant heating element, for example, strips of nichrome ribbon, and suitable control circuitry for maintaining the temperature thereof such that the toner powder image on the support material 34 is coalesced thereto. Another type of suitable fuser is described in U.S. Pat. No. 3,498,592 issued to Moser et al. in 1970. After the fusing process, sheet 34 is advanced by endless belt conveyors 60 and 62 to catch tray 65 for subsequent removal therefrom by the machine operator.

The foregoing sequence of events would be entirely satisfactory under normal circumstances. However, in the event that the sheet of support material 34 is overheated and ignited in fuser 58, it is highly desirable to deactivate the electrophotographic printing machine depicted in FIG. 1 and alert the operator. In this way, the operator may take the necessary emergency measures to prevent the spread of the fire. Accordingly, it is necessary to have a burning sheet detector disposed in the region of conveyor 60. As shown in FIG. 1, a pair of resistance elements 64 and 66 are disposed transversely across conveyor 60. Resistance elements 64 and 66 are spaced from the surface of conveyor 60 permitting an article such as a sheet of support material 34 to pass under elements 64 and 66 on conveyor 60. Preferably, resistance elements 64 and 66 form a pair of legs of bridge circuit means, or a wheatstone bridge 68 (FIG. 3) which will be described hereinafter in greater detail. The arrangement of resistance elements 64 and 66 relative to endless belt conveyor 60 will be described in further detail with reference to FIG. 2.

Although a preponderance of toner material is transferred to support material 34, invariably some residual toner particles remain on photoconductive surface 12 after the transfer of the powder image to support material 34. These residual toner particles are removed from photoconductive surface 12 as drum rotates through cleaning station F. Here, the residual toner particles are first brought under the influence of a cleaning corona generating device (not shown) adapted to neutralize the electrostatic charge remaining on the toner particles. The neutralized toner particles are then mechanically removed from photoconductive surface 12 by a rotatably mounted fibrous brush 70. A suitable brush cleaning device is described in U.S. Pat. No. 3,590,412 issued to Gerbasi in 1971. Rotatably mounted fibrous brush 70 is positioned at cleaning station F and maintained in contact with photoconductive surface 12. In this way, residual particles remaining on photoconductive surface 12 are cleaned therefrom after each successive transfer operation.

It is believed that the foregoing description is sufficient for purposes of the present disclosure to indicate

the general operation of an electrophotographic printing machine embodying the teachings of the present invention.

Referring now to the specific subject matter of the present invention, FIG. 2 depicts the mounting arrangement for resistance elements 64 and 66 of wheatstone bridge 68 (FIG. 3). As shown therein, resistance elements 64 and 66 are elongated wires extending transversely across endless belt 72 of conveyor 60. Endless belt 72 is entrained about a pair of opposed spaced rollers 74 and 76 adapted to rotate so as to move belt 72 at a predetermined speed. In this manner, endless belt 72 advances sheet 34 with the coalesced toner powder image thereon in the direction of arrow 73, to the next successive endless belt conveyor 62. Resistance elements 64 and 66 are temperature sensitive and their effective resistance is dependent upon the thermal environment. It is, therefore, evident that if sheet 34 is burning, the heat from the burning sheet will initially change the effective resistance of resistance element 66 relative to resistance element 64 so that wheatstone bridge 68 developes an electrical output signal proportional to the difference therebetween indicating the presence of a burning sheet on belt 72. Resistance elements 64 and 66 are secured at opposed ends thereof by dielectric blocks 78 and 80. As shown in FIG. 2, resistance elements 64 and 66 are electrically connected to one another at dielectric block 80, whereas they are isolated from one another at dielectric block 78. While resistance element 64 and 66 are both shown as extending across belt 72, it is evident that only one need be so utilized. The other resistance element may be spaced from belt 72 to compensate for normal environmental changes in the region thereof.

Referring now to FIG. 3, there is shown the detailed arrangement of bridge circuit means 68, current generating means 82, and signal generating means 84 as well as display means 86. As shown in FIG. 3, bridge circuit means on wheatstone bridge 68 includes resistance elements 64 and 66. Resistance elements 64 and 66 are connected to one another electrically at terminal 88 and, connected in common to signal generating means or voltage comparator 84. At the other end thereof, resistance elements 64 and 66 are electrically connected at terminals 90 and 92, respectively to current generating means, or a source of constant current 82. In addition thereto, a suitable potentiometer 94 is connected in parallel with resistance elements 64 and 66 at terminals 90 and 92, respectively. Potentiometer 94 is also electrically connected to voltage comparator 84.

By way of example, constant current source 82 generates approximately 90 milli-amps from a 15 volt DC source. A suitable voltage comparator 84 is Model No. μA 741 C made by the Fairchild Company. However, it is evident that this is but one type of voltage comparator which would be satisfactory for use in the foregoing circuitry. The output from voltage comparator 84, is preferably, a digital output with a voltage ranging from about +15 volts to about −15 volts DC. Resistance elements 64 and 66 are, preferably, elongated tungsten wires approximately 12 inches long with a diameter of about 0.0035 inches. The wires are disposed approximately one-half inch above endless belt 72 extending substantially parallel to one another transversely thereacross, and spaced about 1 inch apart. When wires of this type are utilized, a suitable potentiometer of 10,000 ohms will operate satisfactorily when connected in the wheatstone bridge arrangement of FIG. 3. Preferably, the tungsten wires utilized as resistance elements 64 and 66 have a high melting point, low oxidation susceptibility and are impervious to fire damage. In addition thereto, resistance elements 64 and 66 have a high change in effective resistance per degree change in temperature.

When resistance elements 64 and 66 are arranged as depicted in FIG. 2, the resistance elements are used to produce a differential output therefrom, i.e., as the flaming sheet passes under one element the output will rapidly change with respect to that of the other element. One element is utilized to null the effects of ambient temperature so that only the temperature difference between the elements will yield a response. Alternately, one element may be disposed adjacent belt 72, while the other element is spaced therefrom. This insures that one element detects the presence of the burning sheet, while the other element is used to compensate for the effects of variations in the ambient temperature. The differential output from the bridge circuit indicates the presence of a burning sheet on the conveyor. The foregoing arrangement is particularly suited for use in an environment having elevated ambient temperatures, e.g., in the vicinity of the fusing apparatus, provided, however, that the ambient temperature does not approach that of the flame temperature of the support material.

In operation, it is evident that when a burning sheet is present on endless belt 72, the resistance of resistance element 66 changes relative to resistance element 64 producing an error signal which is amplified by voltage comparator 84 to produce a digital output therefrom. The digital output from voltage comparator 84 actuates display means 86. In addition thereto, the digital output from voltage comparator 84 is utilized to deenergize the printing machine so that the burning sheet is not advanced to catch tray 65. In this manner, the risk of injury to the operator is minimized. Furthermore, voltage comparator 84 develops an output signal therefrom which actuates display means 86. Display means 86 may be a luminescent panel on the machine face or, in lieu thereof, a buzzer or alarm, adapted to alert the operator to the burning sheet within the machine.

While the present invention has been described in connection with a pair of resistance elements, one skilled in the art will appreciate that the invention is not necessarily so limited and that one resistance element may be utilized in lieu of a pair of resistance elements. In this type of arrangement, one resistance element is disposed adjacent the conveyor system. An additional fixed resistor is incorporated in the wheatstone bridge replacing the other resistance element. Once again the differential output of the wheatstone bridge will indicate the presence of the burning sheet. However, this arrangement does not compensate for the effects of ambient temperature as does the arrangement wherein a pair of resistance elements are utilized in the wheatstone bridge.

In recapitulation, it is evident that the wheatstone bridge arrangement of the present invention in conjunction with a suitable voltage comparator, current course and display detects burning sheets of support material being advanced by an endless belt conveyor from the fusing apparatus of an electrophotographic printing machine. In this manner, the machine may be

deactivated and the operator alerted to the presence of the burning sheet so as to take the appropriate remedial action to prevent the spread of the fire therefrom.

Thus, it is apparent that there has been provided in accordance with this invention a device for detecting the presence of a burning sheet of support material on a conveyor system that satisfies the objects, aims and advantages set forth above. While this invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

What is claimed is:

1. A device for indicating the presence of a burning article on a moving conveyor system, including:

a first resistance element adjacent the conveyor system, said resistance element having a variable effective resistance dependent upon thermal conditions in the region thereof;

means responsive to a variation in the resistance of said first resistance element for generating an output signal indicative of the presence of the burning article on the moving conveyor system;

bridge circuit means having associated therewith said first resistance element and a second resistance element spaced from said first resistance element to compensate for normal thermal variations in the environment; and

means for generating a substantially constant current to energize said bridge circuit means.

2. A device as recited in claim **1**, further including means, responsive to said signal generating means, for displaying the output signal to alert an operator that a burning article is disposed on the conveyor system.

3. A device as recited in claim **1**, wherein said signal generating means includes a voltage comparator arranged to provide a digital output corresponding to the variation in resistance of said first resistance element to indicate the presence of the burning article on the moving conveyor system.

4. A device as recited in claim **3**, wherein said first resistance element is preferably made from an elongated tungsten wire.

5. An electrophotographic printing machine of the type having a conveyor system arranged to move a sheet of support material having a toner powder image adhering substantially permanently thereon from a fusing apparatus adapted to heat and coalesce the toner powder image to the sheet of support material, wherein the improvement includes:

a first resistance element adjacent the conveyor system, said resistance element having a variable effective resistance dependent upon thermal conditions in the region thereof;

means, responsive to a variation in the resistance of said first resistance element, for generating an output signal indicating that the conveyor system is moving a burning sheet of support material from the fusing apparatus;

bridge circuit means having associated therewith said first resistance element and a second resistance element spaced from said first resistance element to compensate for normal thermal variations in the environment; and

means for generating a substantially constant current to energize said bridge circuit means.

6. A printing machine as recited in claim **5**, further including means, responsive to said signal generating means, for deactuating the printing machine and displaying the output signal to alert a printing machine operator that a burning sheet exited the fusing apparatus on the conveyor system.

7. A printing machine as recited in claim **5** wherein said signal generating means includes a voltage comparator arranged to provide a digital output corresponding to the variation in first resistance of said resistance element to indicate the presence of the burning sheet on the moving conveyor system.

8. A printing machine as recited in claim **7**, wherein said first resistance element is, preferably, made from an elongated tungsten wire.

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