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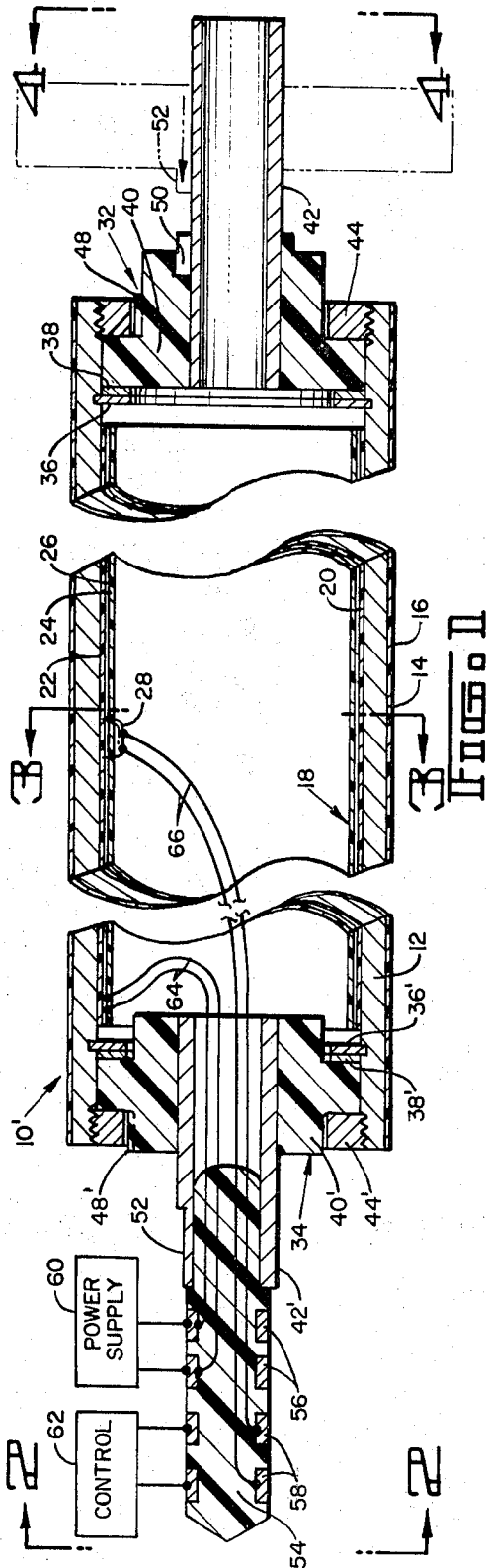
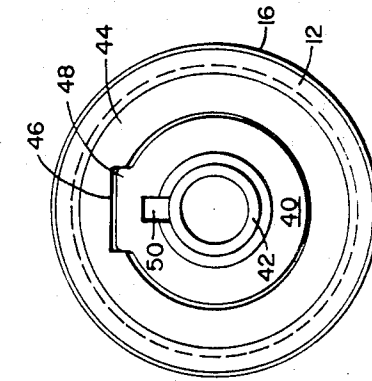
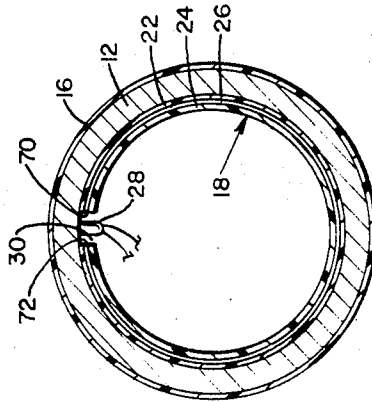
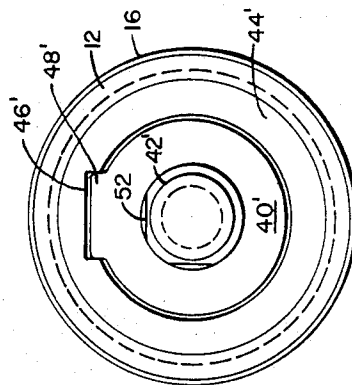
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HEATER ROLL

Filed April 25, 1967

2 Sheets-Sheet 1



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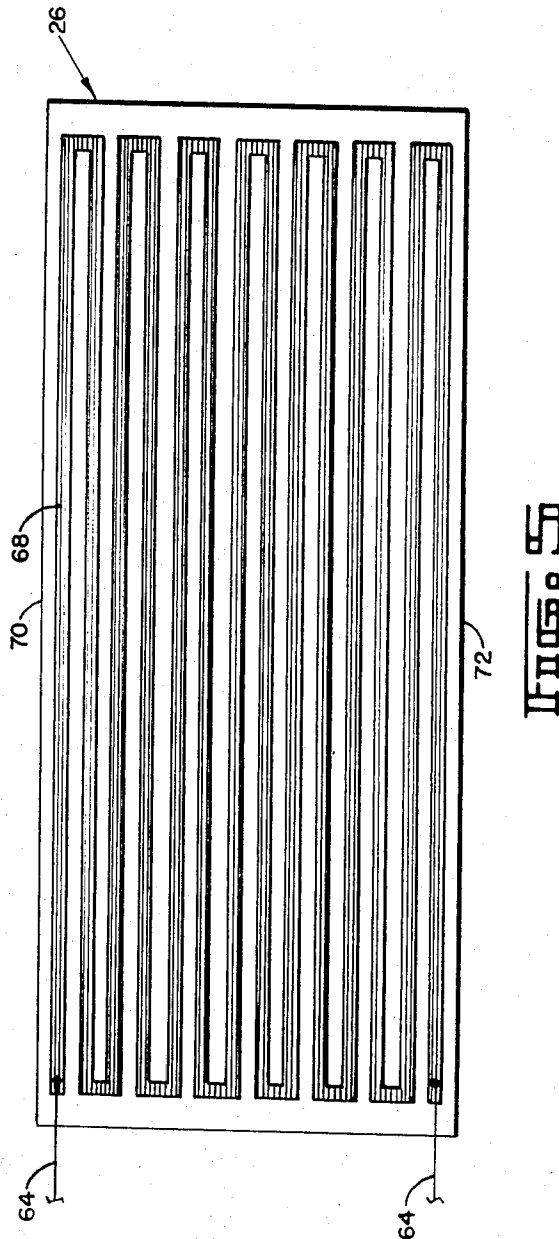
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1

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## HEATER ROLL

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8 Claims

### ABSTRACT OF THE DISCLOSURE

A heater roll having a hollow cylindrical roll body with a heating element in intimate contact with the inner surface of the cylindrical body. The heating element is an insulated printed circuit which can be evenly distributed about the interior surface of the cylindrical roll body. Each end of the cylindrical roll body has an end cap which has a heat insulating element to minimize heat losses, and an individual shaft segment is encased in the heat insulating element in each end cap.

### BACKGROUND OF THE INVENTION

#### Field of the invention

This invention relates to heater rolls for use in applications where it is desired to apply heat through the use of a rotating cylindrical roll element. This invention particularly relates to heater rolls for use in electrostatic copying machines wherein heat is employed to set a developer or toner powder such as in a xerographic process. However, although the invention will be described in relation to its application to a xerographic reproduction process, it will be expressly understood that the invention is not limited thereto, but rather the invention may be employed to meet any requirement for a heated roller element.

#### Description of the prior art

The heater roll of a known type of xerographic reproduction apparatus has a cylindrical tube body which is mounted for rotation on metallic shaft segments encased in metallic end sections. A heater element is located on the axis of the tube body and transfers heat to the cylindrical roll body by radiation heat transfer. The heater cylindrical roll body then applies the heat for use in setting the toner or developer powder. The use of radiation heat transfer to heat the cylindrical roller element has encountered a significant problem in thermal lag, i.e. the responsiveness of roll temperature under varying demands of thermal output. In addition, the manner in which the roller element was mounted through metallic end sections provided significant heat loss paths which, together with radiation heat transfer, severely impaired the efficiency of the system by creating a temperature differential along the outer surface of the cylindrical roller element.

### SUMMARY OF THE INVENTION

The present invention has eliminated the above noted deficiencies and others of the prior art by providing a novel heater roll. The heater roll of the present invention has a cylindrical tube roller elements in which heat transfer is accomplished by the more efficient method of conduction heat transfer. A flexible, moldable heater element is in intimate contact with the inner surface of the cylindrical tube roller element to provide this more desirable conduction heat transfer. The cylindrical roller element is mounted for rotation by two shaft segments, one segment being secured to each end of the cylindrical roller element on the axis thereof. The shaft segments are imbedded in heat insulating elements in end caps which are secured to the ends of the cylindrical roller element and

2

the shaft segments are thus insulated from the roller element.

The present invention employing a heater element in intimate contact with the internal surface of the cylindrical roll, and having insulated end caps for the separate shaft segments, has produced a significant performance advance over the prior art, particularly in reducing the heating time lag and temperature differential along the roll surface encountered in the prior art. In addition, operating efficiency is significantly improved by elimination of the heat loss paths previously present in the prior art.

Accordingly, one object of the present invention is to provide a novel heater roll having improved time lag and temperature differential characteristics.

Still another object of the present invention is to provide a novel heater roll particularly suitable for use in electrostatic reproduction processes such as xerography.

Other objects and advantages will be apparent from the following detailed description and drawings.

### DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a cross-sectional view of the heater roll of the present invention, the center portion being broken away to indicate a length contraction.

FIGURE 2 is a view along line 2—2 of FIGURE 1 showing the left end of the roll of FIGURE 1.

FIGURE 3 is a view taken along line 3—3 of FIGURE 1 showing the central portion of the roll of FIGURE 1.

FIGURE 4 is a view taken along line 4—4 of FIGURE 1 showing the right end of the roll of FIGURE 1.

FIGURE 5 is a view showing a typical printed circuit for use as the heat generating element in the present invention.

### Description of the preferred embodiment

Referring now to FIGURE 1, the heater roll 10 of the present invention is shown. The body of the heater roll is a cylindrical tube 12 which is preferably made of aluminum but which also may be made of copper or other material of relatively good thermal conductivity and relatively high resistance to corrosion at elevated temperatures. The outer surface 14 of tube 12 has a thin coating 16 (on the order of from 0.0005 to 0.003 inch) of tetrafluoroethylene, such as TFE Teflon, or other low surface energy characteristic material. As is well known in the art, heater roll 10 contacts the copy paper to set the toner or developer powder on the copy paper, and the low surface energy characteristic material on the external surface of heater roll 10 prevents the toner or developer powder from adhering to the outer surface of the roll.

A heating element 18 is bonded to essentially the entire inner surface 20 of aluminum tube 12 so that heating element 18 is in intimate contact with and conforms to the shape of the inner surface of tube 12. The intimate contact between heater element 18 and the inner surface of tube 12 may, for example, also be achieved by other means such as an adhesive, or a deformable inner cylinder or an expandable foam in contact with the inner diameter surface of element 18, rather than by bonding. As will be explained hereinafter, a slight longitudinal gap or space may be present in heating element 18 for the positioning of heat sensing devices.

Heating element 18 is formed as a sandwich structure having outer layers 22 and 24 and an inner layer 26 sandwiched therebetween. Outer layers 22 and 24 are both insulating material, preferably a composite of silicone rubber with a glass fabric, each layer being approximately 0.012" thick. The inner layer 26 is a foil circuit such as may be produced by stamping or etching techniques, and

it is employed as an electrical heat generating element. The foil circuit is approximately 0.0015" thick and is shown in detail in FIGURE 5. Silicone rubber is preferably employed as the outer insulating layers 22 and 24 because of its high temperature operating capability and also because it will flow under molding pressure and temperature during curing to fill or minimize voids in the contact between outer layer 22 and the inner surface 20 of tube 12. The sandwich-type heating element 18 may initially be in the form of a flexible, moldable sheet of sandwich material, and it is shaped and brought into contact with inner surface 20 on an inflatable mandrel or other similar device and then heated to a curing temperature and allowed to cure under pressure to bond to surface 20. An adhesive coating may also be applied to inner surface 20 if desired. The glass fabric in each of the layers of silicone rubber provides a positive barrier to prevent the inner layer 26 of foil circuit from penetrating the silicone rubber during molding. It will be apparent that any such penetration of a foil circuit must be avoided to prevent a short circuit condition such as would result if the foil circuit contacted aluminum tube 12.

A thermistor 28 or other transducer is mounted centrally of inner surface 20 to sense the temperature of tube 12 and to generate control signals for regulating the temperature. Thermistor 28 is preferably located in a longitudinal gap in heating element 18. The showing in FIGURE 3, taken along line 3—3 of FIGURE 1, shows the longitudinal gap 30 in more detail. As can be seen in FIGURE 3, heating element 18 conforms in the shape of a cylinder to the inner surface of tube 12, but rather than forming a complete cylinder, the abutting edges of heating element 18 are separated a small amount to form longitudinal gap 30 in which thermistor 28 may be located.

Referring once again to FIGURE 1, the ends of roll 10 are fitted with end caps 32 and 34. End cap 32 on the right end of roll 12 has a retaining ring 36 which snaps into a groove or recess in tube 12. A thrust washer 38 butts against retaining ring 36 and is also in engagement with a heat insulating element 40 which may be a phenolic material or other high strength heat insulating material. A steel shaft 42 is embedded in phenolic insulator 40, and a retaining nut 44 threads into tube 12 to butt together phenolic element 40, thrust washer 38 and retaining ring 36.

Referring to the left end of roll 12, end cap 34 also has retaining ring 36', thrust washer 38', phenolic insulator 40' with embedded shaft 42' and retaining nut 44'. It will be observed that the shape of the phenolic insulator in end cap 34 is slightly different than the phenolic insulator in end cap 32 in that the outboard end of phenolic insulator 40' does not extend beyond retaining nut 44 as much as phenolic insulator 40 extends beyond retaining nut 44 and the inboard central portion of phenolic insulator 40' extends through thrust washer 38' and retaining ring 36'. This slight difference in shape is described merely to illustrate a way to provide a desired length of engagement between phenolic insulator 40' and its shaft segments 42' when the operating environment of roll 10 does not allow for an overhang of the phenolic as in end cap 32.

The shaft segments 42 and 42' are located on the axis of tube 12 and serve to mount heater roll 10 for rotation. It will be observed that shaft segments 42 and 42' are both substantially isolated by their phenolic insulators 40 and 42' from aluminum tube 12. The shaft segments 42 and 42' do not present heat sink paths, and thus the insulated shaft segments serve to minimize heat losses.

Referring now to FIGURE 4, an end view of end cap 32 is seen. A recess 46 is provided in retaining nut 44, and a corresponding lug 48 on insulator 40 is positioned in recess 46 so that insulator 40 and retaining nut 44 are secured together by keying or other means. In assembling the unit, nut 44 and insulator 40 would be fitted together and then inserted as a unit into tube 12. A key recess 50 is also formed in insulator 40, and recess 50 serves to receive a driving element to transmit driving motion

through phenolic insulator 40 to retaining nut 44 and then to tube 12. The driving element is indicated generally in FIGURE 1 as finger 52 which could, for example, extend from a gear or other wheel, and the arrow associated with finger 52 indicates that the finger would be moved to the left to come into driving engagement with key recess 50. The direction of threaded engagement between retaining nut 44 and tube 12 is such that the direction of rotation of the heater roll during operation urges retaining nut 44 in the direction to tighten the engagement between retaining nut 44 and tube 12, and thrust washer 38 serves to provide an even distribution of forces on phenolic insulator 40.

Referring now to FIGURE 2, an end view of end cap 34 is seen. In a manner similar to the keying of insulator 40 to retaining nut 44, insulator 40' is shown keyed to retaining nut 44' by the engagement between lug 48' and recess 46'. However, insulator 40' and nut 44' can be secured together by any other suitable means. Shaft 42' may be provided with one or more flats 52 for set screwing a support bearing.

Referring once again to FIGURE 1, a shaft extension 54 of insulating material is secured to shaft 42'. Shaft extension 54 contains a first set of slip rings 56 and a second set of slip rings 58. Slip rings 56 are connected to a power supply 60 and slip rings 58 are connected to a control device 62 which in turn is connected to power supply 60 to regulate the current output of power supply 60. Slip rings 56 are connected via conductors 64 to the printed circuit comprising inner layer 26 of the heating element, and slip rings 58 are connected via conductors 66 to receive signals from thermistor 28. In the operation of the heater roll, for example, at a typical operating temperature of 350° F., the current delivered from power supply 60 causes a resistive heating of circuit 26, and the thermal energy is transferred by conduction to heat tube 12 with a very short time lag, tube 12 thus being relatively uniformly heated with a minimal temperature differential. If the temperature of tube 12 deviates from a predetermined desired level, the deviation is sensed by thermistor 28 and a control signal is delivered via conductors 66 and slip rings 58 to control 62, and control 62 in turn generates a compensating signal to regulate the current output of power supply 60 to establish the predetermined desired temperature level. Roll 10 is, of course, rotated on shafts 42 and 42' during this operation.

Referring now to FIGURE 5, a typical foil circuit forming the inner layer 26 for use in the heating element is shown. The foil circuit consists of a conductive path 68 type 321 stainless steel on an insulating material which may be one of the sandwich layers 24 or 26. The opposite ends of the conductive path are connected to conductors 64. The legs of the conducting path are equally spaced apart so that a relatively uniform heat source is created when inner layer 26 is formed into its cylindrical shape. The longitudinal shape is formed by bringing edges 70 and 72 of the insulating material into opposing relationship to form longitudinal gap 30 of approximately the same size as the spacing between any two legs of the conductor path. In this manner, the relatively even distribution of the heat source is maintained even though longitudinal gap 30 is provided for the location of the thermistor.

While a preferred embodiment has been shown and described, various modifications and substitutions may be made without departing from the spirit and scope of this invention. Accordingly, it is to be understood that this invention has been described by way of illustration rather than limitation.

What is claimed is:

1. A heater roll including:

a cylindrical element, said cylindrical element having first and second ends and an inner surface and an outer surface;

5

a heating element in intimate contact with said inner surface of said cylindrical element;  
 end caps at said first and second ends of said cylindrical element, each of said end caps having a heat insulating element at least partly contained within said cylindrical element and a shaft segment embedded in said insulating element and extending outwardly of said cylindrical element along the axis of said cylindrical element for rotatably supporting said cylindrical element;

at least one of said end caps having a retaining ring secured to said cylindrical element for retaining said heat insulating element; and

a retaining nut threadably engaged to said cylindrical element;

at least part of said heat insulating element being held between said retaining element and said retaining nut; and

means for energizing said heating element.

2. A heater roll as in claim 1 wherein:

said heating element is a flexible element having first and second layers of insulating material and a heat generating element between said first and second layers; and wherein

said heat generating element is a foil circuit having a plurality of equally spaced conductors; and wherein said heating element is a sheet extending around said inner surface of said cylindrical element with a space between opposing edges of the sheet equal to the spacing between said conductors; and including

a temperature sensing element in said space between opposing edges of said heating element; and

means responsive to said temperature sensing element for controlling the temperature of said heating element.

3. A heater roll as in claim 2 wherein:

said layers of insulating material are a fabric impregnated rubber material capable of flowing and adher-

6

ing to said cylindrical element under predetermined pressure and temperature; and wherein said heat generating element is a foil circuit.

4. A heater roll as in claim 1 wherein:

the heat insulating element of said one of said end caps has means for connection with a drive element for rotating said heater roll; and wherein

said heat insulating element of at least said one end cap is secured to the retaining nut thereof, the normal direction of rotation of said heater roll being such as to tend to tighten the engagement between the retaining nut of said one end cap and said cylindrical element.

5. A heater roll as in claim 4 wherein:

said means for energizing said heating element includes slip ring means secured to the shaft of the other of said end caps.

6. A heater roll as in claim 5 wherein:

the insulating element of each of said end caps is a phenolic element; and including thrust washer means between the retaining ring and the phenolic element of each end cap.

7. A heater roll as in claim 1 including:

a coating of material having low surface energy characteristics on said outer surface of said cylindrical element.

8. A heater roll as in claim 1 wherein:

said heater element is bonded to said inner surface of said cylindrical element.

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