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ELECTROSTATIC DATA RECORDING APPARATUS WITH RADIANT ENERGY INPUT CONVERTER MEANS

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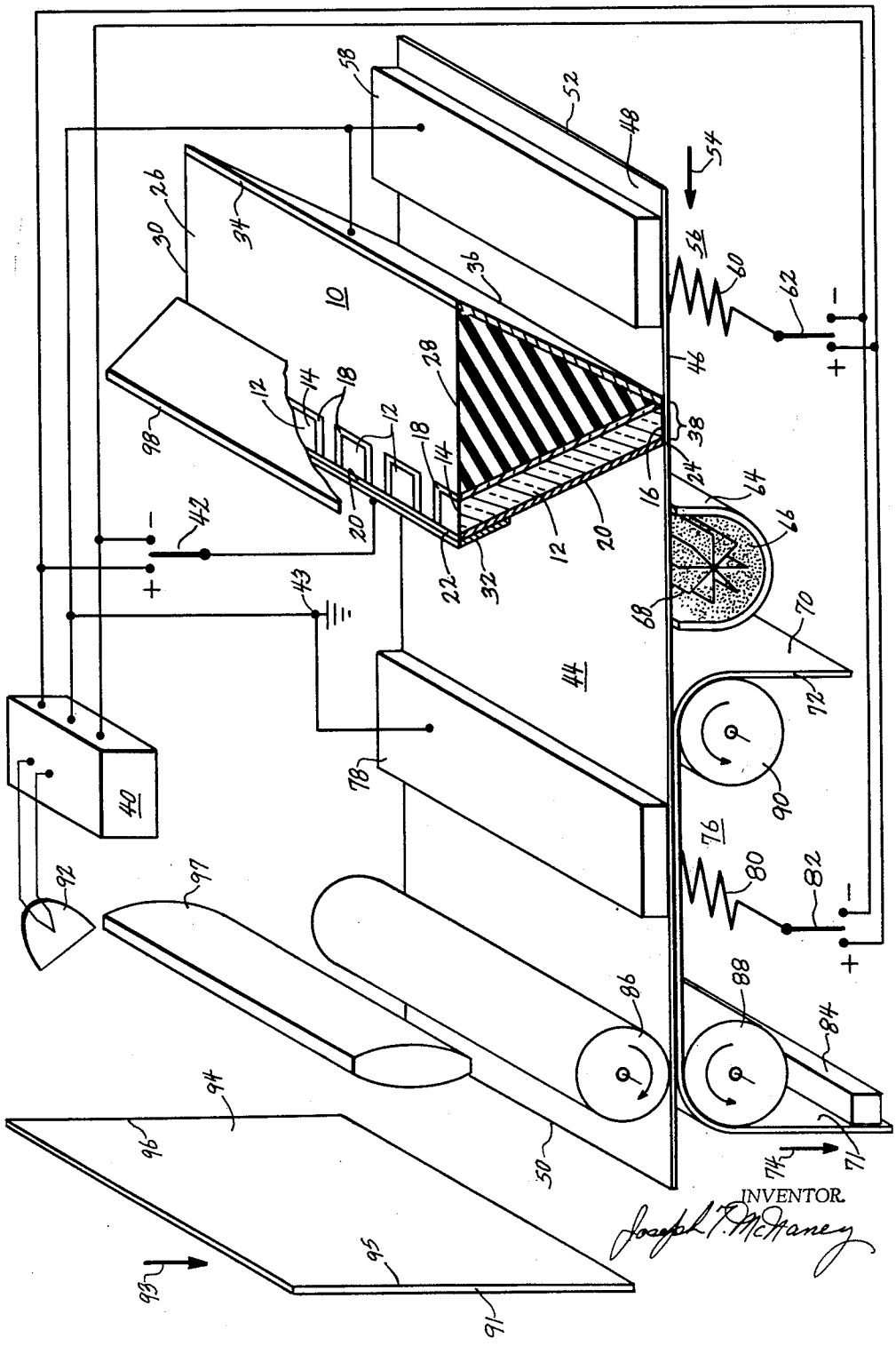

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ELECTROSTATIC DATA RECORDING APPARATUS WITH RADIANT ENERGY INPUT CONVERTER MEANS

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This invention relates to improvements in electrostatic data recording apparatus which is designed to receive input information in the form of radiant energy and provide a recording of the information on media such as ordinary writing paper or the like.

In apparatus presently designed to provide recordings on media of the type to which I have referred, in response to input information in the form of radiant energy, and utilizing an electrostatic process of printing, such apparatus includes the use of a drum, or a plate, on which a layer of photoconductive material is supported as a means of printing on ordinary paper. In these systems of printing, an electrostatic latent image, corresponding to data appearing on an original copy, is established on the surface of the photoconductive layer upon the exposure of the layer to light rays corresponding to the original copy. The application of a developing powder to the layer makes visible the data in latent image form on the surface of the photoconductive layer. The powder is then transferred to a record medium, such as paper, whereupon the powder is fixed to the paper by means of heat.

I have found apparatus such as this to be expensive to maintain in view of the relatively short life expectancy of the photoconductive material used on the plates or drums of this type of equipment.

It is an object of the present invention to utilize the photosensitive converter means shown and described in my U.S. patent application Serial No. 85,259, filed January 27, 1961, now Patent Number 3,050,623, issued August 21, 1962, which will obviate the need of supporting a photosensitive material on a plate or drum and thereby overcome the problems of short life such materials are subject to when used in this manner.

A further object of the present invention is to utilize my improvement in photosensitive converter means in combination with an endless belt of relatively thin material having exceptionally high electrical resistance properties which will permit input information in the form of radiant energy to be recorded on ordinary record media such as writing paper or news-print materials.

It is still a further object of my invention to utilize the endless belt means referred to as a means of protecting the converter means from coming in contact with the relatively inexpensive paper media, developing powders, etc.

Other objects and advantages of the present invention will become apparent from the following description when read in conjunction with the accompanying drawing.

The drawing is a diagrammatic presentation of my improvement in recording apparatus showing a view in perspective, and partially in cross section, of those elements considered most essential from the standpoint of adequately illustrating the invention in conjunction with the following description thereof.

Referring now to the drawing, the invention utilizes a radiant energy-to-electrical energy converter **10** being of a type shown and described in my U.S. patent application referred to above. In the present application, however, the converter **10** is being adapted to a system of recording wherein the record media is not at all critical insofar as its surface resistance is concerned which involves the ability of the surface to hold an electrostatic latent image charge. The present invention, as described in detail below, makes use of an endless belt of extremely thin electrically resistive material intermediate the converter and inexpensive record media which performs a very important function of isolating the converter from the record media and development powder.

The converter **10** includes a plurality of light conducting fibers **12**, each having a first end **14** and a second end **16** and, as I have explained in the above application No. 85,259, for the efficient conduction of light waves from the first end **14** to the second end **16** of such a fiber, I have included a jacket **18** of light conducting material having an index of refraction less than the index of refraction of the fiber **12**. Unless a fiber **12** is jacketed with such material, light waves entering the one end **14** will either escape from the fiber into an adjacent medium, if of a higher index, or, be absorbed to a large extent by an adjacent medium if it is opaque in character. The lower index jacket, therefore, will permit light waves entering the one end **14** to be conducted to the other end **16** by means of internal reflections which take place after the light waves have penetrated the jacket **18** beyond the interface of the jacket **18** and the fiber **12**.

Each of the light conducting fibers **12** of the converter **10** have a predetermined index of refraction, a longitudinal dimension exceeding its cross sectional dimension and an outer surface generally along its longitudinal dimension. As I have indicated, each of the fibers **12** is provided with a light conducting jacket **18** having an index of refraction which is less than the predetermined index of the fiber **12**, extending from the first end **14** to the second end, **16**, and intimately joined with the outer surface of the fiber **12** to form a smooth interface along the juncture.

In order that I may accomplish one of the primary objectives of the invention, each of the light conducting fibers **12** is provided with a longitudinally extending layer of photoconductive material **20**, which is disposed upon and intimately joined with an uncoated part of the outer surface of the fiber **12**, having a first end **22** and a second end **24**. The photoconductive material **20** may be selected from among certain materials such as selenium, cadmium sulphide, silver selenide, and like materials. The photoconductive material **20** may be utilized preferably in a thin layer along part or all of the longitudinal dimension of the uncoated outer surface. It is only necessary to the invention that the photoconductive material **20** be of sufficient length on each fiber **12** to isolate the one end **22** from the opposite end **24**. When not exposed to radiant energy, each layer **20** of each fiber **12** will act as a high resistance element to the flow of electrical current, however, when individually exposed to radiant energy the layer **20** of each fiber **12** will function as a conductor of electrical current.

Upon the entry of radiant energy through one end **14** of a given fiber **12**, the resultant spiralling and scattering of reflected light waves during their travels toward the opposite end **16** is responsible for, and therefore provides, the necessary illumination of the longitudinally extending layer **20** for the conversion of the layer **20** from a high resistance path to a low resistance path for the flow of electrical current therethrough.

The jacketed fibers **12** are supported in an electrical insulating support means **26** in a side-by-side arrangement, extending from a one end **28** of the support means **26** to an opposite end **30** thereof. There is a first electrode **32** connected operatively with the photoconductive material **20** adjacent the first end **22**, and a second electrode **34** supported by the support means **26**, spaced apart and, thereby, insulated from the photoconductive material **20**.

A spacing between the lower edge 36 and the second end 24 of the photoconductive material 20 is designed to provide an air gap 38 between the lower edge 36 of the second electrode 34 and a second end 24 of a longitudinally extending layer 20 of each fiber 12.

A source of potential 40 is connected between the first electrode 32 and the second electrode 34 through a switch means 42. The second electrode 34 is connected preferably to a central point, or ground point 43, of the source 40. The switch means 42 is provided to allow the first electrode 32 to be connected to either a positive or a negative polarity of the source 40 with respect to ground 43.

An electrostatically polarizable member 44, preferably in the form of an endless belt, has a first surface 46 and a second surface 48. Although not shown in the drawing as an endless belt, it should be understood that the end 50 of the member 44 may be extended and thereby joined with the opposite end 52 to form an endless belt. The second surface 48 of the member 44 is supported in contact with the converter 10 adjacent the air gap 38. The member 44 is preferably a thin material having exceptionally high electrical resistance properties. The member 44 thickness dimension between the first surface 46 and the second surface 48 may be from a few tenths of one-thousandth of an inch to several one-thousandths of an inch. Materials from which the member 44 can be fabricated may be chosen from a number of compositions which are well known in the art under the names of nylon, Teflon, Vinylite and the like. When in operation, the member 44 will be motivated in the direction of arrow 54 in relation to the converter 10 which will be supported in a stationary position.

The invention utilizes a means 56 for effecting a uniform electrostatic polarization of the member 44, just prior to being moved past the air gap 38. The polarization means 56 is illustrated as consisting of an electrode 58 supported in contact with the second surface 48 of the member 44, and an electrostatic polarizing element 60 being supported adjacent the first surface 46 of the member 44. The polarizing means 56 illustrated represents but one form of a number of different systems which may be used and the invention is not to be limited to the means 56 illustrated. The electrode 58 is connected to the ground point 43 of the source 40, and a switch means 62 is provided to allow the element 60 to be connected to either a positive or to a negative polarity of the source 40 with respect to ground 43. If, for example, the switch means 62 is made to connect the element 60 to the positive polarity, the establishment of an electrostatic flux, or electrical radiation, between the element 60 and the electrode 58 will result in a degree of ionization of the space particles and material within the space, between the electrode 58 and the element 60, to the extent that a loss of electrons in atoms within the member 44 adjacent the first surface 46 thereof will leave the first surface 46 is a positively charged ionic condition.

As the member 44 is moved in the direction of arrow 54, and past the air gap 38 of the converter 10, the positively charged surface 46 will be subjected to the influence of another source of radiation from the converter 10. If, for example, the switch means 42 is made to connect the first electrode 32 to the negative polarity of the source 40, the establishment of an electrostatic flux, or electrical radiation, between the second ends 24, respectively of predetermined illuminated layers 20 and the lower edge 36 of the second electrode 34 will result in a degree of ionization of space particles or material within the gap 38, to the extent that a gain of electrons in atoms within the member 44 will neutralize, or convert to a negatively charged ionic condition, selected areas of the first surface 46 of member 44. The neutralized, or negatively charged, areas of an otherwise positively charged surface 46 will represent an electrostatic latent image on the surface 46 of the member 44.

As the movement of the member 44 in the direction of arrow 54 progresses, the latent image will be developed into a visible image by one of a number of well known electrostatic image developing techniques. The method illustrated in the drawing consists of a receptacle 64 of electrostatically charged electroscopic powder particles 66 which are brought into contact with the first surface 46 of the member 44 by the rotation of an agitator 68. Depending upon the electrostatically charged condition of the powder particles 66, the force exerted by tension existing near the electrostatically charged areas of the surface 46 will either attract powder particles thereto, or repel powder particles therefrom. If, for example, the powder particles 66 are given a positive charge, they will be attracted to the neutralized, or negatively charged, areas of the surface 46 and be repelled from the positively charged areas. The powder particles will, therefore, adhere to those areas to which they are attracted, making visible the electrostatic latent images on the surface 46 of the member 44.

The surface 46 of the member 44 on which latent images have been made visible is brought into contact with a first surface 70 of a record medium 72, which medium 72 is made to move in the direction of arrow 72 at a rate which equals the speed at which the member 44 is made to move in the direction of arrow 54. At this location in the course of the movement of the member 44, powder particles adhering to its surface 46 will be transferred to the first surface 70 of the record medium 72 with the aid of another electrostatic flux generator 76 consisting of an electrode 78, supported preferably in contact with the second surface 48 of the member 44, and an electrostatic polarizing element 80 being supported adjacent a second surface 71 of the record medium 72.

The electrode 78 is connected to the ground point 43 of the source 40, and a switch means 82 is provided to allow the element 80 to be connected to either a positive or a negative polarity of the source 40 with respect to ground 43. If, for example, the switch means 82 is made to connect the element 80 to the negative polarity, the establishment of an electrostatic flux, or electrical radiation, between the element 80 and the electrode 78 will provide the electrostatic stress necessary to force the positively charged powder particles to be attracted to, and also adhere to, the first surface 70 of the record medium 72. As the record medium carrying the visible image continues to advance in the direction of arrow 74, the second surface 71 will come in contact with a heater 84. Heat from the heater 84 causes the powder particles to be fused into the medium 72 and, thereby, provide a permanent record of the visible image.

The application of motive force to either of the two rollers 86 and 88, or both, will permit the member 44 and the medium 72 to be driven at the required speed in the directions of arrows 54 and 74, respectively. A third roller 90 is shown to illustrate a further means necessary to support the medium 72 in a position adjacent the first surface 46 of the member 44.

In the process of making a duplicate, or a recording of data, appearing on an original recording of data 91, the latter will be supported in the necessary relationship to the first ends 14 of the fibers 12. The data on the original 91 will be illuminated, for example, by means of a source of radiant energy 92, powered by the source of potential 40. The recording of data 91 will be made to move in the direction of arrow 93 at a rate of speed equal to the rate of movement given member 44 and medium 72. A limited area on the surface 94 will be imaged on the first ends 14 of the fibers 12 by means of an image lens system 97 and a reflector 98 such as a mirror, supported intermediate the surface 94 and the first ends 14 of the fibers 12. The actual area viewed by the converter 10 at any given period of time may be equal to 0.001", or less, in height,

and extending from one side **95** of the recording of data **91** to the opposite side **96**. As the data on the surface **94** is being moved in the direction of arrow **91**, and the member **44** is being moved in the direction of arrow **54**, a latent image of the data will be transferred to the first surface **46** of the member **44** having a resolution exceeding 1,000 picture elements per linear inch in the direction of travel and also across the member **44**.

Although I have shown and described but one embodiment of a recording apparatus it should, of course, be understood that many other embodiments embracing the general principles and construction set forth in this application may be utilized and still be within the ambit of the present invention.

The particular embodiment of this invention illustrated and described herein is illustrative only, and the invention includes such other modifications and equivalents as may be readily noted by those skilled in the art, and within the scope of the appended claims.

I claim:

1. In a recording apparatus including

(*a*) a longitudinally extending layer of photoconductor material having first and second ends;

(*b*) a plurality of first light conductor means having a predetermined index of refraction for supporting said layer and conducting light to said layer;

(*c*) second light conductor means jacketing each of said plurality of first light conductor means and having an index of refraction less than said predetermined index for controlling the reflection of light through said first light conductor means and reflection of light to said layer;

(*d*) an electrode spaced apart from the second end of said layer and defining an air gap therebetween; and

(*e*) means for extending the influence of an electrical potential from said first end of said layer to said second end and across said air gap upon the reflection of light to said layer;

the improvement comprising

(*f*) a record medium and means intermediate said air gap and said record medium for (1) isolating said air gap from said record medium, (2) receiving an electrostatic latent image upon the extension of said influence of electrical potential across said air gap and (3) conveying a development of said latent image to said record medium.

2. In a recording apparatus including

(*a*) a longitudinally extending layer of photoconductor material having first and second ends;

(*b*) a plurality of first light conductor means having a predetermined index of refraction for supporting said layer and conducting light to said layer;

(*c*) second light conductor means jacketing each of said plurality of first light conductor means and having an index of refraction less than said predetermined index for controlling the reflection of light through said first light conductor means and reflection of light to said layer;

(*d*) an electrode spaced apart from the second end of said layer and defining an air gap therebetween;

(*e*) means for extending the influence of an electrical potential from the first end of said layer to the second end thereof and across said air gap upon the reflection of light to said layer; and

(*f*) a record medium;

the improvement comprising

(*g*) recorder means including image developer means intermediate said air gap and said record medium; and

(*h*) means for (1) isolating said air gap from said image developer means and (2) conveying said developer means to said record medium as a function of light reflection to said layer and influence of electrical potential across said air gap.

3. In a recording apparatus including

(*a*) a longitudinally extending layer of photoconductor material having first and second ends;

(*b*) a plurality of first light conductor means having a predetermined index of refraction for supporting said layer and conducting light to said layer;

(*c*) second light conductor means jacketing each of said plurality of first light conductor means and having an index of refraction less than said predetermined index for controlling the reflection of light through said first light conductor means and reflection of light to said layer;

(*d*) an electrode spaced apart from the second end of said layer and defining an air gap therebetween;

(*e*) means for extending the influence of an electrical potential from the first end of said layer to the second end thereof and across said air gap upon the reflection of light to said layer;

(*f*) a record medium; and

(*g*) image developer means;

the improvement comprising

(*h*) means for (1) isolating said air gap from said record medium and said developer means, (2) receiving an electrostatic latent image as a function of light reflection to said layer and electrical potential across said air gap, (3) attracting said developer means thereto in response to an electrostatic latent image received thereon, and (4) conveying said developer means to said record medium for transferring thereto.

4. In a recording apparatus

(*a*) a longitudinally extending layer of photoconductor material having first and second ends;

(*b*) a plurality of first light conductor means having a predetermined index of refraction for supporting said layer and conducting light to said layer;

(*c*) second light conductor means jacketing each of said plurality of first light conductor means and having an index of refrection less than said predetermined index for controlling the reflection of light through said first light conductor means and reflection of light to said layer;

(*d*) an electrode spaced apart from the second end of said layer and defining an air gap therebetween;

(*e*) means for extending the influence of an electrical potential from the first end of said layer to the second end thereof and across said air gap upon the reflection of light to said layer;

(*f*) a record medium; and

(*g*) image developer means intermediate said air gap and said record medium;

the improvement comprising

(*h*) a dielectric medium adjacent said air gap and movable in relation thereto for (1) receiving an electrostatic latent image upon the extension of the influence of an electrical potential across said air gap, (2) supporting image developer means attracted thereto by the latent image thereon, (3) conveying image developer means supported thereon to said record medium and (4) preventing said developer means and said record medium from coming in contact with said air gap.

5. In a recording apparatus

(*a*) a longitudinally extending layer of photoconductor material having first and second ends;

(*b*) a plurality of first light conductor means having a predetermined index of refraction for supporting said layer and conducting light to said layer;

(*c*) second light conductor means jacketing each of said plurality of first light conductor means and having an index of refraction less than said predetermined index for controlling the reflection of light through said first light conductor means and reflection of light to said layer;

(*d*) an electrode spaced apart from the second end of said layer and defining an air gap therebetween;

(*e*) means for extending the influence of an electrical potential from the first end of said layer to the second end thereof and across said air gap upon the reflection of light to said layer; and

(*f*) a record medium;

the improvement comprising

(*g*) a thin sheet of dielectric medium being light insensitive, bridging said air gap and movable in relation thereto;

(*h*) means for establishing an electrostatic latent image on said dielectric medium as a function of light reflection to said layer and influence of electric potential across said air gap; and

(*i*) means for developing said latent image and transferring said development to said record medium;

(*j*) said dielectric medium being adapted to isolate said air gap from said last stated means and said record medium.

6. The invention as set forth in claim 1 additionally including,

(*g*) said last stated means comprising a belt of light insensitive dielectric material movably related to said air gap.

7. The invention as set forth in claim 2 additionally including,

(*i*) said last stated means comprising a belt of light insensitive dielectric material bridging said air gap and movable in relation thereto.

8. The invention as set forth in claim 3 additionally including,

(*i*) said last stated means comprising a thin sheet of light insensitive dielectric material bridging and in operative contact with said gap and capable of being moved past said air gap.

References Cited in the file of this patent

UNITED STATES PATENTS

2,716,826	Huebner	Sept. 6, 1955
2,898,468	McNaney	Aug. 4, 1959
3,001,849	Walkup	Sept. 26, 1961
3,007,049	McNaney	Oct. 31, 1961
3,015,304	Carlson et al.	Jan. 2, 1962