

[54] **ELECTRIC DISCHARGE RECORDING SYSTEM HAVING A DUAL SCANNING AND RECORDING HEAD**

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[63] Continuation of Ser. No. 91,657, Nov. 23, 1970, abandoned.

Foreign Application Priority Data

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[52] U.S. Cl. 178/6.6 R, 178/7.6

[51] Int. Cl. H04n 1/24, H04n 3/06

[58] Field of Search 178/6.6 A, 6.6 R, 6.7 R, 178/7.1, 7.3 R, 7.6; 346/74 E, 74 CH, 8 R

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[57] **ABSTRACT**

A high speed scanning device including a rotary holder equiangularly carrying a plurality of scanning heads each including an optical scanning system for scanning an original, a discharge electrode in spaced apart relation with a recording medium and a photoelectric effect element for transducing the light signals from the optical scanning system into electrical signals for controlling the intensity of the discharge produced between the discharge electrode and the recording medium. Upon rotation of the rotary holder, the discharge electrodes and photoelectric effect elements are successively connected to and disconnected from a common electric circuit outside of the rotary holder by a commutator-like switching system. In addition, easy magnification change is possible by changing the positions of the discharge electrodes relative to the optical scanning systems. A bulky original such as a book or the like may be copied.

8 Claims, 6 Drawing Figures

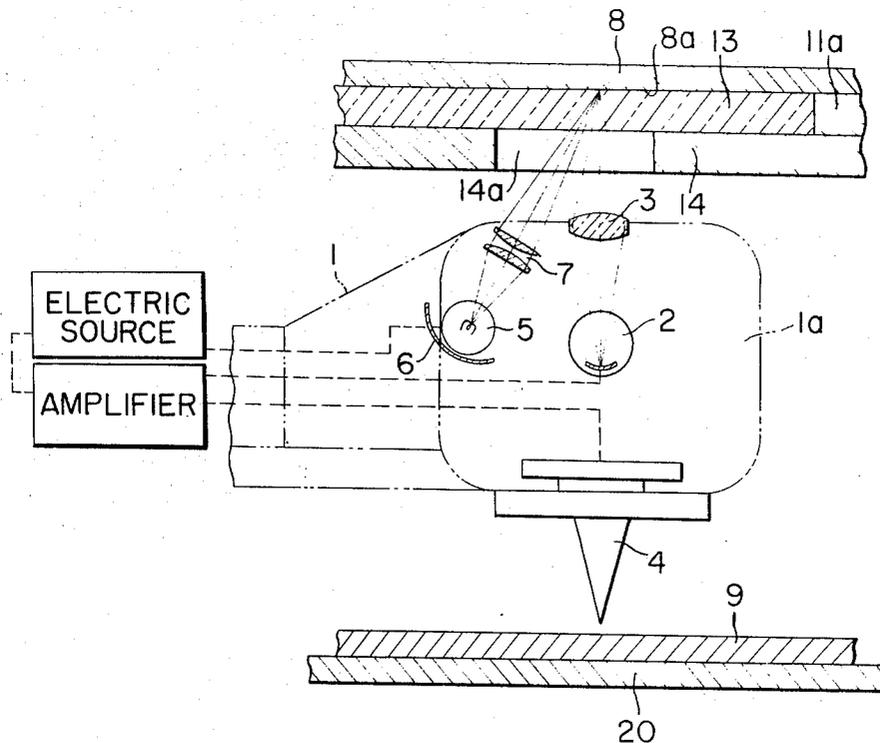


FIG. 1

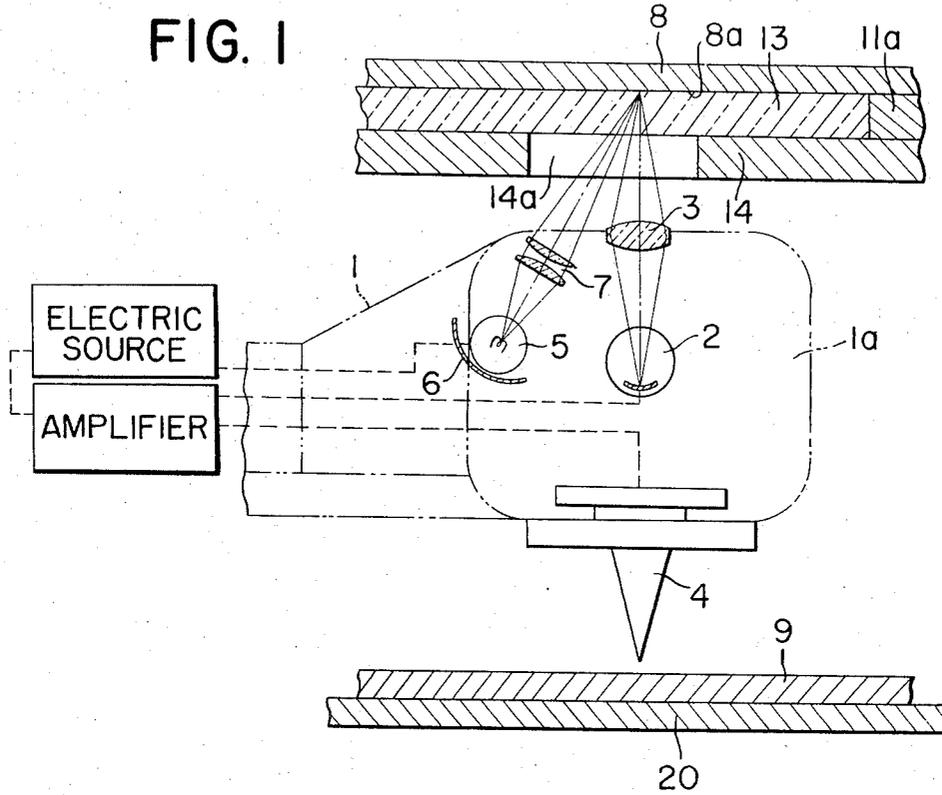
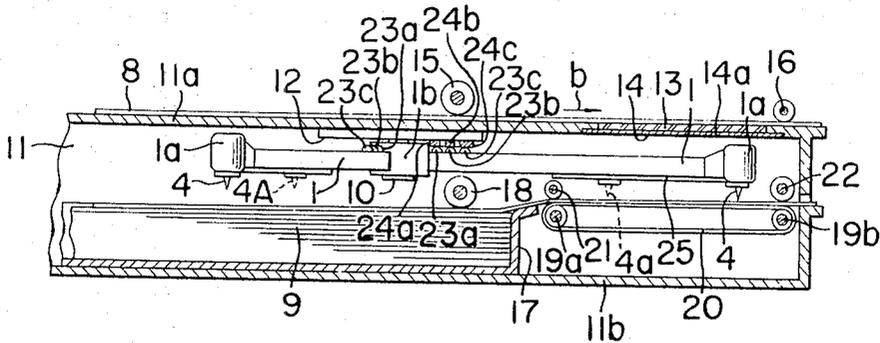


FIG. 2



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FIG. 3

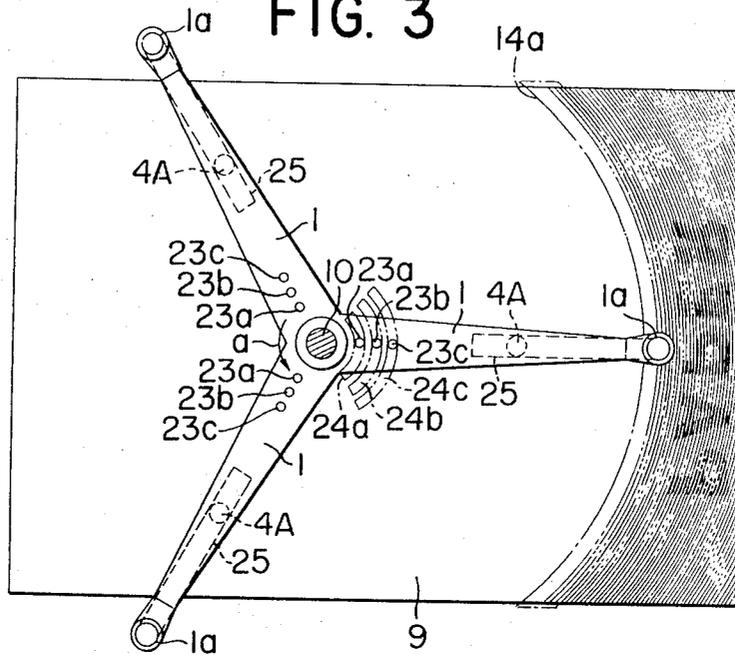
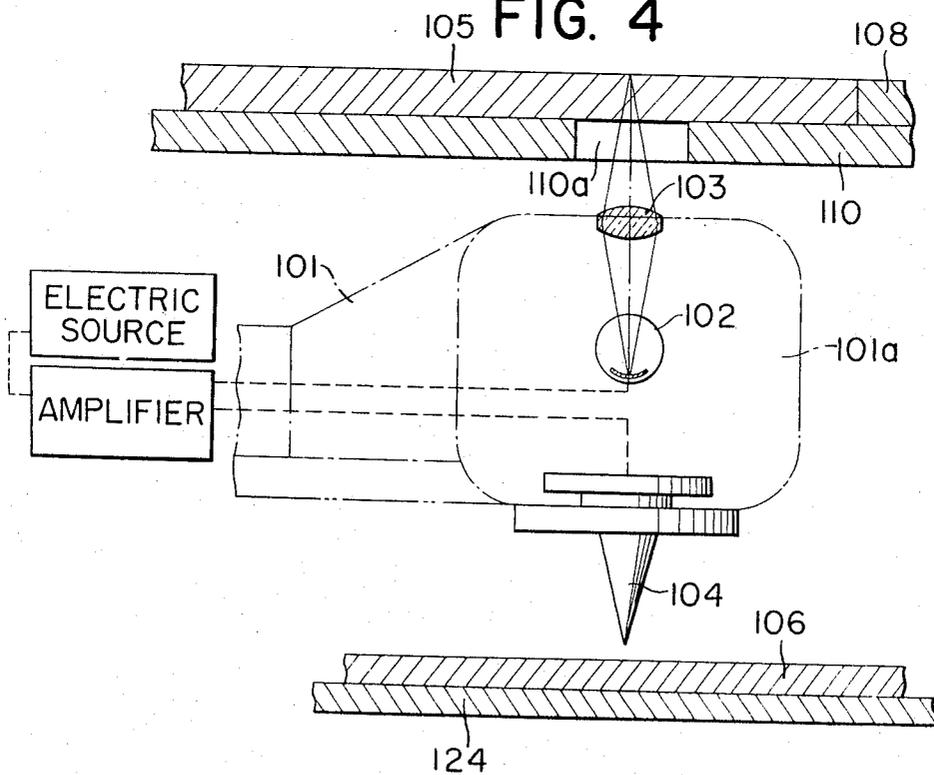


FIG. 4



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FIG. 5

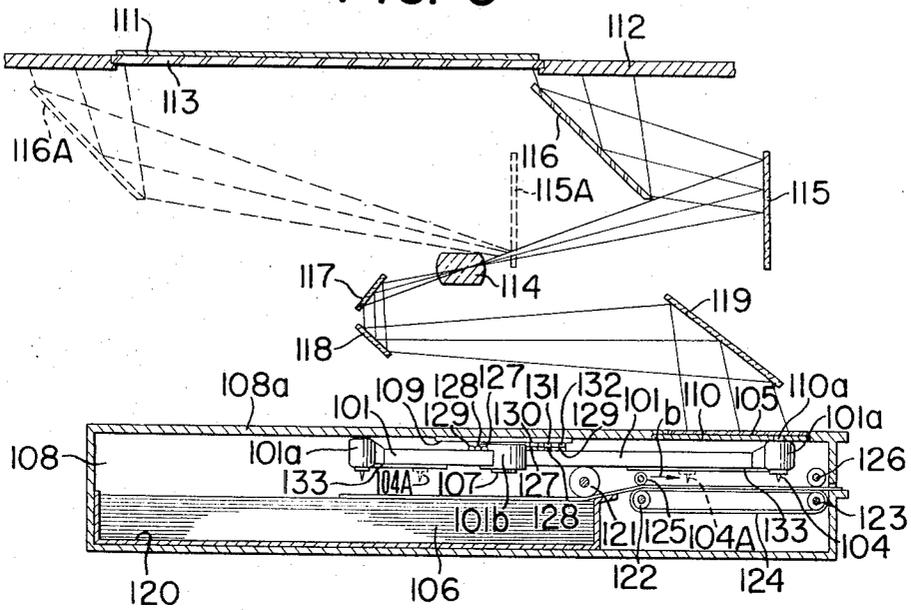
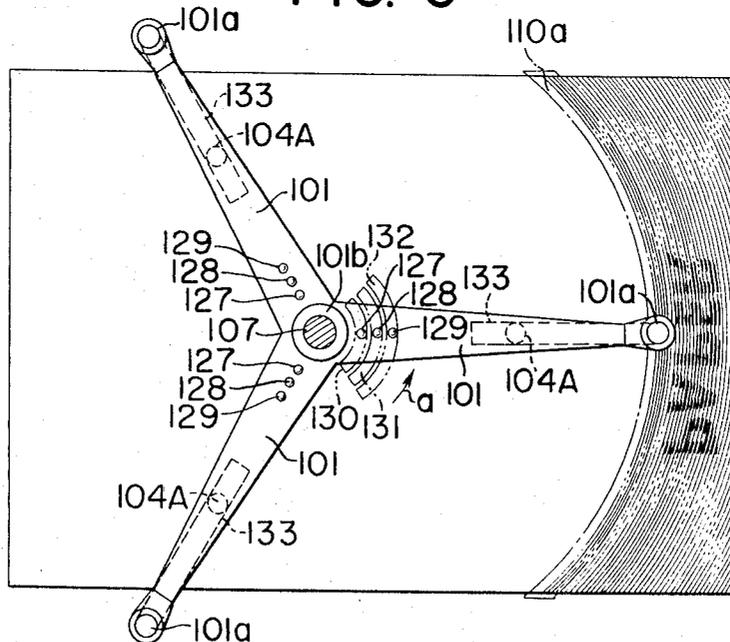


FIG. 6



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ELECTRIC DISCHARGE RECORDING SYSTEM HAVING A DUAL SCANNING AND RECORDING HEAD

This is a continuation, of application Ser. No. 91,657
filed Nov. 23, 1970 now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to generally an electro-
photocopying machine and more particularly to an
electric discharge recording system of the type in which
an original to be copied is scanned by an optical scanning
system having a photoelectric effect element which
produces an appropriate signal to control an electric
discharge between a discharge electrode and a recording
medium, thereby forming upon the recording medium an
electrostatic latent image or "discharge-breakdown"
image depending upon the type of the recording medium
used.

Known is an electric discharge recording system in
which two rotary drums around which are wrapped an
original to be copied and a recording medium respectively
are disposed in opposed relation with a scanning
head and a discharge electrode respectively both of
which are reciprocated widthwise of the rotary drums
and in synchronism with each other so that the original
may be copied upon the recording medium by the electric
discharge. However, because of the mechanism of the
conventional electric discharge recording system of the
type described, the originals to be copied are limited
to those in the form of a sheet and the number of
scanning heads and accordingly the number of discharge
heads cannot be increased in a simple manner, so that
the scanning speed cannot be increased beyond a certain
speed.

Even if both the scanning heads and the discharge
electrodes are increased in number, the number of
oscillators or amplifiers and other electric or electronic
equipment must be increased accordingly, so that the
system inevitably becomes large in size, complex in
mechanism and expensive to manufacture.

In the conventional electric discharge recording system
the relative speed of the scanning head with respect
to the discharge electrode must be adjusted in correlation
with each other in order to change the magnification
of a copy, so that the system becomes also complex
in mechanism. Furthermore, a simple change of
magnification is impossible.

SUMMARY OF THE INVENTION

It is therefore one of the objects of the present invention
to provide an improved electric discharge recording
system capable of copying not only a sheet-like
copy but also a bulky copy such as a book or magazine.

It is another object of the present invention to provide
an improved electric discharge recording system
capable of copying at high scanning speed by a plurality
of scanning heads each including a discharge head.

It is also another object of the present invention to
provide an improved electric discharge recording system
capable of the simple magnification change.

According to one aspect of the present invention, a
plurality of scanning heads each incorporating therein
an optical scanning system, a discharge electrode and
a photoelectric effect element such as a photoelectric
tube or the like for transducing the light signals from
the optical scanning system into the electrical signals

for controlling the intensity of the discharge produced
between the discharge electrode and a recording medium
are carried by a rotary holder in equiangularly
spaced-apart relation with each other. The photoelectric
effect elements and the discharge electrodes in the
plurality of scanning heads may be electrically
connected to and disconnected from a common electric
circuit outside of the rotary scanning head holder
through a commutator-like switching system between
the rotary holder and the circuit so that upon rotation
of the rotary holder and synchronized transportation of
an original above the path of rotation of the scanning
heads and the recording medium in a suitably spaced-
apart relation with the discharge electrodes, both of the
photoelectric effect elements and discharge electrodes
are successively energized for scanning the original and
producing the discharge between the discharge electrodes
and the recording medium during the time interval
the discharge electrodes rotate across the recording
medium, thereby forming an electrostatic latent image
when an electrophotographic photosensitive paper is
used or a "discharge-breakdown" image when a discharge
breakdown paper is used. Thus, a high speed
scanning and accordingly high copying speed may be
attained by a simple mechanism hitherto unattainable
by the conventional system.

According to another aspect of the present invention
the discharge electrode in each of the scanning heads
is so disposed as to be slidably displaced along guide
means relative to the optical scanning system so that
the ratio of the radius of rotation of the discharge
electrode to that of the optical scanning system may be
varied, thereby enabling to change the magnification of a
copy in a very simple manner.

According to another aspect of the present invention
the reflecting illumination system is incorporated in
each of the scanning heads so that the system may be
made compact in size.

According to another aspect of the present invention
a scanning type optical projection system is combined
with the electric discharge recording system so that the
scanned light image of the original may be projected
upon a screen. The light image projected upon the
screen in turn is scanned at high speed by the plurality
of scanning heads of the type described and the
discharge recording is made upon a recording medium
transported in synchronism with the scanning operation
of the optical projection system. The speed ratio
between the optical projection system and the recording
system may be varied so that the magnification of
a copy may be very easily changed. Since an optical
projection system is used, a bulky copy such as a book
or the like may be copied easily in a simple manner.

In an electric discharge recording system in accordance
with the present invention, the recording medium
may be of various types, such as, electrophotographic
copying papers, the stencil papers for mimeograph,
the plates used in offset printing, or "discharge-
breakdown" papers of the type in which the back
surfaces thereof are so treated as to produce colors at
parts subjected to the discharge breakdown. In case
electrophotographic copying papers are used, the
electrostatic latent images formed may be developed by a
suitable conventional electrophotographic process. In
the case where discharge breakdown paper is used, a
positive copy may be directly obtained.

The present invention will become more apparent from the following description of the preferred embodiments thereof taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING:

FIG. 1 is a diagrammatic fragmentary view of a first embodiment of the present invention for explanation of the principle thereof;

FIG. 2 is a fragmentary sectional view of the first embodiment;

FIG. 3 is a top view of FIG. 2;

FIG. 4 is a diagrammatic fragmentary view for explanation of the principle of second embodiment of the present invention;

FIG. 5 is a fragmentary sectional view of FIG. 4; and

FIG. 6 is a top view of FIG. 4 from which the screen and the shielding plate are removed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIRST EMBODIMENT, FIGS. 1, 2 and 3

Referring to FIG. 1 illustrating the principle of the first embodiment of the present invention, a scanning head generally designated by 1a mounted is at the free end of a holder 1 and comprises a photoelectric tube 2 in optically opposed relation with an optical scanning system 3, a discharge electrode 4 fixed to the undersurface of the scanning head 1a and is electrically connected to the photoelectric tube 2 through an amplifier, and an illumination system comprising a light source 5 connected to an electric source, and its reflector 6 and a condenser system lens 7 for illuminating the surface 8a of an original 8 to be copied. The original 8 is placed upon a transparent member 13 such as a glass plate which in turn is overlaid upon a shield plate 14 supported by a top plate 11a of a housing 11 (see FIG. 2). A recording medium or paper 9 is placed over a belt 20 to be described in more detail hereinafter in spaced apart relation with the discharge electrode 4 of the scanning head 1a.

The original 8 is illuminated by light from the illumination system in the scanning head 1a through an arcuate aperture 14a formed through the shield plate 14 and the light reflected by the original 8 is scanned by the optical scanning system 3 and made incident upon the photoelectric tube 2 as will be described in more detail hereinafter. Therefore, the intensity of the scanned light image incident upon the photoelectric tube 2 may be transduced to that of an electric current. The amplifier or the discharge circuit is controlled by the current from the photoelectric tube 2 so as to produce a discharge between the discharge electrode 4 and the recording paper 9, thereby forming an electrostatic latent image or "discharge-breakdown" image on the paper. This image formation process is well known to those skilled in the art so that no further detailed description will be made.

Next referring to FIGS. 2 and 3, the first embodiment will be described in more detail. As viewed in FIG. 3, in the instant embodiment, the three holders 1 are in the form of arms radially extending from a boss 1b securely fixed to a shaft 10. The shaft 10 is rotatably supported by a bearing member 12 securely fixed to the undersurface of the top plate 11a and is driven by a suitable driving means such as an electric motor in the direction indicated by the arrow a. In the instant em-

bodiment three holders 1 are shown each carrying at its free end the scanning head 1a of a type described. The arcuated slot 14a (See FIG. 3) is formed through the shield plate 14 in opposed relation with the path of rotation of the scanning heads 1a about the shaft 10.

Terminals 23a, 23b and 23c of the photoelectric tube 2, the illumination system and the discharge electrode 4 are disposed upon the upper surfaces of the holders 1a closer to the boss 1b. The bearing member 12 is provided with arcuate contacts 24a, 24b and 24c which are also the terminals of the amplifier or the like and the electric source. The contacts 24a, 24b and 24c are disposed in opposed relation with the paths of rotation of the terminals 23a, 23b and 23c on the holders 1 so that they may be electrically connected with each other only the time interval the discharge electrode 4 of each holder 1 rotates across the recording paper 9. It is therefore seen that the length of the arc of each arcuate contact is determined accordingly. Thus, only when the discharge head 4 of each holder 1a rotates across the recording medium, the photoelectric tube 2, the illumination system and the discharge electrode 4 of each scanning head 1a are energized by the electric source and the amplifier or the like.

The original 8 placed upon the original holder 13 is transported by a feed roller 15 driven by a suitable driving means (not shown) and a pressure roller 16 serves to hold the original 8 firmly upon the original holder 13.

The belt 20 transporting the recording paper 9 transferred thereto by a feeding roller 18 from a recording paper storage 17 within the housing 11 is wrapped around a pair of spaced apart rollers 19a and 19b against which are pressed a pair of rollers 21 and 22 for holding the recording paper 9 upon the belt 20. The rollers 19a and 19b are so driven by a driving means (not shown) in synchronism with the roller 15 that the recording paper 8 may be transported in the same direction with that of the original 8 indicated by the arrow b at the same speed when the scanning heads 1a rotate about the shaft 10.

When the shaft 10 of the holders 1 rotates in the direction indicated by the arrow a, the recording paper 9 may be transported in synchronism with the original 8 and the photoelectric tubes 2, the illumination systems and the discharge electrodes 4 in the scanning heads may be successively connected to the common electric source and the common amplifier or the like so that the discharge recording may be made continuously upon the recording paper 9 without any interruption at a high scanning speed.

In one variation of the present invention, the discharge electrode 4 in each scanning head 1a is slidably mounted on guide rails 25 so that it may be radially displaced relative to the optical scanning system 3. For example, the discharge head 4 which is normally held stationary immediately below the optical scanning system 3 may be moved to the position 4A indicated by the broken lines in FIGS. 2 and 3 so that the ratio between the distance between the shaft 10 and the discharge electrode 4 and that between the shaft 10 and the optical scanning system 3, that is the ratio of the radius of rotation of the discharge electrode 4 to that of the optical scanning system 3 is varied. Therefore it becomes possible to vary the magnification of a copy by simple adjustment of the position of the discharge electrode 4.

In the instant embodiment, the illumination system consisting of the light source 5, its reflector 6 and the condenser lens system 7 has been described as being incorporated in the scanning head 1a, but it will be understood that the illumination system may be a light transmission system instead of a light reflecting system. In this case, the illumination source may be, for example, placed upwardly of the original so that the light transmitted through the original may be scanned by the optical scanning system 3. This arrangement is advantageous when a transparent original is copied.

In another variation of the first embodiment of the present invention, an original holder may be provided independently of the housing 11 in such a manner that the original holder may be displaced reciprocally upon the top of the housing 11. This arrangement is advantageous particularly when an original to be copied is bulky as in case of a book and the like.

In another variation of the first embodiment of the present invention, instead of transporting both of the original and the recording paper in synchronism with each other, they may be held stationary while the scanning head holders 1a may be displaced at a suitable speed relative to them while it is rotated. This arrangement is advantageous because the electric discharge recording system may be designed simple in mechanism.

It is, of course, understood that instead of the photoelectric tube any other suitable photoelectric effect element such as semiconductive devices may be employed.

SECOND EMBODIMENT, FIGS. 4, 5 and 6

The second embodiment of the present invention is a combination of an electric discharge recording system with an optical projection system. First referring to FIG. 4, a scanning head 101a carried at the free end of a rotary holder 101 is substantially similar to that described with reference to FIGS. 1-3 of the first embodiment except that no illumination system is incorporated therein. In addition the secured embodiment has other component parts substantially similar to those described in connection with the first embodiment so that no detailed description will be made.

As shown in FIGS. 4 and 5, atop a top plate 108a of the housing 108 is disposed a screen 105 comprising, for example, a glass plate having a mat surface in opposed relation with an optical scanning system 103 of the scanning head 101a through an arcuate slot 110a formed through a shielding plate 110. A discharge electrode 104 of the scanning head 101a, is suitably spaced apart from a recording paper 106 transported by a belt 124 of the recording paper transporting mechanism which is similar to that of the first embodiment and comprises a pair of spaced-apart rollers 122 and 123, the belt 124 wrapped around them and a pair of rollers 125 and 126 pressed against the rollers 122 and 123 respectively. The recording papers 106 stored in a storage box 120 are fed upon the belt 124 one by one by a feed roller 121. The recording paper transporting mechanism is driven by any suitable drive means in synchronism with the scanning operation of an optical projection system to be described in detail hereinafter.

The scanning head holders 101 also similar to those of the first embodiment are rotatably carried by a shaft 107 through a hub 101b and have electric terminals 126, 128 and 129 for establishing the electrical connection

of the electrical components in the scanning heads 101a with the electric source and the amplifier or the like through arcuate contacts 130, 131 and 132 on a bearing member 109 which serves to rotatably support the shaft 107. The bearing member 109 is fixed to the undersurface of the top plate 108a of the housing 108.

The discharge electrodes 104 are arranged so as to be displaced along guides 133 relative to the optical scanning systems 103 respectively for varying the magnification as described hereinabove.

Upon the screen 105 is projected the light image of an original 111 scanned by the optical projection system of the present invention comprising an original holder 113 of a transparent material supported upon a supporting member 112 and such optical elements as a first movable reflecting mirror 116, a second movable reflecting mirror 115, a projection lens 114 and a series of fixed reflecting mirrors 117, 118 and 119 in the order named along the optical axis from the original holder 113 to the screen 105. The first movable mirror 116 has its reflecting surface inclined by 45° relative to the original holder 113 and to the reflecting surface of the second movable mirror 115 which is perpendicular to the original holder 113.

The original 111 placed upon the original holder 113 is illuminated by a suitable illumination system (not shown) and the light reflected by the original 111 is redirected by the first and second movable mirrors 116 and 115 to the projection lens 114. The light emerging from the projection lens 114 is redirected by the fixed reflecting mirrors 117, 118 and 119 so as to be focused upon the screen 105. In the instant embodiment, the first and second movable reflecting mirrors 116 and 115 are displaced from the original positions indicated by the solid lines in FIG. 5 toward the positions 116A and 115A indicated by the broken lines with a speed ratio of 1 : 2. During this displacement, the original 111 may be scanned and projected upon the screen 105 successively. It should be noted that the length of the optical path between the projection lens 114 and the surface of the original 111 is always maintained equal to that between the projection lens 114 and the screen 105.

As described above, the recording paper transporting mechanism is driven in synchronism with the optical scanning operation of the optical projection system and when a magnification M is desired the speed of the recording paper transportation mechanism is adjusted to 1/M of the speed of the displacement of the first movable reflecting mirror 116. It is therefore seen that in the second embodiment a magnification change may be effected by two methods. First is to displace the positions of the discharge electrodes relative to the optical scanning systems while the second is to vary the speed ratio between the first movable reflecting mirror 116 and the recording paper transportation mechanism. Thus the magnification may be varied in a very wide range. A zoom lens type projection lens may be used as the lens 114 so as to facilitate the magnification change operation and to further widen the magnification range.

When the shaft 107 of the scanning head holders 101 is rotated by a driving means (not shown) in the direction indicated by the arrow a (See FIG. 6), the movable reflecting mirrors 116 and 115 are displaced from their initial positions 115 and 116 for scanning the original 111 while the recording paper 106 is transported in the direction indicated by the arrow b in synchronism with

the scanning operation of the movable mirrors 116 and 115. Therefore the scanned light image of the original 111 is continuously projected upon the screen 105. The light image projected upon the screen 105 in turn is scanned by the optical scanning system 103 of the scanning heads 101a now rotating about the shaft 107. Thus the recording paper 106 is subjected to the discharge produced between the electrode 104 and the paper 106.

What is claimed is:

1. In an electric discharge recording system, the improvement comprising in combination:

- a. a housing having means disposed therein at a copying station for displaying an image of an original to be recorded;
- b. means disposed opposite said displaying means at said copying station for supporting a recording medium on which the image of the original is to be recorded;
- c. at least one scanning head interposable between said displaying means and said recording medium and comprising:
 - i. an optical scanning system on one side of said scanning head opposite said displaying means for optically scanning the image of the original and focusing said image;
 - ii. a photoelectric effect element upon which the image scanned by said optical scanning system is focused and which transduces the intensity of said image into an indicative electric current, and
 - iii. a discharge electrode on the other side of said head opposite said recording medium for producing a discharge between said discharge electrode and the recording medium in accordance with said indicative electric current from said photoelectric effect element;
- d. a rotary holder for supporting said scanning head for rotation through said copying station between said displaying means and said recording medium; and
- e. means in said housing for rotatably supporting said rotary holder with respect to said displaying means and said recording medium such that during rotation of said scanning head through said copying station the optical scanning system of said scanning head will scan the original image simultaneously with the recording of the image by the discharge electrode of said scanning head on said recording medium.

2. The improvement as in claim 1 wherein said discharge electrode is radially displacable on said scanning head whereby the magnification of a copy reproduced on the recording medium may be varied.

3. The improvement as in claim 1 further comprising illumination means incorporated in said scanning head such that the light projected thereby is reflected by the original to be incident upon said optical scanning system.

4. In an electric discharge recording system the improvement comprising in combination:

- a. a housing having a transparent screen therein at a copying station for displaying an image of an original to be recorded;
- b. an original holder for supporting an original above said housing;
- c. an optical scanning projection means for projecting a scanned light image of an original placed upon

said original holder upon said screen, said optical scanning projection means comprising:

- i. a projection lens disposed between said screen and said original holder,
- ii. a first movable reflecting mirror having its reflecting surface inclined at 45° to the plane of said original holder,
- iii. a second movable reflecting mirror having its reflecting surface perpendicular to the plane of said original holder and cooperating with said first movable reflecting mirror to direct the scanned light image to said projection lens,
- iv. a plurality of fixed reflecting mirrors for directing the scanned light image from said projection lens onto said screen at said copying station, said first and second movable reflecting mirrors being movable with respect to each other and said original holder for scanning said original in such manner that the length of the optical path between said projection lens and said original is maintained equal to the length of the optical path between said projection lens and said screen;
- d. means for supporting a recording medium on which the image of the original is to be recorded opposite said screen at said copying station;
- e. a plurality of rotatable scanning heads each rotatable through said copying station during a portion of its rotation and each of said heads comprising:
 1. an optical scanning system disposed in opposed relation with said screen during head rotation through said copying station for optically scanning the light image projected thereupon,
 2. a photoelectric effect element upon which is incident the light image scanned by said optical scanning system and which transduces the intensity of said light image into an indicative electric current, and
 3. a discharge electrode disposed during head rotation through said copying station in spaced-apart relation with the recording medium by a predetermined distance for producing a discharge between said discharge electrode and the recording medium under the control of said photoelectric effect element;
- f. a rotary holder upon which are disposed said plurality of scanning heads in equiangularly spaced-apart relation with each other; and
- g. means in said housing for rotatably supporting said rotary holder with respect to said original image displaying member and said recording medium such that during rotation of said scanning heads through said copying station, the optical scanning systems of said scanning heads will scan the original image simultaneously with the recording of the image by the discharge electrodes of said scanning heads on said recording medium.

5. The improvement as in claim 4 wherein said projection lens in said optical projection system is a zoom lens.

6. The improvement as in claim 4 wherein the speed ratio between the movement of said first movable reflecting mirror and said second movable reflecting mirror is 2 to 1.

7. The improvement as in claim 4 wherein said means for supporting said recording medium transports said recording medium at a speed of 1/M with respect to the

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speed of movement of said first movable reflecting mirror, where M is the desired magnification.

8. The improvement as in claim 4 wherein each of said discharge electrodes is radially displaceable on

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each of said scanning heads whereby the magnification of a copy reproduced on the recording medium may be varied.

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