United States Patent

Yamaji et al.

[15] **3,682,539**

[45] **Aug. 8, 1972**

[54] **LIGHTING APPARATUS FOR ELECTROPHOTOGRAPHIC PHOTOCOPYING MACHINE**

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[73] Assignee: **Canon Kabushiki Kaisha**, Tokyo, Japan

[22] Filed: **June 8, 1970**

[21] Appl. No.: **44,382**

[30] **Foreign Application Priority Data**

June 12, 1969 Japan 44/46594

[52] **U.S. Cl.** **355/3**, 240/1.3, 240/3.1, 355/4, 355/32, 355/37, 355/70, 355/88

[51] **Int. Cl.** **G03g 15/00**

[58] **Field of Search**.....355/3, 4, 32, 37, 70, 88; 240/1.3, 20, 3.1; 96/1.2

[56] **References Cited**

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Assistant Examiner—Monroe H. Hayes
Attorney—Ward, McElhannon, Brooks & Fitzpatrick

[57] **ABSTRACT**

An electrophotographic photocopying machine is provided with a lighting device in which a plurality of different color lamps are carried by a common rotary body so that they may be sequentially and selectively rotated to align with a lighting or exposure position where they are turned on. Each of colored lamps has an optical shielding member supported by the common rotary body, and the colored lamps and shielding members are wholly enveloped by a housing which has an optical opening with which each opening of the shielding members is rotatably aligned in accomplishing an exposure operation.

12 Claims, 4 Drawing Figures

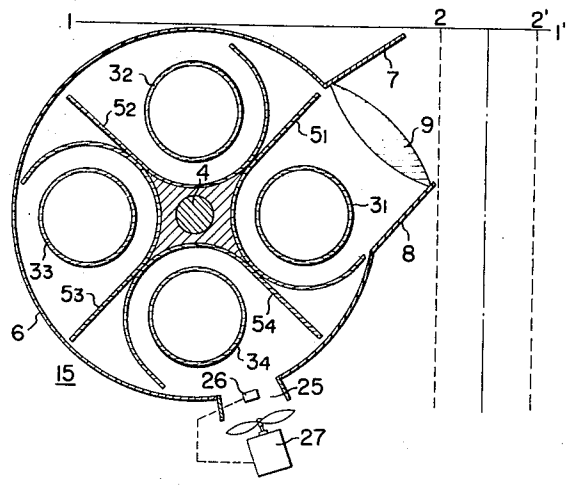


FIG. 1

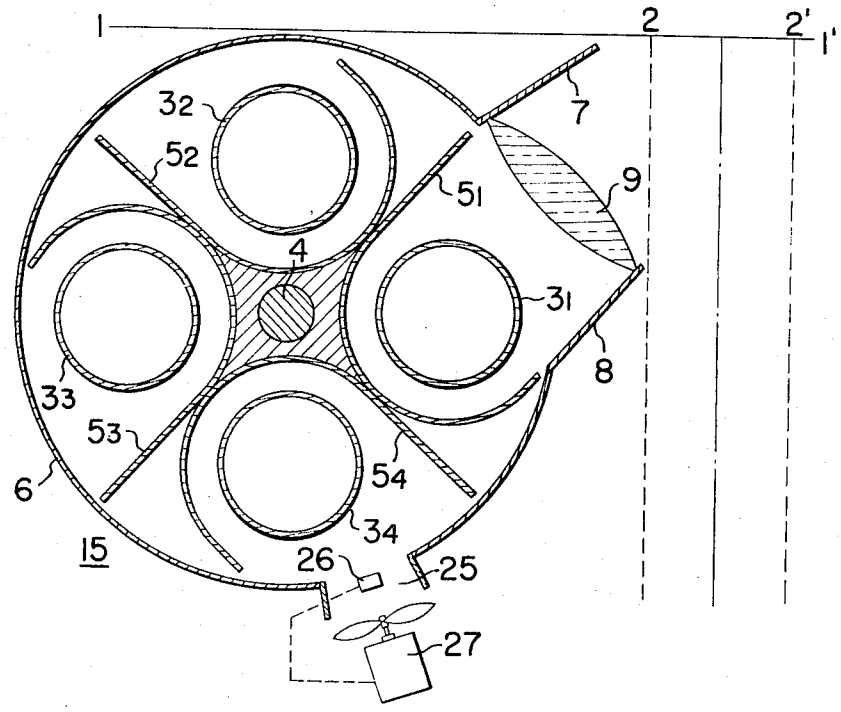

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FIG. 2

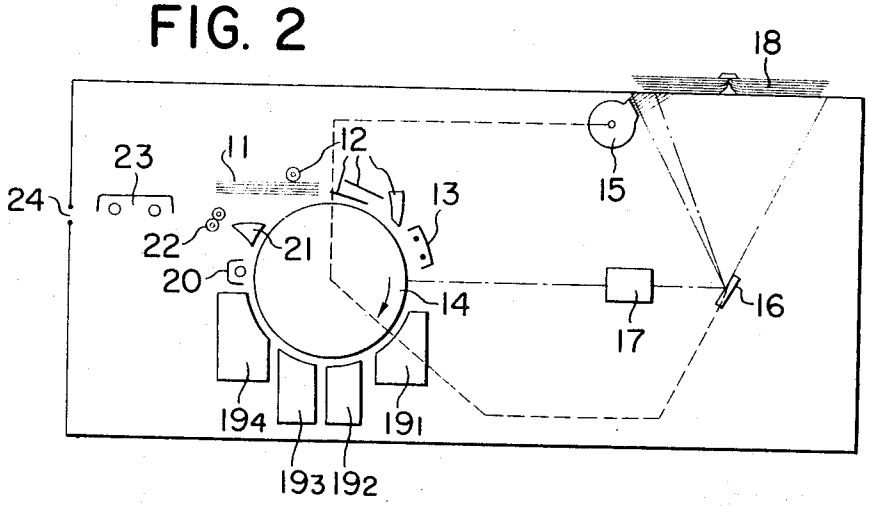

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FIG. 3A

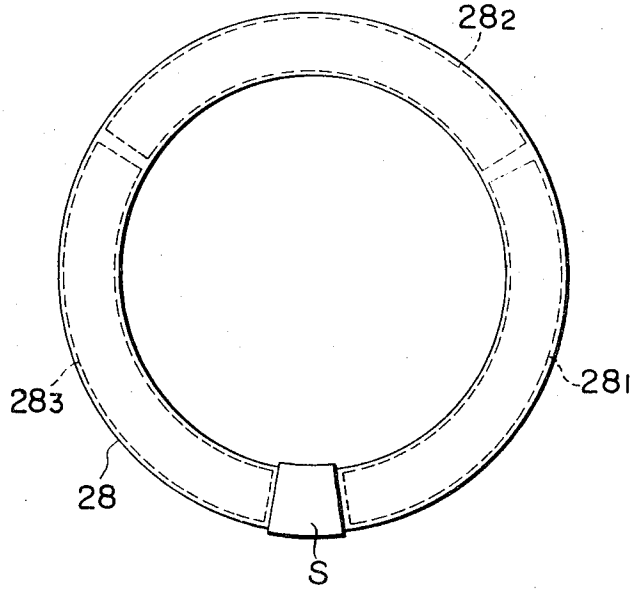
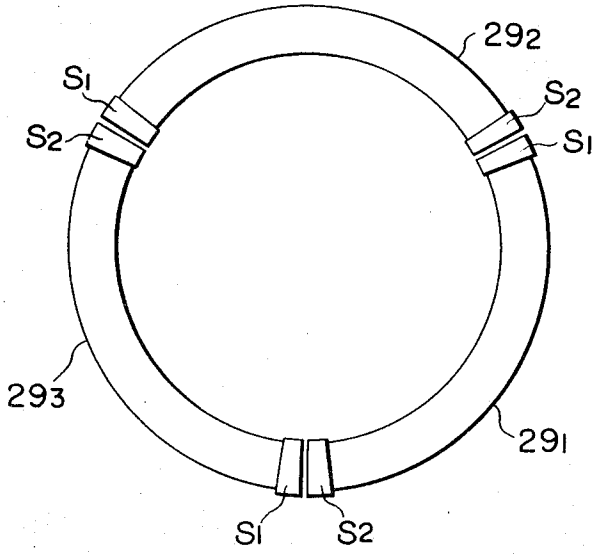


FIG. 3B



LIGHTING APPARATUS FOR ELECTROPHOTOGRAPHIC PHOTOCOPYING MACHINE

The present invention relates to generally an electrophotographic photocopying machine and more particularly a lighting apparatus for photocopying machines.

The electrophotographic photocopying processes are well known in the art. One of the typical processes is an electrophotographic process disclosed in U.S. Pat. No.2221776 granted to Carlson in 1938. That is, a photosensitive member having a photoconductive layer formed upon a conductive support or base is imparted with a uniform electrostatic charge, and thereafter a light image of an original to be reproduced is projected upon the photosensitive member, thereby forming an electrostatic latent image. The latent image is developed by the toner and the developed toner image is fixed by use of heat or a solvent, or transferred to a recording medium such as paper and then fixed. Another process is such that the surface of an insulating layer of a photosensitive member may be imparted with a uniform charge and a light image of an original to be reproduced is projected upon the surface of the insulating layer contemporaneously when the charge having the opposite polarity to that of the first charging or AC corona discharge is applied thereto, thereby forming an electrostatic latent image. If required, the whole surface of the photosensitive member may be irradiated, thereby forming an electrostatic latent image having a high contrast. The latent image is then developed, transferred and fixed. In addition to these processes, there have been known various other types of electrophotographic processes.

Color electrophotographic processes are also known in the art. The fundamental principle of photocopying in color is such that the above-mentioned photocopying processes are repeated so as to add to the image the colored developing agents. That is, an original to be reproduced in color is generally resolved into three colors as in the case of printing in color. The original is first irradiated by the light rays excluding a first color and then an image thus obtained is developed by a developing agent of the first color and fixed. Next in similar manner, the original is exposed by the second and third different color light rays and the images thus obtained are developed by the developing agents of the second and third colors and respectively fixed. Thus, a color copy may be obtained.

Such color photocopying process has mainly employed a low sensitive photoconductor such as zinc oxide so that a higher intensity of light is required for exposure. Therefore, tungsten filament lamps, iodine lamps, etc., are used. But when filters for resolving an original into three colors are used, exposure time is very long ranging from tens of seconds to a few minutes.

Recently, high sensitive photoconductors such as CdS have been employed in the electrophotographic processes and highly efficient fluorescent lamps emitting various color light rays are available for use as light sources for photocopying in color. Light having a desired spectral characteristic may be obtained from these fluorescent lamps without any loss due to the use of filters. The efficiency is high and economical

because the power consumption is less as compared with tungsten filament lamps. Furthermore, heat dissipation is less, service life is long and uniform illumination may be obtained in a relatively simple manner. Thus, these fluorescent lamps are very advantageous for use as light sources for color photocopying. However, it is very inconvenient to replace the fluorescent lamps for each of three exposures in obtaining color copies.

It is therefore one of the objects of the present invention to provide an improved lighting apparatus capable of continuous lighting of different colors for use in electrophotographic photocopying machines.

It is another object of the present invention to provide an improved lighting apparatus for electrophotographic copying machines in which a plurality of different color light sources are carried by a rotary body so that they may be sequentially and selectively rotated to a lighting or exposure position.

It is a further object of the present invention to provide an improved lighting apparatus for use in electrophotographic photocopying machines in which the variation in intensity of light may be prevented by maintaining the temperatures of a plurality of different color light sources constant.

It is a further object of the present invention to provide an improved lighting apparatus for use in electrophotographic photocopying machines which is compact in size because a plurality of different color light sources are enclosed in one housing.

In brief, in accordance with the present invention, a plurality of different color fluorescent lamps are carried by a common rotary body so that they may be sequentially and selectively rotated to a lighting or exposure position where they are turned on. If necessary, all of the fluorescent lamps may be turned on in operation.

According to one aspect of the present invention, each of the fluorescent lamps are optically shielded from each other and enclosed in a housing or lamp house having an optical opening for projection of light and another opening through which is introduced cooling air by a fan. Thus, the lighting operation becomes simple, the light rays other than a desired color light may be securely shielded, and temperature caused by the fluorescent lamps may be prevented so that variation in intensity of light due to temperature rise may be prevented. Thus, an ideal lighting condition may be obtained. For example, the maximum efficiency of a fluorescent lamp may be achieved when the temperature of the wall of the lamp is at 40° C. A plurality of fluorescent lamps may be rotated to the lighting or exposure position in a simple manner so that a high speed photocopying machine for color copies may be manufactured at lower cost.

According to another aspect of the present invention, any desired color of an original in color may be selectively stressed or inhibited so that so-called panchromatic photocopying becomes possible. That is, the original may be reproduced in monocolor having a suitable density difference or halftone.

Attempts have been made to provide panchromatic photosensitive members for electrophotographic process, but they may be provided only when specific photoconductors are used, resulting in insufficient

spectral sensitivity. However, according to the present invention, irrespective of the spectral sensitivity of photosensitive members (plates or paper) and color tones of the originals, copies having a desired tone may be obtained.

Furthermore, according to another aspect of the present invention, the spectral sensitivity of a wide variety of photosensitive members may be utilized to the full extent. That is, the spectral sensitivity of a photosensitive member is dependent upon the photoconductors used so that it has been considered that it is disadvantageous to use different kinds of photosensitive members which are processed by one common photocopying machine. The present invention has solved this problem. That is, the light rays having a color best suited for a specific spectral sensitivity of a photosensitive member may be used so that the sensitivity of this photosensitive member may be utilized to the highest degree. In other words, specific features of various photosensitive members may be utilized to the full extent even when they are processed by the same photocopying machine embodying the present invention.

The present invention will become more apparent from the following description of the preferred embodiments thereof taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a sectional view of a lighting apparatus in accordance with the present invention;

FIG. 2 is a schematic longitudinal sectional view of an electrographic photocopying machine embodying the present invention in one form; and

FIGS. 3A and 3B are top views of some variations of light sources used in the present invention.

FIG. 1 depicts one embodiment of a lighting apparatus in accordance with the present invention, in which 1—1′ designates a surface of an original to be reproduced and 2—2′, a slit through which the original is illuminated or exposed. Red, green, blue and white light sources such as fluorescent lamps 3_1–3_4 are equiangularly disposed for rotation about a rotary shaft 4 and in parallel with each other. The fluorescent lamps 3_1–3_4 have reflectors 5_1–5_4 respectively which are also rotatable about the rotary shaft 4 in unison with the fluorescent lamps 3_1–3_4. The light source group is enclosed in a housing 6 having an opening comprising two auxiliary reflectors 7 and 8 and a cylincrical lens 9 so as to direct to the slit 2—2′ the beam of light emanated from one of the light sources.

When the scanning of the original by the beam of light from the light source 3_1 is accomplished, a lighting apparatus 15 is returned to its initial or home position. During this time interval, the light source 3_1 is turned off while the light source group is rotated so that the next light source 3_2 comes to the lighting position or optical opening and is turned on thereby directing the beam of light from the light source 3_2 toward the slit 2—2′. In the similar manner, the light sources 3_3 and 3_4 are rotated sequentially to the lighting position and turned on, thereby directing the beams of light therefrom toward the slit 2—2′. In consequence, all of the four different color beams may be projected upon the surface of the original.

FIG. 2 depicts a color photocopying machine embodying the lighting apparatus 15 of the present invention. A sheet-like photosensitive member 11 to be referred to as "copying paper" fed to a copy paper feeding device 12 is electrostatically attracted upon a drum 14 and simultaneously imparted with the charge from a charger 13. The lighting apparatus 15 is adapted to displace itself in parallel with an surface of the original 18 in synchronism with the rotation of drum 14 so that the beam of light from the light source 3_1 is directed toward the copying paper 11 through a rotary mirror 16 and a projection lens 17, thereby projecting a light image of the original 18 and forming an electrostatic latent image upon the copying paper 11. Thereafter, the electrostatic latent image is developed by a developing device 19_1, fixed by a fixing device 20 and charged while the drum is further rotated. In this case, the lighting apparatus 15 is returned to the initial or home position and the light source group 3 is rotated so as to locate the next light source 3_2 in the lighting position.

The copying paper 11 is charged and exposed again in the similar manner as described above, but by a different color light beam from the light source 3_2. This time, the electrostatic latent image formed upon the copying paper 11 is developed by a developing device 19_2. In a similar manner, the copying paper 11 is charged, exposed by the light sources 3_3 and 3_4 and developed by developing devices 19_3 and 19_4 respectively. Finally the copying paper 11 is separated by a separating pawl 21 from the drum 14 and delivered to a fixing device 23 through a pair of feed rollers 22. From the device 23, the copying paper 11 is discharged through an outlet 24.

One method of providing a color print by employing the lighting apparatus 15 of the present invention will be described hereinafter. The light source 3_1 is a red lamp having a phosphor coating which emits light substantially in the red region of the spectrum, for example, europium-activated yttrium oxide (typically formulated as Y_2O_3:Eu), and the electrostatic latent image exposed by this light source 3_1 is developed by a cyan toner. The light source 3_2 is a green lamp having a phosphor coating which emits light substantially in the green region of the spectrum, for example manganese-activated zinc silicate (Zn_2SiO_4; Mn) and a magenta toner is used in the developing device 19_2. The light source 3_3 is a blue lamp having a phosphor coating which emits light substantially in the blue region of the spectrum, for example, antimony-activated calcium halo-phosphate [$3Ca_3(PO_4)_2 \cdot Ca(F,Cl)_2$: Sb], and a yellow toner is used in the developing device 19_3. The light source 3_4 is a white lamp having a phosphor coating which emits light almost all over the visible spectral range (the impression of white light when viewed), for example, manganese and antimony-activated calcium halo-phosphate [$3CA_3(PO_4) \cdot Ca$ (F,Cl)$_2$:Mn,5b] and a black toner is used in the developing device 19_4. Red phosphors such as manganese and lead-activated calcium silicate ($CaSiO_3$:MnPb), manganese-activated magnesium arsenate ($6MgO \cdot As_2O_5$:Mn) etc., may be used as phosphor coating of the red lamp 3_1. When the phosphor coating of the blue lamp 3_3 is calcium tungstate ($CaWo_4$) or lead-activated barium silicate ($BaSiO_5$:Pb), the spectral sensitivity may be extended to near ultraviolet and violet-blue wavelengths.

In monochromatic photocopying, a photosensitized member may be used which has a photoconductive layer mainly consisting of CdS having the maximum spectral sensitivity in the red light region and the red lamp 3_1 having the phosphor coating mainly consisting of europium-activated yttrium oxide may be used for exposure while the black toner may be used for developing in the device 19_4. In this case, a black-and-white copy may be obtained at high sensitivity with the red areas in the original not reproduced. When the blue lamp 3_3 having the phosphor coating mainly consisting of antimony-activated calcium halo-phosphate is used for exposure while the black toner is used in 19_4, a panchromatic black-and-white copy may be obtained. The above arrangements are particularly advantageous in that either a pattern of undesired color is not reproduced or a pattern of desired color is emphasized in a color photocopying.

The housing **6** is not limited to the cylindrical one shown in FIG. **1** and in the lighting apparatus **15** of the type in which all of the lamps are turned on, any suitable housing may be used which will not direct light rays toward the lighting position except from for example the lamp 3_1. The housing **6** also serves to shield the light rays from the fixing devices **20** and **23** and may be provided with an opening **25** through which is injected the cooling air by a blower **27** and in which is disposed a thermostat **26**, thereby controlling the temperature of the lamps 3_1–3_4. This arrangement is very advantageous in that the intensity of light may be maintained constant so that the color balance may be well maintained.

Depending upon whether the original to be reproduced is moved or stationarily held in position during exposure, the lighting apparatus of the present invention is held in stationary position or moved. If required a pair of lighting apparatus of the present invention may be disposed in opposed relation with each other so as to direct the light beams to the slit from the both sides thereof. When a pair of lamps each emitting different color light rays are opposed each other in this arrangement, the two different spectral characteristics may be superposed one upon the other so that the tone or quality of the copy may be more precisely adjusted.

As shown in FIG. **3A**, a fluorescent lamp **28** in the form of an annular glass tube having a plurality of sections 28_1–28_3 coated with different kinds of phosphors may be employed. Alternatively, as shown in FIG. **3B**, independent and different kinds of fluorescent lamps 29_1–**29** may be arranged in the form of a circle.

From the foregoing, it will be readily seen that the lighting apparatus of the present invention serves to miniaturize the electrophotographic photocopying apparatus and to carry out photocopying operation continuously at high speed. Also reproduction of any desired color may be stressed or inhibited so that the original may be reproduced in monocolor with a suitable density difference. That is, irrespective of the color tones of the originals and the spectral sensitivity of the photosensitive members, satisfactory copies may be obtained. Furthermore, in the electrophotographic photocopying machine embodying the present invention, may be projected the light rays having a color which gives the maximum sensitivity to a photosensitive member selected from a various types of photosensitive members, so that every feature of the photosensitive members used in electrophotographic photocopying machines may be fully utilized.

What is claimed is;

1. In an electrophotographic photocopying machine comprising electrostatic latent image forming means comprising means for imparting an electrostatic charge to the surface of a photosensitive member and means for projecting a light image of an original to be reproduced upon said surface of said photosensitive member, means for developing said latent electrostatic image, an original holder upon which the original is placed in position and means for lighting the surface of the original,

an improved lighting means comprising a plurality of light sources each emitting light within a different luminous spectrum,

rotary means to which said plurality of light sources are fixed,

a housing enclosing said plurality of light sources upon said rotary means and having an optical opening positioned to direct light from one of said light sources having a desired wavelength range to a predetermined area and

power means for driving said rotary means.

2. A lighting device as defined in claim **1** wherein said rotary means is a rotary shaft.

3. A lighting device of claim **1** wherein each of said light sources is selected to emit a different light within the spectral range of red, green, blue or a combination thereof.

4. A lighting device as defined in claim **1** wherein said optical opening of said housing is provided with a condenser lens and reflectors.

5. A lighting device as defined in claim **1** wherein said plurality of light sources are normally, illuminated and light shield members are interposed between the adjacent light sources so that only the light from the light source opposed to said optical opening is directed toward said predetermined area.

6. A lighting device as defined in claim **5** wherein said light shield members are reflectors.

7. A lighting device as defined in claim **1** wherein said light sources comprise a plurality of sections in a circular glass tube, each of said sections having a different phosphors coating.

8. A lighting device as defined in claim **1** wherein said light sources comprise a plurality of separate arcuate fluorescent lamps arranged to form a circle.

9. In an electrophotographic photocopying machine comprising electrostatic latent image forming means comprising

means for imparting an electrostatic charge to the surface of a photosensitive member and means for projecting a light image of an original to be reproduced upon said surface of said photosensitive member, means for developing said latent electrostatic image, an original holder upon which the original is placed in position and means for lighting the surface of the original,

an improved lighting means comprising a plurality of light sources each emitting light within a different luminous spectrum,

rotary means to which said plurality of light sources are fixed,

a housing enclosing said plurality of light sources upon said rotary means and having an optical opening positioned to direct from one of said light sources light having a desired wavelength range to a predetermined area, said housing being provided with means for cooling said lighting means, and

power means for driving said rotary means.

10. A lighting device as defined in claim **9**, wherein said cooling means comprises at least one fan.

11. Alighting device as defined in claim **9**, wherein each light of different luminous spectrum is selected from the group consisting of red, green, blue and white lights in color and other lights having spectral photographing effect substantially equivalent thereto.

12. A lighting device of claim **9** wherein each of said light sources is selected to emit a different light within the spectral range of red, green, blue or a combination thereof.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,682,539 Dated August 8, 1972

Inventor(s) KEIZO YAMAJI AND TAKAO TORIU

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Page 1 (Item 73) after "Japan" add--and DAI NIPPON TORYO KABUSHIKI KAISHA, Osaka, Japan-- .

Signed and sealed this 1st day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334

UNITED STATES PATENT OFFICE

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