United States Patent

Adelman

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[54] **ELECTROPHOTOGRAPHIC SYSTEM EMPLOYING RECIPROCATING ELECTROPHOTOGRAPHIC PLATE**

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[52] **U.S. Cl.** **355/3**

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

[58] **Field of Search** 355/3

[56] **References Cited**

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[57] **ABSTRACT**

A revolving turret translates an electrophotographic plate successively to charging, imaging, development, image transfer and cleaning stations. The plate is reciprocated into operative relation with developing apparatus, a copy sheet, and cleaning apparatus at the development, image transfer and cleaning stations, respectively. The turret further mounts a corona charging unit for charging the copy sheet while the plate is being developed and a fusing unit for fusing the image on the copy sheet as the plate is being cleaned.

12 Claims, 6 Drawing Figures

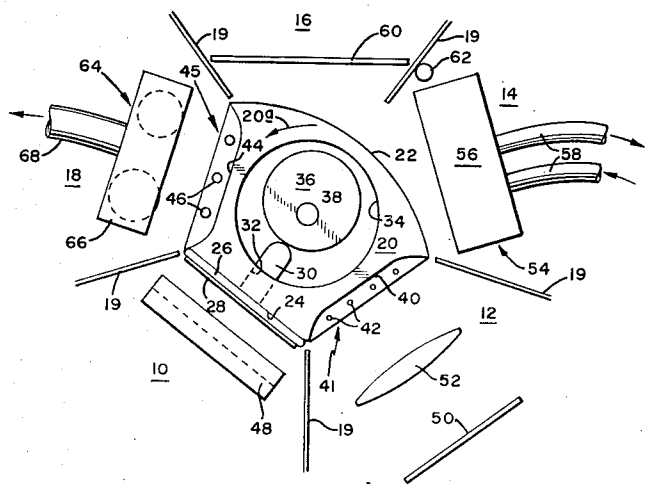
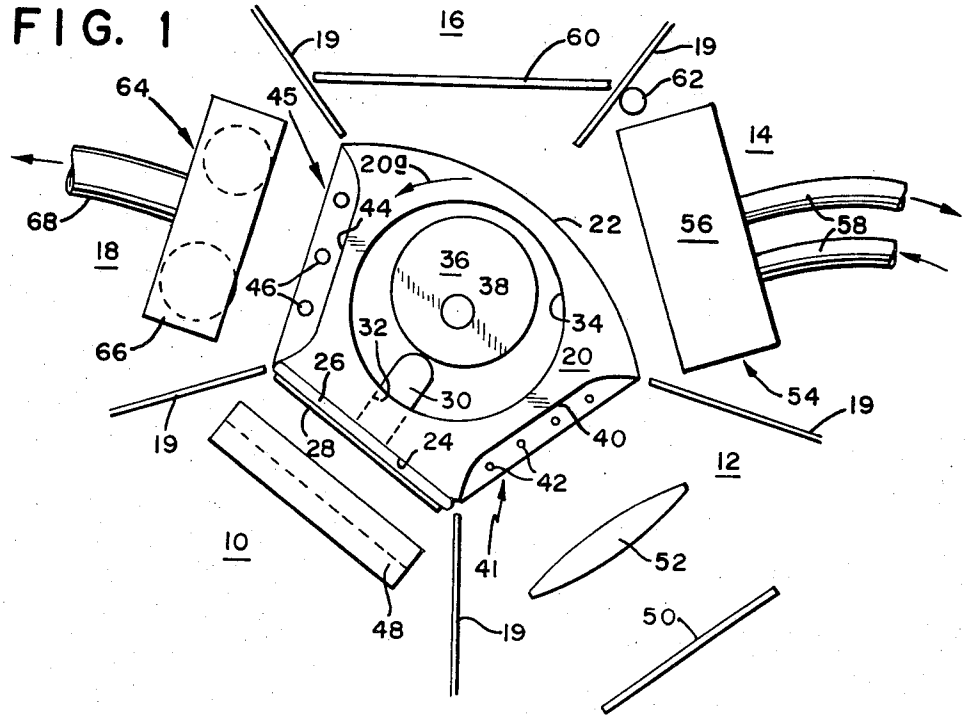


FIG. 1



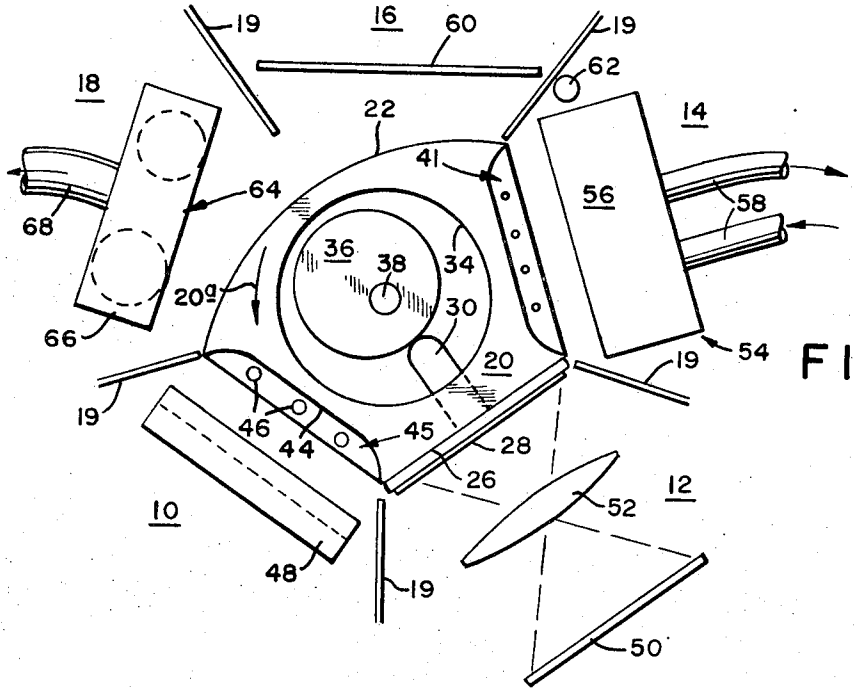
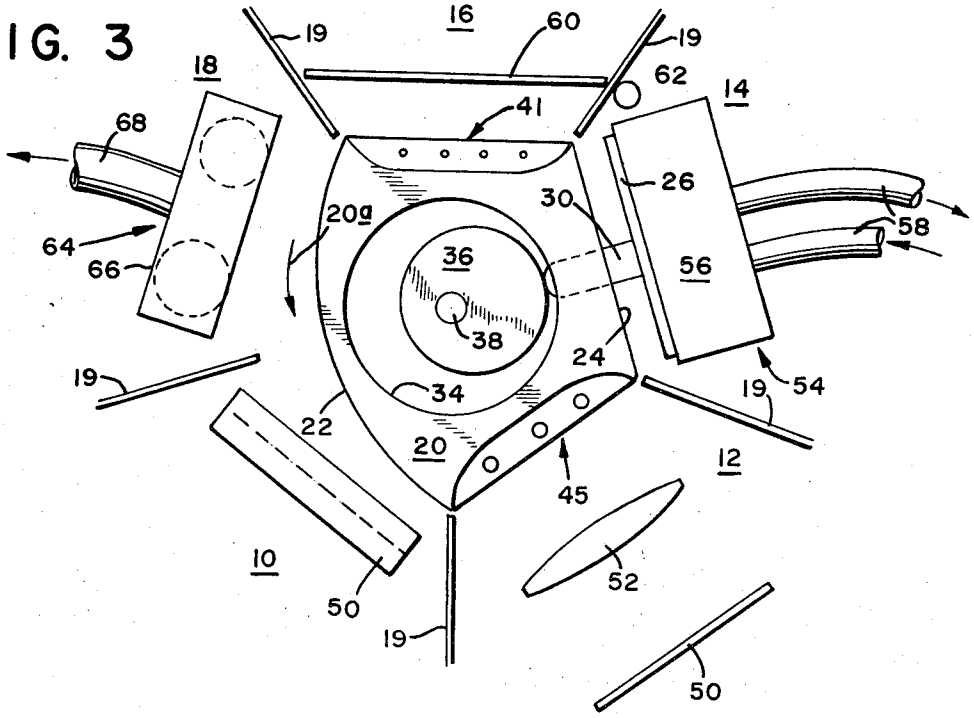


FIG. 2

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FIG. 3



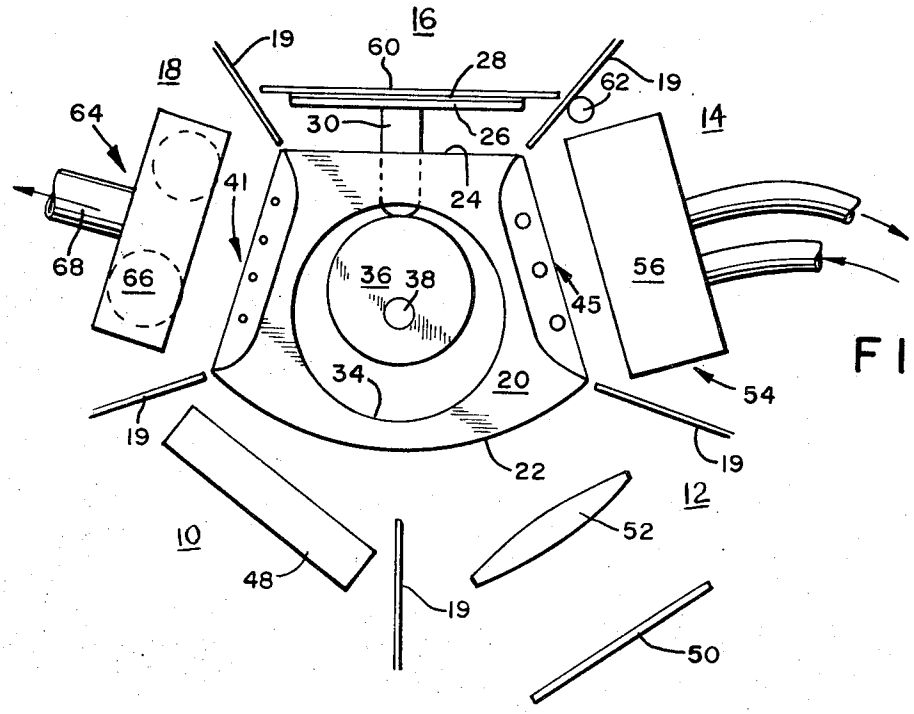


FIG. 4

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FIG. 5

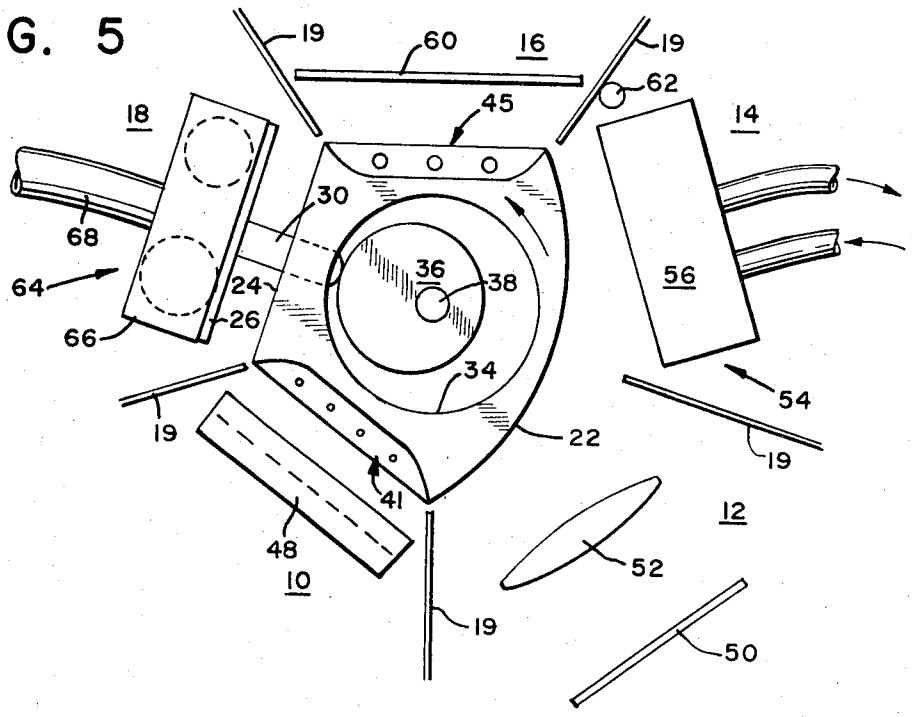
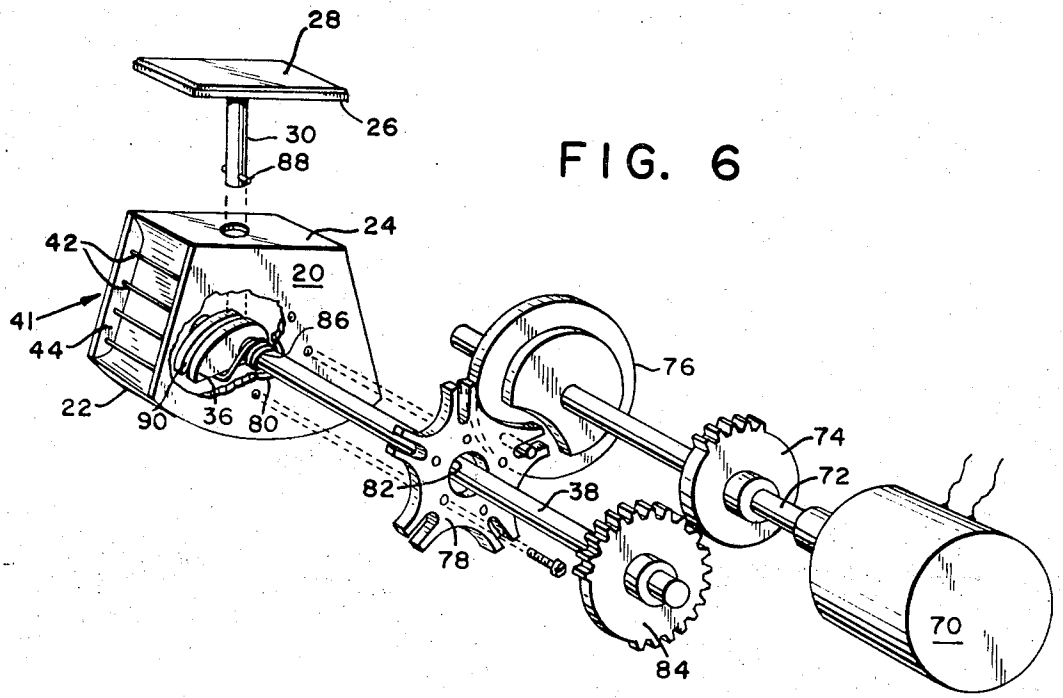


FIG. 6



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ELECTROPHOTOGRAPHIC SYSTEM EMPLOYING RECIPROCATING ELECTROPHOTOGRAPHIC PLATE

BACKGROUND OF THE INVENTION

The electrophotographic apparatus of the present invention constitutes a significant departure from automatic electrostatic photocopier designs heretofore contemplated or in current use. Invariably, at least the ultimate reproduced image receptive member, typically a paper sheet, is translated through the copier along a predetermined feedpath. This is expensive to implement. Moreover, there is always the possibility that the copy sheet will become jammed at some point along its feedpath, which typically results in its destruction, either incident to its being jammed or in attempting to manually remove it. Thus the copy sheets must be of a low unit cost. Also, it is not advisable to feed copy sheets into a photocopier which has pre-recorded valuable information thereon, such as may be the case in micro-imaging photocopy systems, for fear of possible loss. The typically devious character of the feedpath limits the types of usable image receptive members to those having the physical properties to stand the arduous translation through the photocopier.

It is accordingly a general object of the present invention to provide electrophotographic apparatus wherein the reproduced image receptive member remains positioned at an image transfer station throughout the entire electrophotographic process. The operative components required for processing the copy member are automatically brought to the image transfer station in the proper sequence during each copy cycle in an efficient and practical manner by virtue of the instant invention.

Other objects of the invention will in part be obvious and in part appear hereinafter.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided an electrophotographic system including charging, imaging, development, image transfer and cleaning stations arrayed generally in a circle. A revolving turret mounts an electrophotographic plate for successive presentation at the various processing stations during each copy cycle. The mounting of the plate is also reciprocating in character such that the plate may be reciprocated radially into operative relation with processing apparatus located at selected processing stations.

More specifically, the electrophotographic plate is initially positioned by the turret at the charging station and, upon initiation of a copy cycle, is subjected to an electrostatic charge calculated to impart a uniform surface charge on the photoconductive coating of the plate. The turret then indexes the plate to the imaging station where it is subjected to a projection of the image to be copied pursuant to creating a corresponding electrostatic latent image on the photoconductive coating surface.

Next, the turret indexes the plate to the development station. Actuating means included with the turret reciprocates the plate generally radially outward into operative relation with developing apparatus which undertakes to develop the electrostatic latent image by subjecting it to electroscopic toner particles. The actuator means returns the plate to its normal position and the turret indexes it to the image transfer station where an image receptive member had been previously positioned. Again the actuator means reciprocates the plate radially outward to move the developed image on the photoconductive coating surface into contact printing engagement with a surface of the copy member such as to transfer thereto the toner particles in image formation.

The plate is then returned by the actuator means to its normal position and the turret indexes it to the cleaning station. Again the plate is reciprocated radially outward into operative relation with cleaning apparatus for removing residual toner particles from the plate surface. The plate is returned to its normal position and indexed to the charging station, thereby completing a copy cycle.

It is noted that the image receptive or copy member is not translated into image transfer relation with the electrophotographic plate as is normally done. Rather, the copy member remains at all times during a copy cycle positioned at the image transfer station and the plate, once appropriately processed, is translated to it. Actually, the electrophotographic plate breaks through the boundary of the copier as it moves into image transferring engagement with the copy member. Thus, costly sheet feedpaths and synchronizing means are avoided, and the copy member is at all times accessible to the operator.

In addition to the actual image transfer, the copy member is subjected to other processes and, in keeping with the philosophy of my invention, the requisite processing apparatus is brought to the copy member while it resides at the image transfer station. Prior to image transfer the receptive surface of the copy member must be appropriately electrostatically charged in order that the electroscopic toner particles in image formation are attracted thereto. After transfer onto the copy member surface the image must be fixed so as to be made permanent.

To this end, the turret is adapted to mount an electrostatic charging unit at the side of the electrophotographic plate in the direction of indexation of the turret. In addition, the turret is adapted to mount a fusing unit on the other side of the plate from the charging unit. Thus, when the plate is at the development station, the charging unit is automatically positioned at the image transfer station to impose the requisite electrostatic charge on the copy member surface. Furthermore, while residual toner is being removed from the plate surface at the cleaning station, the fusing unit is then automatically positioned at the image transfer station to fuse the toner particles in image formation to the copy member surface, thus rendering the reproduced image permanent.

Preferably, the apparatus of the present invention also includes a lamp positioned to flood the electrophotographic plate and thereby erase the electrostatic latent image as well as any residual charges thereon as it is indexed from the development station to the image transfer station.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIGS. 1 through 5 are schematic views of electrophotographic apparatus constructed according to my invention to illustrate the five indexing positions in an operating cycle of an electrophotographic plate as mounted by a revolving turret; and

FIG. 6 is a perspective view of a suitable mechanism for indexing the turret and selectively reciprocating the electrophotographic plate of FIGS. 1 through 5.

Like reference numerals refer to corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

The electrophotographic apparatus, as schematically illustrated in FIGS. 1 through 5, includes a charging station 10, an imaging station 12, a development station 14, an image transfer station 16, and a cleaning station 18 arrayed in a circle about a revolving turret, generally indicated at 20. Partitions or baffles 19 isolate the various stations from each other. Turret 20 may be five sided to correspond with the number of stations it confronts, however, since only three sides or faces of the turret are utilized in the practice of my invention, the other two sides or faces may be combined in a single curved or arcuate face, as indicated at 22. The revolving turret is suitably mounted for rotation in the counterclockwise direction, as indicated by the arrow 20a.

Face 24 of turret 20 mounts a support 26 which carries an electrophotographic plate 28. This electrophotographic plate may be of conventional construction, consisting of a photoconductive material coated to an electrically conductive substrate. The photoconductive coating may consist of a variety of materials known to have electrophotographic capabilities, such as selenium, zinc oxide in a resin binder, etc.

Support 26 for the electrophotographic plate is suitably joined to a plunger 30 which is slidingly received in a radial bore 32 in turret face 24; the bore opening into a central cavity 34 in turret 20. Thus, the electrophotographic plate 28 is mounted by the turret 20 for movement in essentially an annular path to the various electrophotographic processing stations and also, by virtue of the mounting of the plate support 26 to the turret, is adapted for reciprocating movement from a normal position contiguous with turret face 24 to a radially extended position. To actuate the reciprocating movement of plate support 26, the inner end of support plunger 30 serves as a cam follower, bearing against a cam 36 eccentrically mounted within central cavity 34 on a shaft 38. It is thus seen that by rotation of cam 36 by shaft 38, the electrophotographic plate 28 is reciprocated radially outwardly relative to turret face 24. The significance of this important feature of my invention will become apparent from the description to follow.

The face of turret 20 to the counterclockwise side of face 24 is milled out to form a cavity 40 which is spanned by a plurality of corona wires 42. Thus, this face of turret 20 accommodates a corotron charging unit, generally indicated at 41, whose function will be described subsequently.

The face of turret 20 to the clockwise side of face 24 mounting the electrophotographic plate 28 is also milled out to provide a cavity 44 across which are strung a plurality of heating elements 46. Thus this face of turret 20 accommodates a fusing unit, generally indicated at 45, whose function will likewise be described later. Suitable means such as slip rings (not shown) are utilized to couple electrical energy from appropriate power supplies to charging unit 41 and fusing unit 45.

Referring now specifically to FIG. 1, the illustrated angular orientation of turret 20 is such that the electrophotographic plate 28 is positioned at charging station 10, which is the requisite initial turret orientation for the start of each operating or copy cycle. While the electrophotographic plate 28 is positioned at the charging station 10 it is disposed in confronting relation to a corotron charging unit 48, whose function, upon the initiation of a copy cycle, is to impose a uniform electrostatic charge on the exposed surface of the photoconductive coating of the plate. As is well known, the polarity of this surface charge depends upon the type of photoconductor material used in the electrophotographic plate. Thus, if the photoconductor is selenium, the surface charge should be of a positive polarity. On the other hand, if zinc oxide is employed, the surface charge should be negative.

After an appropriate charging interval, turret 20 is indexed in the counterclockwise direction to momentarily position the electrophotographic plate 28 at the imaging station 12, as is illustrated in FIG. 2. An image to be copied, as borne by an original document 50, is projected onto the charged photoconductive coating surface of the electrophotographic plate 28 by suitable projection optics 52. As is well understood in the electrophotographic art, the projection of an optical image, consisting of a pattern of light and shadow, onto the charged surface of an electrophotographic plate creates a corresponding electrostatic latent image.

After an appropriate exposure interval, turret 20 indexes the electrophotographic plate 28 to the development station 14, as is illustrated in FIG. 3. There are numerous techniques and apparatus known in the art for developing electrostatic latent images, such as, for example, cascade development, liquid toner development, magnetic brush development, etc. While my invention is not limited to any particular development technique, I propose, in the illustrated embodiment of my invention, to employ aerosol development apparatus, generally indicated at 54. As is well known in the art, the aerosol development technique utilizes apparatus consisting basically of a chamber 56 into which electroscopic toner particles in fluid suspension are introduced and exhausted therefrom via conduit 58. To develop the electrostatic latent image, it must be subjected to the developer aerosol within chamber 56. In accordance with my invention, once the electrophotographic plate 28 is positioned at development station 14, cam 36 is rotated by shaft 34 to force the plate radially outward into sealing relation with the open front of chamber 56. The developer aerosol is then introduced into the chamber and the electroscopic toner particles are attracted to the electrostatic latent image carried by the electrophotographic plate, thereby visibly developing it. The developer is exhausted from chamber 56 and cam 36 retracts the electrophoto-

graphic plate back to its normal position adjacent turret face 24.

Still referring to FIG. 3, it will be noted that while the electrophotographic plate 28 is being developed at development station 14, the corotron charging unit 41 is positioned at image transfer station 16 where an image receptive member or copy sheet 60 resides. As is well understood in the art, in the indirect imaging process it is necessary to impose an electrostatic charge on the ultimate image receptive member such that it can attract the toner particles in image formation from the electrophotographic plate. To this end, and in accordance with an important feature of my invention, the corotron charging unit 41 carried by the turret is positioned at the image transfer station 16 to impose the requisite surface charge on the copy sheet 60 while the electrophotographic plate 28 is being developed at the development station 14. The polarity of this charge is the same as the polarity of the electrostatic charge imposed on the electrophotographic plate 28 by the charging apparatus 50 at charging station 10.

As seen in FIG. 4, the turret now indexes to position the electrophotographic plate at the image transfer station 16. Again cam 36 is rotated by shaft 38 to reciprocate the electrophotographic plate radially upwardly into contact printing, image transferring relation with copy sheet 60. It will be appreciated that the copy sheet is supported on a perimetric frame and backed by a suitable backing member, now shown. In order to facilitate the transfer of the toner particles in image formation from the electrophotographic plate 28 to the copy sheet 60, it may be desirable to provide a flood lamp 62 positioned in close proximity on either side of the partition 19 separating development station 14 and image transfer station 16. After the electrophotographic plate 28 has been developed at development station 14, lamp 62 is turned on to flood the plate with light as it is indexed to the image transfer station. This has the effect of erasing or dissipating the electrostatic latent image to which the toner particles were originally attracted. Once the plate has arrived at the image transfer station and is reciprocated upwardly into image transfer relation with copy member 60 by cam 36, it has no surface charges to oppose the image attracting forces of the charge on the copy sheet. If the electrostatic latent image is erased subsequent to development and prior to image transfer, it is preferable that the image transfer station 16 be located in the upright position in order that the forces of gravity do not disturb the image formation of the toner particles on the electrophotographic plate as it is being reciprocated into image transfer relation with the copy sheet 60.

Once the image has been transferred to the copy sheet, the electrophotographic plate 28 is retracted to its normal position and the turret indexes it to cleaning station 18, as seen in FIG. 5. Once again, shaft 38 rotates cam 36 to reciprocate the electrophotographic plate radially outwardly into operative relation with cleaning apparatus, generally indicated at 64. The cleaning apparatus 64 may take a variety of forms such as one or more rotating brushes operating in a box-like enclosure 66 which is coupled to a vacuum source through a conduit 68. The electrophotographic plate is reciprocated into sealing relation with the opened front of the enclosure 66 and the brushes remove any residual toner from the surface thereof.

It will be noted that while the electrophotographic plate 28 is being cleaned, the fusing unit 45 carried by the turret 20 is located at the transfer station 16 and thus is in position to fuse the transferred image to the surface of copy sheet 60. After a sufficient interval to accommodate adequate cleaning of the electrophotographic plate 28 at the cleaning station 18 and fusing of the transferred image to the copy sheet surface at image transfer station 16, the electrophotographic plate is retracted to its normal position and the turret indexes to position it at the charging station 10, thereby concluding an operating or copy cycle and also positioning the plate for the start of the next copy cycle.

It will be appreciated that there are numerous mechanisms capable of producing the requisite indexing movement of turret 20 and reciprocating movement of electrophotographic plate 28. One such mechanism, for example, is shown in FIG. 6. A motor 70 rotates its output shaft 72 through a complete revolution each time it is pulsed from a suitably timed sequence pulse source (not shown). Motor output shaft 72 drives a mutilated gear 74 and the drive member 76 of a conventional five point or position geneva mechanism. The driven member 78 of this geneva mechanism is secured to turret 20. Thus, each time motor 70 is pulsed to rotate its shaft through a complete revolution, turret 20 is indexed to move the electrophotographic plate 28 from one processing station to the next.

Shaft 38 for cam 36 is introduced into the central cavity 34 of turret 20 through an opening 80 in the turret and a central aperture 82 in the geneva driven member 78. The other end of shaft 38 mounts a mutilated gear 84 positioned for selective meshing engagement with mutilated gear 74.

A torsion spring 86 fastened between cam 36 and turret 20 serves to establish a normal angular orientation between shaft 38 and turret 20, but yields upon rotation of the cam shaft independently of the turret to radially reciprocate the electrophotographic plate.

The plunger 30 depending from plate support 26 carries a laterally extending key 88 which is received in a T-slot 90 formed in the peripheral surface of cam 36. Consequently, rotation of cam 36 in one direction pushes the plate support 26 outwardly to its extended position, and upon cam rotation in the opposite direction, the plate support is retracted back to its normal position.

The normal angular orientation of mutilated gear 84 relative to the turret 20 is such that when the latter positions the electrophotographic plate 28 to either the charging station 10 or the imaging station 12, its blank portion is in contiguous relation to mutilated gear 74. Thus, when motor 70 is pulsed to index the electrophotographic plate to the charging station and to the imaging station, gear 74 does not drivingly engage gear 84, and thus the plate is not reciprocated. However, each time the electrophotographic plate is indexed to the development station, the image transfer station and the cleaning station, gear 84 is oriented such that its teeth are in intercepting relation with the teeth on gear 74 as the latter executes a complete revolution. Gear 84 is thus rotated through an increment of rotation, de-

pending upon the number of teeth on the mutilated drive gear **74**, thereby rotating shaft **38** and cam **36**. The electrophotographic plate is reciprocated radially outwardly. As the teeth on gear **74** pass out of engagement with the teeth on gear **84**, shaft **38** is released and torsion spring **86** returns it to its normal angular orientation relative to turret **20**. Cam **36** is thus rotated in the opposite direction to retract the electrophotographic plate **28** back to its normal position.

It will be appreciated that the effective cam surface of cam **36** may be formed having a sector of constant maximum radius so as to provide a predetermined degree of dwell time during which the electrophotographic plate pauses in its extended position to allow sufficient time for image development, image transfer and plate cleaning.

In the foregoing description it is seen that the image receptive member or copy sheet remains, at all times during an operating cycle, at the image transfer station, fully accessible to the operator. Thus, the copy sheet is never endangered by possible malfunctions of the apparatus. The various processing steps to which the copy sheet is subjected are performed at the image transfer station, and thus the apparatus involved in these processing steps are brought to the copy sheets in an efficient and economical manner. Since the possibility of destruction or damage to the copy sheet is removed by virtue of my invention, it will be appreciated that the disclosed apparatus has particular application to microimaging, wherein the image receptive member is in the form of a strip or sheet on which is reproduced a series of reduced images derived from a succession of original documents. In an application such as this, it is seen that the absolute preservation of the copy sheet is of critical importance since it may bear previously reproduced images which, in some instances, may be irreplaceably if the copy sheet were damaged or destroyed.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. An electrophotographic system comprising, in combination:

A. an electrophotographic plate;

B. a charging station including a charging unit for imparting an electrostatic surface charge to said plate;

C. an imaging station including means for selectively discharging the charged plate surface to create an electrostatic latent image corresponding to an image to be copied;

D. a development station including developing apparatus for visibly developing with toner said electrostatic latent image on the plate surface;

E. an image transfer station where the toner in image formation is transferred from said plate to an image receptive member;

F. a cleaning station including cleaning apparatus for removing residual toner from the plate surface; and

G. means mounting said plate for indexing movement from said charging to said imaging, development, image transfer and cleaning stations in sequence during each copy cycle,

1. said means further mounting said plate for reciprocating movement while in said development, image transfer and cleaning stations to move said plate into operative relation with said developing apparatus, image transfer relation with the image receptive member, and said cleaning apparatus, respectively.

2. The system defined in claim **1**, which further includes a second charging unit mounted by said plate mounting means at a location relative to said plate such that, when said plate is indexed to said development station, said second charging unit is automatically positioned at said image transfer station to impose an electrostatic surface charge on the image receptive member.

3. The system defined in claim **1**, which further includes a fusing unit mounted by said plate mounting means at a location relative to said plate such that, when said plate is indexed to said cleaning station, said fusing unit is automatically positioned at said image transfer station to fuse the toner in image formation to the surface of the image receptive member.

4. The system defined in claim **1**, which further includes a second charging unit and a fusing unit both mounted by said plate mounting means in relation to said plate such that, when said plate is indexed to said development station, said second fusing unit is positioned at said image transfer station to impose an electrostatic surface charge on the image receptive member and, when said plate is indexed to said cleaning station, said fusing unit is positioned at said image transfer station to fuse the toner in image formation to the surface of the image receptive member.

5. The system defined in claim **1**, which further includes a lamp positioned intermediate said development and image transfer stations and operative to erase said electrostatic latent image subsequent to its development and prior to transfer of the toner in image formation to the image receptive member.

6. In an electrophotographic system having a charging station, imaging station, development station, image transfer station and cleaning station arrayed in a circle and at which an electrophotographic plate is successively presented, the combination comprising:

A. a revolving turret;

B. a support for the plate;

C. means formed in a face of said turret mounting said plate support for reciprocating movement;

D. revolving means for revolving said turret to index the plate in a circular path to the various stations, and

E. actuating means synchronized to said revolving means for periodically reciprocating said support radially of said circular path during each turret revolution to move the plate into and out of operative relation with development apparatus at the development station, an image receptive member positioned at the image transfer station and cleaning apparatus at the cleaning station.

7. The combination defined in claim 6, which further includes a charging unit adapted to a second face of said turret adjacent said face adapted with said plate support mounting means in the direction of turret revolution, whereby, when the plate is indexed to the development station, said charging unit is automatically positioned at the image transfer station to impose an electrostatic surface charge on the image receptive member.

8. The combination defined in claim 6, which further includes a fusing unit adapted to a second face of said turret adjacent said face adapted with said plate support mounting means opposite the direction of turret revolution, whereby, when the plate is indexed to the cleaning station, said fusing unit is automatically positioned at the image transfer station to fuse the image on the image receptive member surface as transferred thereto from the plate surface.

9. The combination defined in claim 8, which further includes a charging unit adapted to a third face of said turret adjacent said face adapted with said plate support means in the direction of turret revolution, whereby, when the plate is indexed to the development station, said charging unit is automatically positioned at the image transfer station to impose an electrostatic surface charge on the image receptive member.

10. The combination defined in claim 9, which further includes a flood lamp positioned intermediate the development and image transfer stations and operative to erase the electrostatic latent image created at the image station and developed at the development station prior to the image transfer operation at the image transfer station.

11. In an electrophotographic system having a charging station, imaging station, development station, image transfer station and cleaning station arrayed in a circle and at which an electrophotographic plate is successively presented, the combination comprising:

A. a revolving turret;

B. a support for the plate;

C. means formed in a face of said turret mounting said plate support for reciprocating movement;

D. revolving means for revolving said turret to index the plate in a circular path to the various stations, and

E. actuating means synchronized to said revolving means for reciprocating said support radially of said circular path to move the plate, while at at least one of the stations, into and out of operative relation with means located thereat.

12. In an electrophotographic system having a charging station, imaging station, development station, image transfer station and cleaning station at which an electrophotographic plate is sequentially presented, the combination comprising:

A. a mounting;

B. a support for the plate;

C. means mounting said plate support to said mounting for reciprocating movement;

D. means for indexing said mounting to position the plate at the various stations in sequence, and

E. actuating means synchronized to said indexing means for reciprocating said support to move the plate, while at the image transfer station, into and out of image transfer relation with an image receptive member located thereat.

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