Feb. 6, 1962 S. TEISER ETAL 3,019,714

CHARGING AND DEVELOPING APPARATUS FOR ELECTROSTATIC PRINTING

Filed March 31, 1958 5 Sheets-Sheet 1

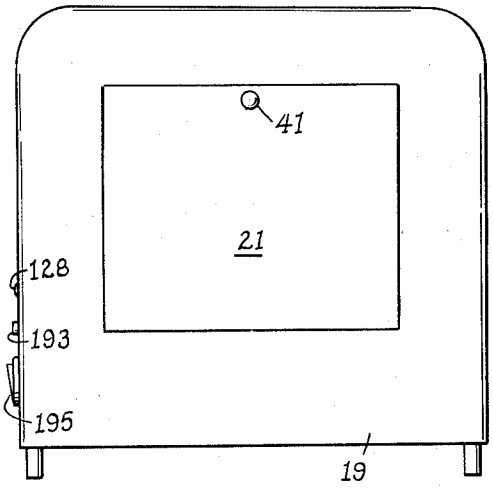

FIG.1

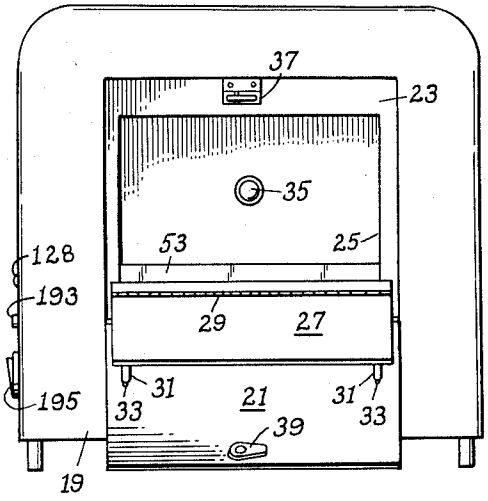

FIG.2

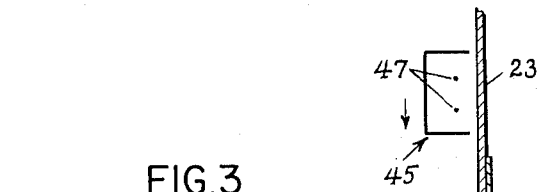

FIG.3

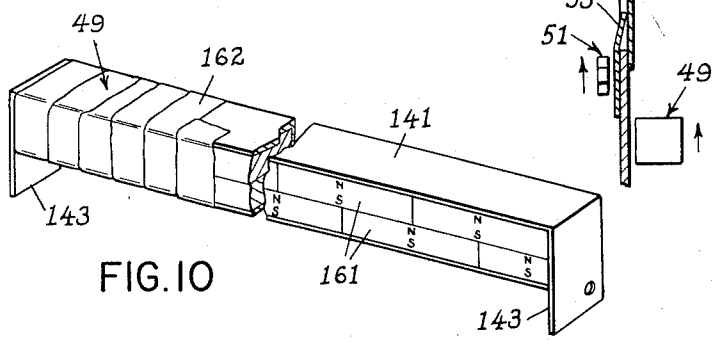

FIG.10

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CHARGING AND DEVELOPING APPARATUS FOR ELECTROSTATIC PRINTING
Filed March 31, 1958 5 Sheets-Sheet 2

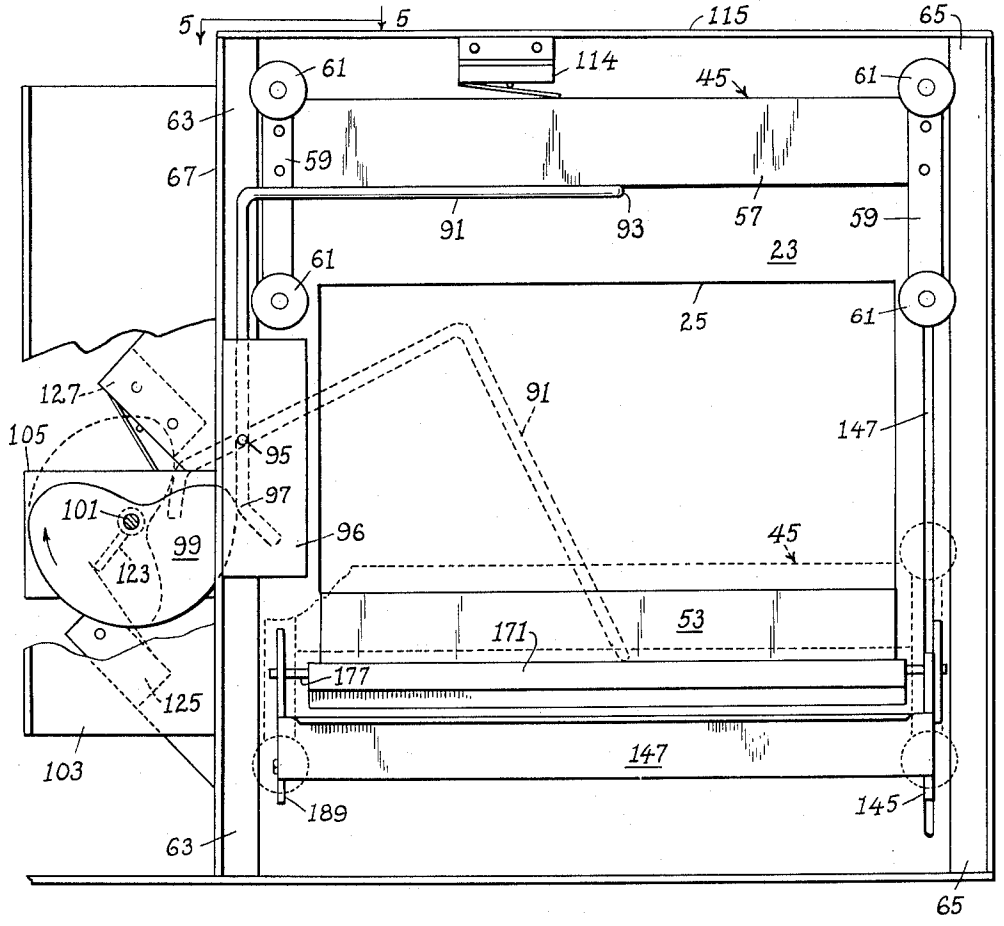


FIG. 4

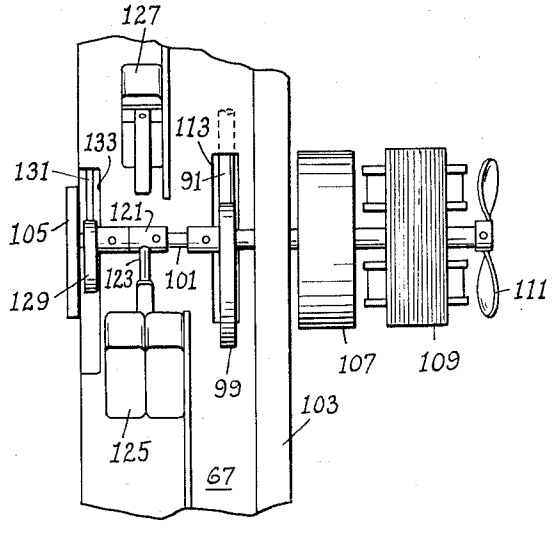


FIG. 7

Feb. 6, 1962 S. TEISER ETAL 3,019,714
CHARGING AND DEVELOPING APPARATUS FOR ELECTROSTATIC PRINTING
Filed March 31, 1958 5 Sheets-Sheet 3

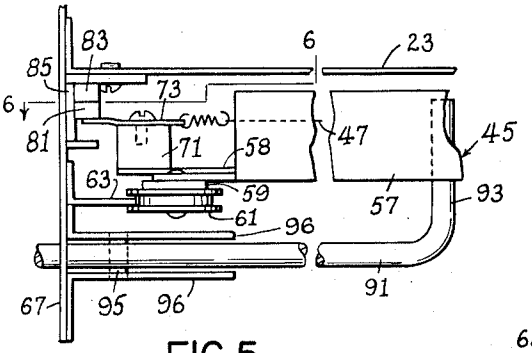
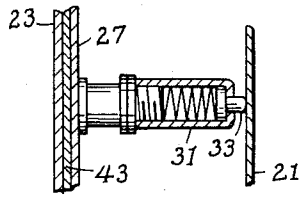


FIG.5

FIG.14



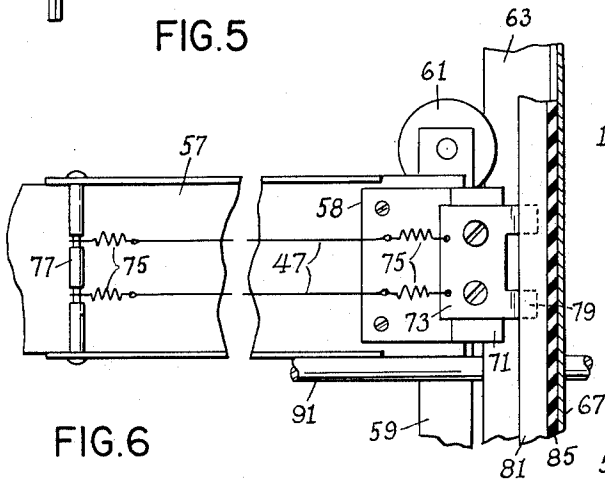


FIG.6

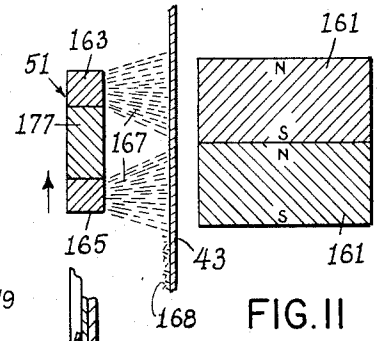


FIG.11

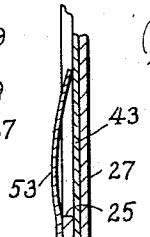


FIG.13

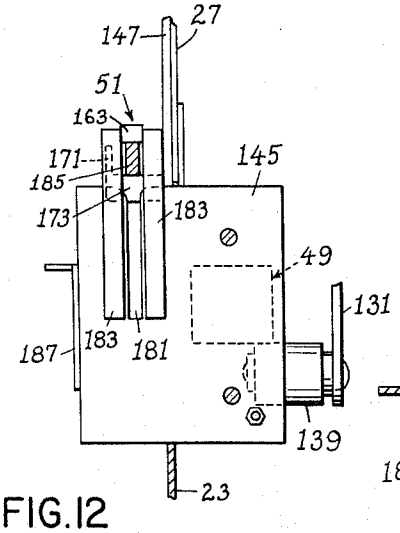
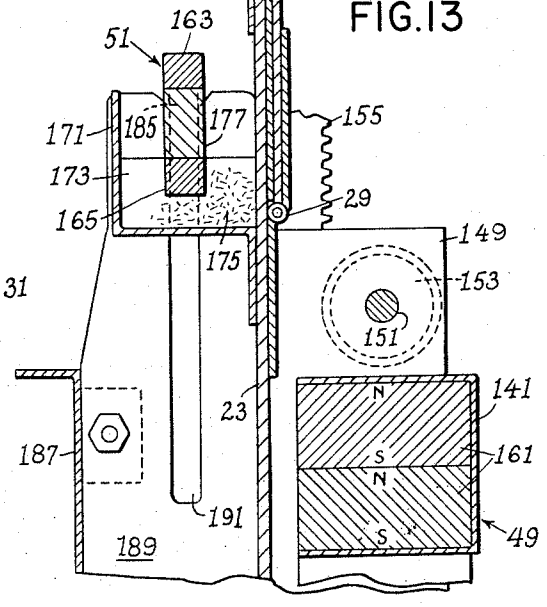


FIG.12



Feb. 6, 1962 S. TEISER ETAL 3,019,714
CHARGING AND DEVELOPING APPARATUS FOR ELECTROSTATIC PRINTING
Filed March 31, 1958 5 Sheets-Sheet 4

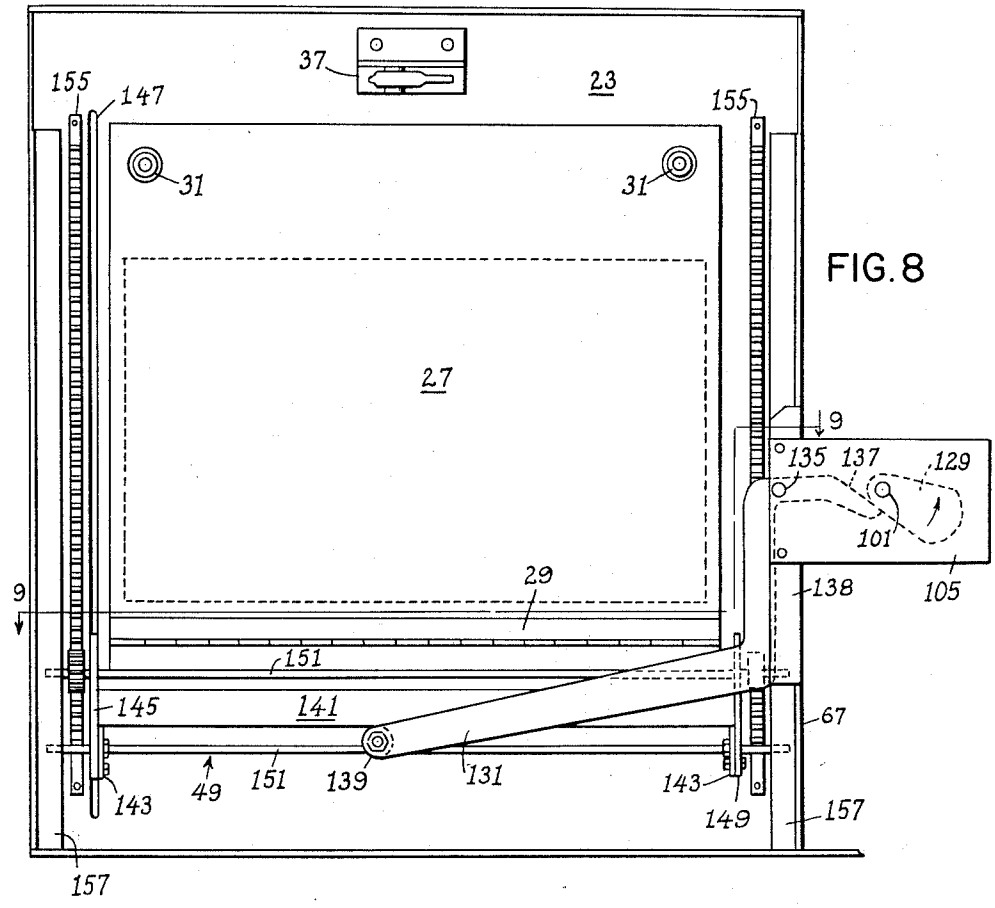
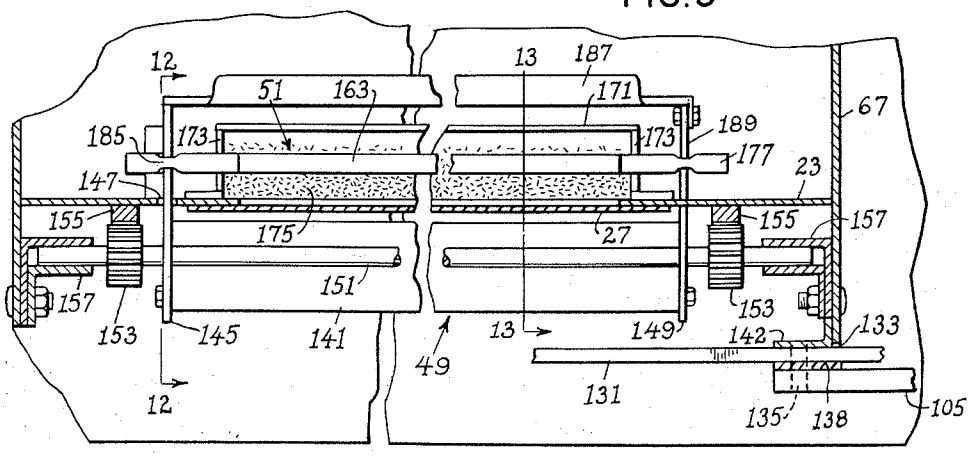


FIG. 8

FIG. 9



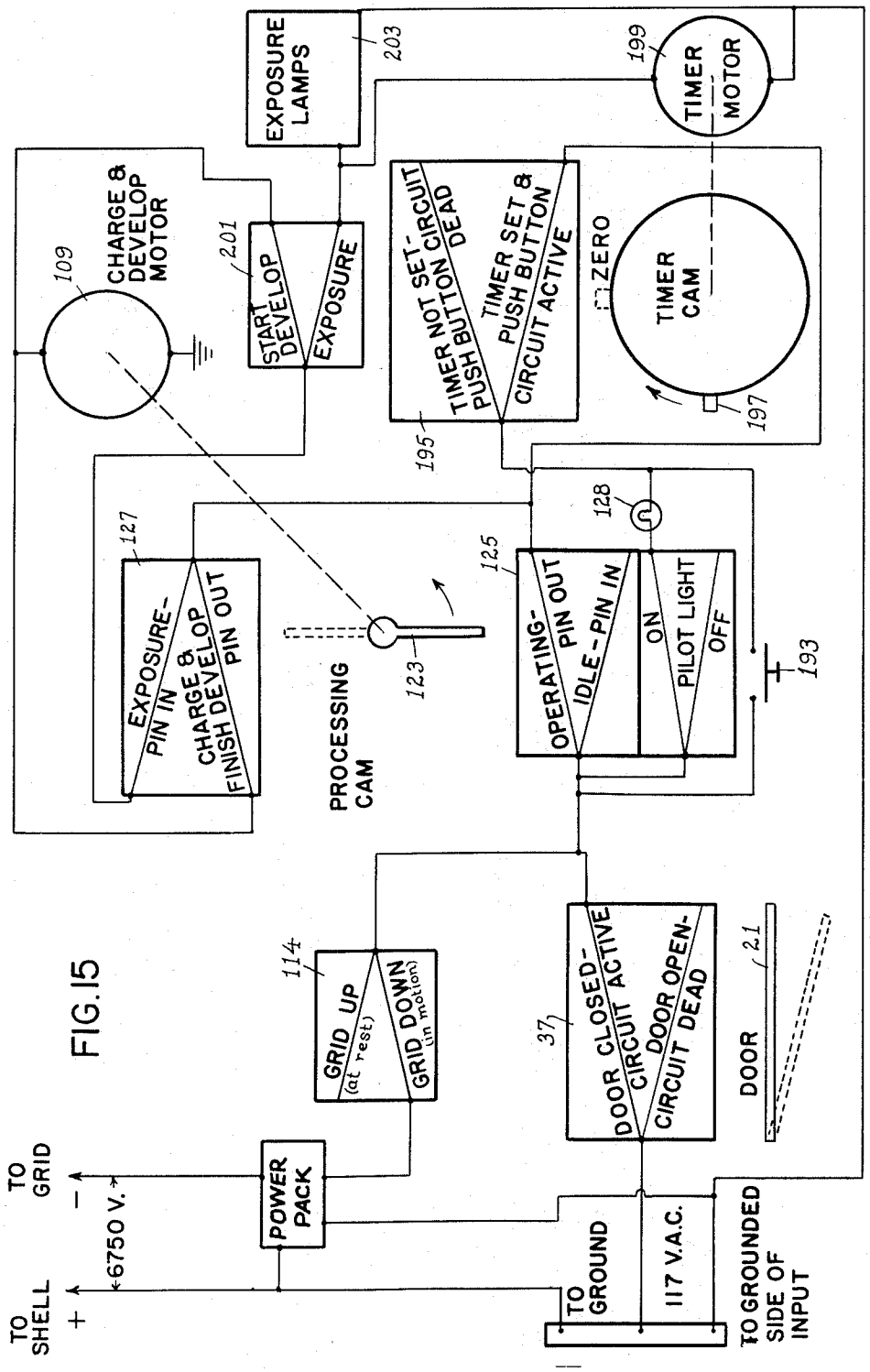

EXPOSURE LAMPS
203
TIMER MOTOR
199
CHARGE & DEVELOP MOTOR
109
201
START DEVELOP
EXPOSURE
TIMER NOT SET-CIRCUIT PUSH BUTTON DEAD
TIMER SET & PUSH BUTTON CIRCUIT ACTIVE
ZERO
TIMER CAM
197
195
128
127
125
EXPOSURE-PIN IN
CHARGE & FINISH DEVELOP PIN OUT
PROCESSING CAM
123
OPERATING-PIN OUT
IDLE-PIN IN
ON
PILOT LIGHT
OFF
193
114
GRID UP (at rest)
GRID DOWN (in motion)
37
DOOR CLOSED-CIRCUIT ACTIVE
DOOR OPEN-CIRCUIT DEAD
DOOR
21
TO GRID
TO SHELL
6750 V.
POWER PACK
TO GROUND
117 V.A.C.
TO GROUNDED SIDE OF INPUT

FIG. 15

United States Patent Office 3,019,714 Patented Feb. 6, 1962

3,019,714

CHARGING AND DEVELOPING APPARATUS FOR ELECTROSTATIC PRINTING

Sidney Teiser and Walter R. Sassaman, Rochester, N.Y., assignors, by mesne assignments, to Magnefax Corporation, Philadelphia, Pa., a corporation of Pennsylvania

Filed Mar. 31, 1958, Ser. No. 724,946
21 Claims. (Cl. 95—1.7)

The present invention relates to electrostatic printing and, more particularly, to a charging and developing apparatus for applying an electrostatic charge to a sheet having a photoconductive layer, holding the charged sheet as it is exposed to produce a latent image, and applying developing material to the latent image.

An object of this invention is to produce a new and improved charging and developing apparatus for use in electrostatic printing.

Another object of this invention is to produce a new and improved charging and developing apparatus for electrostatic printing which operates on a single sheet of treated paper.

Yet another object of this invention is the provision of a new and improved apparatus for electrostatic printing for automatically charging a treated sheet, holding the sheet as it is exposed, and developing the latent image on the sheet.

A further object is the provision of a new and improved charging and developing apparatus for electrostatic printing for operating on a single sheet of treated paper at a time, which apparatus is relatively simple to operate so as to be useable by persons comparatively unskilled in the art and technique of electrostatic printing.

A still further object is the provision of a new and improved apparatus for electrostatic printing for operating on a succession of single sheets of treated paper, and which is operable by ordinary office help to automatically charge and develop a single sheet of treated paper at a time.

Another object is the provision of a new and improved magnetic brush for use in electrostatic printing for applying a developer mix to a treated sheet bearing a latent electrostatic image.

Yet another object is to provide a new and improved magnetic brush for use in electrostatic printing, said brush being inexpensively formed while giving good results.

These and other desirable objects may be attained in the manner disclosed as an illustrative embodiment of the invention in the following description and in the accompanying drawings forming a part hereof, in which:

FIG. 1 is an end elevation of the electrostatic printing unit showing the case and the outside door at the charging and developing end of the unit;

FIG. 2 is a view similar to FIG. 1 showing the outside door open and the paper holder or presser plate down to reveal the interior of the unit;

FIG. 3 is a diagrammatic view of the charging and developing apparatus showing the grid, armature and magnet units in rest position, and also showing the exposure lens;

FIG. 4 is an elevational view of the charging and developing apparatus taken from the interior of the electrostatic printing unit looking toward the outside, the outside case having been removed, the grid unit being shown in its upper or rest position in full lines and in a lower position in dotted lines, an operating motor not being shown and a portion of a bracket being broken away;

FIG. 5 is an enlarged top view of the upper left corner of the apparatus of FIG. 4 (see line 5—5 of FIG. 4) showing the grid unit mount;

FIG. 6 is a section taken approximately on the line

6—6 of FIG. 5 showing the inside of the grid unit, the section being extended to show the other end of the grid unit;

FIG. 7 is a side view of a portion of the apparatus of FIG. 4;

FIG. 8 is an elevational view of the charging and developing apparatus taken just inside the outside door looking toward the interior of the electrostatic printing unit, the outside casing having been removed, showing the magnet unit in its lower or rest position;

FIG. 9 is an enlarged section, partly broken away, taken approximately on line 9—9 of FIG. 8, showing the two ends of the armature and magnet units in their rest position;

FIG. 10 is a fragmentary perspective view of the magnets and their casing with the tape partly broken away;

FIG. 11 is an enlarged schematic view of the armature and magnet units in operative position on opposite sides of a sheet;

FIG. 12 is a section taken approximately on line 12—12 of FIG. 9 showing one end of the armature and magnet units and their connections in rest position;

FIG. 13 is a section taken approximately on the line 13—13 of FIG. 9 and showing the other end of the armature and magnet units in rest position;

FIG. 14 is an enlarged section through one of the spacers on the corners of the paper holder or presser plate showing the outer door closed to hold a sheet in operative position; and

FIG. 15 is a simplified schematic diagram of the electrical system.

The same reference numerals throughout the several views indicate the same parts.

In electrostatic printing or xerography, briefly reviewing its principles, an insulating sheet of paper or other suitable material is given a coating of an appropriate photoconductive material. The sheet is given an electrostatic charge and is exposed to light rays either reflected from or transmitted through a sample or original to be copied, the charge being dissipated from the illuminated areas of the sheet and being retained on the non-illuminated portions of the sheet to form a latent image of the original. The sheet is then developed by applying to it a mixture of dye material. The developer material adheres to the latent image areas and is subsequently fixed so that the dye adheres permanently to the sheet and does not rub off.

The present invention is directed to a charging and developing apparatus and is embodied in a casing containing a complete electrostatic printing unit, the unit being designed so as to be readily operable by persons, such as office help, who are relatively unskilled in the art and technique of electrostatic printing. It is designed to operate on a single treated sheet at a time and is especially useful for making copies of pages of a book or printed material, either from a full sized original or a film or the like.

In FIG. 1 is shown one end of a substantially rectangular casing **19** which houses the complete electrostatic printing unit, the charging and developing apparatus being located at this end of the casing. An outside door **21** is provided in the end of the casing and is hinged at its lower edge to open outwardly and downwardly as shown in FIG. 2. Within the casing approximately parallel to the end wall, and supported by the bottom wall of the casing and an inner framework to be described, is a focal plane support **23** having an aperture **25**. A paper holder or presser plate **27** is hinged to the focal plane support by a transversely extending hinge **29** located a short distance below the edge of the aperture **25**. The paper holder **27** receives a sheet of treated paper and is movable upward-

ly and forwardly with the paper holder 27 to a position pressing against the focal plane support 23. A pair of posts 31 having outer plunger ends 33 are secured to the upper corners of the paper holder 27 on its outer surface. As will be more fully explained later, the outside door 21 presses against the plungers 33 when the paper holder and outside door are moved to a substantially vertical closed position to more securely hold the sheet against the focal plane support 23.

A lens 35 is visible through the open focal plane support aperture 25 and forms part of the exposure apparatus optics. A microswitch 37 is supported on the focal plane support above the aperture 25 behind the top edge of the opening for the outside door 21, and is located so as to be moved to closed position by the outside door 21. As will be apparent later, the charging apparatus includes a high voltage rail, and this switch 37 serves as a safety switch which opens the circuit for the charging apparatus when the outer door 21 is open. It furthermore serves as a master switch disconnecting all of the electrical elements from the supply. The door 21 is held in closed position by a latch 39 operated by a knob 41 accessible from the exterior of the casing.

In the diagrammatic view of FIG. 3, a sheet of treated paper 43 is shown pressed against the aperture 25 in the focal plane support 23. The sheet 43 for use with the present apparatus is preferably a sheet of paper to which has been applied a photoconductive layer. The photoconductive layer, of course, faces inwardly toward the interior of the electrostatic printing unit facing the lens 35. The sheet 43 is charged by means of a grid unit 45 having a plurality of corona discharge wires 47, two wires 47 being used with the present apparatus. The grid unit 45 is mounted inside of the focal plane support 23 and has a rest position above the upper edge of the focal plane support aperture or opening 25.

In operation, the grid unit 45 is connected to a high voltage source and is moved downwardly as shown by the arrow across the width of the opening 25 and then upwardly to its rest position, the corona discharge from the wires 47 charging the photoconductive layer on the sheet 43 with an electrostatic charge of the desired polarity as the grid unit goes through its cycle of operation. Thereafter the exposure is made. In this operation, light rays from a sample or original to be copied are transmitted through or reflected by the original and pass through the lens 35 and impinge upon the photoconductive layer on the sheet 43. As will be understood by those familiar with the process of xerography, the light rays dissipate the electrostatic charge on certain areas of the photoconductive layer and form a latent electrostatic image of the original in other image areas of the photoconductive layer.

A developing apparatus is then actuated to apply to the latent image areas a developing material comprised of a mixture of dye and magnetic carrier particles. The developer apparatus according to the present invention includes broadly a magnet unit 49 and an armature unit 51. The magnet and armature units have a rest position below the lower edge of the focal plane support opening 25 and are mounted for movement upwardly across the opening 25 and then downwardly back to the rest position. The magnet unit is mounted adjacent the outer surface of the focal plane support 23 and moves upwardly and downwardly across the untreated or back surface of the sheet 43. The armature unit 51 is located inside the focal plane support 23 approximately below the grid unit 45 and moves upwardly and downwardly across the photoconductive layer on the sheet 43. The armature unit 51 has associated with it a supply of developing material (not shown in the diagrammatic view, FIG. 3) comprising a mixture of dye and magnetic carrier particles. Briefly, the magnet unit 49 starts upwardly, and after reaching the level of the armature 51 and magnetizing the armature, a pair of brushes of developing material tends to form between the two units and actually does form between the armature 51 and the adjacent face of the paper 43 or the plate 23. Thereafter the magnet and armature units and the brush between them move upwardly together, portions of the brush adhering to the latent electrostatic image carried by the photoconductive layer as the brushes move across the sheet 43. Near the end of the downward movement, the brushes are removed from the paper by means of a deflector 53 which serves to deflect the developing material inwardly away from the surface of the sheet 43 to be caught by a tray (not here shown) below the rest position of the armature 51. It is thus seen that the charging unit performs its operation and is removed from the exposure area of the sheet 43, i.e., the portion of the sheet next to the opening 25, so that the magnet and armature units may thereafter perform their operation. The motion of the grid, magnet and armature units is desirably automatic, and is arranged in a manner to be set forth in greater detail hereafter so that the grid 45 moves downwardly and upwardly, there is a pause for the exposure, and the magnet and armature units move upwardly and then downwardly in sequence once an operator has initiated the action. Of course, the grid, magnet and armature units may be operated manually, if desired.

Referring to FIG. 4, which is a view of the charging and developing apparatus from the interior of the printing unit in front of the lens 35 looking toward the outside, the grid unit 45 is shown mounted for movement from its upper prolonged rest position downwardly to the dotted position and back again. The grid unit includes generally a rectangular U-shaped housing 57 open at its rear end, i.e., the side toward the focal plane support 23, within which are stretched the high voltage wires 47. The back wall of the housing 57 is extended at either side, and a flat insulating plate 58 and a vertically extending leg 59 are secured to one of these extensions. A leg 59 is secured to the extension at the other side. A roller 61 is pivoted to the ends of each of the legs 59. Each of the rollers 61 has a grooved periphery for running along one of a pair of vertically extending tracks 63 and 65. The track 65 is provided by one leg of an angle bar secured to a side wall of an inner framework including a pair of side walls and a top wall, the side walls being fixed to the bottom wall of the casing 19. The other track 63 is provided by an angle bar which is secured to the other vertically extending side wall 67.

In FIGS. 5 and 6, it is seen that the insulating plate 58 secured to the extension of the rear wall of the housing 57, the extension at only one side being shown in these views, has cemented to it a block of insulating material 71. To the outer end of the block 71 is secured a vertically disposed plate 73 of resilient conducting material, having holes near its inner edge, into which holes are hooked the ends of a pair of spaced conducting springs 75. The corona discharge wires 47 are each hooked to the other end of one of the springs 75, the wires 47 extending within the housing 57 in spaced relation to the back wall and the two outwardly directed legs thereof. At their opposite ends, the wires 47 are each hooked to one end of another similar spring 75, the opposite end of which is supported on an insulating pin 77 extending between the two horizontal flanges or legs of the housing 57 substantially parallel to but spaced from the back wall. The outer edge of the conducting plate 73 is provided with a pair of legs 79 which are in sliding electrical contact with a vertically disposed high voltage rail 81. The high voltage rail 81 is disposed in the corner between the focal plane support 23 and the side wall 67 and is insulated therefrom by a pair of insulating blocks 83 and 85. The high voltage rail 81 is connected, of course, to a source of high voltage (about 6700 volts D.C.) by a circuit to be described later.

It can be seen that the grid unit 45 is supported mainly by the rollers 61 engaging in the respective tracks 63 and 65 and that the parts are so arranged that the resilient

conducting plate 73 has its legs 79 pressed into engagement with one side of the high voltage rail 81. If necessary, the legs 79 may be bent in a suitable direction so as to provide a reasonably tight sliding engagement with the high voltage rail. Movement of the grid unit 45 between its upper or rest position and its lower position and thence backwardly to its upper position is achieved by means of a substantially right angled lever 91 having an inwardly bent trunnion end 93 which underlies the bottom leg of the U-shaped housing 57 (see also FIG. 4).

The lever 91, as shown in FIG. 4 in its full line rest position, has a substantially horizontal leg which bears the trunnion 93 and has a substantially vertically extending leg, this latter leg being pivoted at 95 to a pair of spaced brackets 96 extending inwardly from the wall 67. The brackets 96 have inwardly extending substantially parallel walls for guiding the movement of the lever 91 in a substantially planar path in a plane approximately parallel to the focal plane support 23. Below the pivot 95 the lever 91 is angled inwardly to provide an outwardly facing rounded knee 97, which is in engagement with a grid cam 99. Inasmuch as the weight of the grid unit 45 is on the trunnion 93, it can be seen that the knee 97 is constantly pressed into engagement with the cam surface of the grid cam 99.

As best seen in FIG. 7, the grid cam 99 is fixed to a shaft 101 which is journaled intermediate its length in a partition 103 extending substantially at right angles to the wall 67 and being supported thereon in any suitable manner. The outer end of the shaft 101 is journaled on a smaller plate 105 suitably fixed to another portion of the wall 67. The other end of the shaft 101 is connected to a reduction gear unit 107 which is driven by a motor 109 having a cooling fan 111. The cam 99 and the lower end of the lever 91 bearing the knee 97 are movable through an aperture 113 in the partition 67.

The grid cam 99 is generally kidney shaped, as seen in FIG. 4. More particularly, one-half of the circumference of the cam is carried inwardly toward the center of rotation and then outwardly so as to have a kidney or hourglass shape, while the remaining half of the circumference is concentric with the center of rotation of the cam. As will subsequently be more clear, the knee 97 of the lever 91 follows the kidney shaped half of the cam during the charging operation, and is on the circular half of the cam during the exposure and developing operations. In the rest position of the grid 45 as shown in FIG. 4, the knee 97 is at the end of the circular portion of the cam. During charging, the cam 99 rotates clockwise as shown in FIG. 4, and the knee 97 moves inwardly, as a result of which the lever 91 pivots about the pivot 95 to lower the trunnion 93, the grid unit 45 resting thereon moving downwardly by gravity. Of course, when the knee 97 is at the lowest portion on the cam 99, the grid unit is at its lowest position in which the grid wires 47 are at least below the top edge of the brush deflector 53. As the knee 97 follows the outwardly curving second half of the kidney shaped portion of the cam 99, the lever 91 pivots in the opposite direction about the pivot 95 and raises the grid unit 45 until it reaches its upper rest position.

A microswitch 114 is fixed to a top wall 115 of the inner housing in position to be engaged by the top leg of the grid housing 57 when the grid unit is in its upper rest position. The microswitch 114 is included in the circuit for the high voltage bar 81. With the grid unit 45 in its upper position, the switch 114 is open, thus opening the high voltage circuit. As the grid unit moves away from its rest position, the switch 114 is opened thereby to complete the high voltage circuit and it is again closed when the rest position is reached again.

Also fixed to the shaft 101 (see FIG. 7) is a hub 121 having secured to its a processing cam 123 (FIGS. 4 and 7). The processing cam has the form of a projecting radial finger. A pair of microswitches 125 and 127 are suitably fixed to the wall 67 in any suitable manner on opposite sides of the shaft 101 in position to be moved between an open and a closed position by the end of the processing cam 123. In the rest position of the grid unit 45, the processing cam engages the pin on the microswitch 125, in which position the switch 125 is open. During the charging operation, as will subsequently be more clear, the processing cam moves off of this pin on the switch 125 to close the circuit of the motor 109, this circuit remaining closed until the processing cam strikes the pin on the microswitch 127. At this point the circuit of the motor 109 is open, thus halting the movement of the shaft 101 and the cam 99, after which the exposure operation commences.

The switch 125 is desirably a double switch, the other of the switches being connected to a pilot lamp 128 which remains lighted so long as the switch 125 is in its operating position. As will be more clear later, the operator is signalled as to the end of the processing when the lamp goes dark.

Also fixed to the shaft 101 is a magnet cam 129 (FIGS. 7 and 8) which cooperates with a magnet unit operating lever 131. The wall 67 has an aperture 133 through which the lever 131 extends. The magnet cam 129, see FIG. 8, is generally wedge-shaped with circular ends. The shaft 101 is concentric with the circular end at the smaller end of the wedge. The lever 131 is shaped so as to bear on the cam 129 at one end while having vertical motion at the other end to move the magnet unit 49 as described. As shown, the lever 131 includes a central right angled portion and is pivoted at 135 to a flange 138 extending laterally from the forward edge of the partition 67, the pivot being at the inner end of the shorter of the two legs of the central right angled portion. The outer end of this short leg is angled downwardly and has an upper straight edge 137 which engages the edge of the cam 129. To the lower end of the long leg of the central right angled portion of the lever 131 is fixed an inwardly and downwardly extending arm having a roller 139 at its end. As will subsequently be more clear, the roller 139 underlies a laterally extending magnet housing 141 which forms part of the magnet unit 49. It will be seen that the lever 131 is mounted for pivotal movement in a plane approximately parallel to and forward of the focal plane support 23, and is guided in this path by movement in a recess between the flange 138 and another bracket 142 parallel to but spaced from the flange 138. The lever 131 is rocked by the cam 129 during the developing operation to move the magnet unit from its rest position at the lower end of the focal plane support 23 upwardly past the treated sheet and thence downwardly again to the rest position. During the charging cycle the smaller circular end of the cam 129 engages the flat edge 137 of the lever 131, and during the developing operation the larger end of the wedge-shaped cam 129 moves the edge 137 inwardly and then outwardly to produce the desired motion of the magnet unit 49.

The magnet housing 141 is generally rectangular in cross section although open at its inner side, and has a pair of legs extending downwardly from either end. The left leg 143 as seen in FIGS. 8 and 9 is secured to an end plate 145 which extends through a slot 147 in the focal plane support 23. The right leg 143 is secured to an end plate 149 which terminates adjacent the forward edge of the focal plane support. A pair of rods 151 are disposed above and below the magnet housing 141 and extend through the end plates 145 and 149. The upper rod 151 has a pair of pinions 153 secured to either end outside of the end plates, these pinions engaging with a pair of parallel racks 155 attached to the forward surface of the focal plane support 23. To support and guide the movement of the magnet unit 49 along the racks 155, the ends of the rods 151 extend into a pair of vertically extending guide grooves 157 at either side. These guide grooves are conveniently provided by a pair of angle bars having

inwardly directed legs which are separated, the other legs being superimposed and fixed to the respective walls of the inner frame.

The magnet housing 141 preferably contains a plurality of permanent magnets arranged as shown in FIGS. 10 and 11. A plurality of permanent magnets 161 are provided each having a north pole at its upper surface and a south pole at its lower surface, the magnets being desirably held within the housing 141 by a wrapping of insulating tape 162. The individual magnets 161 are arranged in a double row in brick-line fashion, that is, with the joints between the lower magnets midway between the joints of the upper magnets. As shown, six magnets are provided in the top row and five full magnets plus two halves at either end are provided in the bottom row. A single row of magnets may be provided, if desired, however it has been found desirable to have multiple rows of magnets. With multiple brushes, there is for each brush a separate developing action which is additive to that of the other brushes. For the magnets shown here, there are two spaced armatures 163 and 165 so that each armature provides a brush 167 of developer material as shown in FIG. 11. For the two armatures providing the two brushes 167, there are two development strokes while the unit is moving upward and two development strokes while moving downward.

The size of each of the armatures is chosen so as to be no greater than the height and length of a row of magnets 161. By so limiting the size of the armatures, access to the sheet 43 for exposure is assured without moving the sheet. That is, when the magnet unit 49 is below the edge of the deflector 53, the armature unit will also be below this edge, and when the magnet unit clears the top edge of the aperture 25, the armature unit also is clear of the aperture 25.

Because of this relative size of the armatures and magnets, a superior brush is formed. Magnetic brushes such as the brushes 167 are far less stiff than a bristle brush but nevertheless are sufficiently stiff so that they may sweep away dye material as well as deposit it on the sheet 43. With the armatures 163 and 165, a secondary brush 168 is formed at the trailing edge approximately parallel to the sheet 43. Thus, when the armature and magnet units are moving upwardly, the brush 168 is formed at the lower edge of the lower brush 167. When moving downwardly, a secondary brush 168 is formed at the upper edge of the upper brush 167.

This secondary brush 168 is composed of particles of dye and carrier material which have continual movement approximately perpendicular to the surface to the sheet 43. These particles "dance" along rather than sweep, resulting in a series of impacts which provides a better deposit of dye material on the latent image areas without any sweeping-away action. Furthermore, the mixture of dye and carrier material in each brush is constantly shifting whereby there is always a fresh supply of dye material in that portion of the brush next to the sheet. This yields good results in the finished developed sheet.

Secured to the inner face of the focal plane support 23 below the lower edge of the opening 25 therein and the brush deflector 53 is a tray 171 (see FIGS. 12 and 13). The tray 171 is provided by a zigzag shaped piece of sheet metal having a pair of end walls 173 lower than the back wall. The tray 171, in cooperation with the portion of the focal plane support 23 providing its forward wall, provides a rectangular recess in which the developing material 175 is located. The developing material 175, it will be recalled, is a mixture of dye particles and magnetic carrier material, preferably iron fillings.

The armature bars 163 and 165 are preferably made of soft iron and are fastened to opposite edges of a spacer bar 177 of a suitable non-magnetic material, such as brass. As can be seen in FIG. 9, the armature bars are shorter than the distance between the end walls 173 of the tray 171. In the rest position of the armature unit, the spacer bar 177 rests on the top of these end walls 173. It is to be noted that the magnet unit 49 is relatively inexpensive while yet producing good results, and the same may be said of the armature unit.

As has been explained, the magnet unit 49 and the armature unit 51 are so arranged that when the developing operation commences, the magnet unit moves upwardly into alinement with the armature unit, the two units then continuing upwardly together straddling the sheet 43 to be developed. For this purpose, the end plate 145 has a lost motion connection with the armature unit. For this purpose, the end plate is provided with a vertically extending slot 181, the bottom end of the slot occurring a short distance below the joint between the two rows of magnets 161 for a purpose which will be evident later. Secured to the outer surface of the plate 145 are a pair of vertically extending bars 183 which are alined with the vertical sides of the slot 181 and extend upwardly above the top edge of the plate 145 to straddle the spacer bar 177. As best shown in FIG. 9, the spacer bar 177 has a narrowed portion 185 which fits within the slot 181 and restrains longitudinal motion of the spacer bar.

A laterally extending angle bar 187 connects the inner edge of the plate 145 with a plate 189 at the other end of the armature unit. The plate 189 extends toward the focal plane support 23 and is free to move in a vertical path. A lost motion slot 191 is provided in this end plate 189, the lower end of the slot being located just below the joint between the double row of magnets 161. The spacer bar 177 has a narrowed portion, which like the narrowed portion of the other end of the bar, fits within the slot 191.

It can be seen that when the lever 131 is operated to raise the magnet unit 49, the plates 145 and 189 move upwardly also. At the beginning of the operation, the plates 145 and 189 move relative to the armature unit 51 because of the lost motion slots 181 and 191, however when the bottom of the slots engage the ends of the spacer bar 177, the magnet unit, the end plates 145 and 189 and the armature unit move upwardly thereafter together. The brushes 167 of developer material are formed when the two rows of magnets 161 are opposite their respective armature bars 163 and 165, and developer material adheres to the latent electrostatic image on the sheet 43 to be developed as the armature and magnet units move upwardly and then downwardly across the surface of the sheet 43.

It is desirable that the sheet 43 be held tightly in place during the charging and developing operations. As has been briefly explained, referring to FIG. 14 and also FIG. 1, a pair of posts 31 having plunger ends 33 are secured to the upper outer corners of the paper holder 27. The plungers 33 are spring biased outwardly. When the door 21 is moved to its closed position it strikes the plungers 33 thus holding the sheet 43 tightly against the focal plane support 23, thus obviating the necessity of having a close tolerance between these interengaging parts when the unit is manufactured. The brush deflector 53 is bent inwardly at its upper edge to press against the treated side of the sheet 43 and provides a further holding force working in the opposite direction. The brush deflector 53 further serves to deflect the brushes 167 and 168 of developing material from the paper when the magnet and armature units are moved downwardly toward their rest position and deflect the particles of developing material inwardly to be caught by the tray 171. This action assures clean margins on the developed sheet 43.

The breaking of the brushes 167 and 168 each time the armature and magnet units move downwardly to the rest position results in replenishment of the developing material 175 forming each brush. That is, when the units move down past the deflector 53 and separate as the armature unit comes to rest on the tray 171 and the magnet unit continues downwardly, the material which

composed the brushes drops back into the tray **171**. In the tray **171**, this material mixes with a fresh supply of dye material. On the next operation, when a new set of brushes are formed, the new brushes have an adequate supply of dye material at their edges adjacent the sheet **43**, rather than a diminished supply as was the case at the end of the previous development cycle. Thus, it is noted, the reformed brushes are different brushes from the ones in the previous operation.

Although the armature and magnet units have been shown in the preferred embodiment as being connected by a lost motion connection, it is to be understood that they may be coupled by any suitable means which provides for separation of the armature and magnet units so that the material forming the brushes may be replenished as described above.

The schematic diagram of the electrical system, FIG. 15, is thought to be largely self-explanatory and at any rate, will be summarized when reviewing the operation of the present invention. It is to be noted, however, that with the door **21** open the supply is cut off and the circuit is dead. The switch **37** must be closed by closing the door before the apparatus can be operated at all. The apparatus is furthermore initially set into operation by a push button **193** accessible from the outside of the casing **19** as shown in FIG. 1. The push button **193**, furthermore, will not activate the circuit unless a timer **195** is also set. Setting the timer moves a timer cam **197** from its zero position to a set position. The exact structure of the timer cam is conventional, and suffice it to say that it operates to move from a set position to a zero position when a timer motor **199** is activated. Setting of the timer cam **197** also moves a switch **201** to an exposure position wherein the timer motor **199** and a bank of conventional exposure lamps **203** may be activated when the switch **127** is moved to exposure position. The switch **201** is moved to developing position when the timer cam **197** arrives at its zero position, current then flowing through the switch **201** to thereafter energize the charging and developing motor **109**. The operation of these elements will be clarified in the summary of the operation following.

In operation, the outside door **21** is opened, the paper holder **27** likewise opening outwardly and downwardly upon its hinge **29**. Opening of the outside door **21** opens the switch **37** to disconnect all of the electrical elements from the supply line. With the grid unit **45** in its upper or rest position, the switch **114** is also moved to open position, thus providing an additional safety for disconnecting the high voltage rail **81** from the supply. A sheet or treated paper **43** is laid face up upon the paper holder **27**, that is with the photoconductive layer up. The door **21** is now closed, which movement also moves the paper holder **27** and the treated sheet **43** thereon into a substantially vertical position pressing against the focal plane support **23**. The treated sheet **43** is held tightly in place because of the action of the door with the plungers **33** carried by the posts **31** on the outside surface of the paper holder, and the upper edge of the brush deflector **53** also presses against the treated sheet **43** with an outward force. The closing of the outside door **21** moves the switch **37** to a closed position.

The timer **195** is set to give the proper exposure time, this setting movement likewise moving the switch **201** to exposure position. As is evident from the circuit schematic diagram of FIG. 15, the push button circuit is open when the timer is not set. The push button **193** is then closed, and is held closed for a short time by the operator, after which the charging, exposure, and developing operations are automatic.

With the push button **193** closed, and inasmuch as the switch **127** is in its charging and developing position, a circuit is completed through to the charging and developing motor **109**. The motor **109** acting through the reduction gear **107** sets the shaft **101** in rotation. The grid cam **99** is consequently rotated, the knee **97** on the grid operating lever **91** being moved inwardly and then outwardly along the kidney shaped path of the cam **99**. The grid unit **45** thus moves downwardly across the treated sheet **43** and thence back up to its rest position at the upper end of the unit. As the grid unit **45** leaves its rest position, the switch **114** is moved to a closed position completing the circuit to the high voltage rail **81**. The corona discharge wires **47** are thus energized, the corona discharge therefrom imparting to the treated sheet **43** an electrostatic charge of the desired polarity. On moving upwardly to the rest position, the switch **114** is again opened to disconnect the high voltage supply. The inwardly extending trunnion **93** on the grid lever **91** of course slides along the bottom of the grid housing **57** as the lever **91** pivots about the pivot **95**, and the grid unit **45** as a whole rolls along the vertically disposed tracks **63** and **65**. As the shaft **101** begins to turn, the processing cam **123**, which originally in its rest position engages the pin on the switch **125** to hold the switch open, within a short time moves off of the pin on the switch **125** to move the switch **125** to an operating or closed position. At this time, as can be seen from the electrical diagram, the charging and developing motor **109** is energized through the switch **125**, so that the push button **193** may now be released by the operator. Movement of the switch **125** to operating position also energizes the pilot lamp **128**.

When the grid unit **45** has moved back to its rest position and is removed from the exposure area of the sheet, the processing cam **123** has moved approximately 180 degrees and engages the pin on the switch **127** to move the switch **127** to exposure position. The motor **109** is deenergized, thus stopping for the duration of the exposure operation the rotation of the shaft **101** and its associated cams. In exposure position, current flows through the switch **201** to the exposure lamps **203** and the timer motor **199**. Exposure of the treated sheet **43** now commences. When the timer cam **197** has moved from its set position to its zero position, the switch **201** is moved to developing position, thus deenergizing the exposure lamps **203** and the timer motor **199**. At this point the charging and developing motor **109** is again energized and rotation of the shaft **101** and its associated cam again commences to actuate the developing operation. As the processing cam moves off of the pin on the switch **127**, this switch is moved to its charge and develop position, wherein the motor **109** is energized through the switch **127** rather than through the switch **201**.

During the developing operation, the grid cam **99** has its circular half in contact with the grid lever knee **97**, so that the position of the grid unit **45** is substantially unchanged. Conversely, the magnet unit cam **129**, which was rotating with its smaller circular end in contact with the magnet lever **131** during the charging operation, now moves to active position with its larger wedge-shaped end pressing the straight edge **137** of the lever **131** inwardly and then outwardly. The magnet lever **131** pivots about the pivot **135**, thus moving the roller end **139** upwardly and then downwardly, carrying with it the magnet unit **49**. The magnet unit **49**, it will be recalled, has pinions **153** which move over a pair of racks **155**.

On moving from its rest position, the magnet unit **49** moves upwardly relative to the armature unit **51** because of the lost motion connection comprising broadly the slots **181** and **191** in the respective end plates **145** and **189**. When the ends of the spacer bar **177** are picked up by the ends of the slots **181** and **191**, however, the magnet unit and the armature unit are substantially laterally alined, and further movement straddling the sheet **43** is substantially together. As the double row of magnets **161** comes opposite the spaced armature bars **163** and **165**, the armatures are magnetized and a pair of brushes **167** and developer material **175** are formed each extend-

ing from its respective armature toward the permanent magnets 161 until stopped by the focal plane support 23. Another brush 168 is formed at the lower edge of the lower of the brushes 167 approximately parallel to the sheet 43. As the units move upwardly and the brushes 167 and 168 traverse the treated sheet 43, particles of developing material 175 are attracted to the latent electrostatic image area of the treated sheet and are held thereto by electromagnetic forces. As has been explained, the brushes 167 sweep away dye material as well as deposit, while the secondary brush 168 "dances" along and deposits dye material without any sweeping-away action, especially as there is a constantly shifting supply of dye material in the portion of the brush impinging on the sheet. Of course, the developing material particles do not adhere to other areas of the treated sheet 43, that is, those areas where the electrostatic charge has been dissipated by the exposure operation. On descent of the armature and magnet units, the secondary brush is at the trailing edge of the upper of the brushes 167. Near the end of the downward movement the brushes 167 and 168 are broken by the brush deflector 53 so that the particles of developing material 175 are deflected inwardly to fall into the tray 171 when the magnet unit is separated from the armature unit. This occurs when, after the spacer bar 177 has come to rest on the end walls 173 of the tray 175, the magnet unit and the end plates 145 and 189 continue their downward movement, this being possible because of the lost motion connection comprising the slots 181 and 191. The magnet unit 49 and the end plates 145 and 189 come to rest when the roller 139 on the magnet lever 131 reaches its lowest position.

At about the completion of a full revolution of the shaft 101, during the charging and developing operations, the processing cam 123 again comes into contact with the pin on the switch 125, closing the switch and de-energizing the charging and developing motor 109. The pilot lamp 128 simultaneously goes dark, indicating to the operator that the charging, exposure and development operations are complete. The treated sheet 43 bearing an image of the original copy may be removed. The outside door 21 is opened, the paper holder or presser plate 27 also hinging outwardly and downwardly with it. The sheet 43 may now be removed from the paper holder 27 and subjected to the action of a fixer unit to adhere the dye in the developing material permanently to the paper. The developer material previously forming the brushes 167 and 168 which at the end of the development operation was exhausted of dye material, mixes with the other developer material 175 in the tray 171 and is replenished. On the next development operation, a new set of brushes are formed. These new brushes are different from the previous brushes and have an adequate supply of dye material.

The charging and developing apparatus according to the present invention is desirably operated semi-automatically in the manner indicated above. It is designed to operate on a single sheet at a time and is relatively simple in operation so that relatively unskilled help, such as ordinary office help, may carry out the operation with a minimum of supervision. However, the grid unit 45 and the magnet and armature units 49 and 51, respectively, may be operated manually, if desired. The apparatus produces uniform results. This is especially noteworthy inasmuch as the magnet unit 49, composed of a plurality of permanent magnets arranged in brick-like fashion, is relatively inexpensive. Although not restricted to this use, the present apparatus is conveniently used for making copies of pages of books or other printed material, either from a full size original or from microfilm or the like.

It is seen from the foregoing disclosure that the above mentioned objects of the invention are well fulfilled. It is to be understood that the foregoing disclosure is given by way of illustrative example only, rather than by way of limitation, and that without departing from the invention, the details may be varied within the scope of the appended claims.

What is claimed is:

1. A charging and developing apparatus for use in electrostatic printing comprising a light tight housing, means for holding in fixed position therein a sheet treated with photoconductive material at an exposure position wherein the latent image of an object to be copied may be formed, electrostatic charging means, means mounting said charging means for movement across the treated side of said sheet to charge the same, means for exposing said charged sheet and forming a latent image on the charged side thereof, magnet means for forming a brush containing developing material and applying the same to said side of the sheet on which is disposed said latent image, means mounting said magnet means for movement substantially parallel to the sheet between a rest position at said side of the sheet, across the sheet and backwardly to the rest position, said magnet means being arranged to operate subsequent to the operation of said exposing means, and means for imparting movement to said charging means and said magnet means.

2. An apparatus according to claim 1, wherein said magnet means includes an armature unit and a permanent magnet unit mounted on opposite sides of the sheet, said magnet and armature units having portions facing toward said sheet, said opposing portion of said armature unit being no larger than the opposing portion of said magnet unit.

3. An apparatus according to claim 1, wherein said magnet means includes an armature unit and a permanent magnet unit located on opposite sides of the sheet, and means for picking up and releasing said armature unit intermediate said movement of said magnet unit whereby different brushes containing developing material are formed during succeeding movements of said units.

4. An apparatus according to claim 1, wherein said movement imparting means for the charging means is arranged to move the same substantially parallel to the treated sheet between a rest position at said side of the sheet, across the sheet and backwardly to said rest position.

5. Apparatus according to claim 1 wherein automatic means are provided for operating said charging means and magnet means in a sequence in which said magnet means operate subsequent to said charging means following the operation of the exposing means.

6. Apparatus according to claim 1 wherein said treated sheet is held at a substantially vertical focal plane support position and wherein said electrostatic charging means are mounted for movement substantially parallel to the treated sheet from an upper rest position, downwardly across the sheet and upwardly back to said rest position, and said magnet means are mounted for movement substantially parallel to the sheet from a lower rest position upwardly across the sheet and downwardly back to said rest position.

7. An apparatus according to claim 1 comprising a focal plane support having an aperture, means for holding a treated sheet against one side of said focal plane support and covering said aperture, and wherein the electrostatic charging means are mounted for movement substantially parallel to said focal plane support from a rest position at one side of the aperture, across said aperture and backwards to said rest position whereby said charging means is removed from an exposure area of said sheet and the magnet means for forming the brush is mounted for movement substantially parallel to said focal plane support between a rest position at the opposite side of said aperture across said aperture and backwardly to said rest position.

8. An apparatus according to claim 7, wherein said charging and magnet means are carried by said focal plane support and said magnet means includes an arma-

ture unit and a permanent magnet unit mounted on opposite sides of said focal plane support.

9. An apparatus according to claim 7, wherein said charging and magnet means are carried by said focal plane support and said magnet means includes an armature unit and a permanent magnet unit located on opposite sides of said focal plane support, said units being coupled by means for moving said magnet unit prior to and subsequent to said armature unit.

10. A charging and developing apparatus for use in electrostatic printing comprising a light tight housing, means for holding in fixed position therein a sheet treated with photoconductive material at a substantially vertical focal plane support position, charging means for applying an electrostatic charge to the treated sheet, means mounting said charging means for movement substantially parallel to the treated sheet from an upper rest position downwardly across the sheet and upwardly back to said rest position, means for exposing said charged sheet and forming a latent image on the charged side thereof, magnet means for forming a brush containing developing material and applying the same to said side of the sheet on which is disposed said latent image, said magnet means including a magnet unit and an armature unit straddling the treated sheet, means mounting said magnet means for movement substantially parallel to the treated sheet from a lower rest position upwardly across the sheet and downwardly back to said rest position, and means for automatically moving said charging and magnet means in a sequence in which said magnet means operates subsequent to said charging means and following operation of the exposing means.

11. A charging and developing apparatus as set forth in claim 10, wherein said armature unit includes a plurality of spaced bars of magnetizable material and said magnet unit includes a plurality of permanent magnets arranged in a corresponding number of rows in brick-like fashion with the joints between magnets in one row offset from the joints between magnets in an adjacent row.

12. A charging and developing apparatus for use in electrostatic printing comprising a light tight housing, having therein a focal plane support having an aperture, means for holding a sheet treated with photoconductive material in fixed position against said focal plane support, a grid unit for connection to a high voltage supply for applying an electrostatic charge to the treated sheet on the treated side thereof, means mounting said grid unit for movement substantially parallel to said focal plane support from a rest position at one side of said aperture across said aperture and backwardly to said rest position, means for exposing said charged sheet and forming a latent image on the charged side thereof, magnet means for forming a brush containing developing material and applying the same to said side of the sheet on which is disposed said latent image, means mounting said magnet means for movement substantially parallel to said focal plane support from a rest position at an opposite side of said aperture across said aperture and backwardly to said rest position, said magnet means including an armature unit and a permanent magnet unit located on opposite sides of said focal plane support, means for picking up and releasing said armature unit intermediate the movement of said magnet unit whereby a different brush of said material is formed during succeeding movements of said units, a tray for containing said material secured to said focal plane support and supporting said armature unit in said rest position of said magnet means, and means for moving said grid unit and magnet means.

13. A charging and developing apparatus as set forth in claim 12, wherein said means for moving said grid unit and magnet means includes means for automatically operating said magnet means subsequent to said grid unit and following operation of said exposing means.

14. A charging and developing apparatus for use in electrostatic printing comprising a light tight housing provided with a substantially vertical focal plane support having an aperture, a presser plate hinged to said focal plane support for pressing a sheet treated with photoconductive material against said focal plane support, charging means for applying an electrostatic charge to said sheet on the treated side thereof, means mounting said charging means on said focal plane support for movement substantially parallel thereto from a rest position above said aperture downwardly across said aperture and upwardly back to said rest position, means for exposing said charged sheet and forming a latent image on the charged side thereof, magnet means for forming a brush containing developing material and applying the same to said side of the sheet on which is disposed said latent image, means mounting said magnet means on said focal plane support for movement substantially parallel thereto from a rest position below said aperture upwardly across said aperture and downwardly back to said rest position, and means for moving said grid unit and magnet means in a sequence in which said magnet means is operated subsequent to said grid unit and following operation of said exposing means.

15. Apparatus according to claim 14, wherein said magnet means includes an armature unit and a permanent magnet located on opposite sides of said focal plane support and connected by a lost motion connection, and a tray for containing developing material secured to said focal plane support below said aperture and supporting said armature unit in said rest position of said magnet means.

16. An apparatus according to claim 15, wherein said means for moving said charging and magnet means operates automatically.

17. A developing apparatus for use in electrostatic printing comprising a light tight housing having therein a magnet unit including a plurality of permanent magnets, track means for mounting said magnet unit on one side of a focal plane support for movement substantially parallel thereto, means for holding a sheet having an electrostatic charge image against said focal plane support, an armature unit located on the othe other side of the focal plane support facing the charge image on said sheet and including a bar of magnetizable material, tray means for holding magnetic powder containing developing material and supporting said armature unit in a rest position thereof, and means for moving said magnet unit in the direction of said armature unit whereby said armature unit is magnetized and moves thereafter with said magnet unit, a brush of said powder containing developing material being formed and extending toward the sheet and focal plane support sufficiently close to the sheet to cause the developing material to be applied to the said image.

18. A developing apparatus for use in electrostatic printing comprising a magnet unit including a double row of permanent magnets arranged in brick-like fashion with the joints between magnets in one row offset from the joints between magnets in the next row, track means for mounting said magnet unit on one side of a focal plane support for movement substantially parallel thereto, an armature unit located on the other side of the focal plane support and including a pair of substantially parallel bars of magnetizable material separated by a non-magnetic spacer bar, means for holding a sheet having an electrostatic charge image against said focal plane support with the charge image on the side of said armature unit, means coupling said magnet and armature units including a pair of end plates each having a lost motion slot receiving an end of said spacer bar, tray means for holding magnetic powder containing developing material and for supporting said armature unit in a rest position thereof, and means for moving said magnet unit and coupling means in the direction of said armature unit, whereby said magnet unit magnetizes said parallel bars and forms a pair of brushes of said material.

19. A developing apparatus for use in electrostatic print-

ing comprising a magnet unit including a plurality of rows of permanent magnets arranged in brick-like fashion with the joints between magnets in one row offset from the joints between magnets in the next row, means for mounting said magnet unit for movement from a rest position parallel to a focal plane support, an armature unit including a corresponding number of bars of magnetizable material, means for holding a sheet having an electrostatic charge image against said focal plane support with the charge image on the side of said armature unit, means for containing magnetic developer powder material and for supporting said armature unit in a rest position spaced from said magnet unit along the path of movement, and means for moving said magnet unit in the direction of said armature unit whereby said armature unit is magnetized and moves thereafter with said magnet unit, a brush of said developing material being formed and tending to extend between each row of magnets and its corresponding armature bar, portions of each of said armature bars opposing its corresponding row of magnets having an area no greater than that of the opposing portion of its corresponding row of magnets.

20. A charging and developing apparatus for use in electrostatic printing comprising a light tight chamber containing means for holding a sheet treated with photoconductive material at a substantially vertical focal plane support position, said means holding the sheet in fixed position in said chamber with the photoconductive material at an exposure position therein, a high voltage rail extending substantially vertically near said focal plane support position, charging means including substantially vertical track means substantially parallel to said focal plane support position and a U-shaped housing movable vertically along said track means and having a plurality of grid wires mounted within said housing and a resilient contact member electrically connected to said grid wires and bearing against said rail to make sliding contact with said rail during vertical movements of said housing along said track means, means including said rail and said resilient contact member for impressing a high potential electrical charge on said grid wires during vertical movements of said housing along said track means, said housing having a rest position near the top of a sheet held in said focal plane support position, means for exposing said charged sheet and forming a latent image on the charged side thereof, magnet means for forming a brush of magnetic powder containing developing material, means mounting said magnet means for movement substantially parallel to said sheet from a lower rest position upwardly across said sheet and downwardly back to its said rest position, and operating means for first moving said housing from its rest position downwardly across said sheet and then upwardly again to its rest position, to impress an electrostatic charge on said sheet, and then, after a pause for exposure of the charged sheet to a light pattern occasioned by operation of said exposing means, moving said magnet means from its rest position upwardly across said sheet and then downwardly again to its rest position.

21. Apparatus for use in electrostatic printing wherein a brush containing developing material is formed and applied to the latent image on an electrically charged sheet of photoconductive material, comprising magnetic means for forming the brush from said brush material and applying the same to the latent image on the charged side of the sheet, said magnetic means comprising a magnet unit movably mounted on the opposite side of the sheet from said charged side and cooperating with an armature unit movably mounted on the image side of the sheet and magnetizable by said magnet unit when the units move together in opposed relation, a source of brush material disposed in position to be acted upon and picked up by the armature unit when the same is magnetized, means for moving one of said units relative to the other and for simultaneously moving said magnet unit and said armature unit in opposed relation away from the back toward said source, the armature unit remaining at rest and being demagnetized during movement of the magnet unit toward and from the armature unit, said armature unit when demagnetized, releasing the brush material and when again magnetized, picking up substantially fresh brush material from said source for application to the charged side of the next sheet to be acted on.

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Notice of Adverse Decision in Interference

In Interference No. 93,507 involving Patent No. 3,019,714, S. Teiser and W. R. Sassaman, Charging and developing apparatus for electrostatic printing, final judgment adverse to the patentees was rendered July 31, 1964, as to claims 1 and 4.

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