United States Patent

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[54] HIGH SPEED PHOTOELECTROSTATIC COPYING MACHINE

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[52] **U.S. Cl.**.....**355/14,** 355/13

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

[58] **Field of Search**.....355/11, 12, 13, 14, 48, 50, 355/64, 65, 97

[56] **References Cited**

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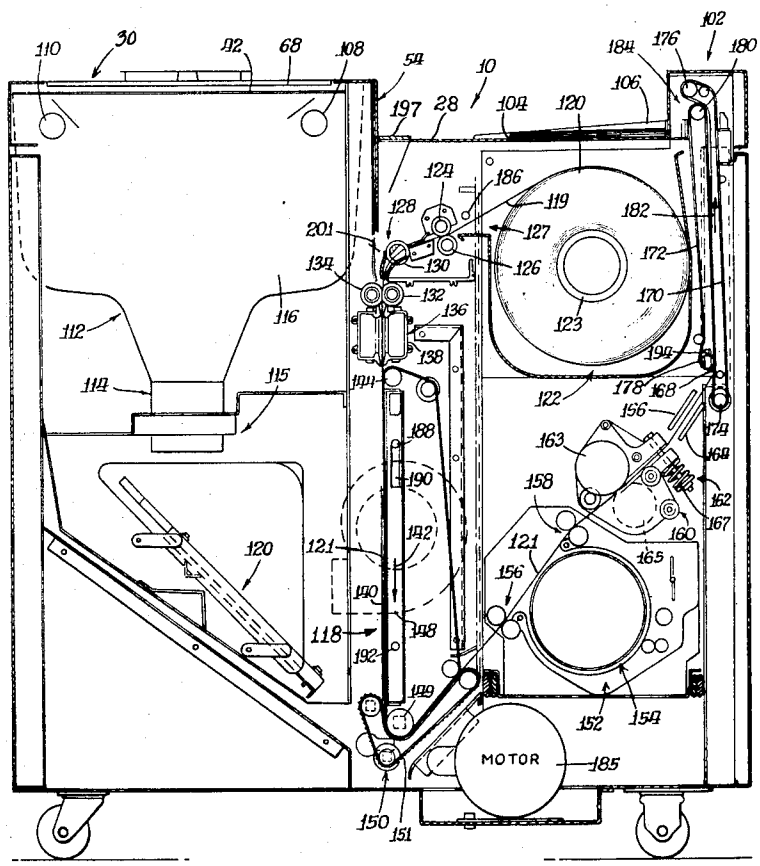
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[57] **ABSTRACT**

A counter controls the processing of multiple copies of an original in a high-speed, roll fed copying machine. Timer circuitry operated in the multiple copy mode provides signals to initiate the feeding of copy material from the roll for successive copies. A movable length sensor in the path of the copy material discontinues the feeding of copy material and actuates a cutter to sever a preselected length of copy material. The time period between signals is variable in accordance with the selected copy length so as to provide a corresponding spacing between successive lengths of severed copy material.

5 Claims, 5 Drawing Figures



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SHEET 1 OF 3

Fig. 1.

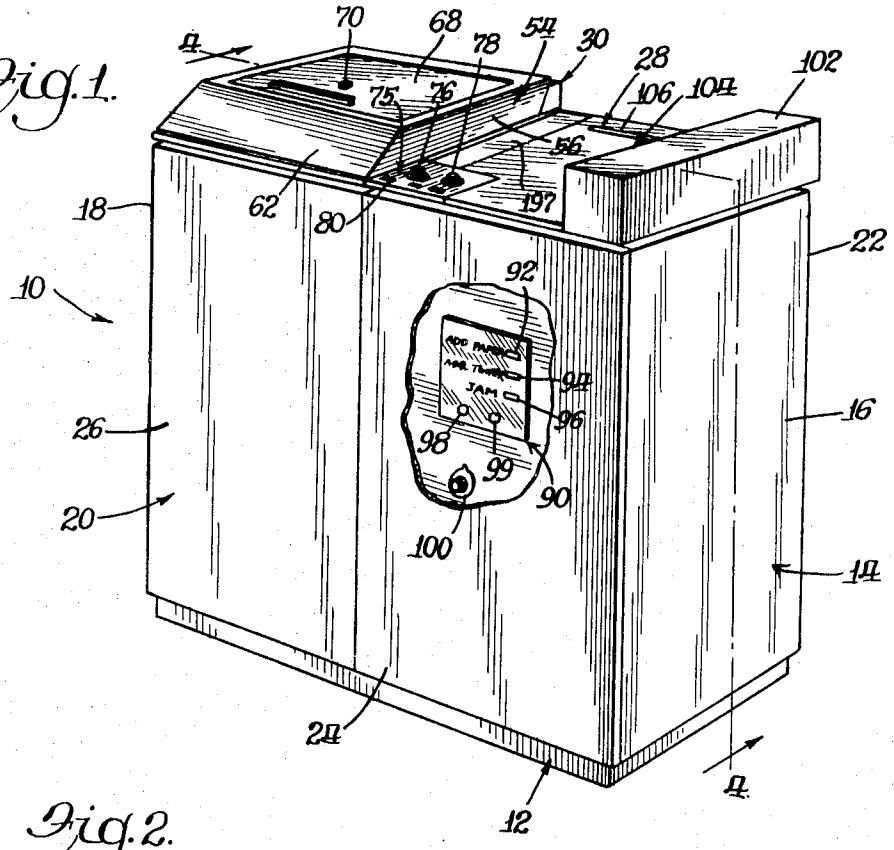


Fig. 2.

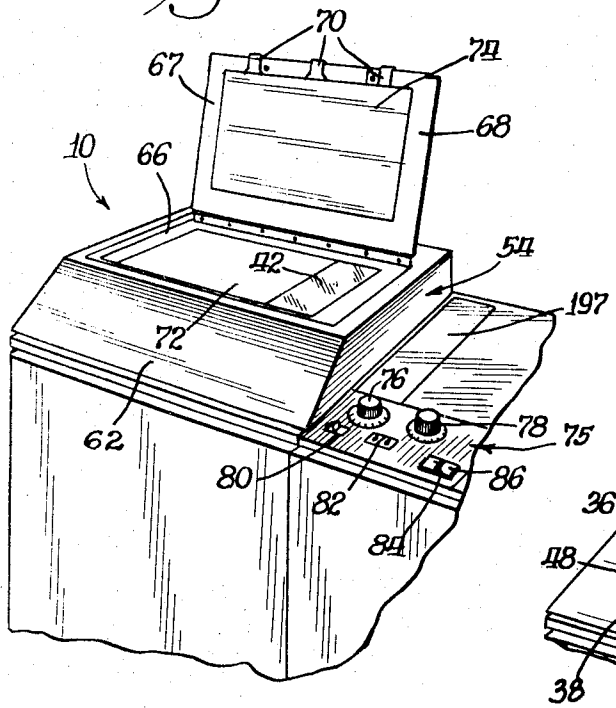
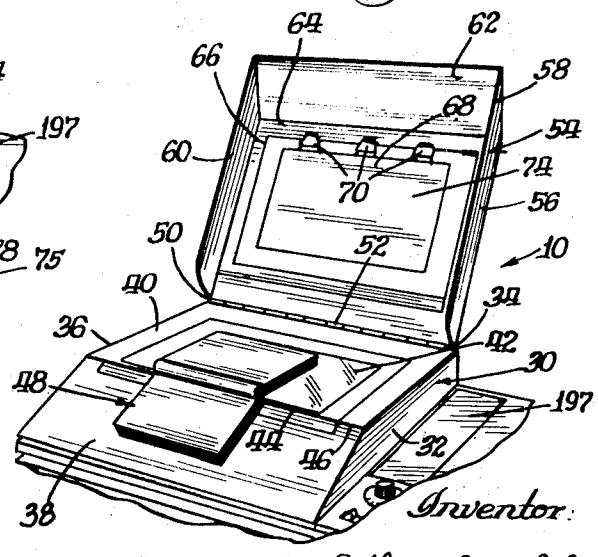


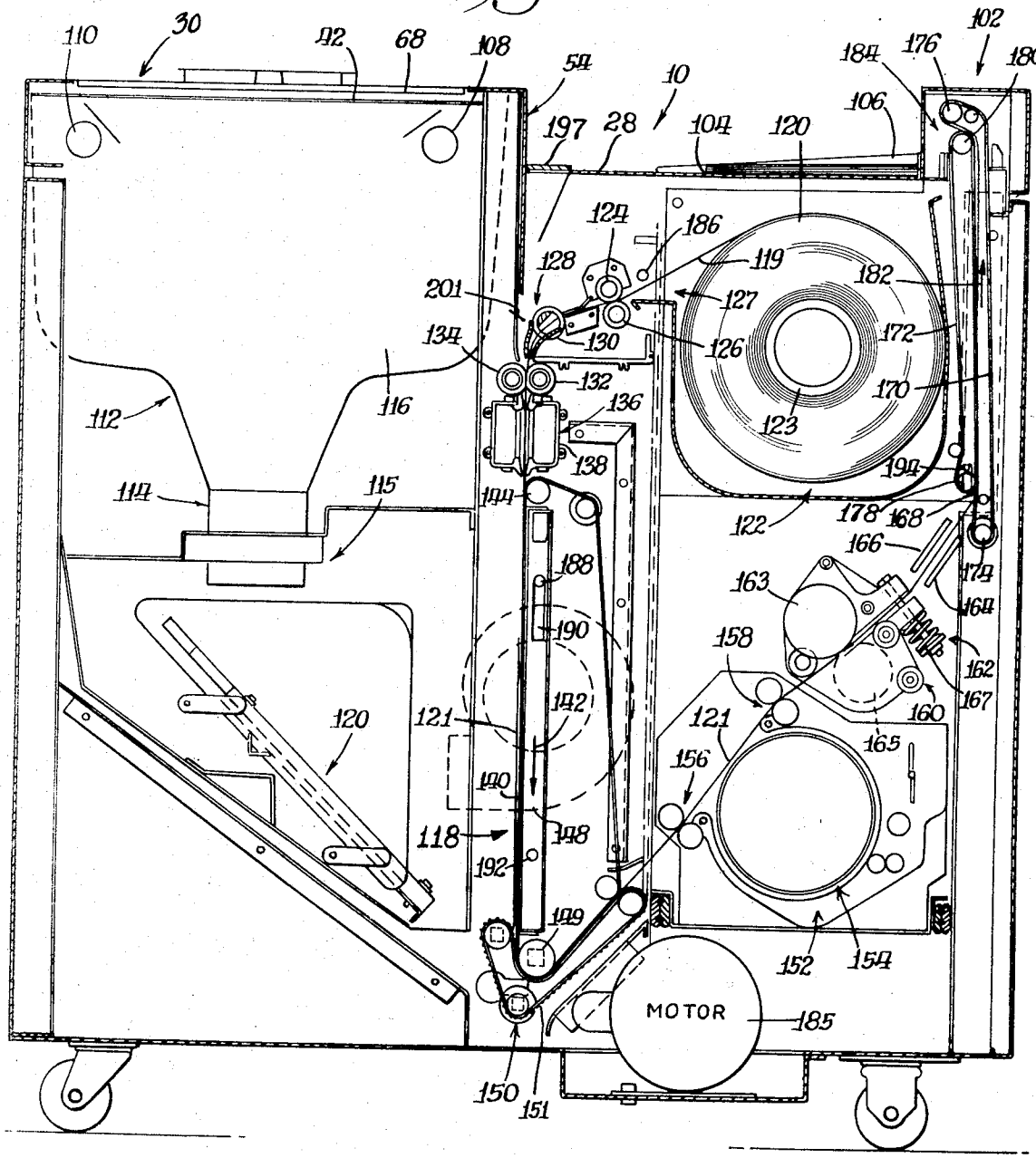
Fig. 3.



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Fig. 2.



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SHEET 3 OF 3

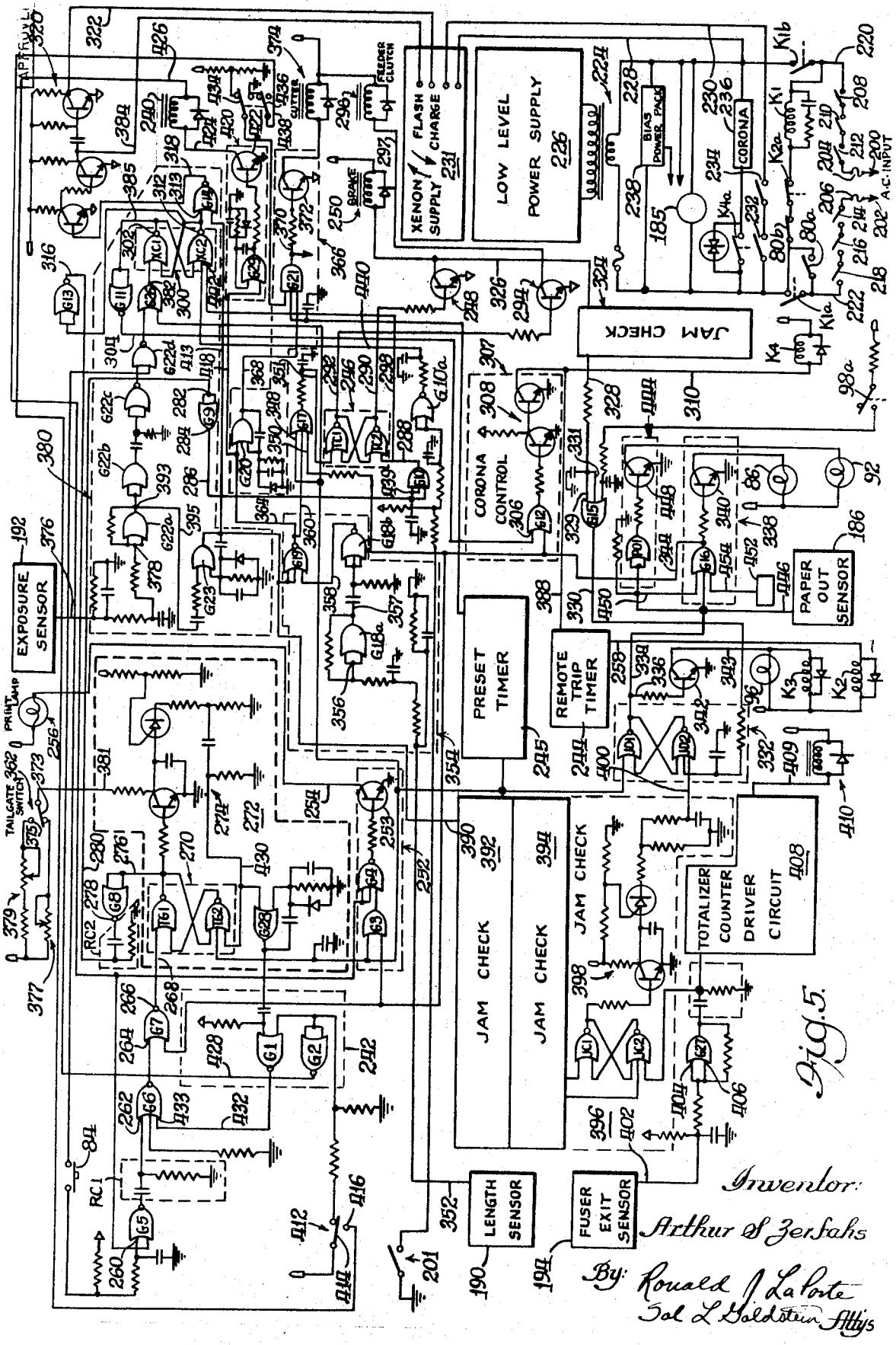


Fig. 5.

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HIGH SPEED PHOTOELECTROSTATIC COPYING MACHINE

BACKGROUND OF THE INVENTION

This invention relates generally to copying apparatus and more particularly to high-speed electrostatic copiers.

The technology of making copies of a graphic original electrostatically involves the application of a uniform electrostatic charge in the dark to a photoconductive surface, selectively discharging the surface by exposure to a pattern of light and shadow in accordance with the original being copied to provide a latent electrostatic image, and rendering the latent image visible by applying finely divided electroscopic particles. The latent image can be developed directly on a photoconductive copy sheet or on another surface from which the visible image is subsequently transferred to a plain sheet.

A wide range of copying machines are available to carry out the foregoing operations. Many copiers of the type which develop the latent image directly on a photoconductive copy sheet employ a liquid developing technique. The use of such a technique makes it necessary to wet the copy sheet so as to apply the electroscopic particles, and subsequently to dry the copy sheet with electrical heating equipment provided in the machine, thereby to evaporate the wetness on the sheet and produce ultimately a dry copy.

While the above is a satisfactory developing technique, it is time consuming and tends to limit the number of copies produced in a given period of time. Furthermore, a great amount of heat is required to dry the wet copies. This, in turn requires a considerable consumption of electrical energy, making it necessary to provide high voltage wiring for the machine.

Other machines use, instead of a liquid developer, a dry toner or developer powder. Development through the use of such toner, however, normally requires a fuser which provides heat to the copy sheet causing the toner to melt and adhere or become fixed to the sheet. Such a fusing device uses a considerable amount of electrical energy to produce the heat necessary to melt and fix the toner. Also, a warm-up time is required to bring the fuser to a high enough temperature to begin making copies. Once warmed up, the fuser must be maintained at least somewhat heated to be able to make copies without a further waiting time.

In addition to the above, many of the electrostatic copying machines discharge the photoconductive surfaces of the copy sheets by exposure to incandescent lighting means. The incandescent light provides good exposure of the photoconductive surface, however, the copy sheet must be held in a stationary condition in the illuminating area and exposed for a given length of time in order that the photoconductive surface is adequately discharged by the light source. This too, increases the time cycle for making copies in the machine.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide a new and improved high-speed copying machine.

It is another object of this invention to provide a copying machine of the above-described type which can be operated on common 115-volt AC household current.

It is a more specific object of the present invention to provide a high volume electrostatic copying machine which utilizes zinc oxide or the like, coated photoconductive sheets.

It is still another object of the present invention to provide a copying machine of the above-described type for processing a pre-selected number of copies of an original document with predetermined spacing between the copies, and wherein the spacing is variable in accordance with the pre-selected length of the copies.

Briefly, a preferred embodiment of a high-speed copying machine according to the invention comprises a housing with a generally uniplanar upper surface. An illuminating station is provided at one end of the housing along a raised upper surface thereof and it includes a transparent glass platen. An integral hinged cover portion and door arrangement is provided along the top wall to permit pages from bound volumes, as well as sheets of original material to be copied easily and accurately on the glass platen. A pair of xenon flash lamps mounted beneath the glass platen within the housing in a specially designed light box configuration provides the light source for a reflected light image which is supplied through an optical system including a reflecting assembly and a lens assembly, to an exposure station disposed in a substantially vertical plane within the housing. Because of the high intensity light given off from the xenon lamp, it need only be operated for a fraction of the time required with an incandescent light source. Furthermore, the copy sheet need not be stopped at the exposure station while being exposed as in the case where an incandescent light source is used.

The exposure station comprises one of the stations along the copy sheet path provided within the housing of the copying machine. Initially, the copy sheet makes up a portion of a roll of photoconductive paper, preferably zinc-oxide coated, mounted for rotation within the housing. The roll of photoconductive paper is passed through a series of rollers and a cutting assembly, and past a movable sensor which selects the length of a copy sheet.

A charging station, including a corona type charging unit, is provided downstream of the cutter assembly and upstream of the exposure station. Thus prior to exposure, the sheet is charged by the corona unit. While continually moving through the exposure station, the severed copy sheet is selectively discharged.

From the exposure station, the copy sheet passes to a developing station. The developing station in a preferred embodiment of the copying machine according to the invention includes a high speed developer of the dry magnetic brush type wherein electroscopic toner particles are transferred from the brush to the imaged areas of the copy sheet. It is to be understood, however, that other types of developers such as, for example, cascade, etc. may be used if desired.

Immediately downstream of the developing station there is provided a fusing station which causes the electroscopic toner particles applied to the copy sheet by the developer to be permanently affixed to the sheet. The fuser station includes a pressure fusing device which without the use of heat, and only by the application of a uniform pressure to the copy sheet causes the toner particles to adhere permanently to the paper. The pressure fuser is extremely fast in fixing the toner and because no heating is required as in the case of conventional heat fusers or dryers, no great power consumption is necessary. Consequently, the copying machine according to the invention is operable on common 115-volt AC household current.

In addition to the instrumentalities described there is provided in the copying machine according to the invention, jam detecting sensors and associated circuitry which is effective to indicate copy paper jams occurring during the copying process. Furthermore, interlock safety switches are provided at various locations about the copying machine housing to disable the operation of the machine in the event cabinet doors are open, the instrumentalities of the machine are out of normal operating position, etc.

The copying machine according to the invention is further equipped to handle pre-cut copy sheets if desired. Circuitry provided in the machine disables the copy paper roll feeding mechanism upon insertion of a pre-cut copy sheet into the machine. The copy sheet is processed in the same manner as a sheet cut from the roll.

DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention and its organization and construction may be had by referring to the description below in conjunction with the accompanying drawings wherein:

FIG. 1 is a perspective view of a preferred embodiment of a high-speed electrostatic copying machine according to the invention;

FIG. 2 and FIG. 3 are enlarged fragmentary perspective views of the original receiving glass platen of the copying machine of FIG. 1 illustrating in greater detail the hinged door and cover arrangement used in copying single sheets or bound volumes and the like, respectively;

FIG. 4 is a longitudinal cross sectional view of the copying machine of FIG. 1 taken along the line 4—4; and,

FIG. 5 comprises a schematic diagram of the electrical circuitry of a preferred embodiment of a high-speed copying machine according to the invention.

DETAILED DESCRIPTION

Referring now to the drawings more in detail, FIGS. 1–3, thereof illustrate a high-speed electrostatic copying machine **10** according to the invention. The machine includes a base support **12**, a housing portion **14** mounted on the base support **12**, including a pair of end walls **16**, **18** (**18** not shown) and a front and back wall **20**, **22**, respectively (**22** not shown). Front wall **20** includes a pair of hinged doors **24**, **26** which can be opened for access to the instrumentalities of the machine.

The top or upper wall **28** of the copying machine **10** includes a raised original sheet illuminating station or table **30** (FIG. 3). The raised illuminating table **30** includes three vertically oriented side walls, **32**, **34**, **36** (**34**, **36** not being shown in FIG. 3), and an inclined side wall **38**. The side walls support a top wall **40** which includes an original receiving window or glass platen **42** (FIG. 3). One edge **44** of the glass platen **42** is coextensive with the upper edge **46** of wall **38** to accommodate a book or bound volume original **48** as shown in FIG. **3**.

Attached along edge **50** of upper wall **40** by a hinge **52** (FIG. 3) is a cover portion and door assembly **54** for covering an original being copied on the glass platen **42** to suppress the flash effects of the light and to hold the original against the glass platen.

The assembly **54** includes a cover portion **56** having opposite side walls, **58**, **60** an inclined wall **62** attached therebetween and a top wall **64** interconnecting the aforementioned walls. The cover portion **56** is of a size large enough to be closed over raised original sheet receiving table **30** with the walls **58**, **60**,**62** extending along side respective walls **32**, **36** and **38** of the table **30** (FIG. 2). An aperture **66** is provided in the top wall **64** of the cover portion **56** and a hinged door member **68** is provided therein for closing off the aperture. A latch mechanism **70** serves to lock door member **68** in a closed position if desired.

In the case wherein a book or bound volume such as **48** is to be copied, the door **68** is latched and the cover portion is pivoted about hinge **52** to an open position. The book is placed on the glass platen and the other half of the book extending over inclined wall **38**. The cover portion **56** is then closed over the book **48** to eliminate light other than that of the illuminating source of the machine.

If a single sheet original, such as **72**, is to be copied, the cover portion **56** is positioned over the table **30**, and the door **68** is opened as shown in FIG. **2**. After the sheet is placed on the glass platen, the door **68** is closed to shield the operator against the flash generated during the copy cycle, and the copy process can begin. A white or reflective center portion **74** of an area similar to that of the glass platen **42**, is provided on the inside surface **67** of door member **68** to aid in illuminating original documents to be copied by reflecting the light from the light source of the machine. The white center portion **74** is especially useful when copying translucent or transparent originals.

Adjacent table **30** along upper wall **28** of the copying machine is an operator control panel **75**, best seen in FIG. **2** of the drawings, comprising a first control dial **76** for selecting the copy sheet length desired, an exposure selector control dial **78** for varying the energy provided to the illumination source of the copy machine, an on-off control button **80**, a copy number selector dial **82**, a print switch or button **84** and a service lamp **86** which indicates the need for attention to the machine.

The last-mentioned service lamp **86** indicates that one of three conditions has occurred in the machine to prevent further operation thereof. In order for the operator to determine which malfunction condition exists, door **24** of machine **10** is opened to reveal another control panel **90**, shown in the cut away portion of door **24** in FIG. **1**. On control panel **90** there are provided three lamps, **92**, **94**, **96** and corresponding indicia indicating the function of the lamp. Lamp **92** when lighted indicates the need for additional paper in the machine. Thus, paper must be added before the machine again functions. Lamp **94** indicates the need for the replenishment of toner in the developer of the machine, and lamp **96** when lighted, indicates that a jam has occurred in the machine.

With the jam detection arrangement of the copying machine **10** when a jam occurs, the lamp is lighted. However, after the cause of the jam is corrected, the machine remains inoperative until a jam reset button **98** is depressed. Thereafter the machine is returned to normal operation. The reset button has been provided as a safety measure which requires a positive action by the machine operator subsequent to the curing of a jam to cause the machine to function properly. Another button **99** is provided to manually add toner to the developer of the machine in the event copies are showing less contrast.

Below the panel **90** there is provided a bias control dial **100** which permits an operator to increase or decrease the bias potential in the developer of the machine. The above-described controls will be discussed in greater detail hereinafter when a full description of the operation of the machine **10** is given.

Moving to the right side of top or upper wall **28** of the copying machine **10** as seen in FIG. **1** there is provided a copy sheet outlet or exit, station **102** whereat a completed copy emerges from the machine to be stacked on the top wall **28** in the space **104**. A stacking guide **106** is provided in space **104** to aid in stacking completed copies.

Referring now to FIG. **4** of the drawings there is shown the interior of the machine **10**, revealing the instrumentalities used in carrying out the copy making process.

At the upper left of the copying machine **10** there is shown the illuminating station **30** including glass platen **42** for receiving an original document to be copied, along with the cover portion and door assembly **54** used to block out external light as well as to shield the operator from the pair of xenon light sources **108**, **110** used to illuminate the original. A light box **112** designed for efficient illumination of the original document is provided below platen **42** in the interior of the machine. An optical system including a lens assembly **114** communicating with the interior **116** of the light box is provided for projecting an image of the original to a copy sheet exposure station **118**. A mirror **120** included in the optical system mounted at approximately a 45° angle beneath lens system **114** and in optical alignment between the lens system and exposure station **118** is employed to reflect an image of the original projected by the lens assembly to sensitized copy material **119** moving past exposure station **118**.

A roll **120** of sensitized copy material **119** is positioned in container **122** on a spindle **123** provided thereon at the upper right hand corner of the machine just beneath upper wall **28**, as seen in FIG. **4**. Copy material **119** from the roll passes from container **122** via feed rollers **124**, **126** along copy paper path **127** through cutter station **128** whereat there is included a rotary cutter assembly **130** used to sever selected lengths of copy sheets from the roll **120**.

Downstream of cutter station **128** along the copy paper path is a pair of feed rollers, **132**, **134**, used to carry sensitized copy material **119** through charging station **136**. Charging station **136** includes a double corona charging unit **138** which effec-

tively charges the sensitized copy material as it is moved therepast prior to the selective discharging thereof in exposure station **118**.

A sensitized copy sheet **121** after being severed from the roll of copy material **119** is carried through exposure station **118** by means of belts **140** which are carried in an anti-clockwise direction as shown in FIG. **4** about rollers **144**, **149**. A vacuum plenum **148** provided behind the moving belts, **140**, serves to cause a reduction in pressure along the surface of the belts in exposure station **118** so that the now severed sensitized copy sheet **121** is held flat against belts **140** as it is imaged. The copy sheet is imaged while being moved through exposure station **118** without stopping.

As the imaged copy sheet leaves exposure station **118** its direction is changed by means of belt arrangement **150**, to be carried past the developer station **152** of the copying machine. The belt arrangement **150** includes belt member **151**, so that the charged surface is engaged by the surfaces of the belt members. At developer station **152** there is provided a high-speed magnetic brush developer assembly **154**, capable of developing copy sheets at the speed of approximately 60 – 70 feet per minute. Feeder roller pairs **156**, **158** are employed to carry the imaged copy sheet past the developer whereat toner particles are attracted to charged areas thereon.

After the toner particles have been applied to the imaged copy sheet paper at developer station **152**, the developed copy sheet is carried through fuser station **160**. At fuser station **160** there is provided a highly efficient, extremely fast fixing, fuser device **162** which uses only pressure (no heat) to fix the loose toner particles adhering to the charged areas of the copy paper. The fuser device includes a pair of roller members, **163**, **165** , mounted in relatively high pressure driving engagement with respect to each other. The pressure is applied by means of coil spring member **167**. A developed copy sheet **121** is transported between the roller members, the pressure applied by the rollers rapidly and efficiently causes the fixing of the toner particles to the surface of the sheet.

The use of such a fuser device plays an important part in the speed at which copies can be made in the copying machine according to the invention. Furthermore, because there is no heat requirement, the machine consumes far less energy and can operate on conventional household current. For a more detailed description of a fuser device of the type shown in FIG. **4**, reference should be made to copending patent application, Ser. No. 694,515 assigned to the same assignee.

Subsequent to passing through the pressure fuser device **162** in fuser station **160**, the completed copy sheet is channeled via guide member **164**, **166** to the nip **168**, of a pair of endless belt feeders **170**, **172** mounted for movement about respective rollers **174**, **176**, and **178**, **180**. The completed copy sheet is sandwiched between the moving belts and is carried upwards in the direction of arrow **182**, to the exit **184** of exit station **102** whereat the sheets are delivered to area **104** provided to receive completed copies, along top wall **28** of the copying machine **10**.

It should be noted that the copy material is transported along the copy paper path **127**, through the copying machine **10** at slightly increasing speeds as it passes from station to station. The progressive, slight increase in speed of the paper prevents buckling as the latter passes to a subsequent processing station. A single drive motor **185** supplies the power to the rollers and belts transporting the copy material along the copy path. Gear arrangements (not shown) are provided to alter the speeds as described. Belts **140**, feed rollers **132** and **134**, belt arrangement **150** and belts **170**, **172** are operated continually. The operation of feeder rollers **124** and **126** however, is controlled through circuitry to be described hereafter.

There are provided in copying machine **10**, along copy paper path **127** sensors for monitoring the paper as it passes therealong to ensure efficient operation of the machine.

Just prior to feed rollers **124**, **126**, upstream of cutter station **128**, whereat the leading edge of the roll of sensitized copy paper **119** is normally positioned, there is provided a sensor **186** for indicating the presence of copy material. In the event the paper is depleted from roll **120**, the sensor **186** causes lamp **92** (FIG. **1**) as well as lamp **86** (FIG. **2**) to be lighted. Furthermore, the operation of the instrumentalities of the machine are inhibited until such time as the paper is replaced.

Downstream of the charging station **136** there is provided a copy sheet length sensor **188** which is manually movable in a predetermined vertical path **190**, adjacent exposure station **118**, by means of control knob **76** discussed heretofore. As will be explained in greater detail hereinafter, the positioning of the length sensor determines the length of copy sheet **121**, cut from the roll **120** of copy paper **119**.

The length sensor **188** serves another purpose also. Upon the depression of the print button **84** (FIG. **2**) to initiate the copying cycle, including the feeding of copy paper from its normal position along the copy paper path, a failsafe timing circuit jam check is energized. The timing circuit, which will be described in greater detail hereinafter, once energized, "-times-out" for a predetermined time period sufficient to permit the movement of the loading edge of the copy paper from its normal position to sensor **188**. If the paper reaches sensor **188**, prior to the "timing-out" of the timing circuit, the copying cycle proceeds normally. On the other hand, if the copy paper should be detained for any reason without reaching the sensor **188** and the timing circuit "times-out", a jam is indicated at service lamp **86** and lamp **96**, and the copymaking instrumentalities of the machine are automatically shut down. Because the sensor **188** is movable toward and away from the normal position of the leading edge of copy paper **119**, the timing circuit "time-out" period is sufficiently great to permit the copy material to reach sensor **188** at a point farthest from the initial position of the copy material, thus ensuring the normal movement of the copy material without a false jam alarm.

Further along the copy paper path **127** near the exit of exposure station **118**, there is provided an exposure sensor **192**. Sensor **192** is used to monitor the movement of the leading edge of a severed, charged copy sheet **121**, proceeding along the copy paper path **127**. Upon sensing the leading edge of a copy sheet **121**, illumination of the original document and exposure of the copy sheet takes place. The copy paper is exposed while being moved through exposure station **118**.

In addition to causing the exposure of the copy sheet to take place, second multi-stage jam check circuitry is actuated. The jam check circuit cumulative time out period is sufficient for an exposed copy sheet exiting the exposure station to pass through developer and fusing stations **152**, **160** respectively, and emerge from the latter station at the entrance to the exit feed belts **170**, **172**. Located at the fuser exit is a fuser exit sensor **194**. If the copy paper passes from the exposure station through the developer and fusing stations and reaches sensor **194** prior to the "timing-out" of the jam check circuitry, actuated when the paper passed sensor **192**, the circuitry is interrupted and the paper continues to pass into the nip of belts **170**, **172**. On the other hand, if the paper, for some reason (jam, etc.) does not reach the sensor **194** within the "time-out" period, then a jam signal is provided and the operation of the feed rollers and copy processing instrumentalities is discontinued.

,Once safely past the sensor **194**, the completed copy sheet **121** is carried out of the machine at exit **184**, and is stacked on the upper wall **28** in the area **104** provided therefor.

A more detailed description of the sensor and timing circuit arrangements will be given hereinafter when discussing the circuitry of copying machine according to the invention illustrated in FIG. **5**.

FIG. **5** illustrates a preferred embodiment of the circuit diagram for a high-speed copying machine according to the invention wherein conventional symbols are used to identify the various logic gates employed in the circuit, i.e. D is an "OR" gate Do is a "NOR" gate, and D is an "AND" gate.

Referring to the lower right hand corner of the circuit diagram, there is shown the input terminals **200,202**, each connected through a respective circuit breaker or fuse **204, 206**, to a 115-volt, A.C. source (not shown) for powering the circuit.

A plurality of interlock switches **208, 210, 212, 214, 216**, and **218**, is provided to ensure that the instrumentalities of the machine are positioned correctly before the machine will function. When all stations of the machine are in a normal operational condition, and the exterior doors of the machine are closed, the above-mentioned switches are also closed, so that current flows via leads **220, 222**.

Connected between lines **220, 222** are the contacts **80*a*, 80*b*** of on-off switch **80** (FIG. 2). The momentary operation of switch **80** closes normally open contact **80*a*** to in turn energize relay **K1** through normally closed contact **80*b*** and normally closed contacts **K2*a*** of the remote trip relay **K2** to be discussed hereinafter. The energization of relay **K1** closes relay contacts **K1*a*, K1*b*** to provide power via transformer **224** to low level power supply **226**. A holding circuit through contacts **K1*a*** and normally closed on-off switch contacts **80*b*** maintains relay **K1** operated so that power continues to be provided to the power supply **226**. Another momentary actuation of switch **80** causes normally closed contacts **80*b*** to open, shutting down the machine.

Also connected to 115-volt power leads **220, 222**, via leads **228, 230**, is the xenon supply **231** which supplies power to lamps **108, 110** (FIG. 4) during exposure. A pair of interlock switches **232, 234**, connected to lead **230**, ensures the operational preparation of the xenon supply **231** before power can be supplied thereto.

A corona supply unit **236** used to power the corona charging unit **138**, (FIG. 4) is connected across the 115-volt leads **220, 222**, through a relay contact **K4*a*** of corona control relay **K4**. In addition, motor **185** (FIG. 4) which drives the copy material transport rollers and belts (FIG. 4) is connected between the 115-volt power supply leads **220, 222**. A bias power pack **238** likewise is connected to the power lead **220** to provide a bias potential in the developer station **152** (FIG. 4).

It is to be understood that the low level power supply **226**, powered through transformer **224** provides low level operating voltages on the order of +5 volts and +27 volts to the copying machine circuitry at various locations (not shown), through standard filter networks (not shown).

The circuitry of copying machine **10**, includes a print button or switch **84** (FIG. 2) for initiating the copy process. For single copies, the switch **84** must be depressed each time a copy is to be made. In the event many copies of an original are to be made, the copy number selector **82** (FIG. 2) is dialed to the number of copies desired, and the count down counter **240** (FIG. 5) counts off one digit after the processing of each copy. To initiate the copying process for each copy during the multiple copy mode, there is provided a multiple copy enabling gate arrangement **242** (FIG. 5) including gates **G1** and **G2**. This will be discussed in greater detail hereinafter.

Upon actuation of the on-off switch **80** to supply power to the copying machine circuitry, the remote trip timer **244** and the preset timer **245** shown in FIG. 5 in block form, each of which includes the usual timing circuit components known in the art, are supplied power from power supply **226**. The timers **244, 245** immediately begin "timing-out". The preset timer "-time-out" period is approximately 0.6 seconds. During this brief period, the logic of the machine circuitry is set at a normal state and made ready for operation. The copy paper transport control register **246** including gates **TC1, TC2**, is set to its normal state which in turn operate transport brake transistor driver **248**. The last-mentioned transistor driver causes the copy roll brake **250** to be energized, thereby to prevent the movement of copy paper roll **120** (FIG. 4). The print light control and driver circuitry **252**, including gates **G3, G4** and transistor **253**, and energizes via lead **254** print lamp **256**, indicating the machine is ready to accept a copy command.

If no print command is given the copying machine, within approximately 25 seconds, the "time-out" period for the remote trip timer **244**, the last-mentioned timer via lead line **258**, causes remote trip relay **K2** to be energized. The energization of relay **K2** opens contacts **K2*a*** in the holding circuit for relay **K1**, to in turn deenergize the last-mentioned relay and open contacts **K1*a*, K1*b***, thus preventing power from the AC source from operating the power supply **226** and the copy machine circuitry. To operate the machine, on-off switch **80** must be reactuated.

In the event a print command is given to the machine, prior to the remote trip timer **244** timing out, whereby print button **84** is depressed, the machine proceeds as follows to produce a copy of an original positioned on the original sheet receiving table **30** (FIG. 3) along the top wall of the machine.

Upon depression of button **84**, a pulse is received at the input **260** of gate **G5**. The output of gate **G5** passes through RC network **RC 1** to provide a position pulse at the input **262** of gate **G6**, which in turn provides a pulse to gate **G7** at the input **264** thereof. A pulse at the output **266** of gate **G7** is sent via lead **268** to the tailgate register **270**, including gates **TG1** and **TG2**, of the tailgate register and timer circuitry **272**, (shown in dotted lines). The register **270** changes states to begin the "timing-out" of the timer portion **274** of the circuitry. The change of state in register **270** causes, via lead **276**, gate **G8** to supply a pulse at the output **278** thereof. The pulse emanating from RC circuitry **RC2** which is approximately of an 80 micro-second duration, travels over lead **280** to the input **282** of gate **G9** and in turn from the output **284** thereof, along lead **286** to gate **G10**, An output from gate **G10** over lead **288** changes the transport control register **246**. A resulting signal over lead **290**, renders transport brake driver **248** non-conductive and releases copy roll transport brake **250**. The change of state of register **246** also causes, via lead **292**, transport clutch driver transistor **294** to become conductive, operating roll feeder clutch **296** over lead **297** to begin the feeding of copy paper from roll **120** (FIG. 4).

The output from gate **G10** also provides, over lead **298**, an operating signal to xenon and corona control register **300** including gates **XC1, XC2**. The changing of the state of register **300** accomplishes three things: (1) a signal is sent from the output **302** of gate **XC1** through gate **G11** and over lead **304** to the input **306** of gate **G12** of the corona control circuit **307**. The output of gate **G12** operates transistor relay driver circuitry **308** to energize relay **K4** over lead line **310**. The operation of relay **K4** closes contacts **K4*a*** to operate the corona supply unit **236**; (2) a signal from the output **312** of gate **XC2** is sent via lead **314** to gate **G13**. The output of gate **G13** is carried over lead **316** to the input of gate **G4** in the print lamp driver circuitry **252** to in turn, turn off the print lamp **256** indicating a copy is being processed; (3) a signal from the output **312** of gate **XC2** is established at the input **313** of gate **G14** and the output of the last mentioned gate provided over lead **318** to the xenon control transistor circuit **320** causes, via lead **322**, the charging of xenon supply **231**.

When the copy roll transport control register **246** changed states to begin feeding copy paper from roll **120** (FIG. 4), a fail-safe timer mechanism or jam check **324** also was energized over lead **326** from the output of transistor driver **248**. The function of the jam check **324** is to ensure that the moving copy paper from roll **120** reaches the paper length sensor **188** provided along the copy paper path of the copying machine (FIG. 4) without jamming. The "time-out" period of jam check **324**, is such that copy paper traveling at the normal speed of the machine can reach the farthest possible setting of the length sensor **188** along the copy paper path **127** (FIG. 4).

In the event the copy paper gets jammed in the machine between its normal idle position, at the entrance to cutter **130** (FIG. 4), and the length sensor, the machine is stopped from further operation to prevent further jamming etc. In fact, if the jam check **324** "times-out" before the copy paper reaches length sensor **188** which preferably includes a photo responsive or the like device, a pulse appears at lead **328** and at the

inputs 329, 331, to gate G15. The output from gate G15 carried over lead 330 causes the changing of state of the jam detecting register 332 including gates JD1, JD2. An output signal from JD1 via leads 334, 336, respectively, causes malfunction detector circuitry 338, including gate G16 and transistor driver 340, to operate the service lamp 86 (FIG. 2) and transistor driver 342 to operate via lead 343, jam lamp 96 (FIG. 1 and energizes the normally deenergized manual jam reset relay K3).

The output of gate G16 is also connected via lead 344 to the input of gate G12, and inputs 348, 350 of gate G17 which in turn is connected via lead 351 to the input of gate TC1 of the transport control register 246. Signals via the last-mentioned leads, serves to disable the feeding of copy paper from roll 120, resetting transport control register 246, to actuate brake 250 and deactuate feeder clutch 296, and the operation of corona supply 236, respectively. Once a jam is cured, manual reset button 98, which operates switch 98*a* (FIG. 5) must be reset to once again reset relay K3. The latter must be done before the copying machine instrumentalities are functional.

If no jam occurs and the copy paper from roll 120 reaches the pre-positioned length sensor 188 prior to the "timing-out" of jam check 324, when the leading edge of the copy paper is sensed by length sensor 188, a pulse is provided thereby along lead 352. The pulse is received at the length sensor circuit 354 at the input 356 to gate G18*a*, which in turn provides an output signal via lead 357 to gate G18*a*. A pulse from the output of gate G18*a* along lead 358 is provided at the input of G19. An output signal from gate G19 provides, in turn a signal along lead 360 to gate G17 which causes transport control register 246 to be reset, via a signal along lead 351 to the input of gate TC1. The last-mentioned occurrence stops the feeding of roll feeder clutch 296 and applies brake 250. Simultaneously with the cessation of the feeding of copy paper by feed rollers 124, 126 (FIG. 4) (20 milliseconds later) the output signal from gate G19 is carried over lead 364 to gate G20 of the cutter control circuit 366, shown in dotted lines. An output signal from gate G20 over lead 368 to gate G21, causes an output pulse over lead 370 from the last-mentioned gate to cause transistor driver 372 to conduct and operate cutter solenoid 374. The cutter 128 (FIG. 4) is rotated to sever a copy sheet 121 (FIG. 4) of a predetermined length from copy paper roll 120. In addition to actuating the cutter, the timing arrangement of jam check 324 is disabled so as not to indicate a jam condition. The signal which resets the jam check circuit is conveyed to jam check 324 via lead 326 from transport brake transistor driver 248. During the previously described occurrences, tailgate timer circuitry 274 continues to "time-out".

As the copy paper passed through the corona charging station 136 which was operated upon initiation of the copy making process it was charged. The now severed copy sheet 121, carried by the continually operated belts 140, proceeds toward sensor 192 (FIG. 4) to cause the exposure of the copy sheet as it moves through exposure station 118. From the time subsequent to the cutting of copy sheet 121 from copy roll 120, to the time the sheet reaches sensor 192, tailgate timer circuitry 274 times out and the tailgate register 270 is reset.

The "time-out" period for the tailgate timer 274 varies, depending upon the copy sheet length selected; i.e. by the positioning of length sensor 188. In every case, however, the "time-out" period is greater than the length of time it takes for the copy paper to reach the length sensor 188. For a copy sheet length less than 12 inches, the "time-out" period is approximately 1.2 seconds. For a copy sheet length greater then 12 inches, the "time-out" period is increased to approximately 1.8 seconds. This is accomplished when the copy length selector knob 76 (FIG. 2) is moved to the desired length. Connected to the shaft of the manually operable knob 76 is a tailgate switch 362. At a length setting less than 12 inches switch 362 is in the position shown in FIG. 5. At a length setting greater than 12 inches, the switch armature 373 is moved upwardly as shown in the figure, to contact 375. At the two settings a resistance circuit 377 or 379, as the case may be, is incorporated via lead 381, into the tailgate timer circuit 274, thereby to alter the "time-out" period thereof. The "time-out" periods are selected to maintain a predetermined distance between and thereby prevent the overlapping of successive copy sheets along the copy paper path of the copying machine according to the invention during the multiple copy mode. This will be explained in more detail hereinafter when discussing the multiple copy mode.

When the leading edge of the severed copy sheet 121 (FIG. 4) reaches exposure sensor 192, a signal emanating therefrom is sent over lead 376 to the input 378 of the first of a series of gates, G22*a*, G22*b*, G22*c*, G22*d*, G26, included in the exposure sensor circuit 380. A signal developed at the output 382 of gate G26 resets xenon-corona control register 300, causing, via xenon control circuit 320 and lead 384, the xenon supply to flash, exposing the copy sheet passing through exposure station 118. At the same time due to the resetting of register 300, a signal is carried over lead 385 to gate G11 and from there via lead 304 to the input 306 of gate G12 of the corona control 307 to in turn deenergize relay K4, turning off the corona control 236 and charging unit 138 (FIG. 4). In addition, a signal via gate G13, serves to relight the print lamp 256 indicating to the operator that another copy can be processed. Simultaneously with the operation of print lamp 256 the remote trip timer 244 is actuated over lead 388 to begin "timing-out".

The pulse developed when the copy sheet 121 tripped the exposure sensor 192, also causes a pulse at the output 393 of gate G22*a*. This pulse is carried over lead 395 to gate G23 whereat an output therefrom is produced and carried via lead 390 to the input of a series of jam check circuits 392, 394, 396. Each of the jam check circuits includes a register, such as that shown for jam check 396, comprising gates JC1, JC2, and timer circuitry, such as 398. The jam checks 392, 394 have been illustrated in block form for simplicity and to avoid duplication of structure. The pulse via lead 390 sets the register (not shown) of jam check 392 and starts the timer circuitry thereof "timing-out". The jam checks 392, 394, 396, operate consecutively to check for the jamming of copy sheets between the exposure sensor 190 and the fuser exit sensor 194, (FIGS. 4 and 5).

Subsequent to the "timing-out" of the timer circuitry of jam check 392, the register thereof is reset, and it in so doing sets the register of the subsequent jam check 394. The last-mentioned jam check 394 in turn "times-out" and thereafter sets the register of jam check 396. The provision of a series of jam checks operated consecutively permits the monitoring of several copy sheets in close succession along the copy paper path between the exposure sensor 192 and fuser exit sensor 194.

In the event a jam occurs between sensors 192 and 194, a signal is provided via lead 400 from jam check 396 to gate JD2 of the jam detection register 332 to change the state thereof and operate the jam lamp 96 and energizes manually resettable relay K3. At the same time, through gate G16, the malfunction lamp 86 is lighted indicating a jam has occured. A signal via lead 344 to the input 348 of gate G17, to the transport control register 246, stops the further feeding of copy paper from roll 120 by actuating brake 250 and deactuating feeder clutch 296.

If no jam occurs and the sheet reaches fuser exit sensor 194 safely, a signal emanating from fuser exit sensor 194, carried along lead 402 to the inputs 404, 406 of gate G27, serves to actuate totalizer circuit 408 to in turn via lead 409 operate totalizer counter 410. The last-mentioned counter totals the number of copies made by the copying machine 10 according to the invention, and may be used for billing purposes, etc.

During the course of travel of copy sheet 121 between exposure sensor 192 and fuser exit sensor 194, the copy sheet is developed at developer station 152 (FIG. 4) by the application of toner powder to the electrostatic image formed on the copy sheet at exposure station 118, and the toner powder is affixed to the copy sheet 121 in the fuser station 160 (FIG. 4) by pressure fuser device 162 provided therein.

Upon reaching the fuser exit sensor **194**, the leading edge of copy sheet **121** enters the nip of rotating belts **170, 172**. The copy sheet is held between the moving belts and carried thereby upwardly toward the exit station **102** of the copying machine to be deposited ultimately in a stack at the top of the copying machine (FIG. **4**).

The remote trip timer which was started earlier, "times-out" if no further copy processing command is given machine **10**, to turn off the machine as described heretofore.

In the case of multiple copies of an original being processed by the copying machine, the operator selects by means of copy number selector **82** (FIG. **2**), the number of copies desired. The copying process is initiated in the same manner as in the single copy mode, and the first copy is made as described above. However, when a single copy is requested, an inhibit signal from gate **G28**, connected to the tailgate register **270**, is applied to the multiple copy enabling gates **G1, G2**. Thus, no signals can be transmitted to the last-mentioned gates and only one copy can be made. On the other hand, in the multiple copy mode, the count-down counter is set at a number greater than zero. Furthermore, the multiple copy request switch **412** is placed automatically in an operated condition so that armature **414** thereof makes contact with contact **416**. Thus, each time the cutter control gate **G20** is actuated, a pulse is sent via lead **418** to the input of gate **G29** of the count-down control **420**. Transistor driver **422** of the last-mentioned control operates count-down counter **240** via lead **424**. This takes place until the count-down counter reaches a zero setting. When this occurs, switch **412** is returned to a normal condition.

During the multiple copy mode, the xenon and corona control register **300** remains in a set state and the print lamp remains unlighted through the processing of the number of copies selected. The signal provided to flash the xenon supply each time a copy is exposed emanates from gate **G23** upon the copy sheet being sensed at exposure sensor **192**. The signal is carried over lead **413** to the input of gate **G14**, which in turn via lead **318**, and circuitry **320** causes the xenon supply to flash. In addition, the remote trip timer **244** is prevented from "timing-out" until the corona control is unoperated, since the last-mentioned timer is controlled thereby over lead **388**.

The removal of the inhibit on the print line permits a pulse to be generated each time the tailgate timer circuitry **274** "-times-out". The pulse traveling over lead **430** to gate **G28** provides a pulse to gate **G1** of the multiple copy enabling gates. Gate **G1** in turn generates a print pulse over lead **432** to the input **433** of gate **G6** to reset the tailgate register **270** and begins the timer circuitry **274** operating again. This occurs for each of the selected numbers of copies, until the last copy is made.

As mentioned heretofore, the distance between copy sheets in the multiple copy mode is determined by the "time-out" period of the tailgate timer circuitry **274**. The "time-out" period is variable in accordance with the movement of the copy length selector knob **76**. Thus, for relatively long sheets, (i.e. greater than 12 inches) a print pulse is provided by the tailgate circuitry approximately every 1.8 seconds until the last of the selected number of copies is made, and for sheets less than 12 inches in length, a print pulse is provided approximately every 1.2 seconds. Since the transport register is reset to stop the feeding of copy material when the copy material reaches the length sensor, prior to the "timing-out" of the tailgate timer, (i.e. less than the "time-out" period) a safe distance is provided between successive copies, and no overlapping of sheets occurs.

The copying machine according to the invention is equipped to handle pre-cut copy sheets or offset-masters as well as roll fed copy paper from roll **120**. In the case wherein it is desired to process copies on pre-cut copy sheets, manual infeed door **197** (FIGS. **2, 3** and **4**) is opened in the direction of the arrow (FIG. **4**) so that the pre-cut sheets may be fed through a paper chute directly into the copy paper path of the machine. Upon opening door **197**, switch contacts **434, 436** (FIG. **5**) are operated to inhibit the operation of cutter **374**. Also, via lead **438** the print switch is disabled so that an inadvertant actuation of the print switch causes no operation of the machine.

When the pre-cut sheet is inserted, the manual bypass switch **201** causes a signal from gate **G10a** to be transmitted via lead **440** to the input **442** of gate **XC2** of xenon and corona control register **300**, and the remote trip timer **244** is disabled. The register changes states causing xenon supply **231** to charge corona unit **236**, to "turn on" for the charging of the pre-cut sheet and to turn the print lamp **256** off. The last-mentioned register remains set until the lead edge of the pre-cut sheet reaches exposure sensor **192**. In the time prior to reaching exposure sensor **192** the sheet is charged-up by passing through charging station **136** (FIG. **4**).

Upon the lead edge of the sheet reaching exposure sensor **192**, the xenon and corona control register **300** changes states, causing the corona unit **236** to cease functioning, the xenon supply to flash exposing the pre-cut copy sheet via the optical system lens **114** (FIG. **4**) to image the sheet, and the print lamp **256** turns on. In addition, the remote trip timer **244** is operated to begin timing out. Furthermore, the jam checks **392, 394, 396** are actuated via lead **390** to ensure the safe, jam-free passage of the copy sheet from the exposure station **118** to the fuser exit sensor **194** (FIG. **4**). The latter is accomplished in the manner described earlier for a copy sheet severed from the roll **120** of copy material.

The copying machine **10** according to the invention, as mentioned earlier, is also equipped with an out of paper detector **444** operated by paper out sensor **186** (FIGS. **4** & **5**). Sensor **186** provides a signal along lead **446** to gate **PO1** of the out of paper detector **444**. An output signal from the last-mentioned gate serves to place transistor driver **448** in a conductive state. The transistor driver **448** in turn operates the add paper lamp **92**. The signal along lead **446** serves also to provide at input lead **450** of gate **G16** to the malfunction detector **338** to, in the manner described heretofore, light service lamp **86** on the top wall of the copying machine. In addition to lighting the lamps, an output from gate **G16** along lead **344** resets the xenon and corona control register **300**, to prevent operation of the corona unit **236** and the xenon supply **231**. The transport register **246** is also reset, preventing operation of feeder clutch **296** which controls the movement of roll **120**, etc. In addition, print lamp **256** is maintained in an off condition, and the print switch **84** is locked out and prevented from being operated.

An out of toner sensor **452** is included in the developer station **152** (FIG. **4**) to indicate the depletion of toner mixture therefrom. Upon detecting the lack of toner material, a signal is generated at lead **454** to gate **G16**, shutting down the operation of the copying machine in the manner described above in the case of the out of paper detector **444**. In addition, service and add toner lamps, **86, 94**, (not shown in FIG. **5**) respectively, are lighted.

Also, included in the developer station **152**, but not shown or described herein, is an arrangement for maintaining the amounts of toner powder and carrier particles at a constant ratio to provide optimum print density, etc. A detailed explanation of such an arrangement may be found in U.S. Pat. No. 3,399,652.

Thus there is provided by the instant invention, a copying machine for processing at a relatively high speed (on the order of 60–70 feet per minute) copies of an original document. Through the utilization of xenon lamps in the illumination of an original to expose copy sheets as they pass through the exposure station as well as pressure fusing, the copy machine is able to process a copy with substantially no stoppage thereof. Because of the pressure fusing arrangement which requires no heat for fusing toner material to the surface of a copy sheet, the machine may be operated on household current and requires no warm-up period prior to processing copies.

While a particular embodiment of the copying machine according to the invention has been shown and described, it

should be understood that the invention is not limited thereto since many modifications may be made. It is therefore contemplated to cover by the present application any and all such modifications as fall within the true spirit and scope of the appended claims.

What we claim is:

1. In an apparatus for making multiple copies of an original on copy material, comprising copy processing stations including charging, cutting, exposing and developing stations spaced along a copy path, a copy material supply including a roll of copy material, copy material transport means for feeding copy material from said roll into said path at a predetermined rate, said cutting station including cutter means for severing predetermined lengths of copy material from said roll, copy selector means for selecting a predetermined number of copies to be made by said apparatus, control circuit means connected to said copy selector means and said transport means for controlling the feeding of copy material from said supply in accordance with the number of copies selected, said control circuit means including timer means having a predetermined time-out period, said timer means being operable to cause said control circuit means to operate said transport means at the beginning of each time-out period, the number of time-out periods of said timer means being controlled in accordance with the number of copies selected, and sensor means positioned at a critical location along said path for sensing the arrival of said copy material thereat, the operation of said transport means being discontinued and said cutter means actuated to sever a length of copy material from said roll in response to the sensing of said material by said sensor means said copy material arriving at said sensor means a predetermined time prior to the timing out of said timer means, thereby to provide corresponding spacing between successive lengths of copy material.

2. The apparatus of claim 1 further including copy length selector means operable to adjust the positioning of said sensor means along said copy paper path, said copy length selector means being connected to said control circuit means for varying said time-out period of said timer means, whereby said predetermined time period is varied in accordance with copy length selection.

3. The apparatus of claim 2 wherein said predetermined time period is of a first duration when said selector means is operated to select a copy length less than a predetermined length and is of a second, greater duration when said copy length selector is operated to select a copy length greater than a predetermined length.

4. The apparatus of claim 3 further including switch means connected electrically to said timer means for varying said time-out period, said switch means having a first position wherein said time-out period is of said first duration and a second position wherein said time-out period is of said second duration, and wherein said length selector means is coupled to said switch means and movable in a first direction to operate said switch means to said first position and movable in a second direction to operate said switch means to said second position.

5. A copying machine for making multiple copies of an original on copy material comprising

copy processing stations including charging, exposing and developing stations spaced along a copy path,

a copy material supply,

copy material transport means for feeding copy material from said supply into said path at a predetermined rate,

copy selector means for selecting a predetermined number of copies to be made by said machine,

control circuit means connected to said copy selector means and said transport means for controlling the feeding of copy material from said supply in accordance with the number of copies selected, said control circuit means including timer means having a predetermined time-out period, said timer means being operable to cause said control circuit means to operate said transport means at the start of each time-out period and operable to initiate another time-out period at the termination of a previous time-out period, the number of time-out periods of said timer means being controlled in accordance with the number of copies selected,

and sensing means positioned at a critical location along said path for sensing the arrival of said copy material thereat,

the operation of the transport means being discontinued in response to the sensing of said material by said sensing means, said copy material arriving at said sensing means prior to the timing-out of said timer means, thereby to provide spacing between successive lengths of copy material.

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