United States Patent [19]

Miciukiewicz et al.

[11] **3,797,347**

[45] **Mar. 19, 1974**

[54] **SEQUENCE CONTROL APPARATUS FOR ELECTROPHOTOGRAPHIC COPYING MACHINE**

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[73] Assignee: **Pitney-Bower, Inc.,** Stamford, Conn.

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[21] Appl. No.: **275,455**

Related U.S. Application Data

[62] Division of Ser. No. 74,737, Sept. 23, 1970.

[52] **U.S. Cl.** **83/205,** 83/265

[51] **Int. Cl.** **B26d 5/26**

[58] **Field of Search** 83/203, 209, 265, 275, 83/205; 355/13, 28, 29

[56] **References Cited**

UNITED STATES PATENTS

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Primary Examiner—J. M. Meister

Attorney, Agent, or Firm—Martin D. Wittstein; William D. Soltow, Jr.; Albert W. Scribner

[57] **ABSTRACT**

An apparatus for controlling the sequential operation of several functions of a fully automatic electrophotographic copying machine. The copying machine has the capability of projecting an image of indicia on a moving document to a piece of copy paper which is moving in synchronism with the document, and of developing a visible image of the indicia on the copy paper. The disclosed apparatus controls, in response to sensing the leading edge of the document, the energization and de-energization of an illuminating lamp, an electrostatic charger, the commencement of feeding of copy paper, the moment of operation of a severing mechanism for severing a sheet of copy paper from a roll thereof and the feeding of a minimum length of copy paper, regardless of the length of the original document, to prevent pieces of copy paper less than that minimum length from being fed through the machine. The apparatus has features of adjustability which assure that sheets of copy paper will be severed from the roll having a length in exact accordance with the length of the original document, and which assure that the indicia on the original document will be reproduced on the sheet of copy paper in exact accordance with the position of the indicia on the document.

24 Claims, 10 Drawing Figures

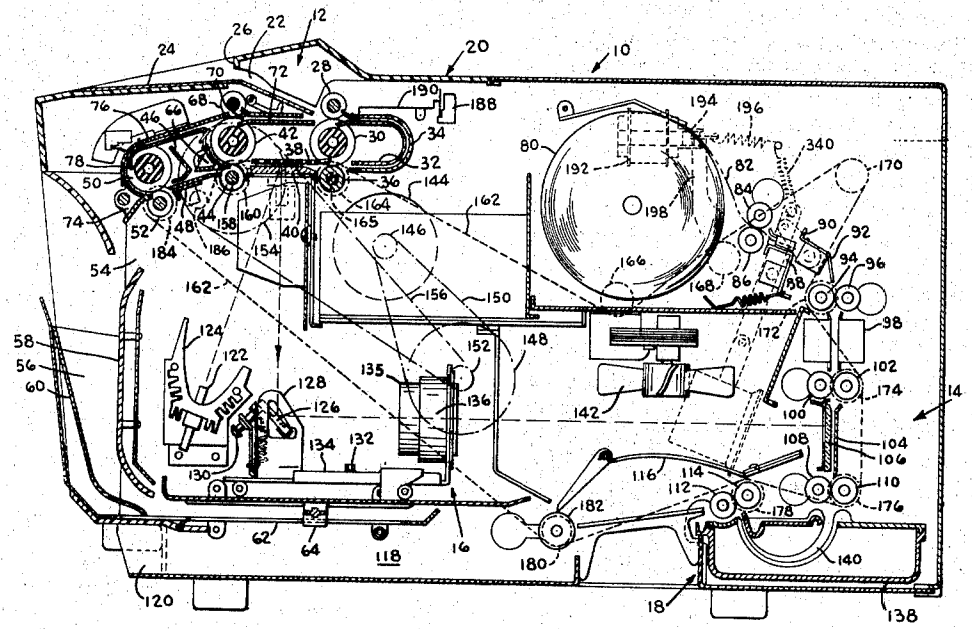
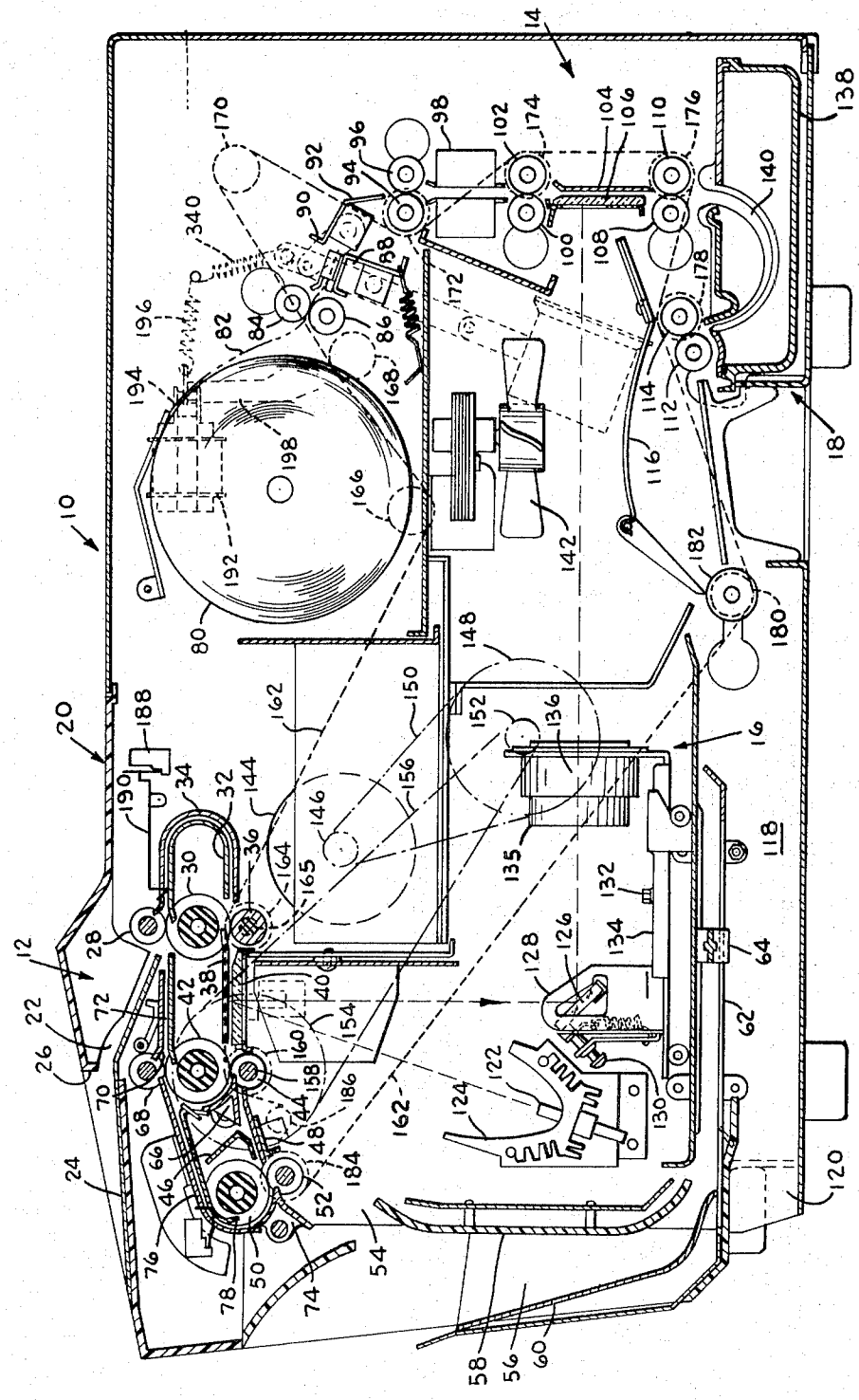


FIG. 1


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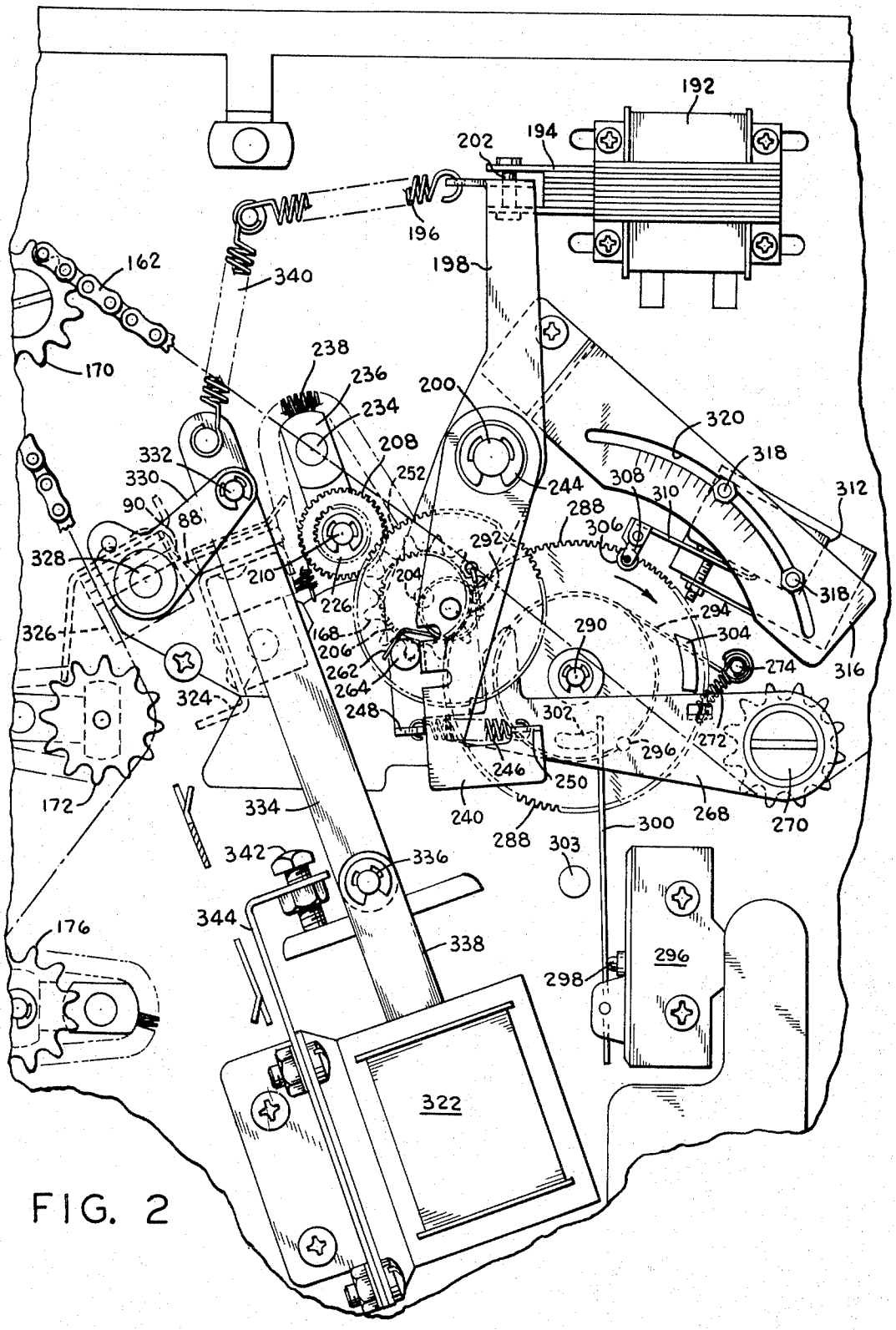

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FIG. 2

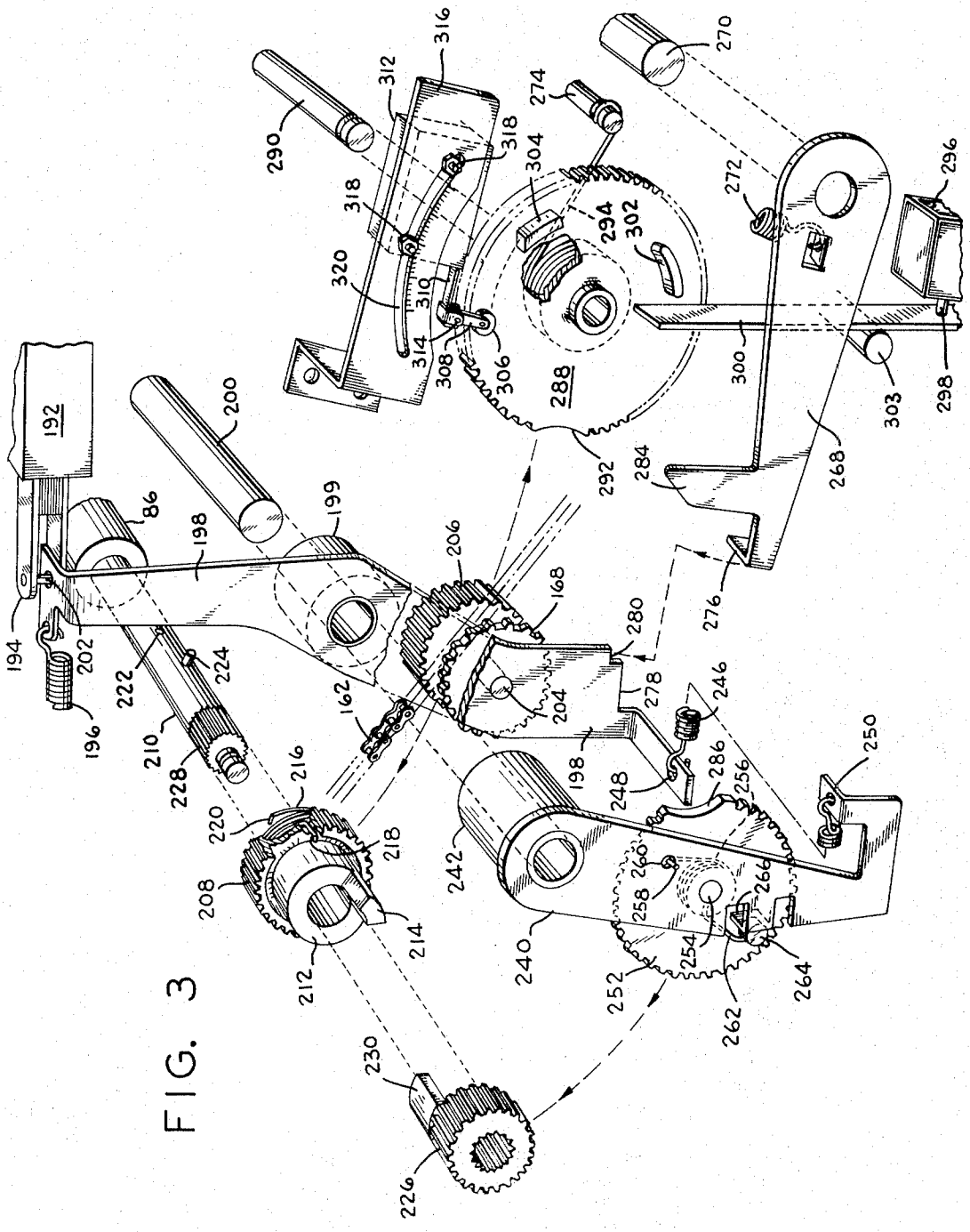

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FIG. 3

FIG. 4

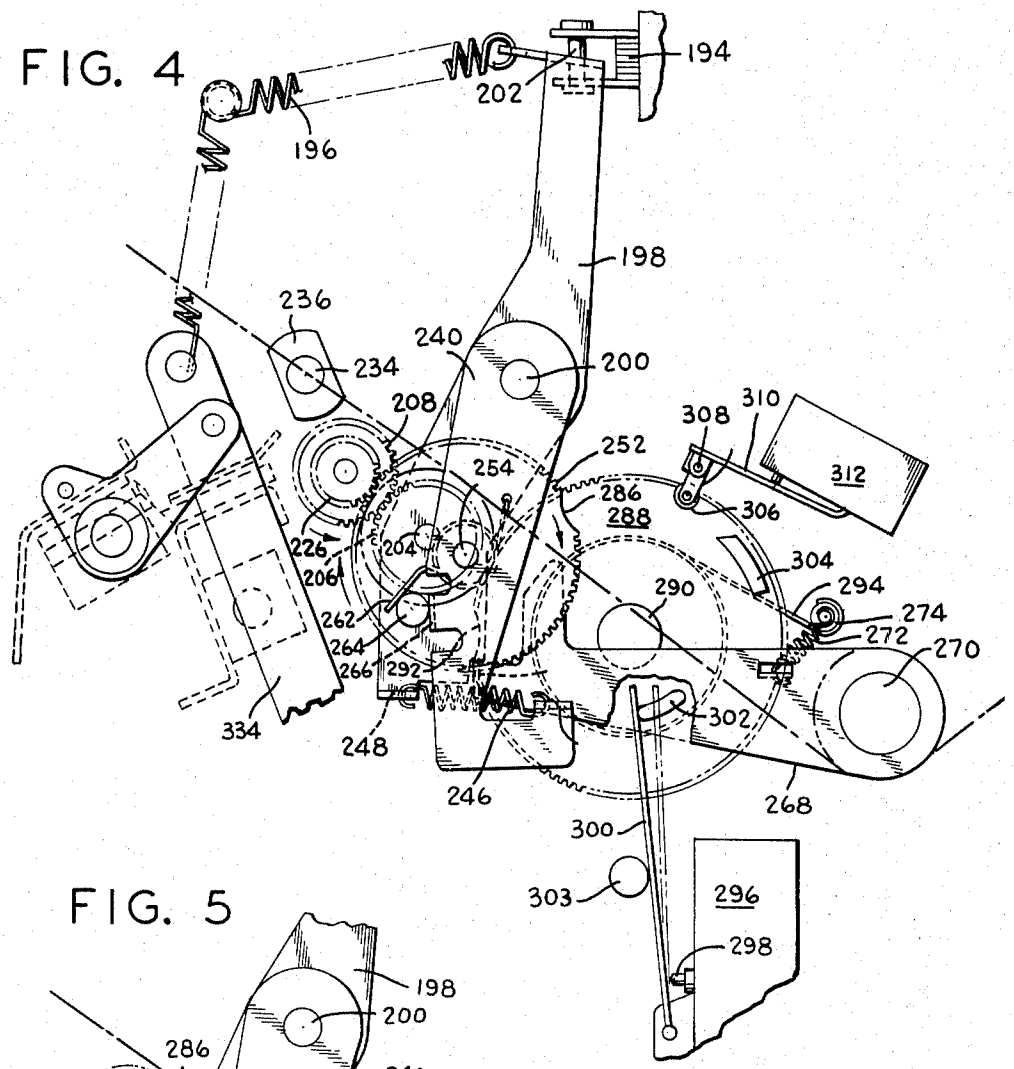

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FIG. 5

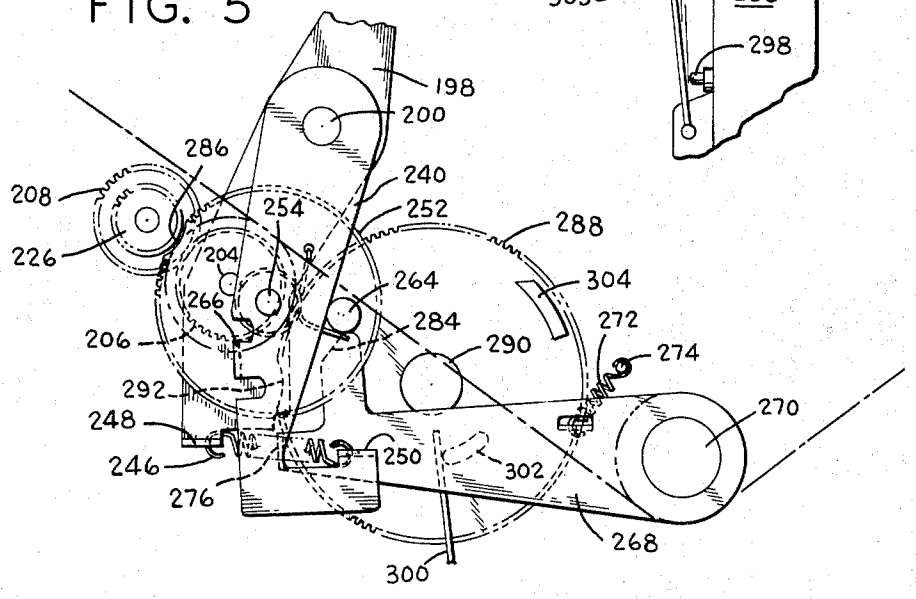

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FIG. 6

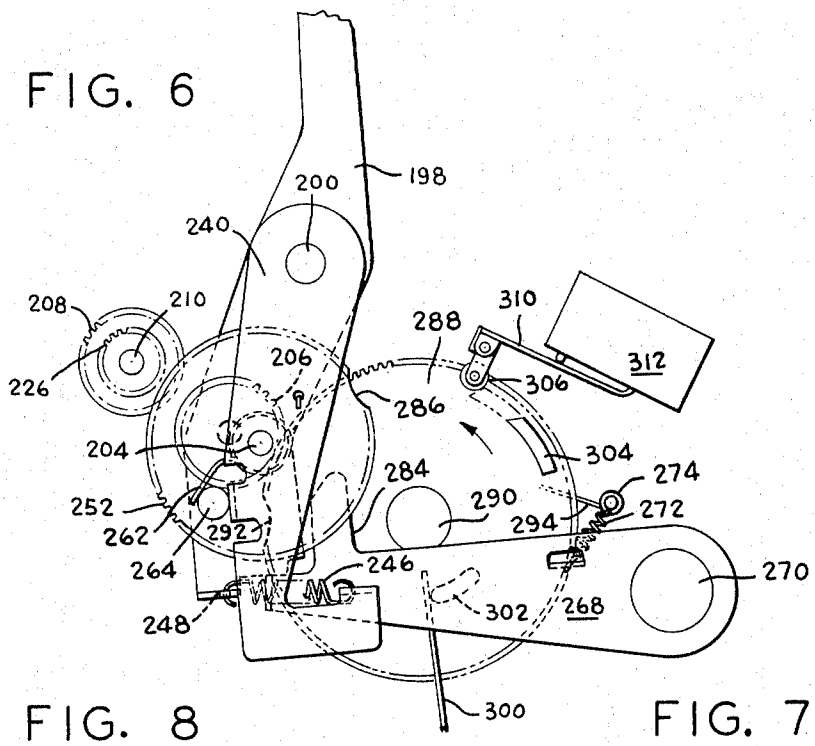


FIG. 8

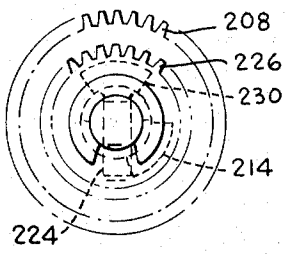


FIG. 7

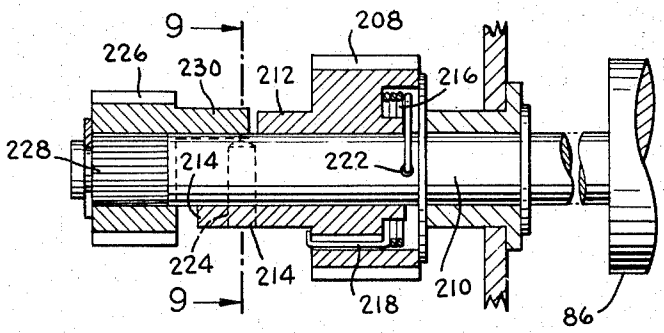
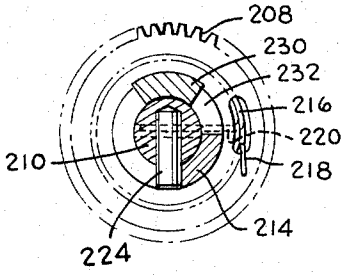


FIG. 9



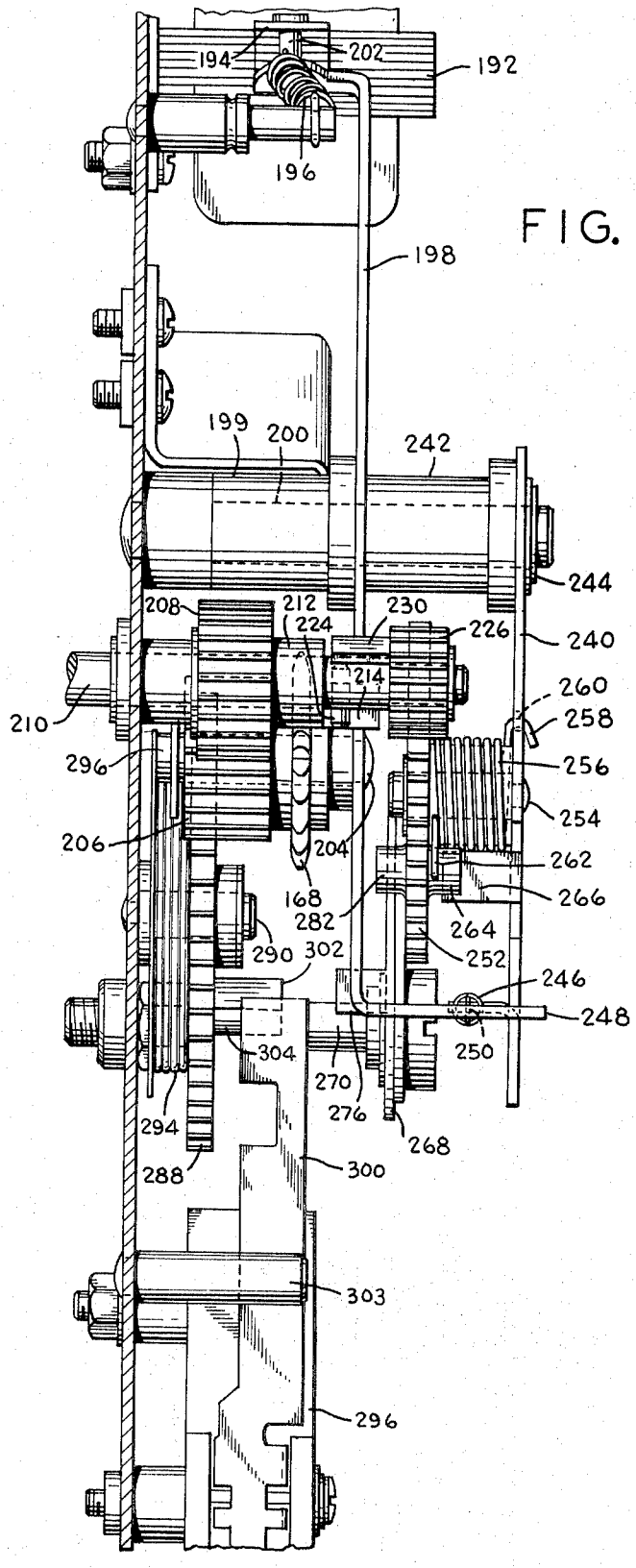

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FIG. 10

SEQUENCE CONTROL APPARATUS FOR ELECTROPHOTOGRAPHIC COPYING MACHINE

This is a division of application Ser. No. 74,737 filed Sept. 23, 1970.

BACKGROUND OF THE INVENTION

This invention relates generally to improvements in operational control mechanisms for electrophotographic copying machines and more particularly to an electro-mechanical sequence control apparatus for controlling, in proper timed sequence, the several operating functions of such machines.

In the prior technology of copying machines of the type to which the present invention relates, one of the major problems consistently encountered is the structural design and development of the apparatus and mechanisms required for automatically controlling the operating functions of the machine in a predetermined timed sequence to effect a desired operational cycle of the machine. As the art has developed in electrophotographic, and particularly in electrostatic, copying machines, this problem has been approached from two principal viewpoints, i.e., substantially all electrical control and substantially all mechanical control. Also, as the copying machines have become more complex and capable of performing more sophistocated functions in an automated manner, the control apparatus and mechanisms therefor have, of necessity, become more complex, with the result that a fully automatic copy machine is now generally a very complicated, expensive and sensitive piece of machinery regardless of the manner or type of control apparatus which it utilizes.

The prior art indicates, as exemplified by U. S. Pat. No. 3,181,420 to Rautbord et al and U. S. Pat. No. 3,330,179 to Zerfahs et al, a preference for predominently electrical control of the operating functions of the copying machine. Other prior art, as exemplified by U. S. Pat. No. 3,187,651 to Eichorn et al and U. S. Pat. No. 3,289,532 to Baumgarten et al, indicates that a substantial amount of electrical control is preferred even where mechanical mechanisms are designed and incorporated to perform some of the functions formerly performed solely by electrical means. Thus it may be concluded that substantially little effort has been directed toward the development of a satisfactory control apparatus which is substantially all mechanical in design and operation and which requires an electrical input only to initiate operation of the apparatus.

Significant disadvantages have been realized in prior art copying machines which utilize predominently, and rely heavily upon, individual and independent electrical controls, such as shown in the first two patents mentioned above, for controlling the various functions of a fully automatic machine. One of the most troublesome of these disadvantages is the large number of paper actuated switches which must be employed to control the several functions of the machine which occur during each operating cycle thereof and which are described in detail hereinafter. Paper actuated switches are not only relatively expensive as compared, for example, to cam actuated switches due to the high degree of sensitivity of the former, but also they are frequently a source of trouble due to the possibility of causing paper jams in the feed paths of the copying machine. This latter aspect is particularly undesirable in the copy paper path of the machine where it requires a considerable amount of disassembly of the machine to clear jammed sheets of copy paper. In general, the more that paper actuated switches can be avoided for control purposes, the greater is the degree of reliability and trouble free operation of the copying machine.

Another disadvantage inherent in a control system which is substantially all electrical is the two-fold problem of the greater probability of malfunction of the copying machine due to loose or bad connections of wire terminals from wear or vibration, coupled with the difficulty in finding the electrical fault in the event of a malfunction. When a mechanical device does not function, the reason is usually apparent upon observation of the device. With electrical controls on the other hand, where complicated circuitry is involved, it is often a difficult and time consuming effort to test all of the circuits to find and correct the fault.

As exemplified by the second two patents mentioned above, prior attempts to incorporate more mechanical control emements into an otherwise predominently electrical system have resulted in relatively complex devices which are capable of performing only one or a limited number of the operational functions which are involved in an operating cycle of the copying machine. Therefore these machines are relatively expensive and very little, if any, less complex than those with substantially all electrical control systems, and accordingly no economic or practical advantage is obtained by the substitution of individual mechanical devices or mechanisms for individual electrical controls for the various functions involved.

Thus the situation is presented that there is no presently known electro-mechanical sequence control apparatus for copying machines of the type hereinafter disclosed which, by substantially all mechanical means, has the capability of controlling, in a predetermined timed sequence, all of the operational functions involved in a fully automatic electrostatic copying machine. These functions are, briefly, though not necessarily in the order listed, commencing copy paper feed at the right moment so that document and copy paper enter the optical system in synchronism; energizing an illuminating lamp and electrostatic charging device at the proper moment; operating a severing mechanism to sever copy paper from a supply roll in lengths corresponding to varying lengths of original documents; positively preventing operation of the severing mechanism until a predetermined length of copy paper has been fed past the severing mechanism; and maintaining the illuminating lamp and the charging device energized until the entire document has passed beyond an illuminating area even though the trailing edge of the document has passed the point at which the leading edge of the document has caused energization of the lamp and charger. Thus it is recognized that there is a need for a relatively simple, inexpensive and highly reliable substantially all mechanical control mechanism which, as the major part of the copying machine control apparatus, has the capability of controlling the sequential performance of these functions automatically and in response to an electrical control element which operates only as the source of an input signal to initiate operation of the control mechanism. In addition, there is a need to provide such a mechanism which has features of easy adjustability to compensate for variables in the overall photocopying process performed by the ma-

chine which result from such factors as manufacturing tolerances and wear and tear on the machine parts.

BRIEF SUMMARY OF THE INVENTION

The present invention fulfills the foregoing needs for presently known copying machines and obviates or eliminates the disadvantages inherent in prior art photocopying machine technology.

The apparatus of the present invention presently finds greatest application in, and is disclosed hereinafter as embodied in, an electrophotographic copying machine which copies on photoconductive copy paper. Such machine typically includes an original document feed path including document feeding means and an illuminating station, a copy paper feed path spaced from the document feed path and having copy paper feeding means and an exposing or imaging station, an optical system for projecting an image of indicia from the document to the copy paper as each moves through its respective path, a means for uniformly charging the copy paper prior to exposing and a means for developing the latent electrostatic image to render the same visible and permanent. There is also preferably included a means for severing sheets of copy paper from a roll thereof stored in the machine.

In the broad opertion of such machine, an original document is fed into the document path through which it is transported by rollers or other suitable feeding means past the illuminating station and then out of the machine. The leading edge of the document causes energization of an illuminating lamp for the document and a charging device for the copy paper, and triggers the operation of an intermittent copy paper feeding means which draws copy paper from th supply roll and advances it through the copy paper path, the paper first passing through a suitable charging device which imparts a uniform electrostatic charge to the photoconductive insulating layer which is on a conductive backing. By means of the control apparatus hereinafter described, the leading edges of the document and copy paper arrive at the illuminating and exposing stations respectively at the same time so that an image of the document is projected onto the copy paper by the optical system. In accordance with principles well-known in the art, the charge on the photoconductive layer is dissipated in the non-image or light struck areas to form a latent electrostatic image on the copy paper which is developed by the application of suitable pigmented particles which adhere to the still charged image areas of the copy paper. The trailing edge of the document triggers operation of the severing mechanism to sever the web of copy paper according to the length of the document, and also actuates a time delay device which delays de-energization of the illuminating lamp and charging device to allow the entire document to be illuminated and copied.

In accordance with the present invention, there is provided control apparatus which includes a sensing means stationed in the document feed path in advance of the illuminating station. The sensing means is adapted to detect the leading and trailing edges of a document sheet as they pass a given point in the document feed path. A control element, which from the description to follow will be seen to act in the capacity of a clutch, normally assumes a first position and is movable under the control of the sensing means to a second position upon the detection of the passage of a document's leading edge. While in the second position, the control element engages first driven means to couple the drive of the main copier drive trail to initial feed rollers stationed in the copy paper feed path. These initial feed rollers, when driven, withdraw copy paper from the supply roll.

When the sensing means senses the passage of the trailing edge of a document sheet, the control element or clutch is returned to its first position where it engages second driven means which is then driven to effect actuation of the severing mechanism to cut the copy paper into a sheet length corresponding to the length of the document sheet.

In accordance with an important feature of the invention, the first driven means includes an adjustable lost motion mechanism operating to impart a predetermined time delay between the moment when the control element assumes its second position and the instant of application of drive to the initial copy paper feed rollers. This feature permits the alignment of the leading edges of the document sheet and the copy paper relative to variations in the copier optics due to manufacturing tolerances thereof, so that the reproduced image has the same placement on the copy sheet as the original image has on the document.

The second driven means also has an adjustable lost motion mechanism for delaying the actuation of the severing mechanism until a predetermined time after the control element returns to its first position. As long as the time delays provided by these two lost motion mechanisms are equal, the copy sheet will be cut into a sheet length equal to that of the document sheet.

As an additional feature of the invention, a latch is provided for latchably engaging the control element or clutch each time it assumes its second position. Third driven means engagable with the first driven means when the control element assumes its second position operates as still another lost motion mechanism to meter out a minimum length of copy paper. When a predetermined minimum length of copy paper has been withdrawn from the supply roll, the third driven means engages the latch to disengage it from the control element so that the latter may return to its first position when the sensing means has sensed the passage of the document's trailing edge. Thus the latch serves to prevent the control element from returning to its first position and initiating the actuation of the severing mechanism until a minimum length of copy paper has been withdrawn from the supply roll. Until this occurs, the control element cannot respond to the sensing means should it sense the passage of the trailing edge of an unusually short or irregular document sheet.

In accordance with still another feature of the invention the control element, after assuming its first position, engages detent means included with the second driven means so as to retain the latter in a restored position. While in this restored position, the second driven means is effective to maintain the projection lamp and charger mechanism of an electrostatic copier de-energized. When the control element moves to its second position, the second driven means is released, allowing it to move to a reference position whereupon the lamp and charger are permitted to be energized. Substantially at the time when the sensing means has sensed the passage of the document's trailing edge, the control element is returned to its first position, whereupon the second driven means is engaged and progres-

sively returned to its restored position. At an adjustably predetermined point during this return movement, the second driven means engages an actuating member, initiating operation of the severing mechanism. When the second driven means reaches its restored position, the lamp and charger mechanisms are d-energized. This delay from the time the control element returns to its first position and the lamp and charger are de-energized allows the original document to pass completely through the illuminating station and the copy sheet to pass completely through the imaging station.

As a more specific feature of the invention, the sensing means takes the form of a switch which is triggered from a first condition to a second condition in response to the passage of the document's leading edge. It remains in this second condition until passage of the documents trailing edge, whereupon it returns to its first condition. The switch controls a solenoid, which is actuated by the switch while it is in its second condition to position the control element in its second position. Thus it is seen that the control apparatus receives only a single input, which in the disclosed embodiment is in the form of a current pulse whole length corresponds to the time required for the original document to pass a given point in its feed path. The various operations automatically initiated and terminated by the control apparatus of the invention are controlled from the sensing switch and are precisely references to the movement of the document sheet through its feed path and to the document sheet length.

It is accordingly an object of the instant invention to provide a sequence control apparatus for synchronizing the various operational functions of photocopy machines.

An additional object of the invention is to provide a sequence control apparatus of the above character whose control functions are coordinated with the movement and length of a document sheet bearing an image to be reproduced on a copy sheet.

Another object is to provide a sequence control apparatus of the above character which requires only a single signal input to initiate and carry out a complete copy cycle of the photocopy machine.

A further object is to provide a sequence control apparatus of the above character for adjustably controlling the withdrawal of copy paper from a supply thereof so as to align the leading edges of the copy sheet and document sheet relative to the copier optics as the former are translated along wholly separate copy and document sheet feed paths.

Yet another object is to provide a sequence control aparatus of the above character operating to adjustably control a severing mechanism so as to cut the copy paper into sheet lengths exactly corresponding to the lengths of the document sheets.

An additional object of the invention is to provide a sequence control apparatus of the above character for adjustably controlling the withdrawal of copy paper and the severance thereof into sheet lengths such that the reproduced image has the same relative location on the copy sheet as the original image has on the document sheet.

Another object is to provide a sequence control apparatus of the above character which is operable to disable the copy paper severing mechanism until after a predetermined minimum length of copy paper has been withdrawn from the supply roll.

A further object is to provide a sequence control apparatus of the above character which operates to coordinate the period of energization of a projection lamp and charger mechanism in an electrostatic photocopier with the movement and length of a document sheet being translated in the document sheet feed path.

Still another object is to provide a sequence control apparatus which is fully adjustable so as to compensate for manufacturing tolerances.

A further object is to provide a sequence control apparatus of the above character which is fully automatic, reliable in operation, inexpensive to manufacture, compact in size, and readily serviceable.

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

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

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

FIG. 1 is a side elevational view, partially in section, of an electrostatic photocopier adapted with the control apparatus of the present invention;

FIG. 2 is a side elevational view of the control apparatus of the invention;

FIG. 3 is an exploded isometric view of the control apparatus of FIG. 2;

FIG. 4 is a side elevational view of the control apparatus of FIG. 2 showing the relationship of the parts during the initial withdrawal of copy paper from a supply roll;

FIG. 5 is a side elevational view of the control apparatus showing the relationship of the parts after a predetermined minimum length of copy paper has been withdrawn from the supply roll;

FIG. 6 is a side elevational view of a portion of the control apparatus showing the arrangement of parts for initiating actuation of the severing mechanism and deactuation of the projection lamp and charging mechanism of the photocopier;

FIG. 7 is a longitudinal, sectional view of the parts assembly mounted on the shaft of an initial feed roller concerned with the withdrawal of copy paper from the supply roll;

FIG. 8 is a left end view of the parts assembly shown in FIG. 7;

FIG. 9 is a sectional view taken along line 9—9 of FIG. 7; and

FIG. 10 is an end view of the control apparatus of FIG. 2.

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

DETAILED DESCRIPTION OF THE INVENTION

GENERAL

Referring now to the drawings and particularly to FIG. 1 thereof, there is disclosed an electrostatic copying machine designated generally by the reference numeral 10 in which the present invention is embodied. The machine 10 comprises a document feeding and illuminating component generally designated by the nu-

meral 12, a copy paper feeding and exposing component generally designated by the numeral 14, an optical system generally designated as 16, and a developing component generally indicated as 18. All of the operating components are contained within a suitable housing generally designated as 20.

DOCUMENT FEEDING AND ILLUMINATING

The document feeding and illuminating component 12 includes an infeed slot 22 defined by guide portions 24 and 26 of the housing 20 through which the leading edge of a document is manually inserted, the leading edge being grasped by a pair of continuously driven feed rollers 28 and 30, the driving means of which is described hereinbelow. The document is moved by the feed rollers 28 and 30 through a turn-around portion of the feed path defined by guide members 32 and 34 to bring the document into engagement with feed rollers 30 and 36 which move the document past an illuminating station defined by an upper guide member 38 and a lower transparent guide plate 40. The document then passes to the feed rollers 42 and 44 and thence between upper and lower guide members 46 and 48 to another set of feed rollers 50 and 52 from which it passes through an exit slot 54 defined by the housing 20 and moves downwardly into a receiving compartment 56 defined in part by a front wall 58 of the housing 20, a guide member 60, a bottom plate 62 and an adjustable back stop 64, so that successive documents fed through the machine will stack up in the receiving compartment 56 and may be manually withdrawn therefrom as a pack.

It should be understood at this point that all feed rollers, guide members and other compartments, both those described above and those hereafter to be described, which extend substantially across the width of the machine 10 are suitably supported by a pair of spaced, parallel, upstanding side plates which form a main frame for the machine 10. Parts which do not span the width of the machine are suitably supported by auxiliary frame members which in turn are supported by the two side frame plates.

Referring still to the document feeding component, it will be seen that provision has been made for recirculating a document around one of two possible closed loop paths so that multiple copies of the document can be made without the document emerging from the machine 10. The patch followed by the document in being continuously recopied depends on the length of the document. Thus, there is seen a gate member 66 which is pivotally mounted between the side frame plates adjacent the rollers 42 and 44, the gate member 66 having fingers which project into the path of the document, the rollers 42 and 44 being suitably notched to provide clearance for the gate fingers. The gate 66 is actually shown in position to intercept the leading edge of the document as it passes over the roller 44 to direct the document around the roller 42 and between it and another roller 68 into a return portion of the document feed path defined by upper and lower guide members 70 and 72. From this point the document passes through the portion of the feed path described above.

Another gate member 74 is pivotally mounted between the side frame plates adjacent the rollers 50 and 52, this gate member having fingers which project into the path of the document, the rollers 50 and 52 also being suitably notched to provide clearance for the gate fingers. The gate 74 is actually shown in position to intercept the leading edge of the document as it passes over the roller 52 to direct the document around the roller 50 and into a further return portion of the document feed path defined by upper and lower guide members 76 and 78, from which the document passes between rollers 42 and 68 to enter the return portion of the document feed path just described above.

Thus it will be readily understood that there is a short closed loop path for short documents and a long closed loop path for long documents. The gates 66 and 74, which determine which closed loop path a document will follow for multiple copying, are operated by suitable solenoids under the control of switches in the document feed path which actually measure the length of the document during a first copying cycle to determine the length of the document, the switches and solenoids setting the gates 66 and 74 so that the document will follow the proper closed loop path. Of course, a manually settable counting mechanism is provided which overrides the document controlled mechanism and sets the gates 66 and 74 to cause the document to exit through the opening 54 in the housing 20 if the counting mechanism is set for making only a single copy of the document. The electrical and mechanical control elements for measuring the length of the document and for operating the gates 66 and 74, as well as the counting mechanism and its overriding association with the gates 66 and 74, all form no part of the present invention and accordingly are not herein further described. For a more complete description of this part of the apparatus disclosed herein, reference may be had to U. S. Pat. application Ser. No. 750,912, filed Aug. 7, 1968 and assigned to the assignee of this application.

COPY PAPER FEEDING AND EXPOSING

Referring now to the copy paper feeding and exposing component 14, there is seen a roll 80 of copy paper suitably supported in a rear portion of the machine 10, the roll 80 having a lead portion 82 extending between a pair of intermittently driven feed rollers 84 and 86 and terminating at the fixed blade portion 88 of a severing mechanism comprising the fixed blade portion 88 and a movable blade portion 90 which is pivotally supported between the side frame plates. The means by which the feed rollers 84 and 86 are intermittently driven, as well as the means for operating the severing mechanism, will be fully described hereinafter.

When the feed rollers 84 and 86 are rotating, copy paper is drawn from the roll 80 and directed, by means of a guide member 92 carried by the movable blade portion 90, between a pair of continuously driven feed rollers 94 and 96 from which the paper passes between the opposed components of a suitable electrostatic charging device 98. Another pair of feed rollers 100 and 102 move the copy paper through an exposing station defined by a rear guide mbmer 104 and a transport guide plate 106, after which feed rollers 108 and 110 move the paper into and through the developing component 18 and a further pair of feed rollers 112 and 114, from which the copy paper is directed by a guide member 116 to a receiving compartment 118 where successive sheet of copy paper are stacked for manual removal from the machine 10 through a suitable access opening 120 formed in the front portion of the housing 20.

OPTICAL SYSTEM

The optical system 16 for projecting an image of indicia from the original document to the copy paper comprises an illuminating lamp 122 and a reflector 124 suitably mounted to direct rays of light to the document at the illuminating station through the transparent guide plate 40, from which the light is reflected by the background or non-image areas of the document to a mirror 126 adjustably held by a bracket 128 which itself is adjustably mounted for fore and aft longitudinal movement in a lower portion of the machine 10. The mirror can be rotated about a horizontal lateral axis by turning the thumb screw 130, while the bracket 128 can be moved longitudinally by loosening one or more suitable holding bolts 132 and moving the bracket 128 relative to a channel member 134 which is fixedly mounted in the machine.

A focusing lens 135 is slidably mounted in a lens housing 136 which is fixedly mounted on the rearward end of the bracket 128. The lens 135 is movable in the housing 136 in order to render the lens adjustable relative to the mirror 126 independently of movement of the bracket 128. The purpose for the relative adjustability of the mirror and lens, as well as the adjustability of the bracket 128 will be made clear hereinbelow.

Thus it is seen that the optical system projects the indicia on the document from the transparent guide plate 40 to the copy paper passing by the transparent guide plate 106 at the imaging station. Since the document and the copy paper are moving at the same speed a sharp line by line scanned image is transferred from one to the other.

DEVELOPING COMPONENT

The developing component 18 comprises a tank 138 for containing a supply of liquid developing toner which contains pigmented particles which adhere to the charged latent electrostatic image remaining on the copy paper after exposure thereof. The copy paper enters a guide member 140 which guides the paper through the body of toner and directs it to the roller 112 and 114 which, in addition to bring feed rollers, are also squeegee rollers for wiping off excess toner from the paper. A fan 142 directs heated air over the copy sheet as it passes under the guide member 116, which is preferably constituted as a series of stiff wires positioned across the width of the paper path, so as to throughly dry the copy sheet before it is delivered to the receiving compartment 118.

ROLLER DRIVE MECHANISM

With the exception of the intermittently operated copy paper feed rollers 84 and 86, all of the feed rollers described above, for both the original documents and the copy paper, are continuously and synchronously driven by a single drive mechanism. This mechanism comprises a motor 144 suitably mounted in the machine 10 which turns a pulley 146 which in turn drives another pulley 148 via the belt 150. A smaller pulley 152 is coaxially mounted with the pulley 148 and drives still another pulley 154 via the belt 156. The pulley 154 is mounted on a shaft 158 which carries the feed roller 44. The shaft 158 also carries a sprocket 160 which rotates with the shaft 158 and drives a chain 162.

Proceeding from the sprocket 160 in a clockwise direction around the machine 10, it will be seen that the chain 162 passes around and is engaged with a sprocket 164 mounted on a shaft 165 which carries the feed roller 36, an idler sprocket 166 adjacent the bottom of the copy paper roll, a sprocket 168 which, as will 132 be more clearly seen hereinafter, is the main input element for the mechanical sequence control mechanism described below, an idler sprocket 170, a sprocket 172 mounted on the shaft which carries the feed roller 94, a sprocket 174 mounted on the shaft which carries the feed roller 102, a sprocket 176 mounted on the shaft which carries the feed roller 110, a sprocket 178 mounted on the shaft which carries the feed roller 114, a sprocket 180 mounted on the shaft which carries a single transport roller 182, a sprocket 184 mounted on the shaft which carries the feed roller 52, and finally an idler sprocket 186.

From the foregoing it will be understood that all feed rollers which do not have sprockets mounted on their supporting shafts are driven either by frictional engagement with the sprocket driven rollers with which they are associated or by engagement of spur gears on adjacent roller shafts, or both. Also all of the sprockets and pulleys, as well as the chain and belts are located on the outer or far side frame plate as viewed in FIG. 1, which accounts for these components being shown in phantom lines.

SEQUENCE CONTROL APPARATUS

General: The sequence control apparatus of the present invention will best be understood by continuous comparative reference to FIGS. 2 and 3 during the following portion of the description of the invention, and with reference to other figures of the drawings as specifically indicated. It will be seen by comparison of FIGS. 1 and 2 that the predominent portion of the sequence control apparatus is located in a rear portion of the machine 10, with just enough of the components (to be enumerated below) being shown in phantom lines in FIG. 1 to be able to orient the mechanism shown in FIG. 2 to the machine as shown in FIG. 1. It should be noted that since the mechanism shown in FIG. 2 is on the outer side of the side frame plate, the orientation of parts shown in FIG. 2 is reversed from those also shown in FIG. 1.

As briefly indicated in the introductory portion of this specification, the sequence control apparatus controls all of the operational functions of the copying machine and causes each function to be performed in its proper timed sequence to thereby initiate, carry out and terminate a proper copying cycle of the machine. The sequence control apparatus is actuated by an input signal which is responsive to the leading edge of a document arriving at a predetermined point in the document feed path. While this may be accomplished mechanically, it is preferred to do so electrically by means of a paper actuated switch, with the balance of the control apparatus operations being achieved mechanically or electro-mechanically but without use of further paper actuated switches.

Thus, with brief references again to FIG. 1, there is seen a paper sensing means comprising a switch 188 suitably mounted adjacent the rear end of the document feed path, the switch 188 having a feeler arm 190 projecting into the document feed path just to the rear of the feed rollers 28 and 30. Closing of the switch 188 energizes a solenoid 192, shown in phantom lines in FIG. 1 and in solid lines in FIG. 2. Energization of the

solenoid 192 pulls in the armature 194 thereof against the action of a tension spring 196 connected to the side frame plate so as to withdraw the armature 194 when the solenoid 192 is de-energized by the trailing end of the document passing the feeler arm 190 of the switch 188, thereby permitting the switch to open. It will be recognized that the solenoid 192 is energized and de-energized once for each copying cycle of the machine 10 in response to the switch 188 being actuated by passage of the leading and trailing edges of each document to be copied.

Initiating Copy Paper Feed: Referring now to FIGS. 2 and 3 generally, it will be seen that the control element comprises a control lever 198 (also shown in phantom lines in FIG. 1) having a sleeve 199 is pivotally mounted on a stud 200 which is connected to the side frame plate (note FIG. 10), the lever 198 being connected by a pin 202 to the solenoid armature so that the control lever 198 is rocked in a clockwise direction as viewed in FIG. 2 when the solenoid 192 is energized from a first position as seen in FIG. 2 to a second position as seen in FIG. 4. The control lever 198 carries a stub shaft 204 on which is rotatably mounted the aforementioned sprocket 168. This sprocket is engaged by the chain 162 so that the sprocket is continuously rotated so long as the motor 144 is operating. Thus the sprocket 168 is a mechanical power input means for the rest of the mechanism to be described.

Formed integrally with, or connected to, the sprocket 168 is a drive gear 206 which continuously rotates with the sprocket 168, this gear, together with the sprocket 168, being carried by the control lever 198 for oscillatory movement therewith. Since the chain 162 follows a path substantially coincident with the path of movement of the sprocket 168, the movement of the sprocket with the control lever 198 does not effect the driving engagement between the sprocket and chain. However, movement of the drive gear 206 with the control lever 198 from the first to the second position performs two functions, one of which is to start feeding copy paper by engagement of the gear 206 with a first driven means and the other is to cause energization of the illuminating lamp and charger by disengagement of the gear 206 with a second driven means, all as fully described hereinafter.

Commencement of copy paper feeding is accomplished through the first driven means which includes a lost motion connection, the purpose of which is fully explained below, the first driven means comprising a gear 208 loosely mounted on a shaft 210 which is rotatably supported by the side frame plates. The shaft 210 carries the feed roller 86 for rotation therewith so that the feed rollers 84 and 86 operate to feed copy paper when shaft 210 is being rotated. The gear 208 is preferably formed integrally with a sleeve 212 from which extends an abutment element 214. A torsion spring 216 extends about the shaft 210 and has one end 218 bent over axially (note FIGS. 7 and 9) so as to be secured to a part of the gear 208. The other end 220 of the spring 216 is bent radially so as to enter a small hole 222 (note FIG. 7) in the shaft 210 so as to be secured thereto. The spring 216 functions to urge the gear 208 in a clockwise direction relative to the shaft 210 until the abutment element 214 strikes a stop pin 224 projecting from the shaft 210, this being the normal or at rest position of the gear 208 on the shaft 210 (note FIG. 9).

The lost motion connection between the drive gear 206 and the feed roller shaft 210 is a gear 226 which is splined to the shaft 210 through spline 228. The gear 226 carries an abutment element 230 which projects into the path of movement of the abutment element 214 mounted on the sleeve 212 of the gear 208. It will be apparent (note FIGS. 9 and 10) that when the gear 208 is rotated in a counter-clockwise direction by means of the gear 206, the abutment element 214 will first move through the space 232 whereupon the abutment element 214 will engage the abutment element 230 to rotate the gear 226 and the shaft 210, thereby driving the feed rollers 84 and 86.

Thus, it will now be apparent, by comparison of FIGS. 2 and 4, that energization of the solenoid 192 as described above performs a clutching function in that it rocks the control lever 198 in a clockwise direction to engage the drive gear 206 with the gear 208 which is then driven in a counter-clockwise direction to drive the shaft 210 through the lost motion connection. FIG. 4 shows the relation of the parts during feeding of copy paper with the control element engaged with the first driven means.

As best seen in FIGS. 2 and 4, the cooperating driven feed roller 84 is carried by a shaft 234 rotatably mounted in a bearing 236 received in a suitable slot (not shown) in the side from plate, and a spring 238 urges the shaft 234 toward the shaft 210 to maintain firm contact between the feed rollers 84 and 86.

Copy Paper Feed Adjustment: The lost motion connection described above between the drive gear 206 and the driven shaft 210 is a significant feature of the present invention. The function of this construction is to provide for adjustment of the actual commencement of copy paper feed in accordance with variations in the focal length of different lenses due to manufacturing tolerances thereof. As briefly indicated in the introductory portion of this specification, it is virtually impossible to manufacture all lenses with identical focal lengths. Accordingly, there will be slight variations from machine to machine in the distance between the focus planes of the illuminating station and the exposing station, this distance being the working length of the lens. With reference to FIG. 1, it will be seen that the vertical component of the optical path in the machine 10, that is, from the illuminating station transparent plate 40 to the mirror 126, is fixed, but that the horizontal component from the mirror to the exposing station transparent plate 106 is not fixed since the mirror bracket 128 is longitudinally adjustable as described above. Accordingly, the optical path can be shortened or lengthened in the machine to accommodate different working lengths of lenses so that a clear, sharp image is projected from one station to the other. Once the mirror is adjusted longitudinally so that the optical path is precisely equal to the working length of the lens, the lens itself can then be adjusted in the bracket 128 so that the working length is divided equally on both sides of the lens. This is done to assure a 1:1 magnification between the indicia on the document and the image projected to the copy paper.

It will be observed, however, that as the mirror is moved longitudinally of the machine for the purpose described above, the point at which the center of the optical field of the lens strikes the illuminating station also moves so that a given point on the document will be viewed by the lens, at any given instant, at a differ-

ent location along the illuminating station. If this situation is not compensated for by some means, the overall image on the copy paper will not be in the same location as the corresponding indicia appears on the document. It is therefore necessary to be able to control the feeding of the copy paper so that the leading edge thereof arrives at that point in the exposing station at which the center of the optical field is located at the exact instant that the leading edge of the document arrives at the corresponding location in the illuminating station. Since the paper contact point of the feeler arm **190** is located upstream from the center of the illuminating station the same distance as the knife blades **88** and **90** are located upstream from the center of the exposing station, one solution to this problem would be to adjustably mount the switch **188** and feeler arm **190** to compensate for any longitudinal adjustment of the mirror **126**. However, this solution is not satisfactory due to the high degree of sensitivity of the paper actuated switch, as indicated hereinabove, and the consequent likelihood of paper jams or other trouble developing by not having a permanent mounting for this switch.

Accordingly, within the principles of this invention, the lost motion coupling between the drive gear **206** and the driven shaft **210** is provided so as to be able to adjustably control the instant at which the copy paper actually begins to move after the switch **188** is closed by the leading edge of an original document. Referring to FIGS. **3, 7** and **9**, it will be seen that the gear **226** is readily removable from the shaft **210**, and by virtue of the splined connection therewith, the gear **226** can be placed on the shaft **210** in a variety of angular positions relative thereto. It will be appreciated that the larger the space **232** between the cooperating abutment elements **214** and **230**, the longer will be the delay in feeding the copy paper after energization of the solenoid **192** by the leading edge of a document closing the switch **188**. Obviously if the gear **226** is installed with the abutment element **230** in contact with the abutment element **214**, there will be no delay and copy paper will feed the instant that the switch **188** is closed. This would be the relationship of the parts only if the mirror **126** were adjusted to view the document at the most advanced viewing portion of the illuminating station.

By the foregoing construction, it will now be appreciated that the image of the indicia on the document will be projected to the copy paper in the same location and orientation, in relation to the leading edge of the copy paper, as the indicia appears on the document so that the finished copy will be an exact duplicate of the original after operation of the severing mechanism as described below.

Minimum Copy Paper Length: Another significant feature of the sequence control apparatus of this ivention is the provision a lost motion means for preventing a piece of copy paper from being severed from the roll which is shorter than the minimum distance between any adjacent pairs of feed rollers in the copy paper path. As briefly indicated in the introductory portion of this specification, it is obvious that if pieces of copy paper are severed which do not span the distance between adjacent pairs of feed rollers, these pieces of paper will not feed through the machine and will cause paper jams which must be cleared. This is a critical problem in the machine of the present invention since short pieces of copy paper usually jam up in the toner tank. this being the low point in the copy paper path. It then becomes necessary to disassemble a portion of the machine, remove and disassemble the toner tank if short pieces of paper are completely immersed in the toner, and reassemble all of these components. This is a time consuming and extremely messy and inconvenient procedure and one that can be entirely avoided by the structure now to be described.

In general, the copy paper web is severed by a mechanism to be fully described hereinbelow under the heading COPY PAPER SEVERING MECHANISM; it need only be understood at this point that this mechanism cannot operate until the control lever **198** returns to its first or normal position which it occupies when the solenoid **192** is de-energized. However, it is possible for the solenoid to be de-energized prematurely, i.e., before sufficient copy paper has been fed. This may occur, for example, by electrical malfunction such as a momentary loss in power, or by operator misuse of the machine, such as by inserting an undersized document to the point where it closes the switch **188** and then withdrawing the document (having noticed it was upside down, the wrong document, etc.) by a sudden tug on the trailing end so as to overcome the frictional driving force on the document. For whatever the reason, prematurely opening the switch **188** would ordinarily permit the severing mechanism to operate with the result that a short strip of copy paper could be fed into the copy paper feed path.

While prior art attempts have been made to overcome this problem by rather complicated electrical means including timers controlling auxiliary or holding circuits, the present invention utilizes a rather simple mechanical locking device which serves to lock the control lever **198** in the second position which it occupies when the solenoid **192** is energized with the result that copy paper will continue to feed and the severing mechanism cannot operate until the locking device is unlocked by operation of a third driven means described below, (a second driven means being described hereinafter), this regardless of whether or not the solenoid **192** has been previously de-energized. The locking device is constructed to remain locked until a length of copy paper has been fed which is sufficient to properly feed through the machine, after which the third driven means unlocks the locking device and the control lever **198** can return to its normal position, if the solenoid **192** has been previously de-energized, thereby discontinuing copy paper feed and allowing the severing mechanism to operate.

Thus, referring to FIGS. **2** and **3** again, it will be seen that the third driven means comprises an auxiliary lever **240** pivotally mounted on the stub shaft **200** by means of a sleeve **242**, both sleeves **199** and **242** being retained on the shaft **200** by means of the E-clip **244** (note FIG. **10**). The levers **198** and **240** are normally urged into contact with each other by means of a tension spring **246** which is interconnected between an outwardly struck tab **248** formed at the lower end of the control lever **198** and an inwardly struck tab **250** formed at the lower end of the auxiliary lever **240** (note FIG. **10**). The shape and arrangement of the parts is such that the left side of the auxiliary lever **240**, as seen in FIGS. **2** and **3**, abuts the tab **248** of the control lever **198** so that the two levers **198** and **240** oscillate as a

unit in response to energization and de-energization of the solenoid **192.**

A gear **252** is rotatably mounted on the auxiliary lever **240** by means of a pin **254** and is normally urged in a counterclockwise direction by a torsion spring **256** which has one end **258** connected to an aperture **260** in the lever **240** and the other end **262** connected to the gear **252.** The spring **256** urges the gear **252** toward a normal or at rest position in which a stud **264** carried by the gear **252** abuts another inwardly struck tab **266** formed on the outer side face of the lever **240** (note FIG. **10**). As best seen by comparison between FIGS. **2** and **4,** when the solenoid **192** is energized and the levers **198** and **240** are rocked in a clockwise direction, the gear **252** is brought into driven engagement with the gear **226** mounted on the feed roller shaft **210** so that the gear **252** is rotated in a clockwise direction thereby as indicated by the arrows in FIG. **4.** Thus the gear **226** functions both to drive the shaft **210** after the lost motion between the abutment elements **214** and **230** is taken up and to drive the gear **252.**

The reason for providing the two levers **198** and **240** with a spring connection therebetween is to eliminate the possibility of the gear **206** being held out of driving engagement with the gear **208** if the gears **252** and **226** should come together tooth to tooth. Since neither of the latter gears are rotating when brought together, they could meet tooth to tooth, and if the levers **198** and **240** were integral with each other, this would prevent driving engagement of the gears **206** and **208.** Resiliently connecting the levers **198** and **240** in the manner described assures that the gears **206** and **208** will mesh regardless of how the gears **252** and **226** come together.

The function of the gear **252,** after rotating through an arc of lost motion, is to unlock a locking lever which engages with the control lever **198** when the latter is moved to its second position by the solenoid **192** and which holds the control lever **198** in the position to which it is thus moved. Referring again to FIGS. **2** and **3,** a horizontally disposed locking lever **268** is pivotally mounted on the side frame plate by a stub shaft **270** (note FIG. **10**) and is urged upwardly thereabout by a tension spring **272** suitably connected between the locking lever **268** and a pin **274** projecting outwardly from the side frame plate. The free end of the locking lever is provided with an inwardly struck tab **276** which normally engages with the lower edge **278** of the control lever **198** when the latter is in its normal position, but which engages with a notch **280** when the lever **198** is moved by the solenoid **192.** When the control lever **198** is so moved, the engagement of the tab **276** with the notch **280** effectively locks the control lever **198** in its second position where it remains until the locking lever is moved downwardly against the force of the holding spring **272** to unlock the control lever **198.**

As best seen in FIG. **10,** the gear **252** is provided with a stud **282** on its inner face which is axially aligned with the previously mentioned stud **264.** The stud **282** is adapted to engage with an upstanding camming arm **284** near the face end of the locking lever (note FIG. **3**) with the result that when the gear **252** has turned through a predetermined arc, the stud **282** moves the locking lever downwardly to disengage the tab **276** from the notch **280** thereby freeing the control lever **198** for return to its first position upon de-energization of the solenoid **192.**

The predetermined arc of lost motion rotation of the gear **252** is approximately 215°, and is determined by the angle, measured in the direction of rotation, between the stud **282** and a cut-out portion **286** on the periphery of the gear **252,** which portion lies contiguous with the teeth of the gear **226** when the gear **252** has been rotated through the predetermined arc. By this construction, and as best seen by comparison of FIGS. **4** and **5,** the rotation of of the gear **252** is terminated at the desired point without moving the axis of the gear **252** since the gear **226** merely slides in the cut out portion **286** and holds the gear **252** in the position against the force of the torsion spring **256.** This effectively holds the locking lever **268** out of locking engagement with the control lever **198.** When the solenoid **192** is de-energized and the lever **198** returns to its normal position, thereby returning the lever **240** to its normal position, the gear **252** is removed from engagement with the gear **226** and immediately rotaes in a counterclockwise direction in response to the torsion spring **256** until the stud **264** again abuts the stop tab **266** on the lever **240.**

The diameter of the gear **252** and the construction and arrangement of the parts cooperating therewith is such that from the instant that the solenoid **102** is energized and the control lever **198** is locked in the paper feeding position until the locking lever **268** is unlocked by rotation of the gear **252,** approximately 5 ½ inches of copy paper will have been fed from the roll **80,** this length being sufficient to span the shortest distance between adjacent pairs of copy paper feed rellers. During this period of paper feeding, it will be recalled from above, the severing mechanism yet to be described cannot be actuated, thus assuring that the minimum length of copy paper required for proper feeding through the copy paper path will be provided.

Illuminating Lamp and Charger Control: As briefly pointed out in the introductory portion of this specification, the sequence control apparatus now being described is provided with means for controlling the energization and de-energization of the illuminating lamp **122** and the charging device **98** in predetermined timed sequence with the other functions of the machine which occur during an operating cycle thereof. The mechanism now to be described, which includes the above mentioned second driving means, actually controls both the energization and de-energization of the lamp and charger as well as the actuation of the severing mechanism, the latter being described, however, under a subsequent heading.

In a copying machine of the type under consideration, it is desirable to maintain the illuminating lamp energized only for minimum time required to make a copy, that is, the time required for the document to traverse the illuminating station. The principal reason for this is to limit as much as possible the amount of heat which is generated when the high intensity lamp is energized. However, for the purpose of simplifying the electrical circuitry and controls, the lamp and charger are in the same circuit and are energized and de-energized by the same control elements. Since the leading edge of the copy paper arrives at the chamber before the leading edge of the document arrives at the illuminating station, as will be apparent from FIG. **1,** it is necessary to energize the charger before the leading edge of the copy paper reaches the charger. Also, it is necessary to maintain the lamp energized until the

trailing edge of the document has passed the illuminating station so that the entire document is copied. The mechanism now to be described achieves these functions in a relatively simple and effective manner.

Referring again to FIGS. 2 and 3, the aforementioned second driving means is seen to comprise a relatively large diameter gear 288 rotatably carried by a stub shaft 290 mounted on the side frame plate (note FIG. 10). The gear 288 is mounted so as to be in driving engagement with the continuously rotating drive gear 206 when the control lever 198 is in its normal spring urged position. The gear 288 is provided with a cut out portion 292 which cooperates with the drive gear 206 in sliding relationship therewith, as seen in FIG. 2, so that in the normal position of the parts before the commencement of an operating cycle the gear 288 is not being rotated by the drive gear 206.

As best seen in FIGS. 2, 3 and 10, a torsion spring 294 extends around the stub shaft 290 and has one end thereof connected to the pin 274, the other end of the spring 294 being connected to a pin 296 carried by the gear 288, the spring being wound so as to normally urge the gear 288 in a clockwise direction as indicated by the arrow in FIG. 2. Thus it will be understood that in the normal position of the parts as seen in FIG. 2, the engagement of the cut out portion 292 with the drive gear 206 is holding the gear 288 against clockwise rotation by the torsion spring 294, the gear 288 being free to rotate in a clockwise direction when the solenoid 192 is energized and the control lever 198 is rocked thereby to its second or paper feeding position which moves the drive gear 206 out of engagement with the cut out portion 292 of the gear 288.

A switch 296 is mounted on the side frame plate and has an actuating button 297 adapted to be depressed by a pivotally mounted actuating finger 300, the finger 300 extending upwardly adjacent the outer side face of the gear 288 in position to be engaged by a boss 302 mounted on the side of the gear 288 (note FIG. 10). The switch 296 is of the "normally on" type with its spring mechanism urging the button 298 outwardly and the actuating finger 300 toward the left as viewed in FIG. 2. Accordingly it will be appreciated that the boss 302 is holding the switch 296 in an "off" condition with the parts in their normal positions as shown in FIG. 2.

In order to energize the lamp and charger, it is necessary to rotate the gear 288 in a clockwise direction to move the boss 302 away from the actuating finger 300 to allow the switch 296 to assume its "normally on" condition. This is accomplished, as briefly indicated above, by energizing the solenoid 192 to rock the control lever 198 to its second or paper feeding position, whereupon the drive gear 206 moves away from the gear 288 to allow the latter to rotate clockwise under the influence of the torsion spring 294. The actuating finger 300 then moves to the left until it abuts a stop pin 303 mounted on the side frame plate. The gear 288 rotates clockwise for about 355°, or to a point where the boss 302 is disposed on the opposite side of the actuating finger 300 which now functions as a stop member to prevent further rotation of the gear 288 under the influence of the torsion spring 294. This position of the gear 288 is shown in FIGS. 3, 4, 5 and 6. As will be apparent from these views, the cut out portion 292 is now disposed away from the drive gear 206.

To de-energize the lamp and charger, it is necessary to return the gear 288 to its starting position shown in FIG. 2 so as to open the switch 296. Thus, when the solenoid 192 is de-energized and the control lever 198 returns to its normal position, the drive gear 206 engages with the toothed portion of the gear 288 to rotate the latter in a counter-clockwise direction until the cut out portion 292 is again contiguous with the drive gear 206. At that point the boss 302 will have moved around to the opposite side of the actuating finger 300 and moved the latter to open the switch 296, thereby de-energizing the lamp and charger.

The diameter of the gear 288 and the construction and arrangement of the parts cooperating therewith is such that after the trailing edge of a document passes the feeler arm 190 of the switch 188 (note FIG. 1), the rotation time of the gear 288 before the boss 302 contacts the finger 300 is sufficient to allow the trailing edge of the document to pass through the illuminating station. Accordingly de-energization of the lamp is delayed after de-energization of the solenoid 192 long enough to allow the entire document to be illuminated and photographed.

Severing Mechanism Control: As briefly indicated above, the gear 288 which controls energization and de-energization of the illuminating lamp and charging device also controls the operation of the severing mechanism yet to be discussed. The control for the severing mechanism can be understood in advance of the description of the severing mechanism itself if it is understood that all that is required to actuate the severing mechanism is an electric impulse signal to a solenoid.

Accordingly, and with reference again to FIGS. 2 and 3, the gear 288 carries a camming boss 304 on the side face of the gear 288 but disposed radially further outwardly than the boss 302 which operates the lamp and charger switch. The camming boss 304 is adapted to engage a cam follower roller 306 rotatably carried by a frame 308 which is pivotally connected to an actuating finger 310 for operating a "normally open" switch 312. The frame 308 is mounted for pivotal movement from the position shown in FIGGS. 2 and 3 in a counter-clockwise direction, but is prevented from pivoting in a clockwise direction relative to the actuating finger 310 by a stop element 314 carried by the frame 308. Thus the camming boss 304 will raise the cam follower 306 in one direction of movement and will merely pivot the roller 306 out of its path in another direction of movement, as more fully explained below.

The switch 312 is adjustably mounted on a plate 316 secured to the side frame plate of the machine 10, the switch 312 being adjustable by loosening the securing nuts 318 and moving the switch along the arcuate slot 320 formed in the plate 316. The purpose of this adjustment is to provide a certain amount of lost motion of the gear 288 before the switch 312 is actuated by the boss 304 in order to control the point of severing of the copy paper web so as to achieve extreme accuracy in cutting the copy paper to the exact length of the original document being copied. The copy paper sheet and document will be of the same length if the degree of lost motion of the gear 288 corresponds to that of the gears 208 and 226, as more fully explained below.

The switch 312 controls energization of a solenoid 322 which in turn actuates the severing mechanism yet to be described in a manner which causes the strip of

copy paper to be cut at the instant that the solenoid **322** is energized. Thus, with reference to FIGS. **2** and **4**, when the solenoid **192** is energized by the leading edge of a document to rock the control lever to its paper feeding position, the large gear **288** is released by the drive gear **206** for clockwise rotation under the influence of the torsion spring **294** as fully explained hereinabove. As the gear **288** rotates from the position shown in FIG. **2** to that shown in FIG. **4**, the blunt end of the boss **304** strikes the cam follower roller **306** and pivots the roller **306** and fram **308** in a cuunter-clockwise direction to that the boss **304** passes under the roller **306** without moving the actuating finger **310** and, therefore, without closing the switch **312**. When, on the other hand, the solenoid **192** is de-energized by the trailing edge of the document and the control lever **198** returns to its normal position so that the drive gear now rotates the gear **288** in a counter-clockwise direction, the slanted or camming end of the boss **304** forces the roller **306** upwardly (note FIG. **6**), to move the actuating finger **310**, thereby closing the switch **312** momentarily to energize the solenoid **322** thus actuating the severing mechanism. It will be recalled from the discussion above that the control lever **198** cannot return to its normal position, nor start the gear **288** rotating, until the gear **252** has completed its rotary movement to unlock the locking lever **268**, thus assuring the feeding of a minimum length of copy paper before the severing mechanism solenoid **322** can be energized.

It will be noticed from FIGS. **4** and **6** that there is a short delay time from the moment the gear **288** begins to rotate until the boss **304** raises the roller **306**, this delay being determined by the lost motion angular distance between the boss **304** and the roller **306** while the gear **288** is in its spring urged position. Thus there will be a predetermined time delay between the trailing edge of the document de-energizing the solenoid **198** and the actuating of the severing mechanism. The reason for this time delay is to compensate for the time delay in the commencement of feeding of copy paper caused by the lost motion connection of the abutment elements **214** and **230** in the drive for the initial copy paper feed rollers **84** and **86**. Thus the more or less of a time delay provided in commencement of copy paper feeding by adjustment of the splined connection of the gear **226** on the shaft **210**, the more or less of a time delay must be provided in energization of the severing mechanism solenoid **322** by movement of the switch **312** on the mounting plate **316**. The latter is preferably provided with a scale which is calibrated to correspond with individual increments of adjustment of the gear **226** to facilitate easy adjustment of the severing mechanism in accordance with any change which may be required in the setting of the lost motion connection.

COPY PAPER SEVERING MECHANISM

As best seen in FIG. **2**, the copy paper severing mechanism frequently referred to above comprises a fixed frame **324** suitably supported between the side frame plates of the machine **10** and which supports a cutting blade **88** previously described in conjunction with the description of the copy paper feed path shown in FIG. **1**. A movable cutting blade **90** also previously described is mounted on a frame **326** which is pivotally supported between the side frame plates by a shaft **328**. A lever **330** is suitably connected at one end to the shaft **328** and is connected at the other end by a pin **332** to the free end of a bar **334**. The other end of the bar **334** is pivotally connected by a pin **336** to the armature **338** of the solenoid **322**. The free end of the bar **334** has a tension spring **340** suitably connected thereto, the spring **340** also being connected to the side frame plate of the machine **10** so as to normally hold the bar **334** and thereby the movable cutting blade **90** in an elevated position as determined by an adjustable stop member **342** mounted on a bracket **344** secured to the side frame plate.

Thus it will readily be seen that energization of the solenoid **322** by closing of the switch **312** draws the bar **334** downwardly to rotate the lever **330** in a clockwise direction, thereby moving the cutting blade **90** downwardly across the fixed blade **88** to sever the strip of copy paper. When the solenoid **322** is deenergized the spring **340** restores the parts to their normal position.

OPERATION

With reference to the drawings, a complete cycle of operation of the copying machine and the sequence control apparatus of the present invention will now be described. Assuming that the machine is set in a single copy mode of operation so that the gate members **66** and **74** are set to direct a document through the document feed path and to the exit slot **54**, a document is inserted through the infeed slot **22** until its leading edge is grasped by the feed rollers **28** and **30**. The leading edge then contacts the feeler arm **190** to close the switch **188** which in turn energizes the solenoid **192** thereby rocking the control lever **198** from its first or normal position to its second or paper feeding position.

At this moment several functions occur almost simultaneously. The drive gear **206** actuates the first driven means by engaging with the gear **208** to start moving the abutment member **214** through the extent of lost motion until it contacts the abutment member **230** whereupon the latter, through the splined connection **228** rotates the shaft **210** and the feed rollers **84** and **86** to feed copy paper past the severing mechanism and into the copy paper feed path. Also, when the control lever **198** moves, the locking lever **268**, under the influence of the spring **272**, moves upwardly to engage the tab **276** with the notch **280** on the bottom of the control lever **198** to lock the latter in its paper feeding position.

In addition, when the control lever **198** moves, the drive gear **206** actuates the second driven means by disengaging from the cut out portion **292** of the gear **288** to allow the latter to rotate in a clockwise direction under the influence of the torsion spring **294** to move the boss **302** out of blocking engagement with the actuating finger **300** so that the illuminating lamp and charging device switch **296** can assume its normally on condition to energize the lamp and charger.

Finally, as soon as the lost motion between the abutment members **214** and **230** is taken up and the gear **226** commences rotation of the roller shaft **210**, this gear also actuates the third driven means by commencing rotation of the gear **252** which was engaged with the gear **226** by the rocking movement of the auxiliary lever **240** which accompanies the rocking movement of the control lever **198** by virtue of the resilient connection between the two levers afforded by the spring **246**. The gear **252** continues to rotate through its degree of

lost motion until the cut out portion **286** thereof engages with the gear **226** at which point the inner face stud **282** on the gear **252** has contacted the camming arm **284** of the locking lever **268** and moved the latter downwardly to free the control lever **198** for return movement to its normal position. At this point, it will be recalled, about 5½ inches of copy paper has been fed past the severing mechanism.

During the copying operation, the original document is fed past the illuminating station while copy paper is fed past the charging device **98** and the exposing station so that the indicia on the document is projected to the copy paper to form a latent electrostatic image thereon in a manner well-known in the art.

When the trailing edge of the document passes the feeler arm **190,** the switch **188** is opened and the solenoid **192** is deenergized, whereupon the control lever **198** returns to its first position under the influence of the tension spring **196.** At this point several inches of document and copy paper have not passed through their respective illuminating and exposing stations, and the following series of events occur.

When the control lever **198** returns to its first position, the drive gear **206** moves out of engagement with the gear **208** thereby effectively interrupting the drive chain through the abutment elements **214** and **230** to the feed roller shaft **210,** whereupon the feed rollers **84** and **86** stop feeding copy paper. Also, the gear **208** is now free to rotate in a reverse direction under the influence of the torsion spring **216** so as to reset the gear **208** and the abutment element **214** to again provide for lost motion at the commencement of the copy paper feeding portion of the next copying cycle of operation of the machine.

Simultaneously with movement of the control lever **198** to its first position, the auxiliary lever **240** is moved to disengage the cut out portion **286** of the gear **252** from the gear **226** whereupon the gear **252** is free to rotate in a counter-clockwise direction under the influence of the torsion spring **256** until the outer face stud **264** abuts against the stop tab **266** formed on the auxiliary lever **240.** This resets the unlocking means for the minimum copy paper length locking lever **268** for operation during the initial portion of the copy paper feeding portion of the next cycle of operation.

In addition, when the control lever moves to its first position, the drive gear **206** re-engages with the second driven means, i.e., with the gear **288** and commences counter-clockwise rotation of that gear with the result that the boss **304,** after a short delay due to the lost motion of this gear corresponding to the delay of the lost motion connection in the initial copy paper feeding means, abuts the camming roller **306** which moves the actuating arm **310** to close the switch **312.** This energizes the solenoid **322** which pulls the bar **334** downwardly to rotate the lever **330** and move the cutting blade **90** downwardly to sever the strip of copy paper.

As the gear **288** continues to rotate, the trailing portion of the document and the now severed sheet of copy paper continue to move through their respective illuminating and exposing stations so that the entire document has been copied by the time that the gear **288** has rotated sufficiently to cause the boss **302** to move the actuating finger **300** to open the switch **296,** thereby de-energizing the illuminating lamp **122** and the charging device **98.** When this latter event occurs, the cut out portion **292** of the gear **288** will again be engaged with the drive gear **206** so as to discontinue rotation of the gear **288.** At this point all of the parts of the sequence control apparatus will have returned to their normal positions or conditions and a subsequent copying cycle of operation may be initiated, either by recirculating the document which has just been copied or by inserting a new document.

The sheet of copy paper continues in its path through the developing solution in the tank **138** and the drying area under the fan **142,** and is subsequently deposited in the receiving tray or compartment **118.** Original documents are collected on the tray **62** after being directed into the receiving compartment **56.**

It is apparent from the foregoing that there is provided a sequence control apparatus for a copying machine which avoids the disadvantages of prior art structures and which achieves the several objects and provides the advantageous features of the invention hereinbefore set forth.

What we claim and desire to secure by Letters Patent is:

1. In a photocopier having a drive train for driving feed rollers to translate copy and document sheets along separate feed paths, a supply roll from which copy paper is withdrawn by normally inoperative initial feed rollers in the copy sheet feed path and a severing mechanism for cutting the copy paper into sheet lengths, control apparatus comprising, in combination:

A. a sensing means located in the document feed path to detect the passage of the leading and trailing edges of the document;

B. clutch means controlled by said sensing means, sad clutch means being operative

1. to normally assume a first position,
2. to move to assume a second position upon the detection by said sensing means of the passage of the document's leading edge, and
3. to return to said first position upon the detection by said sensing means of the passage of the document's trailing edge;

C. first driven means coupled to the normally inoperative initial feed rollers and engaged by said clutch means while in said second position to couple the drive train to the initial feed rollers, thereby withdrawing copy paper from the supply roll; and

D. second driven means operatively coupled to the severing mechanism, said second driven means being engaged by said clutch means upon its return from said second position to said first position to couple the drive train thereto, thereby initiating actuation of the severing mechanism to cut the copy paper into a sheet length corresponding to the length of the document sheet.

2. The apparatus defined in claim **1,** wherein

A. said first driven means includes an adjustable first lost motion coupling fo delaying the start of copy paper withdrawal after said clutch means assumes said second position; and

B. said second driven means includes an adjustable second lost motion coupling for delaying the actuation of the severing mechanism after said clutch means returns to said first position from said second position;

C. the delays imparted by said first and second lost motion couplings being substantially equal.

3. The apparatus defined in claim 1, which further includes latch means engaging said clutch means as it assumes said second position, said latch means being operatively coupled to said first driven means so as to be disengaged from said clutch means after a predetermined minimum length of copy paper has been withdrawn from the supply roll.

4. The apparatus defined in claim 1, wherein said sensing means comprises a switch which is actuated from a first to a second condition by the passage of the leading edge of the document and actuated to return to said first condition by the passage of the trailing edge of the document, said apparatus further including

A. a solenoid actuated while said switch is in said second condition to position said clutch means in said second position; and

B. a spring operable to position said clutch means in said first position while said switch is in said first condition.

5. The apparatus defined in claim 1, wherein

A. said clutch means includes

1. a control lever pivotally mounted for movement between said first and second positions, and

2. a drive gear journalled on said control lever and continuously coupled to the drive train;

B. said first driven means includes a first driven gear engaged by said drive gear when said control lever is in said second position; and

C. said second driven means includes a second driven gear engaged by said drive gear when said control lever returns from said second position to said first position.

6. In a copier having separate document and copy sheet feed paths, a supply roll of copy paper, an initial feed roller operative to withdraw copy paper from the supply roll, and a cutter mechanism operative to cut the copy paper into sheet lengths corresponding to the lengths of the document sheets, control apparatus comprising, in combination:

A. sensing means located in the document feed path and operating to signal the passage of the leading and trailing edges of a document sheet;

B. a control element normally assuming a first position and mounted for movement to a second position in response to said sensing means signalling the passage of a document's leading edge,

1. said control element returning to said first position in response to said sensing means signalling the passage of the document's trailing edge;

C. drive initiating means carried by said control element and movable therewith;

D. driven means associated with the initial feed roller and engaged by said drive initiating means only when said control element assumes said second position, whereby to initiate driven rotation of the initial feed roller and withdrawal of copy paper from the supply roll; and

E. actuator means adapted to be rendered effective to initiate actuation of the cutter mechanism to cut the copy paper into sheet length upon the return of said control element from said second position to said first position.

7. The control apparatus defined in claim 6, wherein said actuator means is so constructed and positioned as to be engaged by said drive initiating means when said control element returns to said first position to initiate actuation of the cutter mechanism.

8. The apparatus defined in claim 6, wherein said sensing means comprises a switch which is closed for the time required for a document sheet to pass a given point in the document feed path, said apparatus further includes:

A. a solenoid actuated during the period of closure of said switch to position said control element to said second position; and

B. a spring acting to return said control element to said first position upon deactuation of said solenoid.

9. The control apparatus defined in claim 6, wherein

A. said driven means includes means for providing an adjustable first time delay between the moment said control element assumes said second position and the application of drive to the initial feed roller; and

B. said actuator means provides an adjustable second time delay, equal to said first time delay, between the return of said control element to said first position and the actuation of the cutter mechanism.

10. The control apparatus defined in claim 9, wherein said means providing said first time delay is a lost motion mechanism.

11. The control apparatus defined in claim 9, wherein said drive initiating means includes a first gear drivingly connected to the drive train of the copier, said first gear

A. drivingly engaging said driven means when said control element assumes said second position; and

B. drivingly engaging said actuator means when said control element returns from said second position to said first position.

12. The control apparatus defined in claim 11, wherein said driven means includes:

A. a shaft drivingly connected to the initial feed roller;

B. a second gear journalled on said shaft and drivingly engaged by said first gear;

C. a spring for angularly orienting said second gear to a reference position when said first and second gears are disengaged;

D. a first abutment carried by said second gear; and

E. a second abutment angularly keyed on said shaft in adjustably spaced relation to said first abutment when said second gear assumes said reference position and engaged thereby to couple drive to the initial feed roller after a predetermined increment of rotation of said second gear by said first gear.

13. The control apparatus defined in claim 11, wherein said actuator means includes

A. a timing gear positioned for engagement by said first gear when said control element assumes said first position;

B. a boss carried by said timing gear;

C. a stop establishing a reference angular position for said timing gear;

D. a spring for rotating said timing gear to said reference position upon disengagement by said first gear; and

E. a switch actuator for actuating the cutter mechanism upon engagement by said boss after a predetermined increment of rotation of said timing gear

by said first gear upon return of said control element to said first position.

14. The control apparatus defined in claim **13,** wherein said switch actuator is adjustably angularly positioned relative to said boss when said timing gear is in said reference position, whereby to vary the magnitude of said predetermined increment of rotation of said timing gear.

15. The control apparatus defined in claim **13,** wherein said timing gear is formed having detent means cooperating with said first gear to retain said timing gear in a normal angular position against the force of said spring,

A. said timing gear being rotated from said reference angular position to said normal angular position by said first gear each time said control element returns to said first position.

16. The control apparatus defined in claim **15,** wherein said detent means is in the form of a cutout in the toothed periphery of said timing gear.

17. The control apparatus defined in claim **15,** wherein said switch actuator is constructed so as to be triggered to actuate the cutter mechanism only when engaged by said boss upon rotation of said timing gear from said reference angular position to said normal angular position.

18. The control apparatus defined in claim **13,** wherein said driven means includes:

A. a shaft drivingly connected to the initial feed roller;

B. a second gear journalled on said shaft and drivingly engaged by said first gear;

C. a spring for angularly orienting said second gear to a reference position when said first and second gears are disengaged;

D. a first abutment carried by said second gear; and

E. a second abutment angularly keyed on said shaft in adjustably spaced relation to said first abutment when said second gear assumes said reference position and engaged thereby to couple drive to the initial feed roller after a predetermined increment of rotation of said second gear by said first gear.

19. In a copier having separate document and copy sheet feed paths, a supply roll of copy paper, an initial feed roller operative to withdraw copy paper from the supply roll, and a cutter mechanism operative to cut the copy paper into sheet lengths corresponding to the lengths of the document sheets, control apparatus comprising, in combination:

A. sensing means located in the document feed path and operating to signal the passage of the leading and trailing edges of a document sheet;

B. a control element normally assuming a first position and mounted for movement to a second position in response to said sensing means signalling the passage of a document's leading edge;

1. said control element returning to said first position in response to said sensing means signalling the passage of the document's trailing edge;

C. drive initiating means carried by said control element and movable therewith;

D. driven means associated with the initial feed roller and engaged by said drive initiating means only when said control element assumes said second position, whereby to initiate driven rotation of the initial feed roller and withdrawal of copy paper from the supply roll;

E. actuator means adapted to be rendered effective to initiate actuation of the cutter mechanism to cut the copy paper into sheet length upon return of said control element from said second position to said first position; and

F. latch means engaged by said driven means and in turn engaging said control element in said second position until a predetermined minimum length of copy paper has been withdrawn from the supply roll.

20. The apparatus defined in claim **19,** wherein said latch means includes

A. a latch element releasably engaging said control element each time the latter assumes said second position; and

B. a driven element engaging said driven means while said control element is in said first position,

1. said driven element being driven through a predetermined distance to engage said latch element, releasing said control element.

21. The apparatus defined in claim **19,** wherein

A. said driven means includes a first gear secured on a shaft drivingly connected to the initial feed roller; and

B. said latch means includes

1. a latch element releasably engaging said control element each time the latter assumes said second position so as to retain said control element thereat,

2. a second gear engageable with and rotated by said first gear when said control element assumes said second position,

3. engagement means carried by said second gear for engaging said latch element to release said control element after a predetermined increment of rotation of said second gear by said first gear, whereby said control element is rendered nonresponsive to said sensing means signalling the passage of a document's trailing edge until a minimum length of copy paper has been withdrawn from the supply roll.

22. The apparatus defined in claim **21,** wherein said latch means further includes

A. a pivotally mounted lever journalling said second gear;

B. resilient means interconnecting said control element and said lever such that said lever is movable with said control element, whereby said second gear moves into engagement with said first gear when said control element assumes said second position;

C. a spring rotating said second gear to a reference angular position upon disengagement of said first and second gears; and

D. detent means on said second gear for establishing a second angular position therefor, whereby said second gear is rotated from said reference angular position to said second angular position to bring said engagement means into engagement with said latch element thereby releasing said control element.

23. The apparatus defined in claim **22,** wherein said detent means comprises a cut-out formed in the toothed periphery of said second gear,

A. said first gear engaging said cut-out to retain said second gear in said second angular position to hold said latch element out of engagement with said control element.

24. The apparatus defined in claim **21**, wherein said sensing means comprises a switch which is closed for the time required for a document sheet to pass a given point in the document feed path, said apparatus further includes:

A. a solenoid actuated during the period of closure of said switch to position said control element to said second position; and

B. a spring acting to return said control element to said first position upon deactuation of said solenoid.

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