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Aasen et al.

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[54] **EXACT LENGTH ADJUSTMENT MECHANISM FOR COPYING MACHINE**

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[21] Appl. No.: **82,861**

[52] **U.S. Cl.** **355/13**, 355/29

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

[58] **Field of Search** 355/13, 28, 29

[56] **References Cited**

UNITED STATES PATENTS

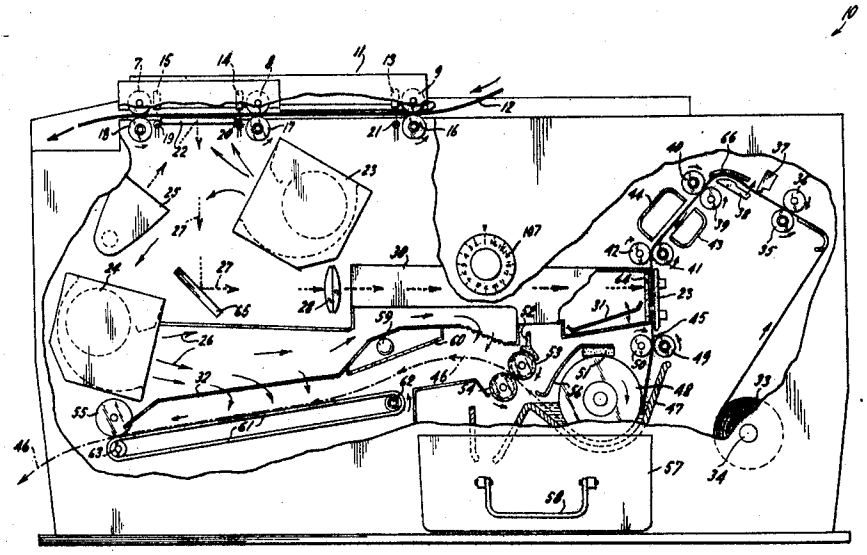
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[57] **ABSTRACT**

A mechanism for controlling the cutting from a roll of a sheet of copy paper whose length is the same as that of an original document fed into a copying machine. As in conventional systems, the leading edge of the original document is sensed to start the feed of copy paper. When the trailing edge of the original document is sensed, a knife operates to cut the copy paper and to stop further feed from the copy paper roll. As is known for systems of this type, the length of the copy paper sheet can be too short or too long, and the leading edges of the original and the copy sheet may not be in optical synchronization. The synchronization problem is overcome by providing an adjustably positioned sensor in the path of the original document. The length of the cut copy sheet is controlled by the setting of a potentiometer in an RC circuit coupled to the relay which controls the copy paper feed and the operation of the knife.

8 Claims, 7 Drawing Figures

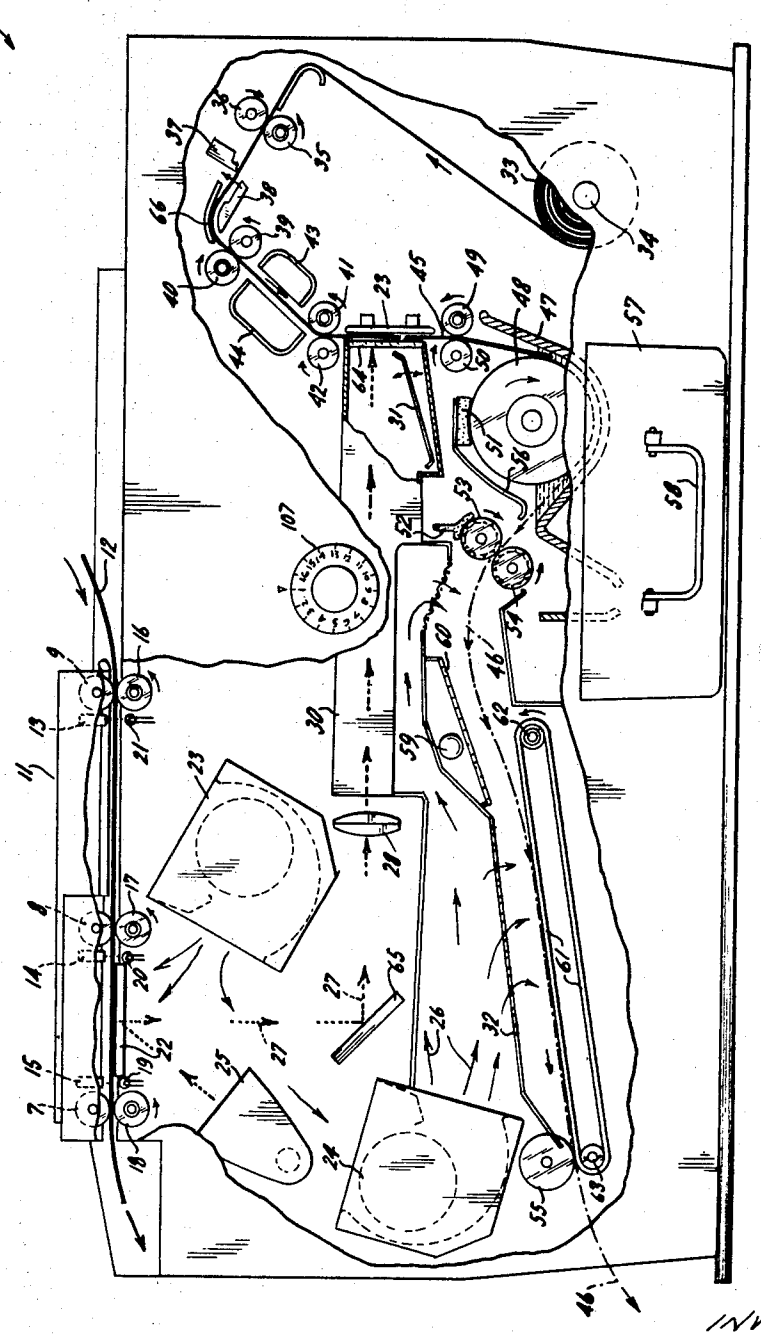


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SHEET 1 OF 2

FIG. 1.



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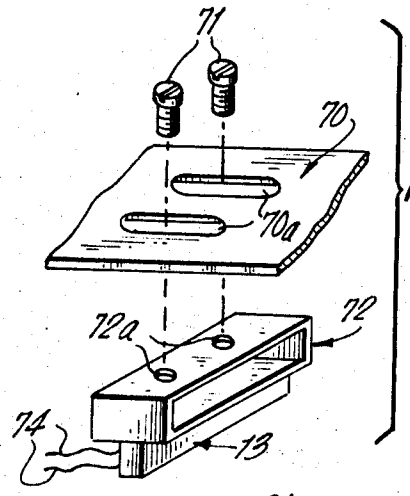
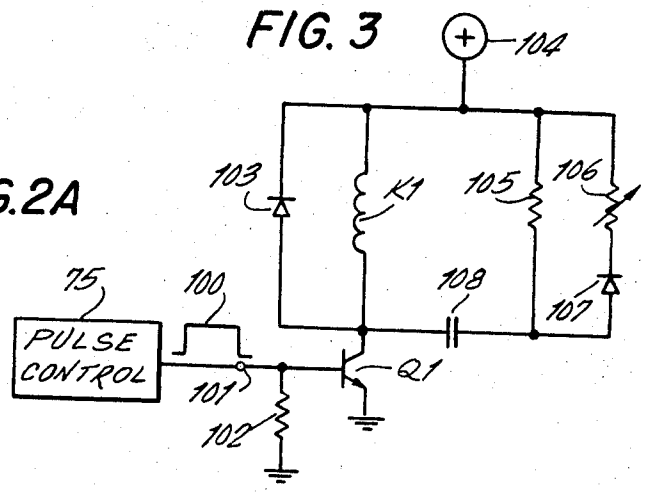


FIG. 2A

FIG. 3



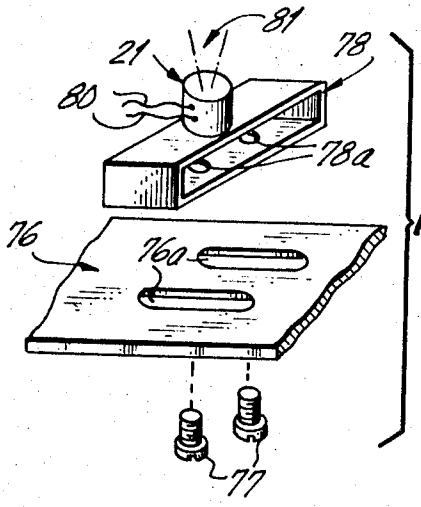


FIG. 2B

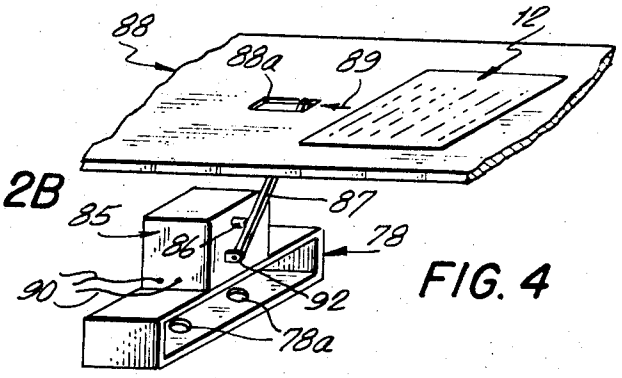


FIG. 4

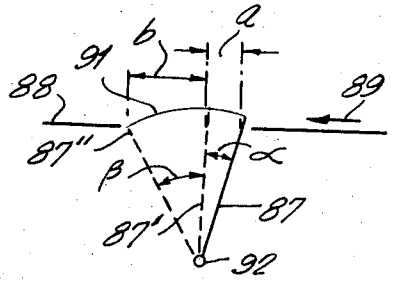


FIG. 5

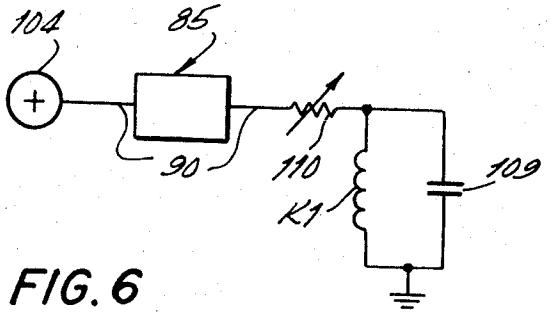


FIG. 6

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EXACT LENGTH ADJUSTMENT MECHANISM FOR COPYING MACHINE

This invention relates to copying machines, and more particularly to mechanisms for controlling the cutting from a roll of copy paper of a sheet whose length is the same as that of an original document to be copied.

In a popular type of copying machine on the market, successive copy sheets are cut from a roll of copy paper. As an original is fed into the machine, a sensor in the original path of movement detects the leading edge of the document to control the start of the feeding of copy paper from the roll. When the same sensor detects the trailing edge of the original document, the paper already fed from the roll is cut and further feed from the roll is inhibited. If the feed rate from the roll is the same as the speed of the original document as it is transported through the machine, the length of the cut copy sheet will be the same as that of the original. Furthermore, by properly positioning the sensor in the original path of movement in front of the scanning window, the leading edges of the original document and the copy sheet will be in optical synchronization as they pass by the scanning window and the exposure window respectively.

In typical machines, certain problems have been encountered with this type of arrangement. For example, the description above assumes that the copy paper is fed instantaneously upon the detection by the sensor of the leading edge of the original document. But the copy paper is fed from a roll which, especially when it is full, exhibits considerable inertia; there can be a noticeable delay between the time that the leading edge of the original document is detected and the time that the copy paper feed rate reaches its nominal value. Such a delay produces two types of error. First, the leading edge of the copy sheet is "behind" the leading edge of the original document and the two are not in optical synchronization. Second, the length of the copy sheet will be too short. Typically, the error (in both optical synchronization and sheet length) can be in the order of one-eighth of an inch.

The above description is most applicable to the case of photo-detector sensors. With such a sensor, an energizing lamp directs light to a photo-detector; when the light is first interrupted it is an indication that the leading edge of the original document has reached the sensor position, and when the photo-detector senses light once again it is an indication that the trailing edge of the original document is passing the sensor. But there are other machines which utilize mechanical sensors. Typical of these is a microswitch with a finger extending into the path of movement of the original document. The leading edge of the original document moves the microswitch finger to the operable position, and the trailing edge of the original document releases it. The finger moves from its initial position to an operative position, the finger being held in the latter position as the original document moves past the sensor. But the microswitch contacts typically change state at a position somewhere between the two extreme positions. This means that the switch contacts remain in the switched state longer than necessary and there results too long a copy sheet.

It is an object of our invention to provide a mechanism for controlling the cutting of exact-length copy sheets from a roll of copy paper and for insuring that cut copy sheets are in optical synchronization with moving original documents.

In accordance with the principles of our invention, the sensor—whether of the photo-detector type or the microswitch type—is positionally adjustable in the path of movement of the original document. In the case of a photo-detector sensor, the sensor is positioned such that for any particular machine the leading edges of the original document and the copy sheet are in optical synchronization. To compensate for the inherent delay in the start of the copy paper feed, the sensor is positioned slightly closer to the original document input of the machine than would be necessary from purely theoretical considerations (which do not take into account a delay in the start of the copy paper feed). When the leading edge of the original document is detected, a relay is operated to control the start of the copy paper feed. When the trailing edge of the original document is detected, the relay is released; this in turn causes the copy paper feed to cease and the knife to operate. A resistor-capacitor network is placed in parallel with the coil of the relay. The capacitor initially charges when the relay is first operated and serves to delay de-energization of the relay when the trailing edge of the original document is detected. The delay in the de-energization of the relay delays the operation of the knife and the cessation of copy paper feed by an amount which compensates for the delay in the start of the copy paper feed. In this way, the length of the cut sheet is made equal to the length of the original document. The resistor in the RC circuit is adjustable in every machine to take into account component differences from machine to machine.

In the case of a mechanical sensor, a capacitor is placed in parallel with the relay coil and a variable resistor is placed in series with the parallel circuit. By placing the capacitor across the relay coil, the relay cannot energize until the capacitor charges. The time taken for the capacitor to charge to that level when the relay becomes energized depends upon the magnitude of the resistor. The arrangement serves to delay the start of the copy paper feed, which in turn shortens the length of the cut sheet to compensate for the otherwise extra-long cut sheet. The position of the microswitch in the forward path of movement of the original document is adjustable to control the optical synchronization between the original document and the copy sheet as in the case of the photo-detector arrangement.

It is a feature of our invention to provide a variably positionable sensor in the path of movement of an original document and an adjustable RC network in the copy paper feed/knife mechanism for controlling optical synchronization between the original document and the copy sheet and the cutting of the copy sheet to a length equal to that of the original document.

Further objects, features and advantages of our invention will become apparent upon a consideration of the following detailed description in conjunction with the drawing, in which:

FIG. 1 is a block diagram schematic of a copying machine in which the present invention can be utilized;

FIGS. 2A and 2B depict an arrangement for allowing the adjustable positioning of a photo-detector sensor in the path of movement of an original document;

FIG. 3 depicts a first illustrative embodiment of our invention—a circuit for controlling the operation of the copy paper feed/knife mechanism of the copying machine;

FIG. 4 depicts a typical, adjustably positionable microswitch detector which can be utilized in the machine of FIG. 1;

FIG. 5 illustrates the problem introduced with the use of a switch of the type shown in FIG. 4; and

FIG. 6 is a second illustrative embodiment of our invention—a circuit for controlling the operation of the copy paper feed/knife mechanism when a switch of the type shown in FIG. 4 is used in a copying machine.

FIG. 1 is the same as FIG. 1 in Van Auken et al. application Ser. No. 725,390 filed on Apr. 30, 1968. The copy paper used in the machine is electrophotographic in nature. It has the ability to retain an electric charge placed on its photoconductive coating by an electrostatic field. The coating can be discharged by the application of light. Typically, copy paper roll **33** of FIG. **1** consists of a base paper with photoconductive zinc oxide particles dispersed in a resin coating. An electrical charge is placed on the front and back surfaces of the zinc oxide coating. When light strikes the zinc oxide particles they become conductive and the charged surfaces are neutralized.

As the leading edge of copy paper roll **33** passes through rollers **35, 36, 39, 40** and **41, 42**, the paper passes through the corona shields **43, 44** which house two sets of very fine wire elements (not shown) across which is placed a high DC voltage supply. The negative wire elements are contained within shield **44** while the positive wire elements are contained within shield **43**. The shields aid in establishing the corona field.

As the copy paper passes through the two sets of oppositely charged wire elements, a uniform negative charge is applied to the photoconductive coating on the surface facing shield **44**. A uniform positive charge is placed on the surface of the coating facing shield **43**. The charges placed on the surfaces of the copy paper will be retained for a reasonable length of time provided it is not exposed to any light. When light strikes the photoconductive coating, the zinc oxide particles which are exposed become conductive, neutralizing the negative and positive charges in the exposed areas.

As the copy paper passes the exposure window consisting of a glassless window strung with monofilament **64** and pressure member **23**, the photoconductive coating is exposed in accordance with dark and light areas on the original to be copied. Rotary knife **38** cuts a copy sheet from the roll such that the cut sheet is the same length as the original to be copied. When knife **38** operates, the copy roll paper feed stops, although the cut copy sheet continues to move past the exposure window to trough **47** in the developing section of the machine.

The original document **12** is fed into the machine between rollers **9, 16** which turn to move the original in the direction shown (from the right end of the machine in FIG. **1** to the left end). As the original passes the scanning window, on top of glass plate **22**, light from two exposure lamps (shown in phantom in FIG. **1**) within reflector **25** is reflected from the light image areas on the original along the dotted arrows **27** as shown. The light passes through lens system **28**, assembly **30** and window **64** to expose the copy paper. The copy paper feed is controlled such that the leading edge of the copy sheet within the exposure window is in optical synchronization with the leading edge of the original within the scanning window, that is, the leading edge of the original document reaches the axis of the optical system within the scanning window just when the leading edge of the copy sheet reaches the axis of the optical system within the exposure window. The copy paper retains a negative charge in those areas corresponding to dark(image) areas on the original. The non-image areas on the original reflect a great deal of light to the surface of the copy paper causing the neutralization of the charged areas corresponding to the non-image areas on the original.

The copy sheet is then fed to trough **47**. As shown in the drawing, the forward end of the copy paper has just entered the trough. The copy sheet continues to travel along path **46** until the copy sheet is ejected from the machine. In trough **47** there is a developer solution consisting of charged toner particles which are attracted to the negatively charged image areas on the copy paper. The attracted toner particles are impregnated and fixed to the copy paper coating by a system of squeegee rollers and forced hot air drying.

When original document **12** is inserted between pick-up rollers **9, 16** the original is transported to the left in FIG. **1**. As the leading edge of the original emerges from rollers **9, 16**, it actuates photocell switch **13**. Each of photocell switches **13, 14, 15** is provided with a respective light source **21, 20, 19**. When the leading edge of the original passes between a light source and its respective photocell switch, the change in state is registered and used to control the machine operation. When switch **13** first operates, a copy paper roller clutch (not shown) is energized to cause copy paper insert rollers **35, 36** to rotate. These rollers pull the forward edge of the copy roll to direct the copy paper through the corona unit. The other rollers along the copy paper path continuously operate. Initially, the forward edge of the copy paper is adjacent to blade **37** and knife **38**. Thus, although the rollers following the knife along the copy paper path rotate continuously there is no copy sheet to be transported through the machine. But once rollers **35, 36** start operating, copy paper is drawn from the roll into the copy paper transport system. The corona unit within shields **43, 44** charges the surfaces of the copy paper. The original and the copy paper are synchronized in their movements. The distance along the copy paper path from the knife to the intersection of the optical axis with the exposure window equals the distance from photocell switch **13** to the intersection of the optical axis with the scanning window. Since the rollers along the original and copy paths move the original and the copy paper at the same speed, and since the copy paper starts to move past the knife under control of rollers **35, 36** just when the forward edge of the original is adjacent photocell switch **13**, at least from a theoretical consideration the original and copy paper are in optical synchronization with each other during the scanning process.

As the trailing edge of the original passes photocell switch **13**, the copy paper roller clutch is disengaged. Rollers **35**, **36** stop turning and copy roll **33** remains stationary. At the same time a knife solenoid (not shown) is energized to cause rotary knife **38** to cut the copy paper to the exact length of the original. The cut sheet continues to be transported by the copy paper transport system through developer trough **47**. Intensifier drum **48** is constantly turned in the direction shown. This insures that the copy paper is guided through the developing trough. The developer solution itself is contained in tank **57** which can be pulled out of the machine by handle **58**. A pumping system (not shown) pumps the developer upward into trough **47**.

The copy sheet then passes under deflector **56** toward the nip of squeegee rollers **53**, **54**. The squeegee rollers remove the excess liquid dispersant from the copy paper and to some slight degree also imbed the attracted toner particles into the zinc oxide coated surface of the copy paper. Wiper **52** wipes metal squeegee roller **53** to prevent "tracking back" or offsetting of a previous image, just as wiper **51** wipes intensifier drum **48**. The copy sheet is then forced down by the circulating air under drier lamp **59** onto belt **61** which moves continuously around rollers **62**, **63**, roller **62** being turned by the constantly rotating chain drive (not shown). The copy sheet is finally passed between belt **61** and plastic idler rollers **55**, several of which may be included on the same shaft. These rollers slightly crease the copy paper so that it will stack properly in the copy receiving tray (not shown).

Blowers **23**, **24** force air (shown by arrows **26**) through the machine as is well known in the art, for example, to dissipate the heat generated by the exposure lamps. A series of guides **32** are provided for properly directing the air.

Shutter **31** can be moved up and down from outside the machine (not shown); the lower the right end of the shutter, the larger the opening and the greater the exposure.

Multiple copy selector dial **107** is marked in equal graduations numerically representing the number of copies desired. If the selector dial is allowed to remain in the normal position (single copy mode) shown in FIG. **1**, the machine will produce only one copy for each original inserted into it. Any other position will provide the number of copies as indicated by the selector dial setting.

In the multiple copy mode, during the first cycle the original is scanned in the usual manner. Before it has travelled far enough to be released by the last set of rollers **7**, **18**, the trailing edge of the original actuates photocell switch **15**. This causes the original transport roller system to reverse and return the original, at a speed greater than the forward speed, to the right toward the normal insertion point. When the leading edge of the original clears photocell **14**, the original transport roller system is again normalized and transports the original to the left past the scanning window where it is scanned a second time. (All references herein to leading and trailing edges of the original are made respectively to the left edge of the original and the right edge of the original in FIG. **1**. Thus, even when the original is being transported in the reverse direction, the leading edge is still considered to be the left-most edge in FIG. **1**.) This procedure is repeated until the multiple copy selector dial **107** is "counted down" to the normal single copy mode position. The dial is decremented one position for each copy made by the machine. When all copies have been made except the last, the selector dial is fully decremented to the single copy mode position, at which time the machine will produce one more copy and deposit the original in the original receiving tray.

To speed up the multiple copy operation, the original is returned only so far as to allow its leading edge to clear the forward end of the scanning window. Since the original immediately starts its forward movement, it is necessary for the leading edge of the copy sheet to be at the forward end of the exposure window by this time, i.e., the copy feed must start while the original is still being moved in the reverse direction. In the single copy mode, the copy feed starts when photocell **13** detects the leading edge of the original. But in the multiple copy mode, except during the first forward feed of the original, the leading edge of the original does not pass photocell **13**. For this reason an alternate mechanism is provided in the Van Auken et al. machine for initiating the copy feed during reverse movement of the original.

A cam in the Van Auken et al machine is clutched to the original forward feed system when the leading edge of the original passes photocell switch **15**. The cam (not shown in FIG. **1**) rotates counterclockwise as the original continues in the forward direction. When the original starts to move in the reverse direction, the cam starts restoring in the clockwise direction. The cam is fully restored when the leading edge of the original passes photocell **15** in the reverse direction. But during the clockwise movement of the cam, some time prior to its full restoration, an "early feed" switch is operated. The operation of the switch starts the copy paper feed. The leading edge of the original must yet travel back past photocell **15** (the switch operates while the leading edge of the original is still to the left of photocell **15** in FIG. **1**) and the scanning window to photocell **14**. The leading edge of the copy paper must travel from the knife to the forward end of the exposure window during the same time interval. The original reverse feed rate is greater than the copy feed rate. To assure proper registration of the original and copy within the scanning and exposure windows it is only necessary to have the cam operate the switch at a point during the reverse movement of the original where the ratio of the distance of the leading edge of the original from photocell **14** to the distance between the knife and that point in the copy sheet path of movement where the copy sheet becomes synchronized to movement of the original is equal to the ratio of the original reverse feed rate to the copy feed rate. In this way the leading edge of the original will reach photocell **14** just when the leading edge of the copy sheet reaches the exposure window.

As soon as photocell **14** detects the leading edge of the original, the original starts moving in the forward direction at the same speed as the copy paper is moving. It is still necessary to cut the copy sheet. This is easily accomplished. The positions of the original and copy paper are the same as though the machine were operating in the single copy mode. Consequently, when photocell **13** detects the trailing edge of the original, it actuates the cutting mechanism and inhibits further

feed from the copy paper roll. The length of the cut copy sheet during each cycle in the multiple copy mode is thus the same as that of the original.

In the original transport system, rollers **16, 9** serve as the original input rollers, rollers **17, 8** serve as the scanner input rollers, and rollers **18, 7** serve as the original exit rollers. Rollers **16, 17** and **18** are driven by a chain (not shown) in either direction. Rollers **7, 8** and **9** are contained in bridge assembly **11** and are in friction contact with their respective lower rollers when bridge **11** is placed on the machine. The bridge is removable so that in the event of an original jam, it can be corrected with little difficulty. Photocell switches **13, 14** and **15** contained in bridge **11** are connected to the rest of the machine by contacts on bridge **11**. The bridge also includes a pressure plate (not shown) for bearing against the original on top of scanning glass **22**. The spacing between the pressure plate and scanning glass **22** is several paper thicknesses.

An original collecting tray (not shown) is provided at the left end of the machine of FIG. **1** for collecting successive originals as they are fed through the machine. During multiple copying, the original is scanned in the forward direction in the usual manner, but before it is released by exit rollers **7, 18**, all three pairs of transport rollers are automatically reversed and the original is returned at high speed in the reverse direction. The original is transported in the reverse direction until the leading edge is to the right of scanning window **22** at which time the control circuit again causes the original to be transported in the forward direction to be scanned again. Photocells **14** and **15** are disposed at each end of the scanning glass and serve various functions in the multiple copy mode of operation. Photocell **13** serves to control the length of the cut copy sheet as well as the copy paper feed.

Copy paper roll **33** is mounted on copy paper roll shaft **34**. Although not shown, as is known in the art, provision is made for placing new copy paper rolls on the shaft as they are used up.

The machine of FIG. **1** will be more clearly understood with reference to the above-identified Van Auken et al. application which is hereby incorporated by reference. An understanding of the operation does not require a complete understanding of the operation of all elements in the Van Auken et al. machine, e.g., the chains for driving the various rollers, etc.

In the electrical control circuit of the Van Auken et al machine, there is a relay **K1** which when first energized controls the operation of the copy paper feed clutch which in turn starts the feed of the copy paper. When the same relay is released, the feed from the copy paper roll stops and the knife operates. The relay is first energized when the leading edge of the original document first passes photocell **13**, and the relay is released when the trailing edge of the original document passes the same photocell. When the machine is operated in the multiple copy mode, the relay is first energized by a means other than photocell **13**. But as far as the present invention is concerned, it is not important to understand exactly how relay **K1** is energized and de-energized in accordance with the operation of photocell **13** or in accordance with some alternate scheme. All that is necessary is to understand that the relay is somehow energized when the leading of the original document passes photocell **13** and is de-energized when the trailing edge passes the photocell. This is shown in FIG. **3** where the coil of relay **K1** is connected in the collector circuit of transistor **Q1**. A pulse **100** is applied by "pulse control" circuit **75** to terminal **101**, connected to the base of transistor **Q1**, and controls the energization of relay **K1**. The pulse begins when the original document first reaches photocell **13**; the pulse terminates as the trailing edge of the original document passes photocell **13**. The positive potential appearing across base resistor **102** causes transistor **Q1** to conduct, current flowing from potential source **104** through the coil of relay **K1** and transistor **Q1**. When relay **K1** is first energized, the copy paper feed begins. The copy paper feed terminates when relay **K1** is de-energized, and at the same time knife **38** operates to cut a sheet from the copy paper roll. If the copying machine is operated in the multiple copy mode, the leading edge of pulse **100** is generated other than under control of photocell **13**, but the same-length pulse is applied at terminal **101** and the time at which the pulse is generated is determined by the position of photocell **13** in the path of movement of original document **12**. As far as the present invention is concerned, it can be best understood without further reference to the multiple copy mode; as will be apparent to those skilled in the art, pulse **100** exists for as long as original **12** blocks the light of lamp **21** from reaching photocell **13**.

When the leading edge of the original document reaches photocell **13**, relay **K1** is energized. Assuming that the relay energizes instantaneously and that the copy paper feed similarly begins instantaneously, the original document and the copy sheet would be in optical synchronization were photocell **13** placed a distance in front of the intersection of the system optical axis with the scanning window which is equal to the distance the leading edge of the copy sheet must travel to the intersection of the optical axis with the exposure window. However, it takes some finite time for the copy sheet to start moving after photocell **13** first operates. The original document thus "gets ahead" of the copy sheet. This not only presents optical synchronization problems, but it also results in too short a length of cut copy sheet (assuming that the de-energization of the photocell results in the immediate cutting of a sheet from the copy paper roll).

The optical synchronization problem can be overcome, as is known by those skilled in the art, by mounting photocell **13** and lamp **21** in the machine such that they can be moved in either direction along the path of movement of the original document. By moving the lamp and photocell to the right (FIG. **1**) for example, it is apparent that the copy paper feed will begin while the original document is farther away from the scanning window. This means that the copy paper has a shorter distance to travel before it reaches the intersection of the optical axis with the exposure window than the original document has to travel until it reaches the intersection of the optical axis with the scanning window. Depending on the characteristics of different machines, the energizing lamp and photocell are adjusted in position until the copy sheet and the original document are in optical synchronization every time an original document is fed into the machine. Mounting

mechanisms for the photocell and the energizing lamp are shown respectively in FIGS. 2A and 2B, such mounting mechanisms being of types known in the art to control optical synchronization. (The present invention is concerned primarily with the exact length adjustment mechanism, although it is apparent that the operation of this mechanism is tied to the control of the optical synchronization inasmuch as the sensor in the original path of movement affects both the optical synchronization and the length of the cut copy sheet.)

Bracket **70** of FIG. 2A is mounted in bridge **11** in any conventional manner, and includes two slots **70***a*. On the underside of bracket **70** there is mounted a bracket **72** which includes two holes **72***a* containing screw threads. Screws **71** are extended through slots **70***a* into holes **72***a* for mounting bracket **72** on bracket **70**. By loosening the screws, bracket **72** can be moved in the left-right direction and the screws can then be tightened to lock bracket **72** in place. Photocell **13** is shown mounted on bracket **72** with wires **74** extending from the photocell. These wires are connected to pulse control circuit **75** in a known manner to control the generation of pulse **100**.

Similarly, bracket **76** is mounted in the main body of the machine and includes two slots **76***a*. Screws **77** extend up through the slots into screw thread holes **78***a* in bracket **78**. Bracket **78** can be moved in the left-right direction by loosening the screws. Energizing lamp **21** is mounted on bracket **78** and emits light as shown by dotted lines **81**. Wires **80** extending from the lamp carry the current for energizing it, the lamp energizing circuit not being shown in the drawing but being known to those skilled in the art.

Brackets **72** and **78** are moved together in the left-right direction in order to adjust the effective sensor position relative to scanning window **22** in FIG. **1**. In the absence of the feeding in of an original document, light from lamp **21** impinges upon photo-detector **13**. As long as the photo-detector is energized, the output of pulse control circuit **75** (FIG. **3**) is low. The output of the pulse control circuit goes high when the leading edge of the original document cuts off light from the photo-detector. Pulse **100** terminates as the trailing edge of the original document passes the sensor and the photo-detector is once again energized.

Although transistor Q1 is shown in FIG. **3** as controlling the energization of relay **K1**, the transistor is simply one example of how the energization of the relay can be controlled. When the transistor conducts, the lower end of relay **K1** is extended through the transistor to ground. In effect, pulse **100** simple connects one end of the relay winding to ground. Any of many circuit elements can be used for this purpose. In fact, in the Van Auken et al application a variety of switches and relay contacts serve to control the energization of relay **K1**. All of these are symbolized by pulse control **75** and transistor Q1 in FIG. **3**. The function of these elements is to provide a ground connection to one end of the winding of relay **K1** when the leading edge of the original is detected (or at the equilavent time during reverse travel of the original in the multiple copy mode of operation) and to remove the ground when the trailing edge of the original passes the sensor. When relay **K1** is first energized the copy paper feed begins. When the relay is de-energized, the copy paper feed ceases and the knife operates.

When transistor Q1 first operates, current flows from source **104** through resistor **105**, capacitor **108** and transistor Q1 to ground. Although this current flows together with the current through the relay coil, it has no effect on the relay operation. Capacitor **108** charges to the potential of source **104** (less any drop across transistor Q1) and current then ceases to flow through resistor **105** and capacitor **108**, although the current continues to flow through the relay coil to keep the relay energized. While transistor Q1 conducts, no current flows through the paths including diodes **103** and **107**.

At the trailing edge of pulse **100**, transistor Q1 turns off. It is at this time that capacitor **108** discharges through the winding of relay K1, current flowing from the capacitor, through the parallel circuit including resistor **105** in one branch and resistor **106** and diode **107** in the other, and the winding of relay K1. As long as the discharge current flows, relay K1 remains operated, the discharge current being in the same direction through the relay winding as the initial current from source **104**. The relay de-energizes only after the current from capacitor **108** falls below that value which maintains the relay energized.

The rate at which capacitor **108** discharges depends upon the setting of potentiometer **106**. The use of diode **107** prevents the initial current through transistor Q1 from flowing through resistor **106**. Thus, the rate at which the capacitor charges is determined solely by the magnitude of resistor **105**. Diode **107** conducts only when capacitor **108** discharges. In this manner, the setting of potentiometer **106** affects only the discharge of capacitor **108**, that is, the duration of the delay in the de-energization of the relay. Although the discharge of capacitor **108** through the winding of relay **K1** results in ringing, the current dissipates rapidly so that relay K1 does not reenergize when the current changes direction. Diode **103** is provided across the winding of relay **K1** only to suppress transients which would otherwise be produced (and possibly damage transistor Q1) when the current through the relay winding finally terminates with the discharge of capacitor **108**.

Were the copy paper feed to begin immediately (and at the proper speed) together with the leading edge of pulse **100**, the length of the cut copy sheet would be equal to that of the original document. Furthermore, the photo-detector could be placed a distance in front of the intersection of the optical axis of the scanning system with scanning window **22** which equals the distance in the copy sheet transport path between the leading edge of the copy paper at knife **38** and the intersection of the optical axis with the exposure window **64**. But because there is a delay in the start of the copy paper feed, the copy paper lags behind the original and the length of the copy sheet which is cut is too short. The optical synchronization problem is overcome by moving the sensor to the right in FIG. **1**. When the leading edge of pulse **100** is generated, the original has a greater distance to travel than the copy paper before the two of them reach the optical axis in their respective scanning and exposure windows. However, the time required for the original document to move the extra distance is made equal to the delay in the start of the copy paper movement. In this manner, optical synchronization is achieved. But this does not produce

a correct length copy sheet because the length of the copy sheet is determined by the time period during which the sensor detects the original document, not where the sensor detects it. It is for this reason that the delay circuit including capacitor **108** and resistor **106** is provided. At the trailing edge of pulse **100** transistor Q1 turns off, but the copy paper feed continues and the knife is not operated. It is only after the delay period that relay K1 de-energizes, the copy paper feed stops and the knife operates.

FIG. 4 depicts a typical prior art microswitch sensor. An original document **12** moves in the direction of arrow **89** on top of support plate **88**. The support plate includes a hole **88***a* in which the finger **87** of a microswitch **85** is mounted. The microswitch is mounted on a bracket **78**, which in turn is supported as is the same numbered bracket in FIG. 2B. By moving bracket **78**, the position of finger **87** within hole **88***a* can be adjusted. The microswitch includes a button **86** and two output wires **90**. When the leading edge of the original document engages that portion of finger **87** which extends up through hole **88***a*, the finger is pressed in toward button **86** to control a connection between the two wires **90**. As the original document continues to move in the forward direction, the finger is held in the operated position. When the trailing edge of the original document passes over the finger, the finger springs back and the connection between wires **90** is broken.

The operation of the microswitch is depicted in FIG. 5. Finger **87** is shown as pivoting around pivot point **92**. Initially, the finger extends slightly above plate **88**. As the leading edge of the original document (symbolized by arrow **89**) reaches the finger, the finger is rotated in the counterclockwise direction. After the finger has moved through an angle α, a connection is established between wires **90**. As the original continues to move, the finger moves through an additional angle β. The original then passes over the upper edge of the finger and holds the finger in the maximum counterclockwise position. When the trailing edge of the original passes over the upper edge of the finger, the finger springs back to the initial position shown in FIG. 5.

The distance *a* represents the distance traveled by the original document after it first engages finger **87** until the finger has rotated through an angle α and the switch has operated. The distance *b* represents the distance traveled by the original document as the finger moves through the additional angle β after the switch first operates. It is apparent that the use of a mechanical sensor of this type results in too long a copy sheet being cut from the roll. The copy paper feed begins when the microswitch first operates, that is, when the leading edge of the original has reached that point on top of plate **88** which is intersected by dotted line **87'** in FIG. 5. Were the switch to release when the trailing edge passed the same point (and assuming that there was no delay in the start of the copy paper feed), the length of the cut copy sheet would be equal to that of the original. However, the switch does not release until the trailing edge of the original document moves through an additional distance *b*. This results in an extra-long copy sheet. Generally speaking, the distance *b* is greater than the length by which the copy sheet is ordinarily too short as a result of delays in the start of the copy paper feed. Although the two effects work against each other, with the use of a microswitch such as that of FIG. 4 what generally happens is that the copy sheet is too long. The circuit of FIG. 5 insures that the copy sheet is of the proper length.

Microswitch **85** is shown symbolically in FIG. 6 connected between potential source **104** and one end of potentiometer **110**. The other end of the potentiometer is connected to the parallel circuit including the winding of relay K1 and capacitor **109**. When microswitch **85** first operates (when finger **87** is in position **87'** in FIG. 5), relay K1 does not energize immediately. Capacitor **109** is initially discharged and the potential across it cannot jump instantaneously. Current begins to flow through potentiometer **110**, and capacitor **109** and the relay coil, to ground. As the potential across the capacitor rises as the capacitor charges, eventually it is sufficient to control the energization of relay K1. The setting of potentiometer **110** determines the delay in the energization of relay K1.

When microswitch **85** releases, capacitor **109** rapidly discharges through the winding of relay K1 so that the relay de-energizes almost instantaneously upon the release of microswitch **85**. Although the discharge of capacitor **109** through the winding of relay K1 results in ringing, the current dissipates rapidly so that relay K1 does not re-energize when the current changes direction.

The setting of potentiometer **110** is adjusted such that the shortened time during which relay K1 is energized (taking into account a delay in the start of the copy paper feed and over-travel of finger **87**) provides an exact length copy sheet. This is most easily determined by experimentation on each machine. Since the setting of potentiometer **110** necessary affects the optical synchronization—the delay in the energization of relay K1 (the start of copy paper feed) after microswitch **85** first operates is determined by the setting of potentiometer **110**—after the proper length copy sheet is achieved, bracket **78** is moved to a position which establishes optical synchronization.

In both of the illustrative embodiments of the invention, the use of a movable sensor together with an adjust RC circuit allows the machine to be adjusted for optical synchronization and copy sheets to be cut to the proper lengths.

Although the invention has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the application of the principles of the invention. Numerous modifications may be made therein and other arrangements may be devised without departing from the spirit and scope of the invention.

What we claim is:

1. A mechanism for controlling optical synchronization between an original document and a copy sheet in a copying machine and the cutting of a copy sheet from a roll of copy paper whose length equals the length of the original document comprising means in the forward path of movement of said original document for detecting the leading and trailing edges thereof, control means responsive to the detection of the leading edge of said original document by said detecting means for initiating the feed of copy paper from said roll and responsive to the detection by said detecting means of

the trailing edge of said original document for terminating the feed of copy paper from said roll and for cutting the copy paper previously fed from said roll, means for enabling the position of said detecting means to be varied in the forward path of movement of said original document, an electrical adjustment means coupled to said control means for enabling the duration of the feed of said copy paper to be varied selectively a predetermined amount for each operation of said detecting means.

2. A mechanism in accordance with claim 1 wherein said detecting means is a photo-detector and said adjustment means includes means for delaying the termination of said copy paper feed and the cutting of said copy paper for a predetermined time interval after said detecting means detects the trailing edge of said original document.

3. A mechanism in accordance with claim 2 wherein said control means includes a relay coil and said adjustment means includes a capacitor and an adjustable resistor connected in series across said coil.

4. A mechanism in accordance with claim 1 wherein said detecting means is a switch having a finger movable by an original document engaging therewith and said adjustment means includes means for delaying the initiation of copy paper feed for a predetermined time interval after said detecting means detects the leading edge of an original document.

5. A mechanism in accordance with claim 4 wherein said control means includes a relay coil and said adjustment means includes a capacitor coupled across said coil and a variable resistor connected in series with said detecting means and said relay coil and capacitor.

6. A mechanism for controlling optical synchronization between an original document and a copy sheet in a copying machine and the cutting of a copy sheet from a roll of copy paper whose length equals the length of the original document comprising means in the forward path of movement of said original document for detecting the leading and trailing edges thereof, control means responsive to the detection of the leading edge of said original document by said detecting means for initiating the feed of copy paper from said roll and responsive to the detection by said detecting means of the trailing edge of said original document for terminating the feed of copy paper from said roll and for cutting the copy paper previously fed from said roll, and means for delaying the response of said control means to detection of the leading and trailing edges of said original document by said detecting means.

7. A mechanism in accordance with claim 6 wherein said delaying means is adjustable to selectively vary the feed of said copy paper.

8. A mechanism in accordance with claim 7 wherein said adjustable delaying means includes an adjustable resistor-capacitor network.

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