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[54] **AUTOMATIC COPY MACHINE COPY PAPER
LENGTH ERROR COMPENSATING SYSTEM**
5 Claims, 7 Drawing Figs.

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83/208, 83/289, 83/365, 355/13
[51] Int. Cl. B26d 5/34
[50] Field of Search 83/203,
205, 285, 286, 289—292, 208, 360—365, 369;
355/13

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ABSTRACT: As an original moves forward, a trailing edge sensor sends an initial cutting signal to a super-precise electronic timer having a capacitor that has already received a voltage generated by the actual speed of advance of the end portion of a strip of copy paper, so that when a regulated voltage is applied to the capacitor, the charging interval of the capacitor is controlled, so that any tendency for lengths to be cut too short or too long is corrected automatically when the capacitor discharges and thereby produces an actual cutting signal for operating a cutter to sever the strip. In the case of "flying" cuts, the strip speed voltage assists, and in the case of strip "standstill" cuts, such voltage "bucks" the charging current of the regulated voltage.

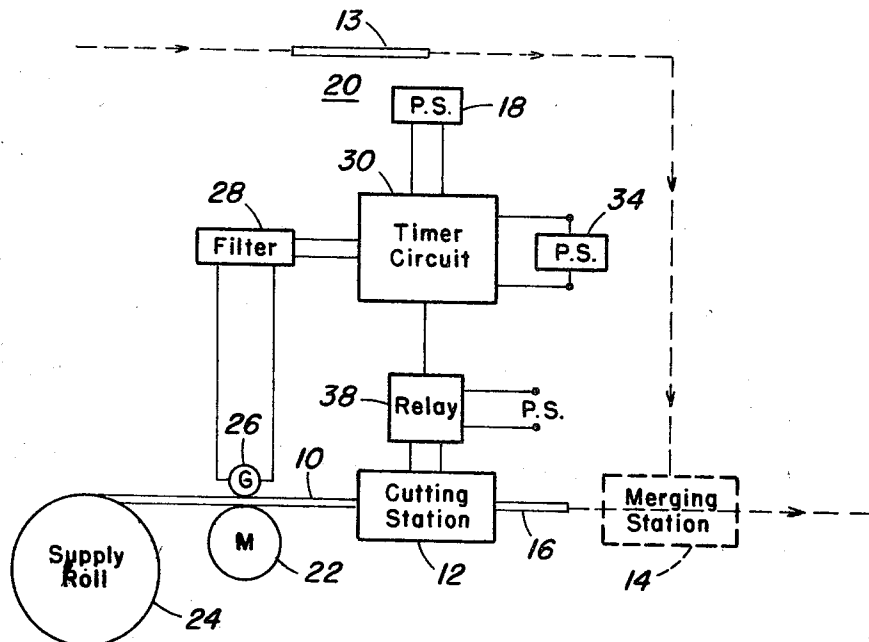


Fig. 2.

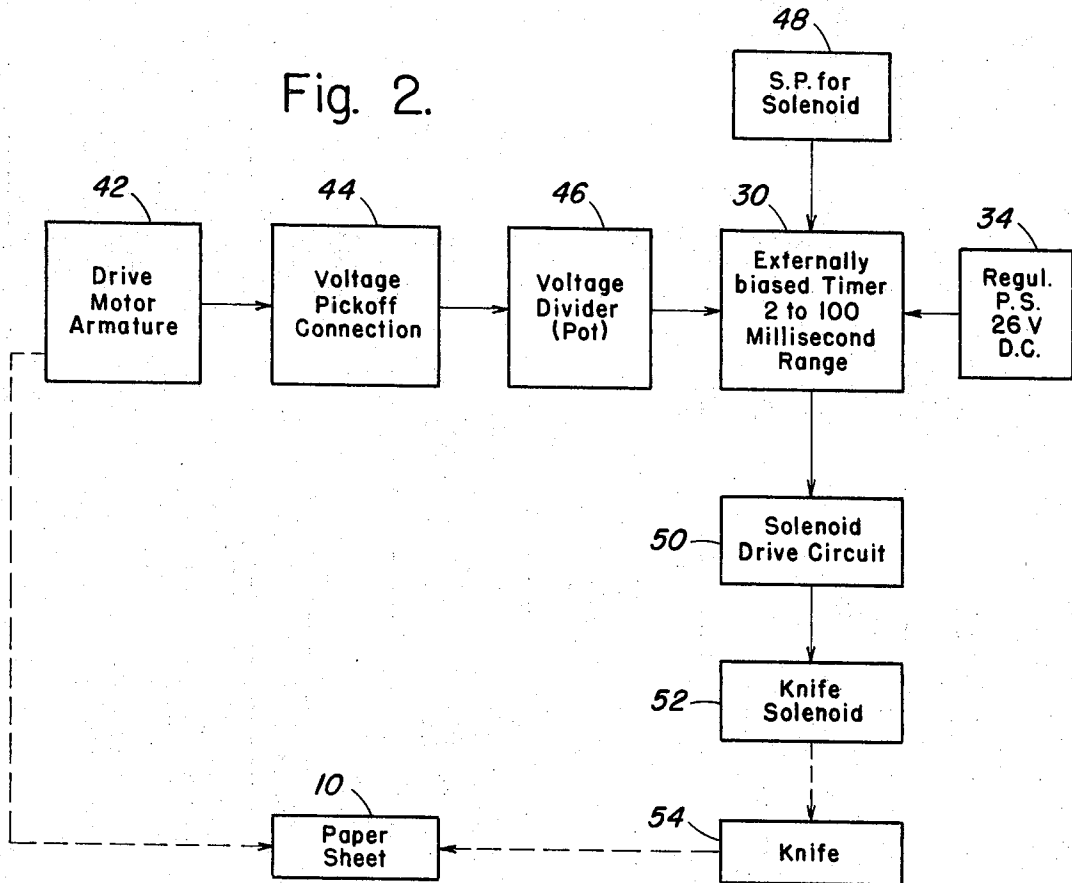
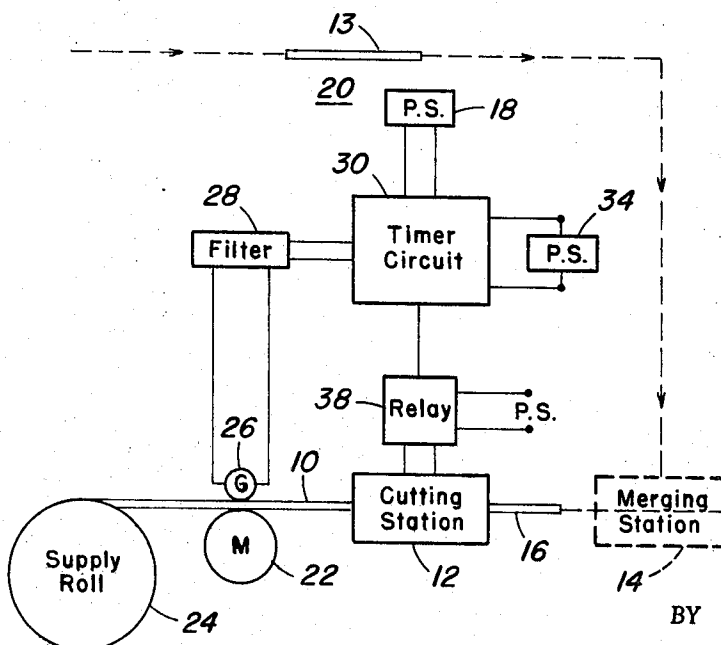


Fig. 1.



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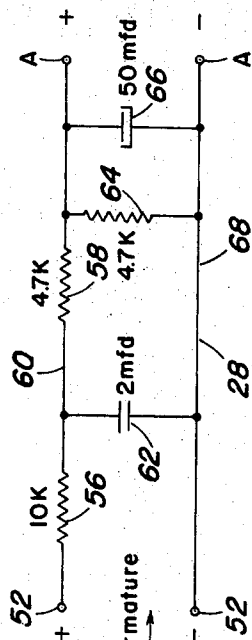


Fig. 4.

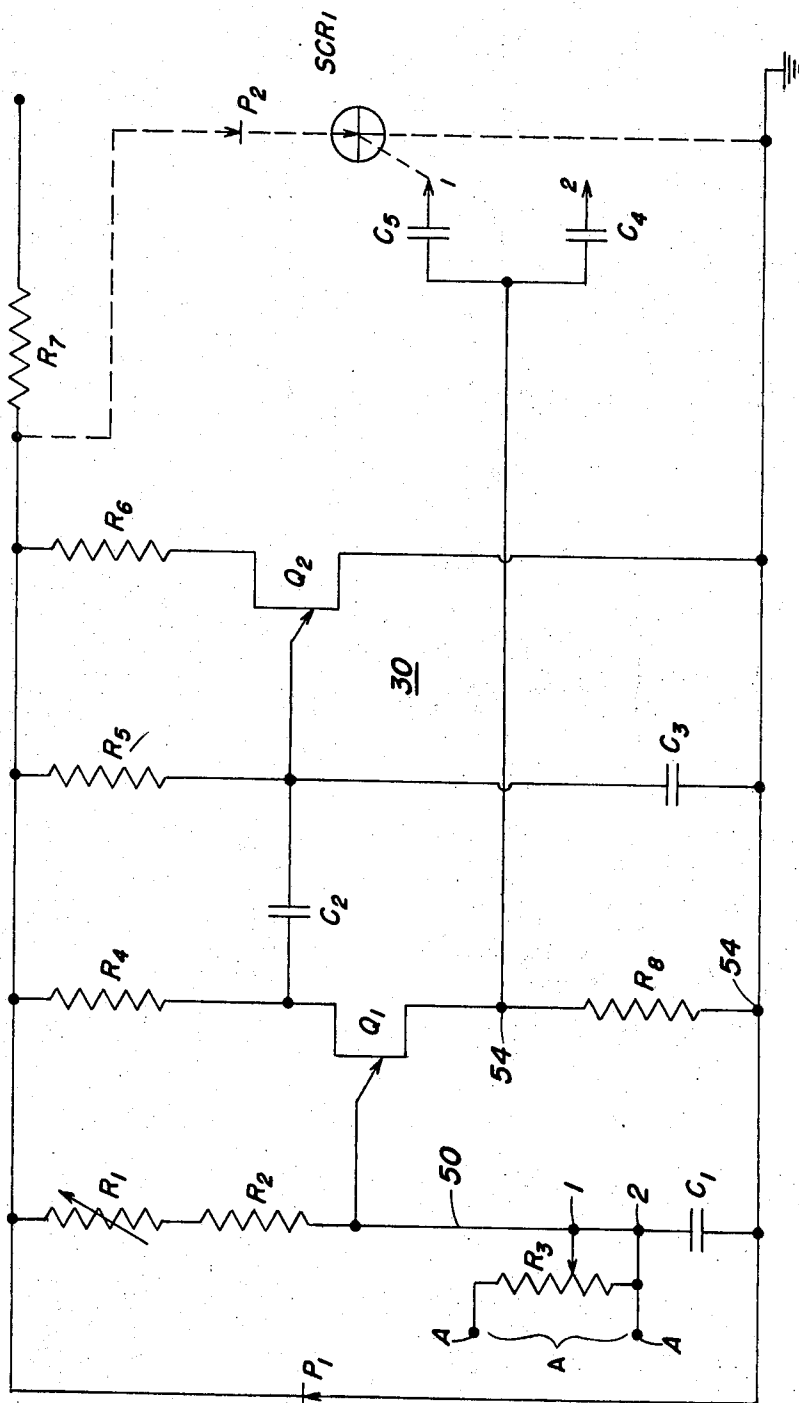


Fig. 3.

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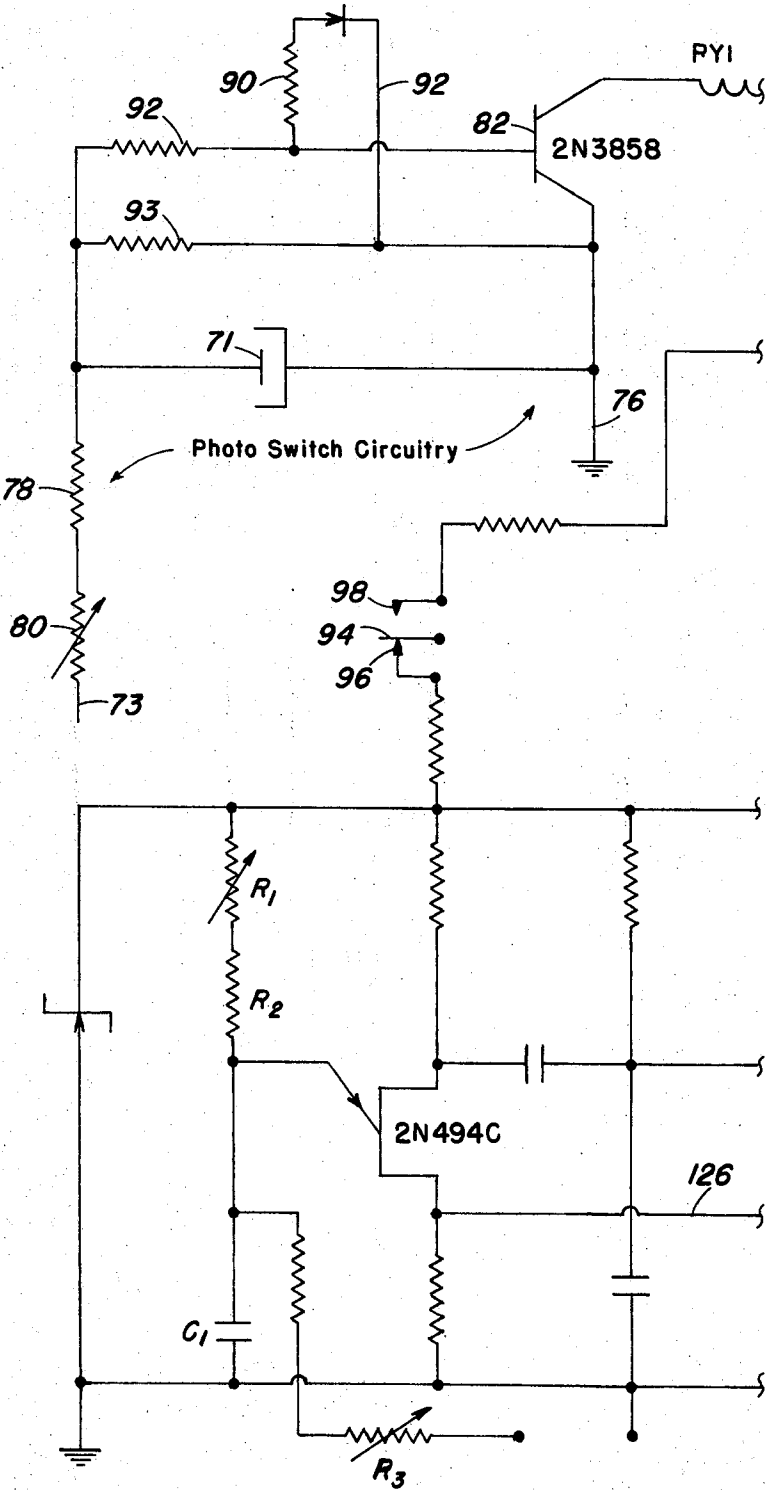


Fig. 5a.

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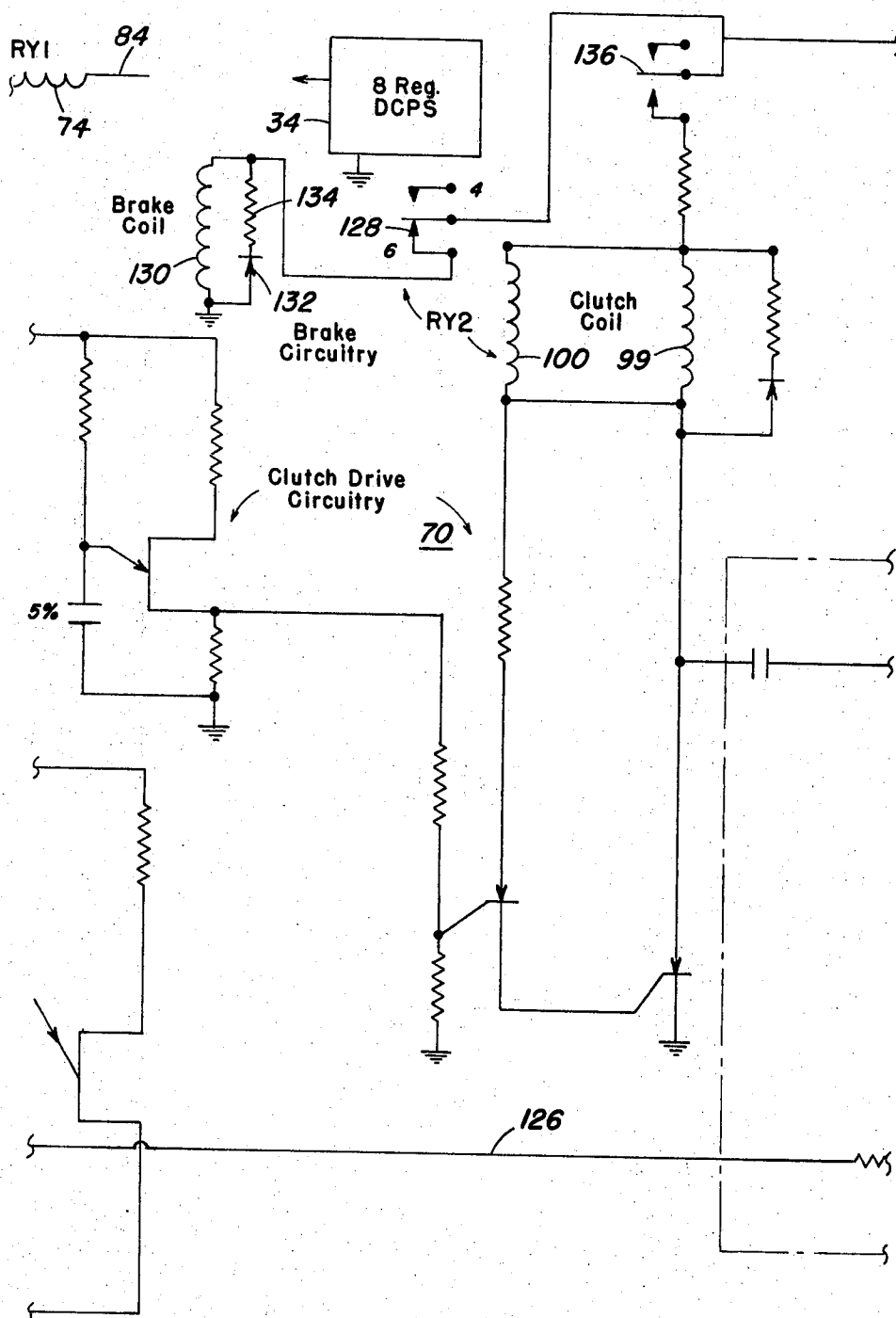


Fig. 5b.

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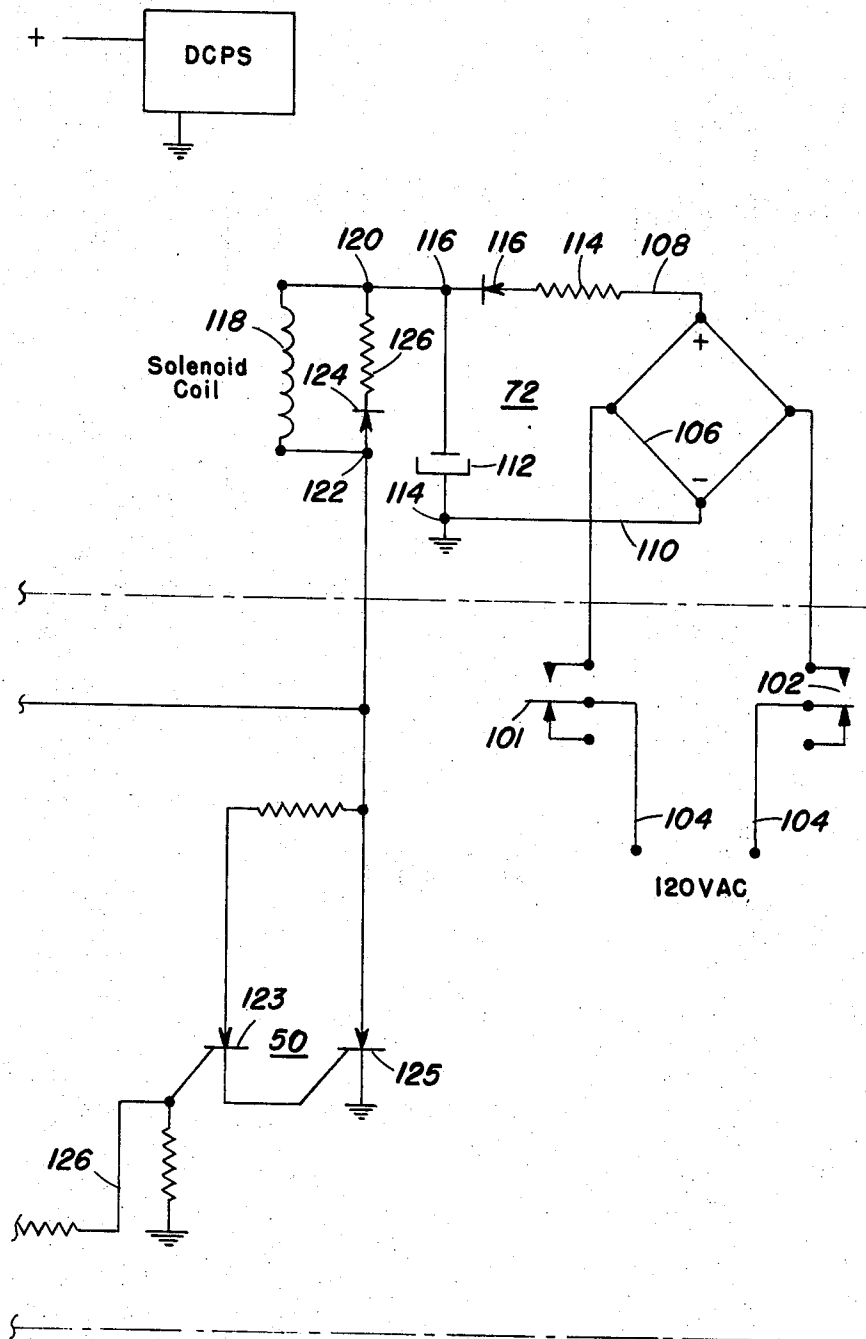


Fig. 5e.

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AUTOMATIC COPY MACHINE COPY PAPER LENGTH ERROR COMPENSATING SYSTEM

This invention relates to automatic photocopy machines, and more particularly, to copy paper handling subsystems therein.

THE PRIOR ART

Automatic photocopy machines are known which employ Diazo, Electrostatic and other processes. For example, in one machine and paper handling combination, a common drive motor provides mechanical power to all elements of the machine via a common drive linkage, such as a drive chain and associated gearing. An electric clutch couples the drive motor to the drive chain.

After the machine is switched "ON" electrically, conveyor belts are set into motion, and an activation subsystem is also turned "ON." With all mechanical, optical, electrical, and chemical elements of the machine now in operation, the machine is ready to produce copy. An original inserted in an input tray is picked up by a conveyor belt receiver and fed into an enclosure of the machine. A leading edge sensor detects the leading edge of the original as it is in transit toward the activation (or exposure) subsystem. The sensor produces a signal which results in releasing a brake, thereby freeing a paper reel-off roll feed device.

A few milliseconds after the release of the brake, another signal produced by the edge sensor, results in the closure of a clutch, transferring mechanical power to paper feed rollers. Another brake of the damping type remains in effect to minimize any recrinkling effect in the paper. The feed rollers reel off copy paper in the form of a strip from the supply roll. The copy paper strip travels into a cutting station containing a knife blade for example. The original merges on top of the copy paper and the two are fed in the activation device with the original between the copy paper and the activation mechanism, such as intense light rays. As soon as the trailing edge of the original is sensed, a cutting signal is produced which results in the operating of the strip cutting knife to sever a length from the strip. Such length is intended to correspond to that of the original.

However, copy paper length undesirably varies with paper transit speed, even though gearing within a machine is such as to maintain a fixed ratio of copy paper roll off speed vs. original transit speed (usually approximately 1:1). The control problem becomes more involved as this ratio varies from 1:1. In the case of "standstill" paper, for example, at a paper transit precutting speed of about 5 ft./min., copy paper lengths are very close to ($\pm$ one sixty-fourth in.) to the original length; while at 60 ft./min., copy lengths may be as much as three-fourth inches ($\pm$ one thirty-second in.) shorter than the original. Such trouble seems to be due to overall slippage when the copy paper is brought to a "standstill" and then cut.

The problem is complicated by the fact that copy lengths can also be undesirably longer than the original as the transit speed increases. This is particularly true when the paper is but on the "fly," i.e., while in transit. On the other hand, when the paper is cut after having stopped to a standstill, as pointed out above, the copy tends to decrease in length with increases in transit speed for the same original.

SUMMARY OF THE INVENTION

A copy paper length error compensating system is provided by the present invention to overcome such difficulties and problems of the prior art. The invention not only solves the problem when the paper is cut upon being brought to a standstill, but also when the paper is cut on the "fly." This feature is especially an advantage when it is appreciated that in the first instance the compensation is positive, and in the second, negative.

According to the invention, a super-precise timer circuit is employed in the sensor signaling circuit which causes operation of the paper cutting action at the proper instant for precise length cutting in response to activation by the trailing

edge of the original. The time of such actual cutting relative to the signal is set automatically by supplying to the timer circuit a direct current, the voltage of which is proportional to the speed of advance of the copy paper immediately prior to the cutting of each length therefrom. In general, in the case of "flying" cuts, the time delay is negative; and in the case of "standstill" cut, positive. In any case, the invention provides copy paper length error compensation automatically over a substantially wide range of paper feed speeds, and comprises means for adjustment to suit the peculiarities of each particular machine with which it is incorporated, which vary with different machines.

In recapitulation, for example, a signal indicative of paper speed is derived either from the armature of the drive motor (voltage) or from a tachometer which follows a paper driven roller. This voltage analogue of paper speed is divided and smoothed (as may be necessary) and fed into the charging network of a millisecond to one second range timer. The signal is coupled to the charging network of the timer in such a way as to buck, or assist, the normal charging current. This is to produce an increase, or decrease, in time delay as speed increases. The externally biased timer will cause solenoid drive circuitry to fire thereby passing current to a knife solenoid which drives the knife that cuts the paper. The time of cutting, is, thus, controlled by the paper transit speed in addition to that of the initial cutting signal of the sensor which is activated by the trailing edge of the original. The actual speed of advance of the end portion of the strip of copy paper immediately prior to cutting is under the control of means, other than that of the present super-precise timer circuit. It is of interest to point out that this same type of speed sensitive timer device can also be used to vary the delay (of start) time of the clutch which drives the copy paper roll-off. The longer the time delay (fixed or proportional to speed), the shorter the copy will be everything else remaining the same. In fact should a push-pull control be desired, two such externally biased timers could be put to good use; one for cutting control (trailing edge action), the other for copy roll-off start control (leading edge action).

THE DRAWINGS

FIG. 1 is a simplified block diagram illustrative of the invention.

FIG. 2 is a similar view of a modification.

FIG. 3 is a circuit diagram of the timer circuit.

FIG. 4 is a circuit diagram of a filter circuit.

FIG. 5a is a first part of a circuit diagram of the modification shown in FIG. 2.

FIG. 5b is a second part of a circuit diagram of the modification shown in FIG. 2.

FIG. 5c is a third part of a circuit diagram of the modification shown in FIG. 2.

FIG. 1

As shown in FIG. 1, the leading edge of a strip 10 of copy paper is automatically advanced at a speed selected automatically from a substantial range of speeds in a cutting station 12 in response to parallel movement therewith of an original 13 toward subsequent merger in merging station 14 with a corresponding length 16 of strip 10 cut therefrom. Such length 16 is severed from strip 10 in response to the passage of the trailing edge of the original 13 past a sensor 18 at an edge sensing station 20. The sensor 18 also controls the operation of a motor 22 which advances the strip 10 from a supply roll 24.

Advancing movement of the strip 10 by motor 22 drives a tachometer-generator 26, the voltage output of which passes through a filter circuit 28 into a super-precise timer circuit 30. The timer circuit 30 preferably is an externally biased cutting signal timing circuit which includes a current storage network. The timer circuit 30 is connected to a voltage regulated direct current power source 34 for supplying normal charging current to the current storage network therein. The sensor 18 comprises means including a drive circuit (which could in-

volve an SCR, power transistor, or a relay) 38 for applying an initial cutting signal to the timing circuit 30 when the trailing edge of each original 13 passes the sensor 18 in the edge sensing station 20.

The strip cutting station 12 is provided with a cutter which acts when operated to sever a length 16 from the strip 10 corresponding to that of the original 13 to be merged therewith for subsequent copying. The cutter is operated when drive circuit 38 is energized by the output of an actual cutting signal from the timer circuit 30. Operation of drive circuit 38 causes cutter energizing current to flow to the cutter drive circuit. Thus, the cutting of lengths 16 from the strip 10 of the copy paper is automatically exactly timed so that regardless of the speed of advance of the strip, the lengths match those of the corresponding originals.

FIG. 2

The paper sheet 10 is advance at a preselected speed by a motor, the armature 42 of which is connected by a voltage pickoff connection 44 to a voltage divider (potentiometer) 46. The output of the latter is fed to the externally biased timer 30, while a regulated DC power supply 34 is also connected thereto. The power supply 48 for a solenoid is connected to the input of the timer 30, while the output thereof is fed to a solenoid drive circuit 50. The latter is connected to a cutting knife solenoid 52 which drives the knife 54 to sever the paper sheet 10.

In prior machines when the paper is cut after being stopped to a standstill, the copy tends to decrease in length with increases in transit speed for the same original. On the basis therefore, of a copy paper being brought to a standstill then cut (or where machine gearing is such as to tend to make copy lengths short), desirable compensation should be positive, i.e., to increase the time delay of the cutting action as the speed of transit increases. Following this premise and considering FIG. 2, the copy paper error compensation system functions as follows: The copy paper 10 is reeled off a storage roll by means of a roll feed (or similar feed-off device) which in turn, is driven by a DC electric drive motor. Signal to start reeling off copy paper is dependent upon an edge sensor which detects the leading edge of an original (to be copied). Following this condition, copy paper is reeled off at some speed (dependent upon a motor speed signal derived from an automatic exposure control device).

During this interval of time from beginning of reel-off to signal to prepare the cut copy paper (from trailing edge sensor looking at the original), the externally biased timer 30 which is the "brain" of the compensation system, monitors the copy paper speed via a smoothing filter network driven by voltage picked off from the drive motor armature 42. Armature voltage is proportioned to copy paper speed. Depending upon the average speed of the paper, the voltage from the armature bucks the normal charging voltage on a timing capacitor in the timer circuit. Time delay is proportioned to charging current which in turn, is proportioned to the net charging voltage per unit time. Higher paper transit speeds produce proportional or mature voltages which result in longer time delays. After the capacitor is fully charged, the timing circuit will fire, thereby generating a gate pulse which will fire SCRs in the solenoid drive circuit 50. This passes the driving voltage from the solenoid power supply 48 to the knife solenoid 52 which in turn, drives the knife 54 thereby cutting the paper 10. Immediately following the paper cutting, the timer 30 is reset, either from a limit switch actuated by the knife 54 or by means of a second time delay device.

THE TIMER CIRCUIT—FIG. 3

The details of the timing circuit 30 as follows: Basically, this is a modification of a known circuit of the G.E. Co. SCR Manual 1967 edition, pages 165 and 166. Predictable time delays from as low as 0.3 milliseconds to over 3 minutes are obtainable from such circuit without resorting to a large value

electrolytic type timing capacitor. Instead, a stable low leakage paper or mylar capacitor C_1 is used and the peak point current of the timing unijunction transistor is effectively reduced, so that a large value emitter resistor may be substituted. The peak point requirement of transistor Q_2 is lowered up to 1000 times, by pulsing its upper base with a $\frac{1}{2}$ -volt negative pulse derived from free running oscillator Q_2 . This pulse momentarily drops the peak point voltage of transistor Q_1 , allowing peak point current to be supplied from capacitor C_1 , rather than via a resistor. Pulse rate of Q_2 is not critical, but it should have a period that is less than .02 ($R_1 \times C_1$). With resistor $R_1 = 2000$ megohms and capacitor $C_1 = 2$ mfd. (mylar). This circuit has given stable time delays of over 1 hour. In the present application, stability over a timing range from 1 millisecond to 100 milliseconds is sufficient.

This simplifies the selection of R_1 and C_1 , but increases the pulse rate requirement of capacitor Q_2 proportionally, a $C_1 = 2$ mfd. in mylar presents no problem, but an R_1 of considerably less than 2000 megohms is most desirable. Resistor r_2 is selected for best stabilization of the firing point over the required temperature range. Because the input impedance of the 2N494C UJ transistor (i.e., capacitor Q_1) is greater than 1500 megohms before it is fired, the maximum time delay that can be achieved is limited mainly by the leakage characteristics of capacitor C_1 . Particularly unique is the breaking of the otherwise normal connection 50 from resistors $R_2 + R_1$ to capacitor C_1 at between points 1 and 2 and the insertion of an external voltage across a potentiometer R_3 into the time delay circuit 30 at such points 1 and 2.

The external voltage DC is generated by the armature of motor driving the paper feed mechanism or by a tachometer DC generator, which monitors the paper feed shaft. This voltage which is analogous to paper speed is applied to terminals 52-52, FIG. 4, and smoothed by filter circuit 28, and then fed into the timing circuit 30 via terminals A, A; which terminal is positive depends upon the action desired. If the compensation required is positive, the polarity will be such as to buck the normal charging potential (and associated current in the R_1 , R_2 , C_1 sequence). Should the reverse be desired, the polarity of the input leads is reversed. Adjustability of resistor R_3 permits presetting a proportional effect.

The output pulse from the timer 30, terminals 54-54 is picked off across resistor R_6 for purposes of firing an SCR gate, or whatever other device is associated with the input of the solenoid drive circuit 50, FIG. 2. The absolute resistance value of resistor R_3 depends upon the input requirements of the solenoid drive circuitry. That of resistor R_6 depends upon the output characteristics of the voltage generator and the smoothing filter 28. For the needs in this application, resistor R_1 is about 10 megohms; R_2 about 2.5K; R_3 and R_4 about 150 ohms; R_5 about 400K; R_6 about 550 ohms; C_2 about .001 mfd.; and C_3 about .05 mfd. Transistor P_1 is a zener diode; Q_1 is a GE 2N494C UJ transistor; and Q_2 , a 2n2646 transistor.

FIG. 4

A satisfactory smoothing network comprising filter 28 is shown in FIG. 11. Such filter includes a 10K resistor 56 in series with a 4.7K resistor 58 in line 60 between terminals 52 and A; and a 2 capacitor 62, a 4.7K resistor 64, and a 50 mfd. capacitor 66 in parallel with each other across lines 60 and 68. Output of the filter 28 is 20 volts (maximum) DC, with 0.04V p-pc. Voltage is applied to terminals 52-52, and after filtering appears across terminals A-A.

FIGS. 5a, 5b, AND 6c

The main circuits of the blocks shown in FIG. 2 are shown in more detail along with the connections therebetween in FIGS. 5a-5c. Circuit 36 is typical of an edge sensing photo electric device which has proven to be satisfactory with the timer circuit 30. Solenoid drive circuit 50 is associated with a circuit 70 which includes the brake and clutch circuitry. A suitable power supply and storage device for the various drives is indicated by circuit 72.

Photo cell 71, FIG. 6a, is connected to the positive terminal of a 26 volt DC power supply by lead 73, and to the other side thereof through a ground lead 76. The lead 73 contains series resistors 78 and 80, the latter being adjustable. Firing of the cell 71, fires transistor 82 and energizes relay coil 74 of relay RY1, through lead 84 from power supply 34 to ground lead 76. The transistor firing circuit 86 includes a diode 88 and resistor 90 in rectifier circuit 92 across the transistor control leads which contain resistors 92 and 93.

When transistor 82 fires, relay coil 74 becomes energized and turns switch contact 94 of the relay RY1 so that it leaves contact 96 and touches contact 98. The latter applies voltage to the clutch drive circuitry 70, energizing the clutch coil 99 and coil 100 relays RY2. The latter operates contacts 101 and 102, connecting leads 104, 104 from a 120 volt AC source to bridge 106 having positive and negative DC output leads 108 and 110. The positive lead 108 is connected to a capacitor 112 through a resistor 114 and a diode 116. The negative lead 110 is connected to the capacitor 112 and to ground at point 114. Point 116 on the positive side is connected to coil 118 of the knife solenoid 50, FIG. 2, at point 120. The other terminal of the coil 118 is connected to point 122 and the latter is connected by diode 124 and resistor 126 to the point 120. Thus, the solenoid coil 118 is energized when transistors SCR's 123 and 125 of the solenoid drive circuit 50 are fired by a pulse from the timer circuit 30 via lead 126. The energization of the coil 100 of relay RY2 also opens contacts 128 to deenergize brake coil 130 having a diode 132 and resistor 134 connected in parallel therewith. Power to the brake coil is also under the control of a microswitch 136 on the knife 54, FIG. 2; or contacts on a time delay contact device following a set of contacts of relay RY2.

THE SYSTEM

This system has been observed (on hundreds of samples basis) to cut copy automatically over speed range (variable at random) to accuracies of original length ± 0.040 in. At any fixed speed of paper transit, copy cut accuracies have been observed to be within limits of original length ± 0.015 in. A common drive motor provides mechanical power to all elements of the machine via a common drive linkage such as a drive chain and gear combination. An electric clutch coupling the drive motor to drive chain is used.

After the machine has been switched "ON" electrically, the drive motor sets the conveyor belts, or other feed-in device (rollers, etc.), into motion. The activation subsystem which may consist of high intensity lamps associated with a drum, or electrostatic field generator associated with grids, wires and/or plates is also turned "ON." The developer subsystem is activated. This may involve the metering of an ammonia vapor into a tank at some desired rate, or evaporation of a developer solution, or the agitation of a developer bath, or the application of an electric field.

Since the specifics of the particular activation (or exposure) and developer subsystems are not in context in this disclosure, treatment of these devices will not be in detail. With all mechanical, optical, electrical, and chemical elements of the machine system now in operation, the machine is ready to produce copy. An original can be inserted into the input tray. The original will be picked up by the conveyor belt (or roller) receiver and fed into the enclosure of the machine. A leading edge sensor detects the leading edge of the original as it is in transit toward the activation (or exposure) subsystem.

This sensor can be a lever actuated microswitch, a photoelectric device, a sonic beam device, a fluidic switch device, or a beta ray switch. Photoswitches appear to be optimum in view of performance versus cost considerations, although a sonic switch worked quite well, in view of transparent originals. The signal is amplified in and by edge sensing circuitry. This deactivates the switch function device associated with the brake drive circuitry which releases the electric brake thereby freeing the paper reel-off roll feed (or similar function) device. A few milliseconds after the release

of the brake (or simultaneously with the brake release signal), another signal is generated associated with the edge sensor which activates the switch function device associated with the clutch drive circuitry. This closes the clutch circuit thereby transferring mechanical power to the paper feed rollers.

A mechanical (strap, magnetic, spring, etc.) type damping brake remaining in effect all the time has shown itself to be valuable in minimizing wrinkling effect in the paper. Although not necessary for accuracy in all machine situations, it has helped in some specific instances. With clutch in and brake out, the paper feed rollers reel off copy paper from the paper roll storage. This is guided by the paper guides in the direction of the paper knife. The copy paper travels under the knife blade in the direction of the activation subsystem. The original merges on top of the copy paper and the two are fed into the activation device with the original between the copy paper and the activation mechanism (usually an intense light source high in UV spectra).

As soon as the trailing edge of the original is sensed, the signal to fire the knife solenoid is generated but delayed for a brief (order of milliseconds) period depending upon the speed information stored in the externally biased timer. Electric power from power supply is delivered to the solenoid after the speed dependent delay.

Speed information exists in terms of the voltage across the armature of the main drive motor. This is fed into the timing network of the externally biased timer. The proportional delay in knife action compensates for copy length error due to speed changes. The knife cuts the copy after the clutch circuitry releases the clutch, the brake circuitry powers the brake and the speed compensation delay. When the knife blade crosses the paper sheet with some overshoot, the system is reset by any suitable reset circuitry.

A "READY" light comes on (for the next copy action) and the edge sensor awaits a new leading edge. The copy having been cut proceeds through the activation subsystem along with the original. After activation, the original and copy are separated and conveyor belts transport the original into an output bin for originals. The copy is transported into the developer subsystem. After development, the copy is conveyed into an output bin for copies.

The present invention, in effect, employs the speed of the strip to be cut to critically present in accordance with such speed the short time interval required between the initial signal to cut and the actual cutting signal for obviating length errors. The paper speed itself is regulated by means separate from the timer circuit which controls the exact time of cutting in response to activation of the trailing edge sensor by movement of the original as the latter moves forwardly for subsequent merger with the corresponding length of copy that is cut from the strip.

I claim:

1. An automatic copy machine paper length error compensating system for precision-timing the operation of a cutter for severing a length from the end portion of a strip of copy paper when the latter is advanced sufficiently for such length to be cut therefrom to correspond to that of an original when the trailing edge of the latter causes a sensor to produce an initial cutting signal, comprising:

a super-precise timer circuit containing a capacitor, the charging time of which controls an interval between receipt of such initial cutting signal and the output of an actual cutting signal for controlling the cutting operation of such cutter;

means acting to apply to said capacitor a DC voltage the value of which is proportional to the actual speed of advance of the end portion of the strip immediately prior to being cut; and

means acting in response to such initial cutting signal to connect said circuit to a regulated source of DC voltage for charging said capacitor to the extent permitted by such strip transit speed voltage to control the actual charging time to the capacitor, which upon discharge

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produces such actual cutting signal for operating the cutter at the precise time required for severing the strip, thereby compensating for any error in copy paper lengths over a substantial range of speed in strip advances.

2. The invention as defined by claim 1, in which the copy paper strip comes to a standstill for cutting by the cutter immediately after the advance of the end portion thereof, and the strip speed voltage is applied to said capacitor in "bucking" relation to that of the regulated voltage, whereby decreases in cut lengths due to increases in paper strip transit speeds are automatically compensated for by corresponding delay in the actual charging time of the capacitor.

3. The invention as defined by claim 1, in which the paper strip is cut on the "fly" while advancing, and the strip speed

voltage is applied to said capacitor in the same relation as that of the regulating voltage, whereby increases in cut lengths due to increases in paper strip transit speeds are compensated for by corresponding decreases in the actual charging time of the capacitor.

4. The invention as defined by claim 1, in which switching means are provided for selectively applying the strip speed voltage to the capacitor in either "bucking," or assisting relation, to that of such regulated voltage.

5. The invention as defined by claim 1, in which means including adjustable resistors are provided for adjusting the strip speed voltage and the regulated voltage applied to said capacitor.

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