June 18, 1963 R. ALEXANDER ETAL 3,094,027

METHOD OF SEVERING WEB MATERIAL AT PREDETERMINED LOCATIONS

Original Filed Jan. 28, 1957 2 Sheets-Sheet 1

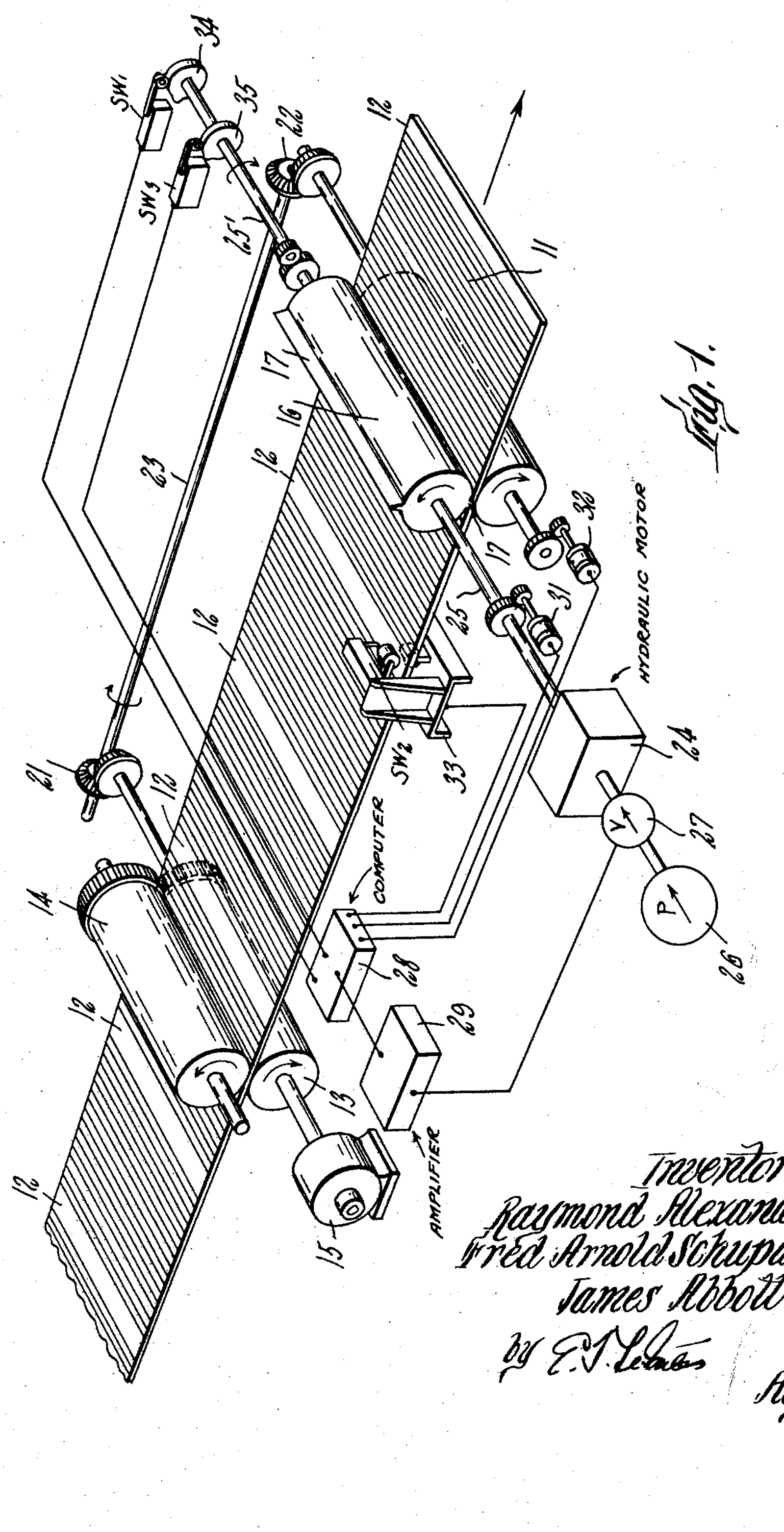


Fig. 1.

Inventors
Raymond Alexander
Fred Arnold Schupan
James Abbott
by E. T. [illegible]
Atty.

METHOD OF SEVERING WEB MATERIAL AT PREDETERMINED LOCATIONS

Original Filed Jan. 28, 1957 2 Sheets-Sheet 2

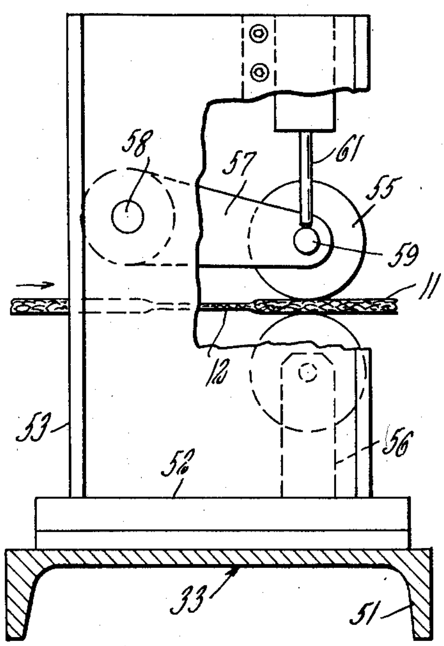


Fig. 2.

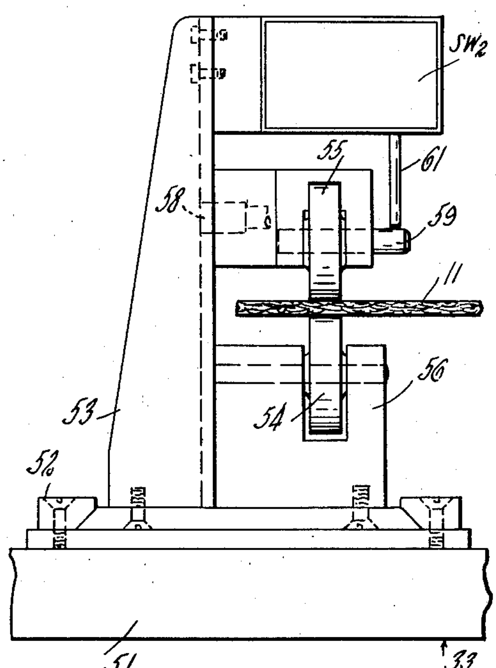
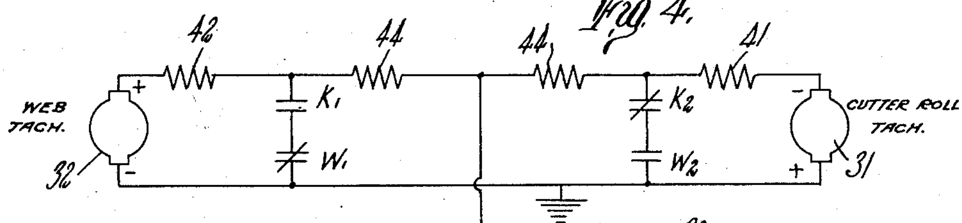
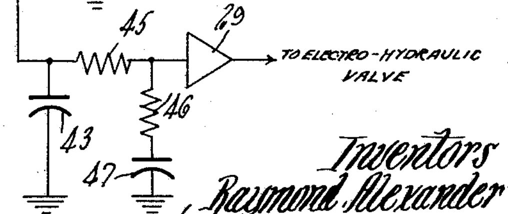


Fig. 3.

Fig. 4.





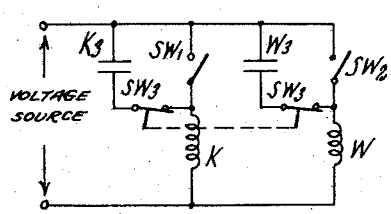


Fig. 5.

Inventors
Raymond Alexander
Fred Arnold Schupan
James Abbott
by ... Atty.

United States Patent Office 3,094,027
Patented June 18, 1963

1

3,094,027
METHOD OF SEVERING WEB MATERIAL AT PREDETERMINED LOCATIONS

Raymond Alexander and Fred Arnold Schupan, Framingham, and James Abbott, Sherborn, Mass., assignors to The Kendall Company, Boston, Mass., a corporation of Massachusetts

Original application Jan. 28, 1957, Ser. No. 636,800, now Patent No. 3,029,675, dated Apr. 17, 1962. Divided and this application July 13, 1961, Ser. No. 130,449
3 Claims. (Cl. 83—37)

This invention relates to register cutting apparatus adapted for the cutting of strip material at predefined locations spaced longitudinally of the strip.

The present application is a divisional application filed as a result of a requirement of restriction under 35 U.S.C. 121 in our co-pending parent application Serial No. 636,800, filed January 28, 1957 now U.S. Patent No. 3,029,675, granted April 17, 1962.

In many cutting processes wherein a long strip of material is to be cut into relatively short sections whose lengths are defined by a special characteristic of the material recurring at fixed intervals, a problem is often created by the fact that the longitudinal spacings of the intervals are non-uniform. This problem is an especially servere one where the intervals deviate from a nominal value in more or less random fashion, and where each cut must be made accurately, within relatively close tolerance limits.

It is an object of the present invention to provide register cutting apparatus which meets all of these requirements and which in addition is especially designed for applications requiring relatively high speed operation. One such application is the cutting of certain textile webs along transverse bars defined by abrupt changes in thickness of the web at randomly varying intervals of from 18 to 24 inches. Although the details of the apparatus will be described in this environment, in view of the fact that the apparatus is adapted to operate at rates as high as 75 cuts per minute along lines within ±⅛ inch from the centers of the bars, the fitness of the apparatus for many other allied applications will be apparent.

The novel features of the invention together with further objects and advantages thereof will become apparent from the illustrative embodiment shown in the accompanying drawings and described in detail hereinafter.

In the drawings:

FIG. 1 is a perspective view of the register cutting apparatus according to the present invention;

FIG. 2 is a side view in elevation of a device for sensing the locations where cuts are to be made;

FIG. 3 is a front view in elevation of the device of FIG. 2;

FIG. 4 is a schematic diagram of the electronic computer employed in the apparatus to derive error voltages for control of the speed of the apparatus; and

FIG. 5 is a schematic diagram of relay circuits ancillary to the computer of FIG. 4.

With reference first to FIG. 1, it will be observed that the strip or web of material to be cut has been designated by the numeral **11**, and the locations or bars defining the required spacing intervals between cuts have been designated **12**. The web **11** moves continuously in a longitudinal direction according to the invention, and to produce such longitudinal travel of the web there is shown by way of example a pair of feed rolls **13** and **14** driven by a motor **15**. Disposed at a fixed station beyond the feed rolls, is a cutter roll **16**, provided with two diametrically opposed cutting knives **17** whose circumferential spacing is equal to the nominal spacing between the bars **12**. A bed for the knives is afforded by

2

an anvil roll **18** which is directly driven from the feed roll **13**. As shown, bevel gears **21** and **22**, mounted on a common shaft **23**, provide the driving connection to the anvil roll, but it will be appreciated that these are merely illustrative of the fact that the speed of the anvil roll is by any convenient means permanently synchronized with the speed of the feed rolls and hence the speed of the web.

The cutter roll **16**, on the other hand, is adapted to be driven at a variable rate of speed relative to the lineal speed of the web in order to correct for each spacing interval of the bars **12**, which is different from the nominal spacing value. To this end, a hydraulic motor **24** is operatively connected to the cutter roll, as by a shaft **25**, and a pump **26** is provided to supply fluid under pressure to the hydraulic motor. Connected in the line between the pump **26** and the motor **24** is a two-stage electro-hydraulic valve **27** which controls the flow of pressure fluid to the motor and hence its speed. A standard torque motor type valve having a substantially proportional response characteristic has been found to operate satisfactorily in this environment, the speed of the motor **24** being very nearly, therefore, in direct proportion to the magnitude of the current applied to the valve. A voltage to produce this current is derived in a computer **28** which is coupled to the valve through an amplifier **29**. The latter is a conventional push-pull direct current amplifier incorporating an oscillator for small amplitude oscillatory movement of the valve at approximately 400 cycles per second.

To supply the computer with information indicative of projected positional errors between each projected line of cut and the center of the corresponding oncoming bar, according to the invention there is geared to the cutter roll shaft **25** a first direct current tachometer generator **31**, and there is geared to the anvil roll a second direct current tachometer generator **32**. The output signals or voltages from the tachometer generators represent the speeds of the cutter roll and the web, respectively. In addition to these velocity signals, there are also fed to the computer, timing or location signals to indicate the arrival of the cutter roll at predetermined angular positions, and the arrival of the bars at a fixed station in advance of the cutter roll. The arrival of each bar is sensed by a device **33** incorporating a switch SW_2 which is adapted to be actuated in response to a sudden change in the thickness of the web. Since such a change occurs at the bars, it follows that switch SW_2 will be momentarily actuated at intervals corresponding to the times of arrival of the bars at the station where the device is located. Specifically, it is located in advance of the cutter roll axis a distance approximately equal to the shortest bar spacing for which the apparatus is designed to compensate. Location signals to represent the arrival of the cutter roll at predetermined angular positions are produced by a switch SW_1, actuated by a cam **34**. Cam **34** is mounted on a shaft **25'** adapted to run at twice the speed of the cutter roll shaft **25** and has a single abrupt lobe which defines these angular positions when in contact with the switch SW_1. Cam **34** is oriented so that switch SW_1 will be actuated at the same time as switch SW_2 when an oncoming bar spacing is encountered which is precisely equal to the nominal spacing value aforementioned. Finally, a reset cam **35** is provided on the shaft **25'** in addition to the cam **34**. Cam **35** also has a single abirpt lobe which is oriented so that a switch SW_3 will be actuated shortly following each cutting interval.

The character of the error voltage applied to the valve **27** and the manner in which it is derived by the computer **28** will now be described with reference to FIGS. 4 and 5. With reference first to FIGURE 4, it will be observed that the tachometer generators **31** and **32** are oppositely connected through load resistors **41** and **42**, respectively, to a circuit which is adapted to provide voltages which are integral functions of the output voltage from the tachometer generators. In particular, this integrating circuit is formed with a capacitor **43** and resistors **44**, one for each of the tachometer generators as shown. Connected in parallel relation to the integrating circuit across the respective tachometer generator load circuits is a pair of switching circuits. The switching circuit associated with tachometer generator **32** is comprised of normally open relay contacts K_1 and normally closed relay contacts W_1 connected in series with one another. The switching circuit associated with tachometer generator **31** is seen to comprise normally closed relay contacts K_2 and normally open relay contacts W_2, likewise connected in series with one another. Relay contacts K_1 and K_2 are adapted to be actuated together, that is, they are actuated by a common coil, and the same is true for the relay contacts W_1 and W_2.

The result of this arrangement is that the output signals or voltages from both tachometer generators will be applied to the integrating circuit when all the contacts K_1, K_2, W_1, and W_2 are either in their normal conditions as shown, or in an actuated condition. If only the relay contacts K_1 and K_2 are actuated, however, only tachometer generator **31** will be connected to the integrating circuit, since relay contacts K_1 and W_1 will then be effective to by-pass the signal from tachometer generator **32** with respect to the integrating circuit. Contrariwise, actuation of relay contacts W_1 and W_2 alone, effectively bypasses the signal from tachometer generator **31** so that only the signal from tachometer generator **32** is applied to the integrating circuit.

Coupled to the integrating circuit, that is, across the capacitor **43**, there is provided a filter network including resistors **45** and **46** and a capacitor **47**. As shown, each of these elements is disposed in series relation with one another across the capacitor **43**, the output voltage from the filter network being developed across resistor **46** and capacitor **47**. This output or error voltage is applied to the amplifier **29** which, in turn, is coupled to the electrohydraulic valve described in connection with FIG. 1. As will be apparent to those skilled in the art, the purpose of the filter network is to improve the stability of the overall system at certain critical frequencies.

FIG. 5 illustrates diagrammatically the circuit for actuating the relay contacts K_1, K_2, W_1 and W_2. As shown in FIG. 5, there is associated with the contacts K_1 and K_2 an actuating coil K which is connected across a suitable energizing source through the switch SW_1. There is also provided a holding circuit for the coil K which is formed with one section of the normally closed switch SW_3 and a normally open contact K_3 actuated in common with contacts K_1 and K_2. Similarly, contacts W_1 and W_2 are actuated by a coil W connected across the energizing source through the switch SW_2, there being associated with the relay coil W a normally open contact W_3. The latter, in combination with an other section of the switch SW_3, forms a holding circuit for the coil W. Accordingly, once either of the coils K and W have been energized by the momentary closure of switches SW_1 and SW_2, respectively, they will be held energized so long as switch SW_3 remains closed. When the switch SW_3 opens, however, both coils will be deenergized simultaneously.

The operations of the apparatus will be described first for the case where the oncoming spacing interval between the bars defining the next section of the web to be cut is equal to the nominal spacing value. It will be assumed that at the time of the preceding cut, and immediately thereafter, the respective speeds of the cutter roll and of the web itself are substantially the same. That this is so, will become apparent as the description of the operation proceeds. Thus, owing to the relation established between the position of the sensing device **33** and the setting of the cam **34**, switches SW_1 and SW_2 will be actuated simultaneously after the previous cut has been made. As a result, relay contacts K_1, K_2, W_1 and W_2 will be actuated and, once actuated, they will remain so by virtue of the operation of the respective holding circuits associated with the relay coils K and W. It follows that both the tachometer generators **31** and **32** will then be coupled to the integrating circuit to provide an output voltage which is an integral function of any difference in voltage which may arise as a result of relative speed variations between the tachometer generators. Since the tachometer voltages reflect the lineal speed of travel of the web on the one hand, and the circumferential speed of the cutter roll on the other, the output voltage from the integrating circuit will reflect projected positional errors between the oncoming knife and the bar to be cut. If, for example, tachometer generator **32** runs at a faster speed momentarily than tachometer generator **31**, indicating that the oncoming bar will arrive too soon, it will be seen that the resulting error voltage will be positive. Since the sense of the valve is such that its opening increases in response to a positive voltage, the speed of hydraulic motor **24** will be increased so as to correct for such positional deviation. Conversely, a relative increase in speed of the tachometer generator **31** will result in a negative voltage being applied to the integrating circuit, and an integral function thereof being applied to the valve, so that speed of the motor will be decreased. In other words, the apparatus, according to the invention, maintains the relative speeds of the web and the cutter roll closely synchronized throughout the cutting interval in this assumed case, so that when the cut occurs, the line of cut will correspond very closely to the center line of the bar. After the cut has been made, switch SW_3 is actuated, de-energizing the coils K and W, and restoring the relay contacts K_1, K_2, W_1 and W_2 to their normal conditions. It will be seen that this does not affect the relations of the tachometer generators to the integrating circuit, however.

Assuming that the oncoming spacing interval between bars is greater than the nominal spacing value, so that under existing speed conditions the cut would be made too soon, what happens is that switch SW_1 is actuated before SW_2. The cutter roll may be thought of as leading the web under this assumed condition. As a result, only the relay contacts K_1 and K_2 will be actuated at first, and only the cutter roll tachometer generator **31** will be operative on the integrating circuit. Accordingly, a definite time integral of the tachometer voltage, de-limited by the interval between the actuation of the switches SW_1 and SW_2, will be produced. This voltage represents the positional error between the bar and the knife caused by the greater than nominal spacing of the bar from the cut bar preceding it. Since the voltage is negative, motor **24**, and hence the cutter roll, will be slowed down.

In this regard, it will be observed that once relay coil W is energized, and tachometer generator **32** is also operative on the integrating circuit, the decrease in speed of the cutter roll will result in a positive voltage being applied to the integrating circuit due to the relatively higher speed of the tachometer **32**. Thus, as the knife slows down to meet the bar, the previously established negative charge on the capacitor **43** will be reduced, and ultimately neutralized, indicating that no further correction in the cutter roll speed need be applied for proper registry of the knife with the oncoming bar, at least insofar as the increased bar spacing is concerned. Rather the computer functions for the remainder of the cutting interval to keep the cutter roll in synchronism with the web and to correct only for relatively small positional errors arising from minor speed variations as in the first assumed case. At the precise instant of cut, the cutter roll speed will be very nearly equal to the web speed so that no puckering of the material takes place.

Finally, if it is assumed that the oncoming section to be cut is shorter than a nominal length section, switch SW_2 will be actuated before switch SW_1. As a result, only the web tachometer 32 will be operative on the integrating circuit at first, and the error voltage developed thereby will be positive to reflect the amount the cutter roll must be advanced to catch up with the web. After the error voltage has been established, both tachometer generators will be coupled to the integrating circuit and, as before, the effect of the cutter roll tachometer 31 will be to reflect the progress of the correction applied on the basis of the initial error voltage. Once the correction has been made, very nearly synchronous operation will follow for the remainder of the cutting interval.

FIGS. 2 and 3 illustrate in detail a sensing device 33 which has been found to be especially well-suited for use with certain textile materials. As shown, this sensing device includes a bed 51 provided with a pair of guide rails 52 which, in combination, are adapted to mount a supporting frame 53 for the sensing elements and to permit positional adjustments thereof with respect to the bed. The sensing elements themselves are constituted by a pair of rollers 54 and 55, the former being rotatably mounted in a fixed block 56, and the latter being mounted for pivotal as well as rotational movement. To this end, there is provided a pivot arm 57, at one end pivoted about a pin 58, and at its other end provided with a shaft 59 mounting the roller 55. Disposed above the roller 55 is the switch SW_2 and its associated plunger 61. As shown, the orientation of the switch is such that the plunger 61 projects downwardly into registry with the shaft 59, against which it is urged by the internal bias of the switch.

Normally, the plunger 61 will be caused to assume an upward position due to the passage of the main body of the web 11 between the rollers. When the rollers encounter the bars 12, however, which are thinner than the main body of the material, roller 55, and hence the plunger, will be permitted to fall sufficiently to reverse the condition of the switch. These operations will, of course, recur in the apparatus of the invention at intervals determined by the spacing of the bars and the speed of the web. Although the above described thickness sensing device is preferred for the illustrative application described herein, it will be apparent to those skilled in the art that in the case of different types of material, a somewhat different type of sensing device may be preferable. In fact, since the apparatus of the present invention is in no way dependent upon any special kind of sensing device, it will also be equally applicable to those applications where the cutting intervals are defined merely by printed indicia such as register marks. In such case, a conventional photocell sensing device might be substituted for the device 33 described herein.

Similarly, it will be appreciated that the apparatus might optionally be arranged to vary the speed of the web rather than the speed of the cutter roll in order to produce the required registry between the knives and the bars. Various modifications of this nature that take advantage of the novel features of the invention will no doubt occur to those skilled in the art and, therefore, the invention should not be deemed to be limited to the illustrative embodiment described herein by way of example. Rather, the invention should be deemed to be limited only by the scope of the appended claims.

What is claimed is:

1. A method for severing strip material at locations spaced longitudinally of the strip at intervals defined by longitudinally spaced indicia on the strip comprising continuously feeding the strip longitudinally past spaced first and second stations, spacing the stations a distance equal to normal spacing between indicia on the strip, sensing the arrival at said first station of a said location, repetitively moving a cutter into and out of engagement with said strip at said second station, driving the strip feed and the cutter at a speed to cut the strip once at each location, producing a first velocity signal proportional to the speed of said strip, producing a second velocity signal proportional to the rate of said cutting operations, the velocity signals being equal when the strip feed and the cutter speeds are synchronized, producing a first location signal upon sensing of the arrival of a said location at said first station, producing a second location signal upon arrival of said cutter at the position in its travel corresponding to the position of the strip when said location is at said first station such that said location signals will be simultaneously generated when said locations are normally spaced, interrupting one only of said velocity signals upon occurrence only of a corresponding one of said location signals, and terminating such interruption upon occurrence of the other location signal, combining said velocity signals into an error signal, the error signal being directly proportional to the time integral of the difference between said velocity signals, and varying the relative speed of said cutter and strip in accordance with variations in said error signal to tend normally to keep the motion of said cutter in synchronism with the motion of said strip while moving said cutter to cut said strip only upon arrival at said second station of a said location.

2. The method of claim 1 wherein said cutter is moved along a circular path.

3. A method for severing strip material at locations spaced longitudinally of the strip at irregular intervals defined by longitudinally spaced indicia on the strip, comprising continuously feeding the strip longitudinally past first and second stations spaced apart a distance approximately equal to the minimum of said intervals, sensing the arrival at said first station of the next on coming said location, rotating by fluid pressure a cutter along a circular path into and out of cutting engagement with said strip at said second station, driving the strip feed and the cutter at a speed to cut the strip once at each location, driving a direct current tachometer generator in timed relation with said feed mechanism to produce a first velocity signal proportional to the speed of said strip, driving a second direct current tachometer generator in timed relation with said cutter for producing a second velocity signal proportional to the speed of said cutter, the velocity signals being equal when the strip feed and the cutter speeds are synchronized, producing a first location signal upon sensing of the arrival of said next location at said first station, producing a second location signal upon arrival of said cutter at the position in its travel corresponding to the position of the strip when said next location is at said first station, such that said location signals will be simultaneously generated when said locations are normally spaced interrupting one only of said velocity signals upon occurrence only of the corresponding one of said location signals and terminating such interruption upon occurrence of the other location signal, combining said velocity signals into an error signal which is directly proportional to the time integral of the difference between said velocity signals, controlling the flow of pressure fluid which rotates said cutter to vary the speed of said cutter in accordance with variations in said error signal to tend normally to keep the motion of said cutter in synchronism with the motion of said strip while operating said cutter to cut said strip only upon arrival at said second station of a said location.

References Cited in the file of this patent

UNITED STATES PATENTS

2,075,095	Cordes	Mar. 30, 1937
2,599,430	Beuerman	June 3, 1952
2,707,027	Brown	Apr. 26, 1955