

March 30, 1965

J. W. DRENNING ET AL

3,175,441

CHANGEOVER DEVICE FROM REGISTER TO NON-REGISTER  
CONTROL OF A CUT-OFF MECHANISM

Filed Jan. 3, 1962

2 Sheets-Sheet 1

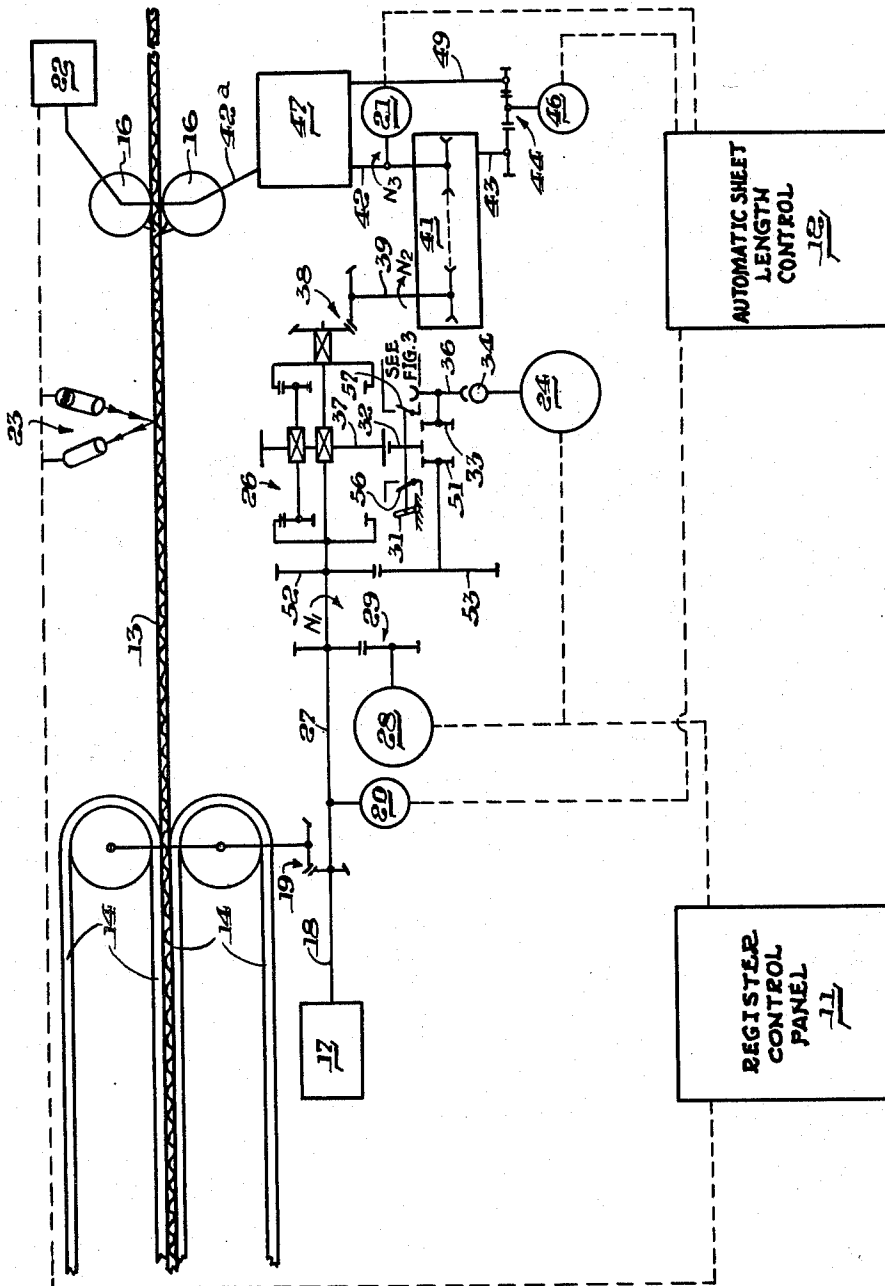


Fig. 1.

INVENTORS.  
JOHN W. DRENNING,  
WARREN A. STEWART.

BY  
Leo L. Mac Lossi.  
their  
ATTORNEY.

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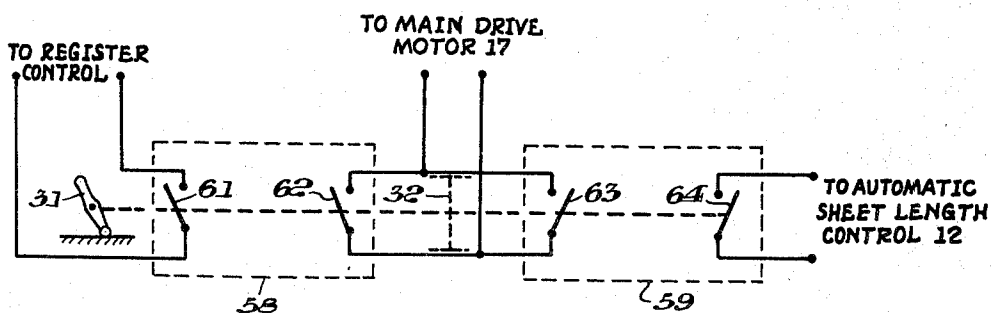
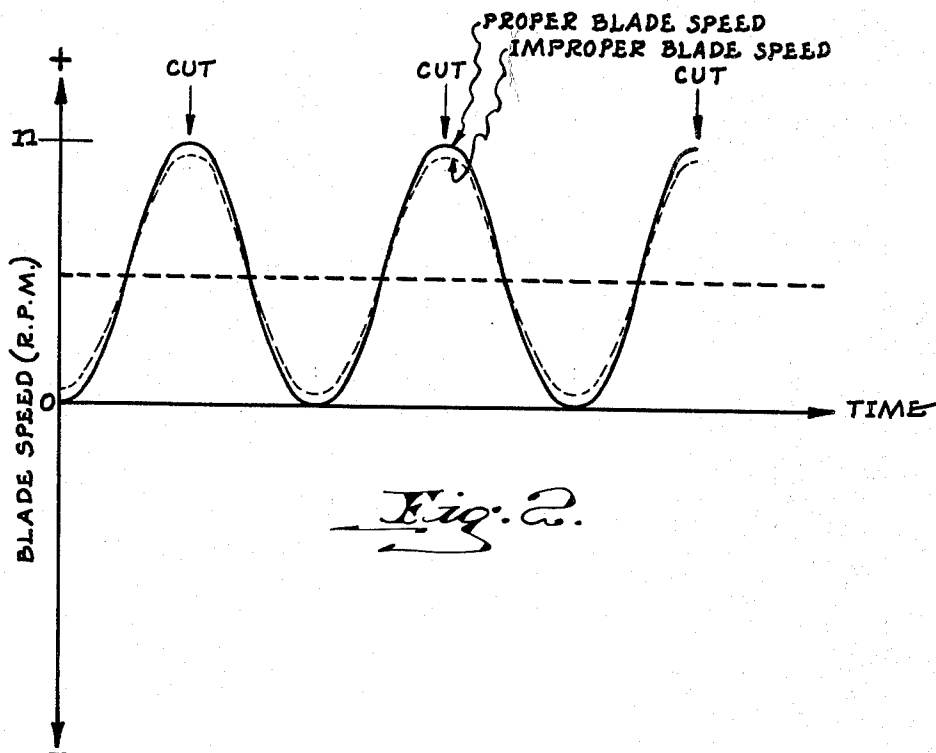
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INVENTORS,  
JOHN W. DRENNING,  
WARREN A. STEWART.  
BY  
Leo J. MacLennan,  
their ATTORNEY.

1

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## CHANGEOVER DEVICE FROM REGISTER TO NON-REGISTER CONTROL OF A CUT-OFF MECHANISM

John W. Drenning, Baltimore, and Warren A. Stewart, 5  
Monkton, Md., assignors to Koppers Company, Inc., a  
corporation of Delaware

Filed Jan. 3, 1962, Ser. No. 164,050

5 Claims. (Cl. 83—76)

The present invention relates to the control of cut-off mechanisms and more particularly to a control system for a corrugator cut-off knife adaptable to use both for the accurate cutting of pre-printed paper materials and conventional unprinted materials.

In accordance with current practices in the manufacture of corrugated board, board with a pre-printed liner may occupy only a portion of the scheduled manufacturing run for any given work day. Therefore, at such times as the cutting of printed board has been completed, the system must be readily adaptable to the manufacture of conventional unprinted board.

Further, in the manufacture of corrugated board the system must be adjustable to a great range in cut-off lengths with the longest as much as eight times the smallest and must provide an infinite selection of sizes within this range.

It is therefore an object of the present invention to provide the control system for the cut-off mechanism with shift means by which this control may be readily converted from register control, wherein the positions at which the cutting of the web is actually effected are correlated with the position of the writing or designs pre-printed on the board liner, to the conventional automatic sheet length (non-register) control employed for unprinted board.

Another object of the present invention is the provision of a shifting mechanism operable to quickly and simultaneously make all the electrical and mechanical connections required to change from register to non-register operation or vice-versa.

Still another object of the present invention is the provision of an improved register control device capable of correcting for errors in the length of sheet severed without overspeeding of the cut-off knife at the time of cut.

A further object of the present invention is the provision of a safety inter-lock arrangement for the shifting mechanism in order to insure that the gears of all power transmitting mechanisms are properly engaged before power is applied to the drive shaft.

Other objects and features of the invention will become apparent to those skilled in the art as disclosure is made in the following detailed description of a preferred embodiment of the invention as illustrated in the accompanying sheet of drawing in which:

FIG. 1 is a schematic representation of the mechanical elements of the improved two-way control system embodying both register and non-register control for selective operation,

FIG. 2 is a graph illustrating the discrepancy in blade speed between an improperly timed cutting operation and one in which the blade speed control shaft is properly controlled and

FIG. 3 discloses the switch arrangement for making up the electrical connections to initiate either register or non-register operation.

FIG. 1 is a block diagram showing the relationship between the electronic register control panel 11 employed for control of the cutting mechanism during register operation, the automatic sheet length control 12 employed during non-register operation and the mechanical elements employed to quickly and effectively transfer from register to non-register operation.

2

The electronic register control panel 11 may be a mechanism such as is described in detail in the General Electric bulletin GEH-1909B (System No. CR7515-W210). Similar apparatus are manufactured and marketed by other companies. Certain other standard commercial components to be referred to below forming part of the detector system are also described in this G.E. bulletin.

Corrugated board 13 is advanced by feed belts 14 and passes between rotary cut-off knives 16 which sever the corrugated board 13 into selected lengths in response either to register control panel 11 or automatic sheet length control 12. Belts 14 are employed in place of rollers to prevent damage to the board 13 through the pinching thereof. Although not shown completely in the drawing belts 14 are extensive in length and provide a friction grip against board 13 to move the board toward knife 16. The entire driving apparatus is a massive structure of high inertia resistant to changes in speed thereby making it difficult to effect control changes in the speed of belts 14. For this reason changes in sheet length must be impressed at the cut-off knife with any changes in board speed occurring solely as a reaction through the mechanical connections against the impressed control effort.

Certain errors are introduced into the cutting operation for which compensation must be made. The first of these errors is that which occurs when board 13 becomes displaced longitudinally with respect to cutters 16 due to some intermittent surge of feed belts 14 or to some small amount of slip between feed belts 14 and board 13. This type of error is one generally referred to as a "space error" requiring "space correction." Correction of this type of error requires only that the cutters 16 be reoriented with respect to the board 13 and is accomplished by a momentary speeding up or slowing down of the rotation of cut-off knives 16 thereby temporarily repositioning knife 16 with respect to web 13.

If the error is cumulative so that it becomes continually necessary to speed up or slow down cut-off knives 16, a second type of error called "velocity error" is said to have developed. This error is introduced whenever the velocity of the web 13 is not properly related to the velocity of the cutters 16. When cumulative errors of this type are small they can be adequately automatically compensated for by register control 11. However, when such an error becomes inordinately large, the only adequate correction therefor instead of continuously speeding-up or slowing down the knife is to change the ratio of the speed of feed belts 14 to the speed of cut-off knives 16. The present invention specifically provides for such an adjustment as will be described in detail below.

In order to provide for correction of such errors certain parameters of the operating system components must be measured, these parameters differing depending on whether register or non-register operation is employed.

Thus, drive motor 17 rotates drive shaft 18 which rotates drive feed belts 14 through suitable gearing 19. Since the speed of board 13 is a function of the speed of belts 14, a measure of the speed of rotation of shaft 18 provides a fairly reliable indication of the speed with which board 13 is being fed to the cut-off knives 16. The speed of shaft 18 is sensed by means of tachometer generator 20, or some similar device, which generates a signal proportional to the speed of board feed. In addition, tachometer generator 21 is connected to the drive shaft for the cut-off knives 16 and generates a signal proportional to the speed of the cut-off knives 16. These signals are transmitted to the automatic sheet length control 12 during non-register operation.

The position and speed of cutter 16 is determined by selector switch 22 mechanically geared to cutter 16. This selector switch 22 contains phototubes, a light-source

3

lamp and an amplifier tube (none of which are shown), and produces an amplified signal indicating the position of cutter 16. This amplified signal of cutter position is transmitted to the electronic register control panel 11 during registered operation. An additional parameter for registered operation is the sensing of the position of the printed matter or design which has been pre-printed on the board 13 to determine its instantaneous relationship to the cut-off knives 16. The sensing of the position of this pre-printed matter on the material is accomplished by means of scanning head 23, which device consists essentially of a phototube, an amplifier tube, and a light source, none of which are shown in the drawing, since such equipment is available commercially. These sensed parameters are compared in register control panel 11 to determine any deviation from the selected standard length of cut.

During registered operation, if the sensed information forwarded to electronic register control panel 11 by scanning head 23 and selector switch 22 indicate that a correction is required, a corrective signal is applied to correcting motor 24 which is connected to operate continuously in one direction and, ordinarily, at a given speed called the "base speed." This "base speed" is somewhat less than the rated speed of the motor whereby when a correction is called for by the electronic register control panel 11, correcting motor 24 is simply speeded up or slowed down depending on whether correction is required to increase or decrease the speed of cut-off knives 16. This arrangement eliminates errors due to friction introduced during the starting and stopping of the usual correction device and also eliminates the need for motor reversal.

The corrective increase or decrease in speed of correcting motor 24 is applied through the specially designed mechanical differential 26 located, as shown in the preferred embodiment, in the drive shaft 27. The power required to drive correction motor 24 is supplied by the pilot generator 28 which is geared to the drive shaft 27 by means of suitable gearing 29.

The necessary mechanical and electrical connections to place the device into register operation are effected by the movement of shift lever 31 to the right to a position wherein idler gear 32 is engaged with gear 33. The resulting re-orientation of electrical components is discussed in detail in connection with the description of FIG. 3. Gear 33 is continuously driven by correction motor 24 through worm 34 and pinion 36. Rotation of idler gear 32 produces rotation of outer gear 37 of mechanical differential 26 and thereby through actuation of suitable gearing 38 causes input shaft 39 of mechanical variable speed transmission 41 to rotate at a speed ( $N_2$ ) equal to, less than or greater than the speed ( $N_1$ ) of drive shaft 27.

Shaft 39 is connected to mechanical variable speed transmission 41, which device establishes a given speed ratio between input shaft 39 and output shaft 42. This speed ratio can be adjusted by the rotation of correction shaft 43, which shaft may be rotated through suitable gearing 44, by correction motor 46. Correction motor 46 may be automatically readjusted by automatic sheet length control 12 during non-register operation or may be manually reset through a manual adjustment of automatic sheet length control 12 during register in order to eliminate over-speeding (or underspeeding) of cut-off knives 16 at the time of cut. Such overspeeding at time of cut has been universally employed during register operation to compensate for discrepancies between the position of the printed intelligence and the position of the blades of the cut-off knives 16 in spite of its damaging effects on the web material.

If desired, an alternate construction not illustrated may be employed wherein mechanical differential 26 is located in output shaft 42.

The function of acceleration means 47 is to insure

4

that during each revolution the blades of cut-off knives 16 are automatically substantially instantaneously adjusted to travel at the same speed as the board 13 throughout the period of time during which the blades are actually slicing through the board even though the blades are traveling at other than board speed before and after this adjustment. The construction and operation of such a device is disclosed in U.S. Patent No. 2,879,845 issued to J. P. Haas and assigned to Koppers Company, Inc., the assignee of the present invention. As shown schematically in FIG. 1 herein output shaft 42 from variable speed transmission 41 transmits power to knife drive shaft 42a through acceleration means 47.

Acceleration means 47 in effect supplements the action of variable speed transmission 41 wherein the ratio of the speed of cutters 16 with respect to the speed of board 13 is determined automatically. In practice, with both the balanced and unbalanced types of cut-off knives, adjusting shaft 49 employed to vary the adjustment of acceleration means 47 is mechanically tied to shaft 43, the rotation of which shaft controls the variable speed transmission ratio. Thus, for each speed ratio of the transmission and therefore for each sheet length selected, there is a unique speed of the blades of cutters 16 during the cutting process. In this manner the cut-off mechanism is susceptible to adjustment for the cutting of widely varying sheet lengths.

It is also obvious that the setting of acceleration means 47 will not be changed unless variable speed transmission 41 is also readjusted simultaneously. This simultaneous adjustment of shafts 43 and 49 simultaneously produces both a change in the average speed of knives 16 and also a change in the instantaneous speed of knives 16.

Therefore, during registered operation scanning means 23 and selector switch 22 monitor the relative positions of the printed intelligence or register marks (not shown) on board 13 and the position of the blades of the cut-off knives 16. Should an error be detected for which correction is required, the signals from these detecting devices are transmitted to the electronic register control panel 11. This device in turn directs register correction motor 24 to apply the requisite correction to the input to the cutter drive through mechanical differential 26 specially designed so that the input speed  $N_1$  thereto and the output speed  $N_2$  therefrom when correction motor 24 is running at base speed are equal.

Since the automatic sheet length control 12 is not operative during the period in which electronic register control panel 11 is operative, there is normally no adjustment available to vary the speed ratio of variable speed transmission 41 during register control operation. In accordance with this speed ratio a change in  $N_2$ , the speed of the output shaft 39 from mechanical differential 26, temporarily overspeeds or underspeeds cut-off knives 16 to provide the proper length cut by compensating for the detected error. However, presently known register control devices have no provision for assuring that the speed of the blades of cut-off knives 16 at the time the cut is made is the same as the speed of the board 13.

The only manner in which conventional register controls such as are described in U.S. Patent No. 2,599,430 issued to R. A. Beuerman can adjust for errors of any type is to overspeed (or underspeed) the cut-off knives. As a consequence thereof the knife blades are not moving at board speed at the time of cut and, if the change in speed is not a minor one, this will result in board damage as will be more fully described below in connection with FIG. 2.

Therefore, in one aspect thereof the present invention incorporates means whereby in the event that a sizeable "velocity correction" is required, the speed ratio of the variable speed transmission 41 may be readjusted. This is accomplished by manual reset of slow speed correction motor 46 which rotates shaft 43 through gearing 44.

5

Such movement also, of course, changes the setting of acceleration means 47.

In addition, errors of lesser magnitude are adequately corrected in the present device without producing board damage during the cutting operation as a result of over-speeding or underspeeding by applying the desired correction to knives 16 through specially designed differential 26 in conjunction with acceleration means 47.

Also in the event that the daily plant operation encompasses the manufacture of boxes both from conventional unprinted board as well as pre-printed board, the conversion from register to non-register operation is facilitated by the present invention wherein by simply resetting shift lever 31, idler gear 32 may be disengaged from correction motor 24 and become engaged with gear 51. In this manner the input speed  $N_1$  into mechanical differential 26 is maintained equal the output speed  $N_2$  of shaft 39 as a result of the by-pass arrangement of gears 52 and 53 which drive gear 51.

Occurring simultaneously with the changes in the arrangement of mechanical components upon movement of shift lever 31 is the requisite shift in electrical connections which are described below in connection with FIG. 3. As a result of this shift in electrical connections from registered to non-registered operation the electronic register control panel 11 and its accompanying detection components are disabled and the automatic sheet length control 12 is brought into active electrical operation.

After conversion to non-register operation any deviation from the selected sheet length established as the standard within automatic sheet length control 12 is determined by a comparison of the voltages generated by the speeds detected by tachometer generator 20 (board speed) and tachometer generator 21 (cut-off knife speed). The difference in the voltages generated by tachometer generators 20 and 21 are compared within automatic sheet length control 12 with a standard voltage representing the selected sheet length. Any error between the algebraic sum of the tachometer generator voltages and the standard voltage produces a signal which automatically actuates correction motor 46. Rotation of correction motor 46 causes simultaneous readjustment of shaft 43 and adjusting shaft 49 through gearing 44 producing the requisite change in the ratio of speeds  $N_2$  and  $N_3$ . This change results in the necessary change in adjustment of both mechanical differential 26 and acceleration means 47 and simultaneously produces both a change in the average speed and of the instantaneous speed of cut-off knives 16 at the time the board is cut whereby the blades of cut-off knives 16 are moving at board speed.

The non-register operation described above is the same as would take place in conventional cut-off machines not coupled with a register control wherein no mechanical differential 26 is employed and wherein the shaft speeds  $N_1$  and  $N_2$  are equal with a single shaft being employed in place of shafts 27 and 39.

For register control, however, the addition of a differential, such as mechanical differential 26 is required. In this case  $N_1$  and  $N_2$  are no longer necessarily equal and the sheet length being cut is determined by the ratio of speeds  $N_1/N_3$ . However, the setting of the accelerating means 47, which controls the actual blade speed at the time of cut, is still determined by the ratio  $N_2/N_3$ . Thus, whenever the two speeds  $N_1$  and  $N_2$  are unequal, the blade speed at the time of cut will be in error. It is for this reason that mechanical differential 26 has been specially designed to assure that when the correction motor 24 is operating at base speed,  $N_1$  and  $N_2$  are equal.

As an illustration of this point, FIG. 2 graphically presents blade speed plotted against time for a balanced cut-off knife set to cut a 73.5 inch length sheet. The straight dotted line shown thereon represents the speed of the blades of a cut-off knife under the control of conventional electrical and mechanical register control apparatus. This apparatus would differ from the mecha-

6

nism shown in FIG. 1 through which register control is effected in two respects. First, the control effort would be applied to cutters 16 directly from transmission 41 via shaft 42 without the benefit of acceleration means 47. Second, no allowance would be made in the design of differential 26 to insure that  $N_1$  be equal to  $N_2$  when correction motor 24 is running at base speed.

As indicated, the blades are shown as moving at constant speed. In the event that the need arises to adjust the blade speed to correct the length of sheet cut, cut-off knives 16 are simply oversped or undersped to some new constant velocity. Such arrangements are suitable for cutting thin sheets wherein the stretch of the web is sufficient to compensate for distortion caused by the wide difference between blade speed and web speed at time of cut.

If then to this conventional electrical and mechanical register control apparatus the acceleration means 47 is added in the position shown in FIG. 1 intermediate transmission 41 and cutters 16, the graph representing the variation of blade speed with time would appear as the oscillating dotted line. Although the blade speed is changed by acceleration means 47 to more closely approximate board speed at the time of the actual cut, the blade speed is still sufficiently in error to result in buckling any web of the thickness and stiffness of corrugated board and in crimping or bending the leading edge of the cut.

Thus, overspeeding or underspeeding of the knife blades at the time of cut during register operation cannot be eliminated solely by interposing acceleration means 47. Solution of the problem demands not only that acceleration means 47 be interposed as described, but also that differential 26 be of specific design to insure that  $N_1$  is equal to  $N_2$  when correction motor 24 is running at base speed. This latter requirement has been embodied in the present invention by designing each of the various gears comprising differential 26 and gearing 38 with the proper number of teeth relative to each other. As an example of a properly designed differential, the ring gear connected to shaft 27 has 114 teeth, the planetary gear meshing therewith has 46 teeth, outer gear 37 mounting the planetary gears has 140 teeth, the ring gear gear connected to gearing 38 has 100 teeth, the planetary gear meshing with this ring gear has 32 teeth, the bevel gear mounted on shaft 39 has 31 teeth and the bevel gear meshing therewith has 40 teeth. Numerous other combinations can be devised in view of the teachings disclosed herein.

When both the above-mentioned requirements have been provided as in the register control apparatus shown in FIG. 1, the graphic representation of the variation of blade speed with time is shown in FIG. 2 as the oscillating solid line. At the time the cut is actually being made through board 13, the instantaneous speed of the blades of cutters 16 coincides with board speed " $n$ " and the cut is made sharply without crimping or bending.

As has been stated earlier, if the error in the cut is of large magnitude, the system is provided with means for manually adjusting automatic sheet length control 12 during register operation thereby simultaneously changing both the ratio of  $N_2/N_3$  and also changing the setting of acceleration means 47.

Any repositioning of shift lever 31 to make the proper mechanical connections for registered or non-registered operation also results in the simultaneous resetting of the necessary electrical connections.

FIG. 3 shows an arrangement of switches 61, 62, 63, 64 which are mechanically connected to and actuated by shift lever 31. When shift lever 31 is moved to the right to register position to effect the aforementioned mechanical connections, contacts 61 and 62 close simultaneously therewith, energize the electronic register control panel 11 and permit main drive motor 17 to operate. Since contacts 63 and 64 remain open, the automatic sheet length control 12, though not de-energized during registered op-

eration, is unable to execute automatic or high speed changes in the variable speed transmission 41. As previously noted, it is highly advantageous to be able to make manual adjustments of the speed ratio and setting of acceleration means 47 during registered operation through the slow speed correction motor 46 and for this reason automatic sheet length control remains energized.

In the event that shift lever 31 is not fully engaged in either the registered or the non-registered position, as for example, in the position shown in FIG. 3 contacts 62 and 63 remain open, preventing operation of main drive motor 17. Register control panel 11 and automatic sheet length control 12 are also inoperative, since contacts 61 and 64 remain open. The prevention of the operation of main drive 17 precludes damage to the mechanical differential 26.

By moving shift lever 31 in the opposite direction, to the left for non-registered operation, switches 63 and 64 are closed and switches 61 and 62 remain open. Simultaneously therewith the necessary mechanical connections for effecting non-registered operation are made. The automatic sheet length control 12 is made operative while the register control panel 11 is disconnected. At the same time main drive motor 17 is made operative.

Therefore, by the present invention a cutting mechanism has been provided with means for selectively shifting to either registered or non-registered operation or to a safety inter-lock position wherein operation of the cutting mechanism is precluded and whereby changeover of all electrical and mechanical connections may be simultaneously effected.

Also, by introducing a specially designed differential and an accelerating means into the mechanism for effecting register control of a cut-off knife the present invention obviates overspeeding of the blades at the time of cut during register operation.

In addition, a novel gearing arrangement is provided for a one-to-one speed ratio across the register control mechanical differential 26 when the cutting mechanism is converted to non-registered operation. Further, continuous monitoring of the sheet length during registered cutting operations may be effected to compensate for gross velocity errors.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and the scope of the invention as set forth in the appended claims.

What is claimed:

1. A cut-off mechanism for severing selected lengths of material from a moving web thereof comprising driving means, web cutting means, differential means connected with said driving means, a mechanical variable speed device connecting said differential means and said web cutting means, said cut-off mechanism having in combination therewith a register control for registered cutting of said material and an automatic sheet length control for non-registered cutting of said material, first mechanical means arranged in juxtaposition with said differential means for selective connection therewith for transmitting control forces thereto, said first mechanical means being actuated by said register control, first means connected with said register control for operating said register control, second mechanical means connected to said driving means and in juxtaposition with said differential means for selective connection therewith for operating said differential means at a 1 to 1 speed ratio, second means for electrically operating said automatic sheet length control, and means connected to said first and second means movable to a first position for simultaneously actuating said first means and connecting said first mechanical means with said differential means and movable to a second position for simultaneously actuating said second means and connect-

ing said second mechanical means with said differential means.

2. A cut-off mechanism substantially as recited in claim 1 wherein each of the first and second means comprise a plurality of switches and wherein the actuating and connecting means comprises a shifting lever interconnected with a laterally movable idler gear and with said switches.

3. A cut-off mechanism substantially as described in claim 2 wherein the first mechanical means comprises an electrically-powered worm and pinion drive.

4. A cut-off mechanism substantially as described in claim 3 wherein the differential means is a mechanical differential having a 1 to 1 speed ratio when the electrically-powered worm and pinion drive operates at "base speed" and the second mechanical means comprises a set of gears interposed between the power input to said mechanical differential and the outer ring gear of said mechanical differential.

5. A cut-off mechanism for severing selected lengths of material from a moving web thereof comprising in combination: web cutting means; drive means connected to said web feed means and to said web cutting means; a mechanical differential; a first shaft connecting said drive means with said mechanical differential; an automatically adjustable variable speed device; a second shaft connecting said mechanical differential with said variable speed device; means connected to said web cutting means for changing the speed of the blade of said web cutting means to web speed during actual cutting of the web; a third shaft connecting said variable speed device with said speed changing means; register control means; first means arranged in juxtaposition with said mechanical differential for selective connection therewith for imposing speed corrections upon said mechanical differential in response to said register control means; said mechanical differential operating at a 1 to 1 ratio when said first means is connected thereto and operates at "base speed"; automatic sheet length control means; second means connected to said variable speed device and to said speed changing means for automatically changing the speed ratio of said variable speed device and adjusting said speed changing means in response to said automatic sheet length control; third means connected to said first shaft and in juxtaposition with said mechanical differential for selective connection therewith for operating said mechanical differential at a 1 to 1 ratio and selective means adjacent said mechanical differential selectively movable to first, second, and third positions; said selective means at said first position including means for disabling said drive means, said register control means and said automatic sheet length control means, said selective means at said second position including means for enabling said drive means and said register control which in turn actuates said first means and disabling said automatic sheet length control means, and said selective means at said third position including means for connecting said third means with said mechanical differential, enabling said drive means and said automatic sheet length control means which in turn actuates said second means and disabling said register control means.

#### References Cited by the Examiner

##### UNITED STATES PATENTS

|           |       |                  |        |
|-----------|-------|------------------|--------|
| 2,356,841 | 8/44  | Gregory          | 83—76  |
| 2,618,047 | 11/52 | Mansell          | 83—76  |
| 2,623,589 | 12/52 | Price            | 83—365 |
| 2,634,811 | 4/53  | Schaelchlin      | 83—76  |
| 2,693,234 | 11/54 | Seidman          | 83—364 |
| 2,840,163 | 6/58  | Fischer          | 83—371 |
| 3,029,675 | 4/62  | Alexander et al. | 83—76  |
| 3,084,579 | 4/63  | Melville         | 83—74  |

ANDREW R. JUHASZ, *Primary Examiner*.

CARL W. TOMLIN, WILLIAM W. DYER, Jr.,  
*Examiners.*