

[54] SHEET LENGTH CONTROL SYSTEM

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[51] Int. Cl. B26d 5/00

[58] Field of Search 83/37, 38, 71, 76

[56]

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UNITED STATES PATENTS

3,175,440	3/1965	Drenning.....	83/76
3,195,385	7/1965	Paterson.....	83/76
3,244,863	4/1966	Paterson.....	83/76
3,267,781	8/1966	Sterns et al.	83/76 X
3,276,647	10/1966	Lewis, Jr. et al.	83/76 UX
3,355,973	12/1967	Rubinstein et al.	83/76
3,411,388	11/1968	Rappaport.....	83/76

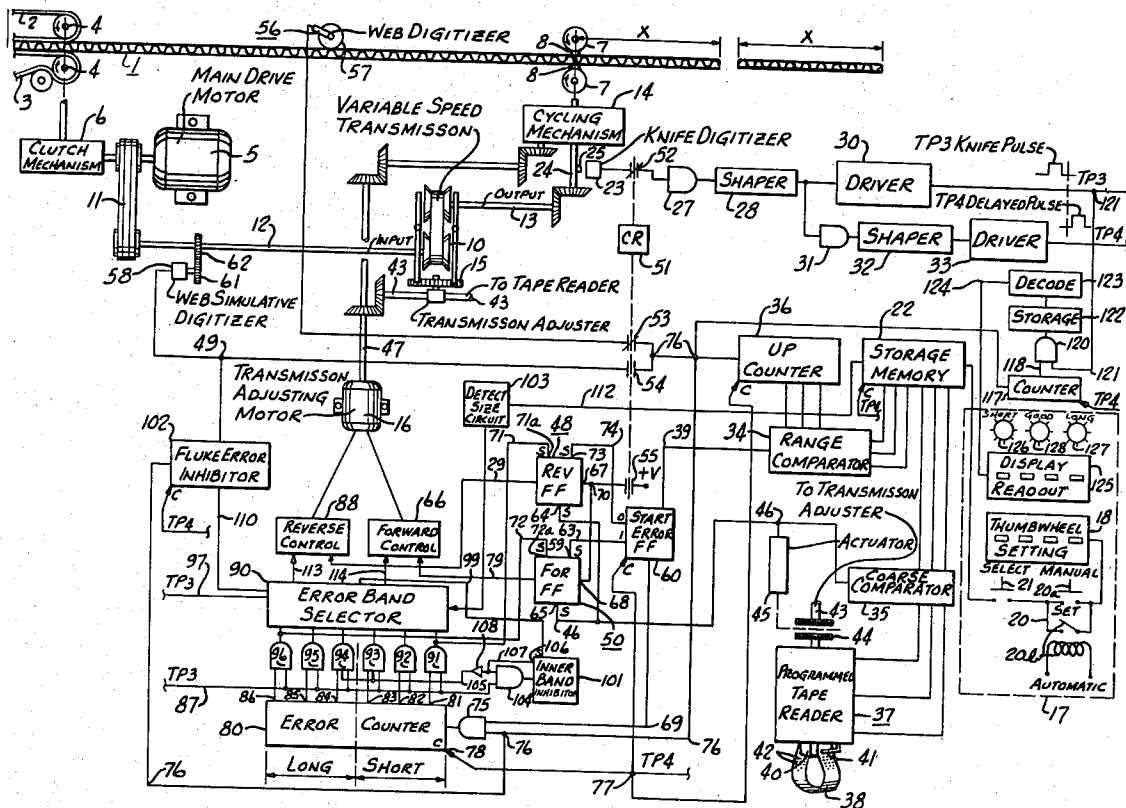
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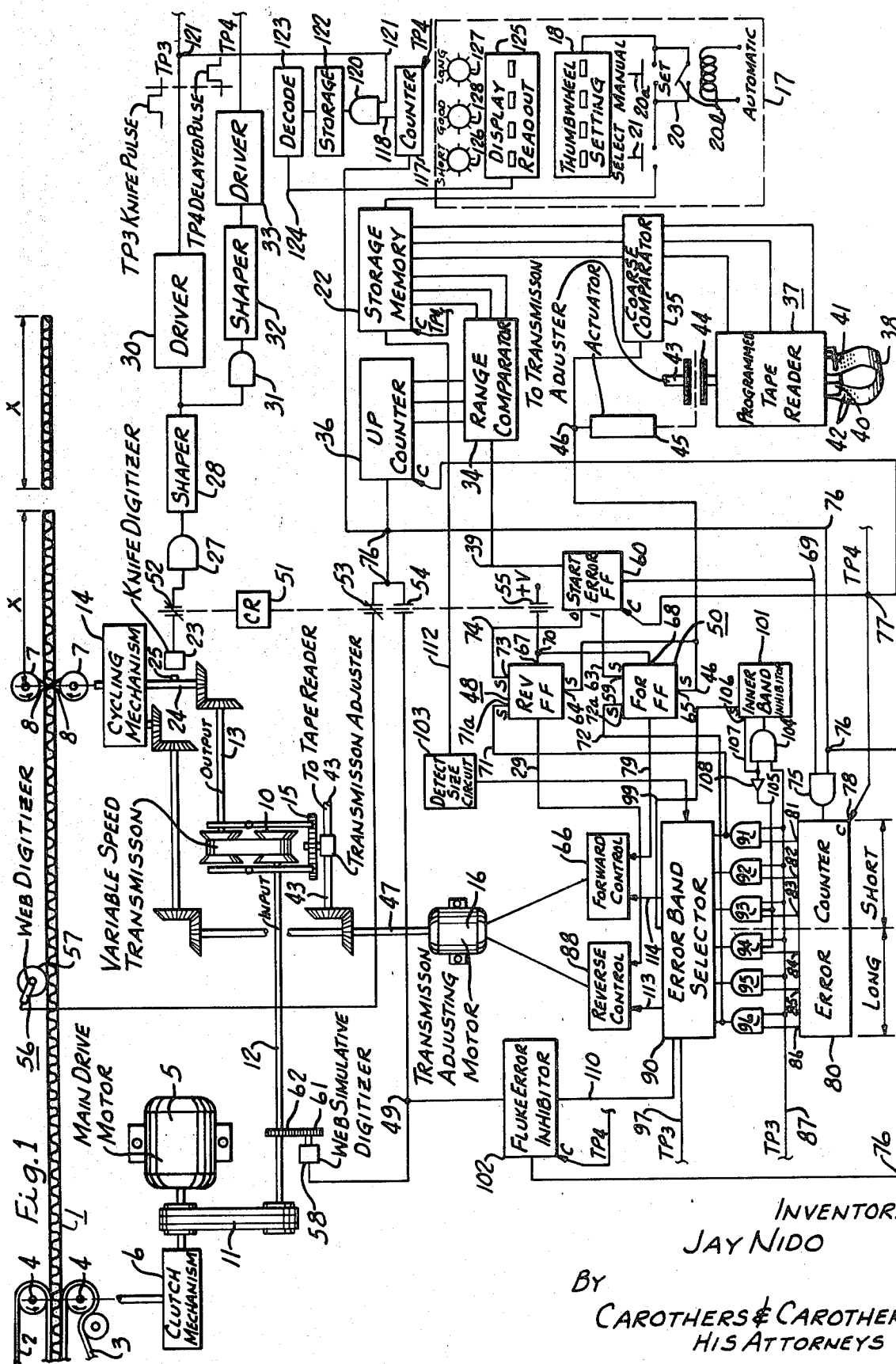
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ABSTRACT

A sheet length control system for use in connection with a material feeding and material processing apparatus to maintain uniform treatment of the material as processed by the processing apparatus within a predetermined and desired tolerance. Such material processing apparatus is exemplified in the use of a cutoff machine to cut into equal desired sheet lengths a continuously moving web of material. Digitizer means are used to produce signals the ratio of which is representative of the desired sheet length and the amount that the ratio of the signals varies from the desired sheet length ratio is used to produce an error signal indicative of whether the sheet length cut is shorter or longer than the predetermined sheet length value. Error band selective means receives the error signal produced to produce a signal characteristic of the error magnitude. Means are provided to be responsive to the error band selective signal for correcting the sheet length to correspond to the predetermined sheet length value within an acceptable tolerance.

15 Claims, 5 Drawing Figures



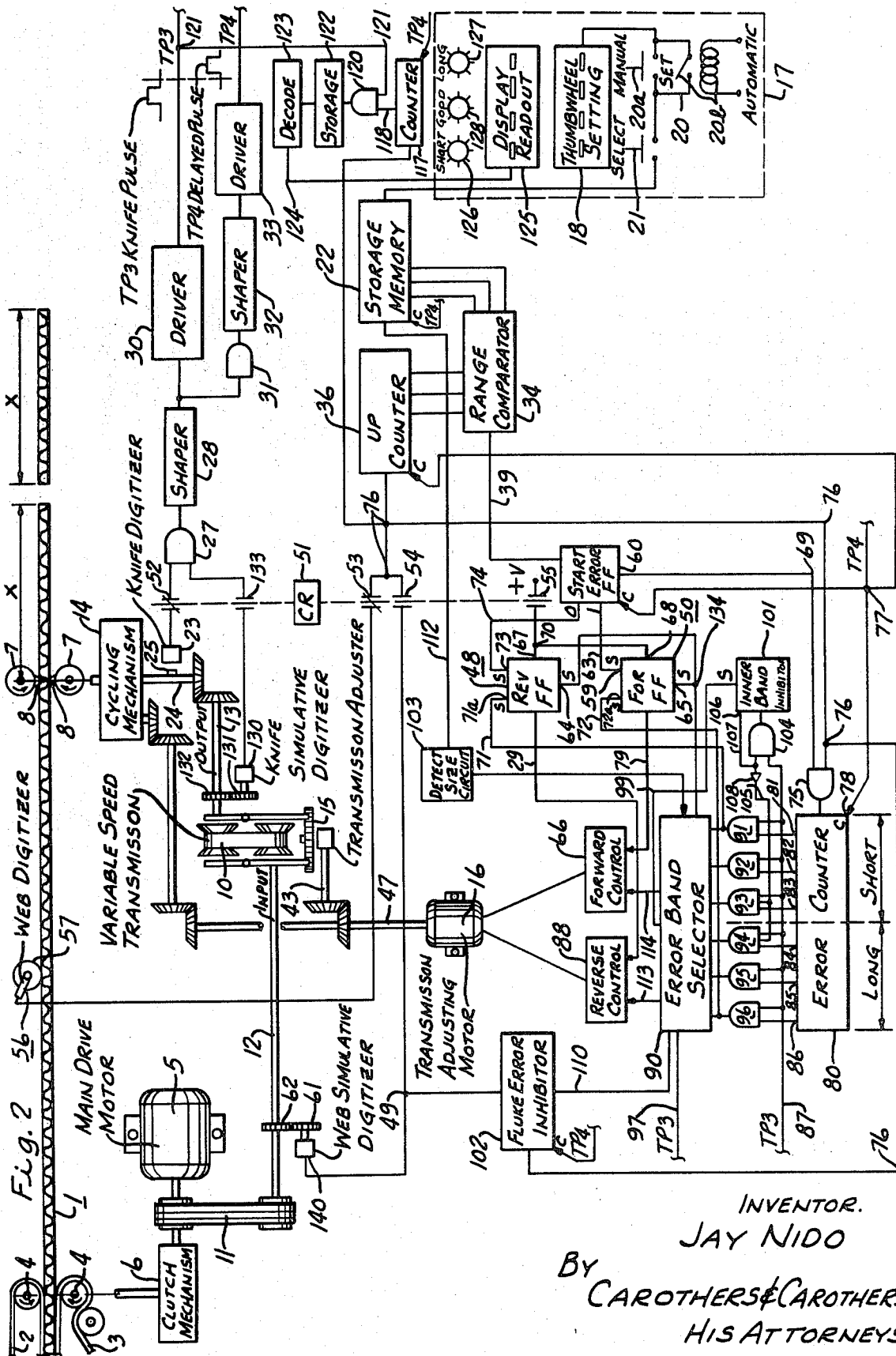


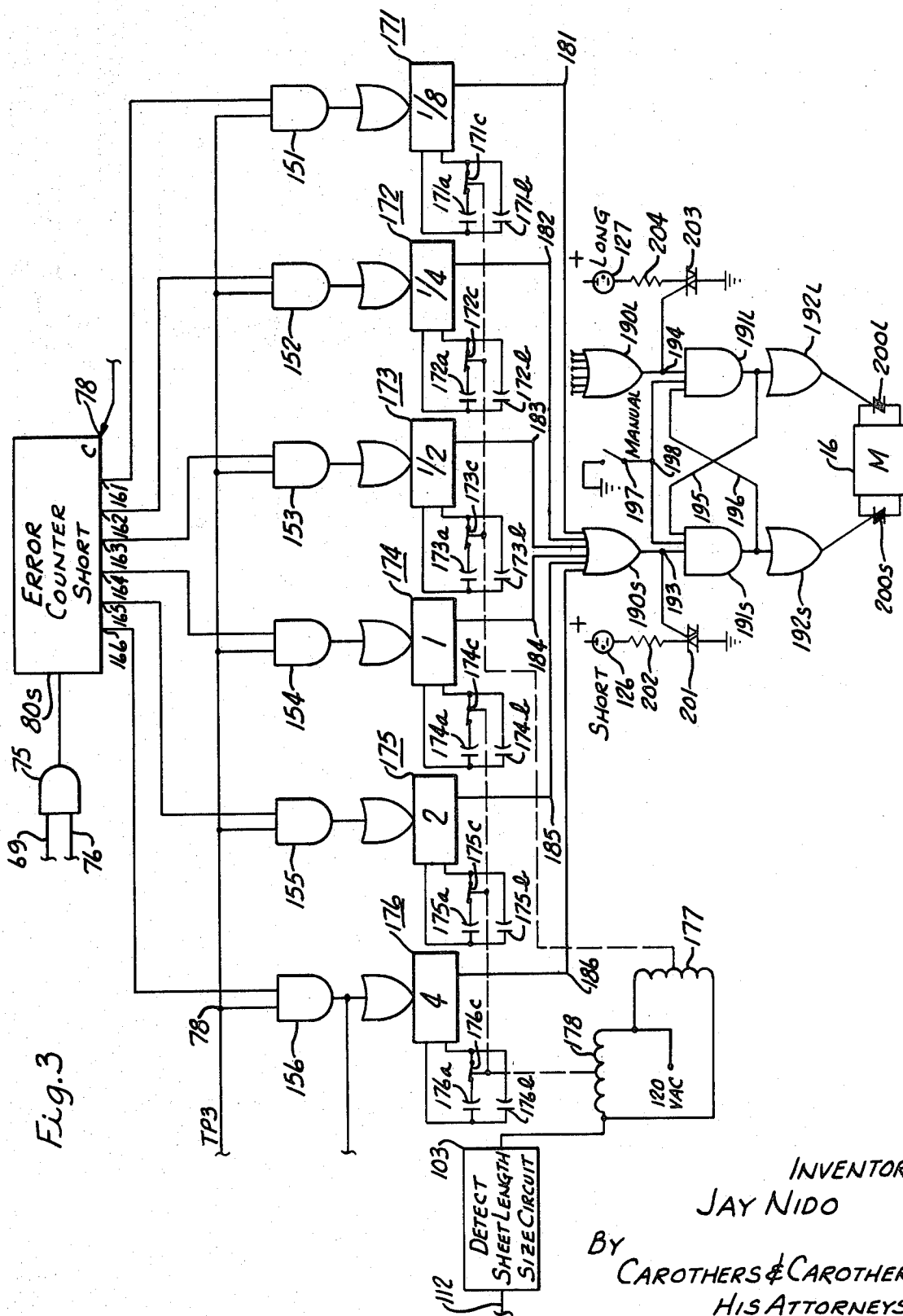
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Fig. 4

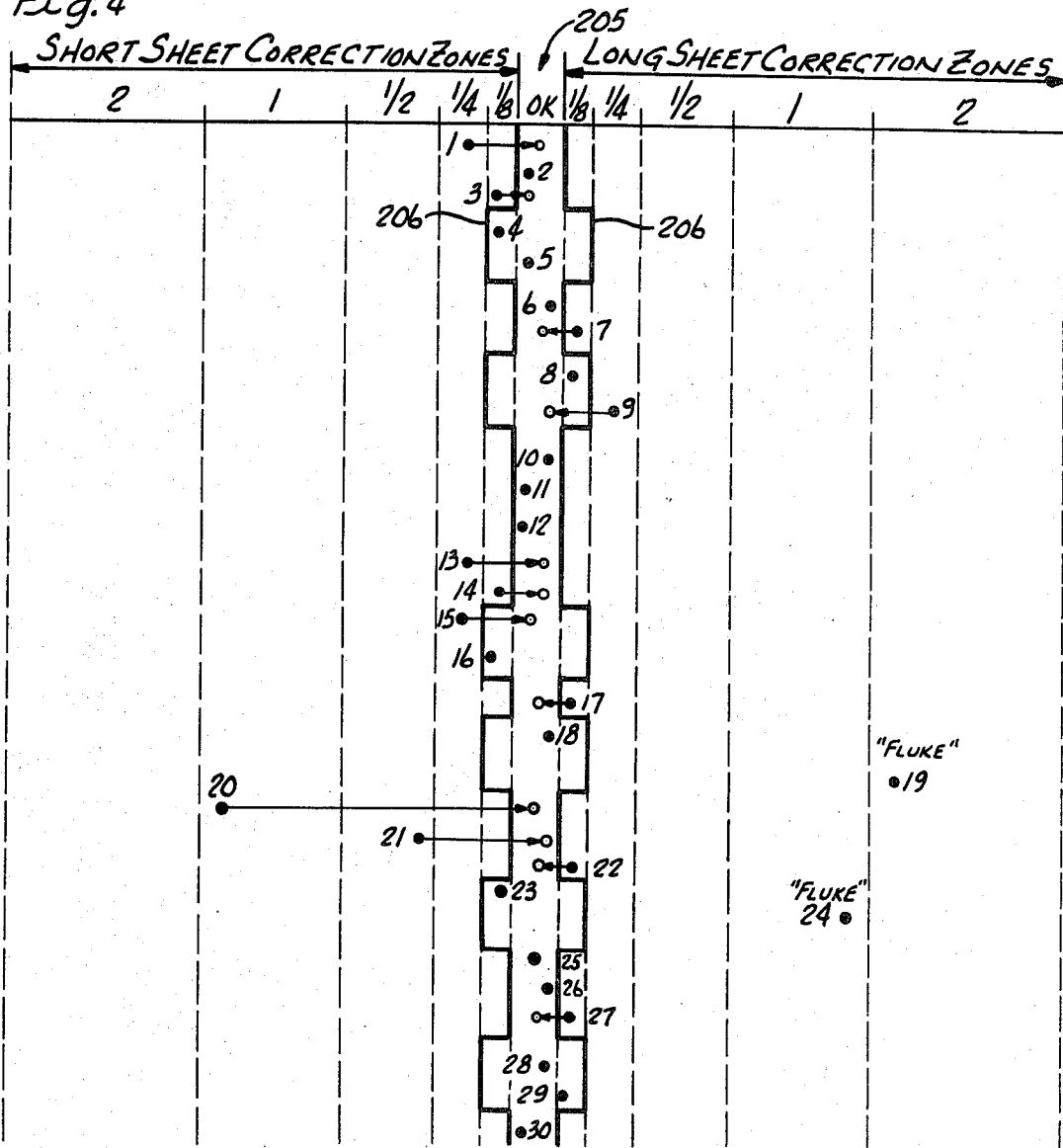
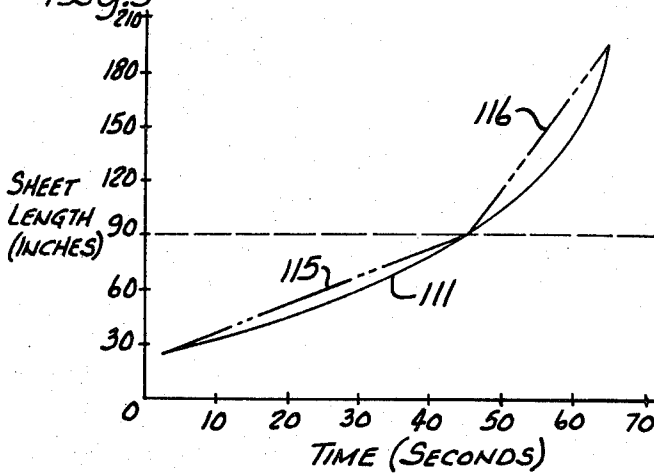


Fig. 5



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SHEET LENGTH CONTROL SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to the automatic control of material feeding apparatus in conjunction with the material processing apparatus receiving the material as fed thereto as, for example, in cutoff apparatus which is monitored by self-regulating means, which means includes the ability to compensate for the operation of the cutter speed for variations caused by (a) inherent mechanical heterogeneity in operation of the cutoff apparatus and (b) periodically but repeated changes in the rate of flow of material to the cutoff apparatus.

While the system comprising this invention has a broad range of utility in other fields of art concerning the uniform production of materials fed to a material processing apparatus, the present invention finds its most prominent application at the present time in connection with cutoff apparatus used in the production of corrugated paperboard webs being cut into uniform sheet lengths according to customer specifications from a moving web of material of such board initially produced through a series of production line operations consisting, first, of a single facer which produces a continuous flow of transversely fluted paper which has been glued to one side of a continuous sheet of facing paper which is thereafter stored in a bridge or dwell area and, thence, is moved to a double facer wherein the transversely fluted paper with a single facing is faced on its opposite face with facing paper to produce a continuous web of material. After the double facing of the transversely fluted paper has been accomplished, the continuous moving web of material is then cured while traveling through a heating section and thereafter, generally under conventional machinery, is slitted and scored and then cut into proper lengths by the cutoff apparatus according to customer specifications. It is the control of this cutter apparatus in relationship to the manufacturing and feeding of this continuous moving web of material consisting of a web of corrugated paperboard through a sheet length control system that is of particular interest herein.

Further comment is unnecessary concerning the operation of the above mentioned equipment and apparatus for the manufacture of the sheet board since the operation of such apparatus is well known within the prior art, for example, as recently explained and set forth in U.S. Pat. No. 3,411,388, as well as other prior art patents.

The following is a list of the prior art patents concerned with sheet length control systems, the ultimate purpose of which is to control the operation of the cutoff apparatus relative to the rate of flow of the moving web of material into the cutoff apparatus: U.S. Pat. Nos. 3,175,440; 3,176,557; 3,181,403; 3,195,385; 3,244,863; 3,267,781; 3,324,751; 3,355,973; and 3,411,388.

Each of the foregoing listed patents contemplates a sheet length control system which systems generally can be divided in two major categories. The first category involves initial adjustment of the cutoff apparatus to obtain the sheet length desired for a production or coarse run and is termed "coarse correction mode." Sheet length specifications are obtained from customers who desire for purposes, such as the manufacture of cardboard boxes, that a specific amount of sheet cardboard be cut into selected inform predetermined lengths. In order that the cutoff apparatus be capable of cutting sheets of different lengths, a variable speed transmission is employed to drive the rotating shears or knives in the cutoff apparatus. It should be understood that most cutoff apparatus consist of two pairs of such rotating shears or knives. However for purposes of explanation with simplification, reference herein will only be made to one such set of knives, it being understood that a plurality of cutoff apparatus each utilizing one or more pairs of knives may well be contemplated in the use of the control system comprising this invention.

A main drive motor is connected to drive a variable speed transmission which in turn drives in unison the pair of cutter knives in such a manner that the knife blades of the cutter

knives meet for shearing engagement for each revolution thereof.

The variable speed transmission permits alteration in the relative velocity of rotation of the cutter knives as is well known in the art.

By the same token, the main drive motor is also connected to the machinery referred to above as the double facer wherein, after the second and opposite facing paper has been applied to the transversely fluted paper to complete the board, the board is then pulled through a heating section to establish a cured bond of the paper facing mediums with the transversely fluted paper glued therebetween but also to feed the continuous web of board material into the cutoff apparatus. Thus, the main drive motor drives the oppositely disposed feed belts feeding the web of material to the cutoff apparatus as well as to rotate the pair of cutter knives of the cutoff apparatus through the variable speed transmission to cut the web of material into sheets of predetermined uniform length, which length can be controlled by adjustment of the operation of the transmission.

The second of the above mentioned categories involves the continuous correction of sheet length during operation of the cutoff apparatus. The need of an automatic sheet length control system for cutoff apparatus of the type mentioned is well known in the art, the principal reasons being due to the utilization of the variable speed transmission driving the cutoff cutter knives which is used to adjust the angular velocity of the rotating knives relative to the linear velocity of the moving web.

The variable speed transmission must be capable of transmitting enormous mechanical energy in the form of horsepower output in order to properly drive the cutter knives through a cycling mechanism to be referred to hereinafter in more detail. The best known type of transmission of the variable type to perform this function which is presently used exclusively in connection with such cutoff apparatus is known as the "Reeves" variable speed transmission which is disclosed in U.S. Pat. No. 2,613,545. The Reeves type transmission is excellent for operation of the cutoff apparatus not only because of its capability of transmitting enormous horsepower requirements, but also because it is capable of absorbing tremendous inertia forces developed in the cutoff apparatus, which forces are fed back to the Reeves transmission and are termed "reverse torque." However, the excellent capabilities of this transmission are also accompanied by the inherent impreciseness of the transmission in its ability not to be able to precisely maintain the same output to input ratio, which ratio is directly comparative to the ratio relationship of the angular velocity of the cutter knives relative to the linear velocity of the moving web of material. This is not only true in connection with this particular type of transmission, but also with respect to other types of variable speed transmissions that have been used in connection with such cutoff apparatus.

By the same token, the linear velocity of the moving web of material in actual practice is never a constant velocity due to variations caused in slippage between the above mentioned oppositely disposed feedbelts and the moving web of material as it is being withdrawn from the heating section. As a further complication of this linear velocity, the heating section in curing the prefabricated sheet board causes the board to shrink thereby affecting the actual linear velocity of the moving web of material.

From the foregoing, it can be readily seen that continual correction for small sheet length variations from a desired preset length is necessitated and is termed "fine sheet length correction mode."

As a result of the fact that the cutter knives are incapable of accurately maintaining a preset constant velocity due to the above mentioned inherencies, sheet length variations being produced by the cutoff apparatus from the moving web of material thereto will continually occur unless correction is brought about in the ratio relationship of the angular velocity of the cutter knives relative to the linear velocity of the mov-

ing web of material to permit the cutoff apparatus to cut sheet lengths of desired specifications. Undesirable sheet-to-sheet variations not only bring about needless waste of prefabricated sheet board which is highly accumulative over an entire course or production run, but also produce sheet lengths of very over and under desired sheet lengths not meeting the specific requirements of the customer within acceptable customer tolerance, usually no more than one-fourth inch or in many situations today even less. The requirements of customer tolerance in connection with sheet length has placed an optimum requirement in accurate control of sheet length during a production run, which sheet length control must take into consideration the inherent variables above mentioned affecting the actual sheet length obtained from sheet-to-sheet as cut by the cutoff apparatus during such a production run.

By providing a fine sheet length correction mode, sheet-to-sheet variations may be substantially reduced to within an acceptable tolerance. At this point it should be understood the total elimination of sheet-to-sheet variations from a specified and specific desired sheet length should not be the goal in sheet length control because accurate precision sheet-to-sheet length is not practically feasible due to the above mentioned inherent heterogeneities in operation of the material feeding processing apparatus.

As indicated above, sheet length is determined by the velocity of the web of material and the frequency of rotation of the cutter knives as explained in U.S. Pat. No. 3,175,440. It is apparent to those skilled in the art that the sheet length being cut is measurable through the ratio relationship of the angular velocity of the cutter knives as compared to the linear velocity of the moving web of material. Upon establishing the desired ratio relationship for a particular sheet length, a control system can be utilized to detect a variation from the desired ratio relationship and thereafter make necessary corrections to the variable speed transmission driving the rotary cutter knives to bring the ratio relationship back into conformity with the desired relationship.

There are many ways of obtaining this velocity relationship to obtain the same constant ratio and it may be accomplished in the form of an analog system as in the case of U.S. Pat. No. 3,176,557 or a digital system, as in the case of Pat. No. 3,267,781. Regardless of what system is utilized, the ratio developed will be the same and as such can always be used as a basis for determining proper correction of the angular velocity of the cutter knives relative to the linear velocity of the moving web of material being fed to the knives.

As set forth in U.S. Pat. No. 3,176,557, mention should be made herein that in the operation of the pair of cutter shears or knives relative to the moving web of material to the cutter knives, the angular velocity of the rotating knives must be the same as the linear velocity of the moving web of material moving between the two knives at the time of cutoff. Otherwise, the moving web of material moving at a linear velocity not equal to the tangential velocity of each blade comprising the pair of cutter knives will cause the cutter knives to tear the moving web of material producing nonuniform sheet lengths of material and even at times ripping the moving web of material and, as a result, rendering the cutoff apparatus completely unproductive of uniform sheet length during a production run. Thus, a cycling mechanism is mechanically interposed between the variable speed transmission and the pair of cutter knives in order to insure that the tangential velocity of the cutter blades is equal to the linear velocity of the moving web of material at the time of cutoff. Depending upon the sheet length being cut, the cycling mechanism will accelerate or decelerate the speed of the cutter knives in order that the speed will be equal to the linear velocity of the moving web of material at the time of cutoff. Thus, for example, when short sheet lengths are being cut during a production run, the angular velocity of the cutter knives must be accelerated between periods of cutoff and then decelerated at the time of cutoff so that the angular velocity will be equal to that of the linear velocity of the moving web. On the other hand, where long

sheet lengths are being cut during a production run, the angular velocity of the cutter knives must be decelerated between periods of cutoff but accelerated in the proximity of the time of cutoff so that the angular velocity is equal to the linear velocity of the moving web.

The cycling mechanism does not form a part of the invention herein, but such mechanisms are well known in the art, one type being disclosed in U.S. Pat. No. 3,176,557, and still another type is shown in U.S. Pat. No. 2,389,341.

The sheet length control systems of the prior art, whether of the analog or digital type, have been designed toward the end of providing a precise control of sheet length during a production run as well as in some cases providing quick and accurate changing from one sheet length of another when changing from one production run to a new production run. Such control systems have accomplished sheet length correction by providing a correction signal for sheet length error which correction signal is proportional to the error and also compensates for the nonlinearity of the adjustment of the variable speed transmission over a given sheet length range as well as compensating for slippage in connection with the feedbelts. However, such control systems, although operative, have not been of optimum performance from a practical standpoint and thus leave room for further improvement in uniformity of sheet length control throughout a production run as well as making an efficient and fast sheet length change or coarse correction. For example, in connection with U.S. Pat. Nos. 3,181,403 and 3,267,781, correction of sheet length during a coarse run is accomplished by storing to a predetermined capacity a number of error signals and when the capacity level has been obtained, a signal is produced to make adjustment to the motor controlling in the variable speed transmission to adjust the cutter knives' angular velocity relative to the linear velocity of the moving web of material to conform to the desired ratio relationship representative of predetermined sheet length. A memory system is employed to observe by sampling to determine if a correction in sheet length is desirable. Thus, it can be seen that several incorrect sheet lengths can occur before actual correction is finally made to the variable speed transmission to make correction for the inaccurate sheet length. In the case of large sheet errors, correction can only be accomplished with respect to every other sheet. By the same token, the sheet length control systems as disclosed in U.S. Pat. Nos. 3,324,751 and 3,355,973 require uniform but discreet incremental correction steps, the number of steps corresponding to the magnitude of the error in sheet length which finally tends to bring the actual sheet length being cut into uniformity with the desired sheet length. Thus, the control corrects for sheet length variations in equal incremental steps regardless of the size or amount of the sheet length error. Such uniform incremental steps of correction require usually more than one step and thus more time to make the necessary correction and also require means to inhibit in the acceptable tolerance range to prevent overcorrection.

SUMMARY OF THE INVENTION

It is the chief aim of the sheet control system comprising this invention to provide for maintenance of average sheet length during a production run wherein (a) fine sheet length corrections are made through the controlling of the variable speed transmission, the magnitude of error, that is, the difference between the actual sheet length cut and the desired sheet length, as initially selected, (b) in the fine correction mode, small sheet length error is corrected immediately, after which the control system for a selected number of cutoff operations is inhibited from operation to permit the entire mechanical operation of the cutoff apparatus to "settle out" to determine whether the sheet length correction mode is sufficient, (c) for errors in sheet length of large magnitude but within a fine sheet correction zone, correction is made immediately and as a result fewer incorrectly cut sheet lengths result as compared to prior art control systems, and (d) a

FIG. 1 is a schematic block diagram of the sheet length control system comprising this invention including a fine sheet length correction mode and a coarse correction mode.

FIG. 2 is a schematic block diagram of the sheet length control system of FIG. 1 but utilizing a different type of coarse correction mode.

FIG. 3 is a schematic diagram showing in detail the operation of the error band selective means of this invention.

FIG. 4 is a diagram illustrating the typical operating characteristic of the sheet length control system comprising this invention relative to the error tolerance zones adjacent either side of the OK or acceptable tolerance range.

FIG. 5 is a graphic illustration of the time required for adjusting the variable speed transmission versus the sheet length being cut by the cutoff apparatus.

Referring now to FIG. 1 there is shown in schematic block diagram the sheet length control comprising this invention. The prefabricated sheet board 1 is pulled from the double facer through a heating and curing section by means of the upper and lower feedbelts 2 and 3 which are driven by the rolls 4 by means of the main drive motion 5 through the clutch mechanism 6. The clutch mechanism 6 may be placed in engaged or disengaged position to feed the prefabricated sheet board 1 to the processing apparatus, which in this case is indicated as a cutoff apparatus in the form of the cutter knife carriers 7, each of which is provided with a knife blade 8. The knife cutters cut the moving web of material or sheet board 1 into preselected sheet lengths indicated by the arrows X in FIG. 1.

The main drive motor 5 is also connected to drive the variable speed transmission 10, which is a Reeves type transmission, through the pulley and belt arrangement generally indicated at 11, which drives the input shaft 12 of the variable speed transmission 10. The output shaft 13 of the variable speed transmission is connected to drive the cycling mechanism indicated at 14, the function of which has been explained previously and, as indicated, does not form a part of this invention. The cycling mechanism 14 in turn drives the cutter knife carriers 7.

The variable speed transmission 10 is provided with means for adjusting its output to input shaft revolution ratio by means of a transmission adjuster generally indicated at 15. The transmission adjusting motor 16 is connected to drive the transmission adjuster 15 to properly set the output to input shaft ratio of the variable speed transmission 10 as well as being connected to adjust the cycling mechanism 14 in order to insure that the tangential velocity of the cutter blades 8 is equal to the linear velocity of the moving web of material 1 at the time of cutoff. In this connection, the illustration as shown in FIG. 1 shows the cutter blades 8 at the time of cutoff.

The sheet length control system as shown in FIG. 1 includes both a coarse correction mode and a fine sheet length adjustment mode. The control is designed so that a coarse correction can be made in an efficient and fast manner when changing from one sheet length to another to shift the sheet length error within the designed sheet length error band range, which in the particular embodiment shown is a designed plus and minus 4-inch error band range. Usually the coarse correction mode will make correction to the nearest whole inch of the desired sheet length, which desired sheet length is set on the thumbwheel setting 18 of the control panel 17. The thumbwheel setting includes a series of dials in hundreds, tens, units and fractions thereof so that the thumbwheel setting may immediately be set for the desired sheet length within any desired range from zero to several hundred inches and fractions thereof. It is customary in cutting fabricated sheet board to cut sheet lengths within a range of 20 inches to 300 inches. Operating personnel may set each of the digits in the thumbwheel setting 18 for the desired sheet length including any fractional sheet length, say 225¼ inches, after which the select switch 20 which may be operated by either its manual portion 20a or automatically by the control system through the use of the coil and contact 20b to permit the operating personnel to be in a position to push the select switch 21. The

select switch 21 is of the latching type so that upon its depression it will remain closed until pressed again by the operating personnel to release the same. Upon operation of the select switch 21 the storage memory circuit 22 receives the sheet length set on the thumbwheel setting and places this in its memory which comprises a series of flip-flop memory circuits. The output of the storage memory is indicative electronically of the thumbwheel setting at 18.

Reference is now made to the knife digitizer shown at 23, which digitizer is of the transducer type. The shaft 24 is provided with a projection 25 which enters a magnetic field of the digitizer 23 upon every revolution of the shaft 24. The projection 25 thus distorts the magnetic field of the digitizer 23 producing a pulse which is fed to the AND gate 27. It should be understood at this point that every revolution of the shaft 24 is coincident with every revolution of the cutter knife carrier 7 and, thus, is indicative of a cut being made by the blades 8. The knife digitizer produces a pulse output of one pulse for every revolution of the knife blades 8 and, therefore, is representative of a cut being made by the blades 8.

The pulse from the knife digitizer 23 is fed to the AND gate 27, which is a buffer to eliminate regenerative effects and is sensitive to the pulse signal to the extent of producing an output when the pulse signal goes from a plus value to zero, which signal is received by the pulse shaper 28 and refines the pulse signal received from the knife digitizer 23 to produce a uniform square pulse at the output of the shaper 28. This shaped pulse is then directed to the driver gate 30 which in reality represents a power amplifier to produce a pulse of sufficient strength to be operative on the rest of the circuitry comprising the sheet length control system.

The pulse from shaper 28 is also directed to a second AND gate 31, which is also a buffer and is identical to AND gate 27 to eliminate regenerative effects. The shaper 32 receives the pulse from the AND gate 31 to provide a uniform shaped pulse similar to that provided by shaper 28 except in this case the shaper 32 causes the shaped pulse to be delayed in time relation as compared to the pulse originally received at the output of the shaper 28. This delayed relationship is depicted in FIG. 1 wherein the shaped and amplified knife pulse from driver 30 is indicated as TP3. The pulse as properly shaped by shaper 32 is amplified by power amplifier and driver 33 and is depicted as delayed pulse TP4. It will be readily seen hereinafter that knife pulse TP3 generally functions as a gating pulse in operation of the coarse and fine sheet length adjustment modes whereas the delayed pulse TP4 is a clearing pulse for all the integrated network circuits.

Reference is again made to the storage memory 22 which now has in its storage capacity the thumbwheel setting selected in connection with the thumbwheel shown in 18 on the control panel 17 upon operation of the select switch 21. The output of the storage memory 22 is fed to a range comparator 34, used in the fine sheet length correction mode as well as a coarse comparator circuit shown at 35 and used in connection with the coarse correction mode. The range comparator 34 differs from coarse comparator 35 in that range comparator 34 operates to compare signals from the up counter 36 and the storage memory 22 within a range band of plus and minus 4 inches. Comparator 35 reads the storage memory signal which is indicative of the thumbwheel setting 18 and compares this to the sheet length value set on tape in the programmed tape reader 37.

The programmed tape reader 37 is a direct reading punched tape programmer which comprises a punched tape and a direct reading system. The MYLAR laminate tape 38 is a closed loop tape provided with a progressive series of linearly aligned holes 42 which are representative in value of consecutive sheet length in inches, as, for example, starting from 20 inches up to 300 inches. Each consecutive arrangement of openings in the MYLAR tape are indicative of 20, 21, 22, 23 inches, etc., on up to 300 inches. The programmed tape reader 37 produces an electrical signal indicative of the position of the MYLAR tape so that the comparator 35 can com-

coarse correction is accomplished within a minimal amount of time by changing the ratio relationship of knife to web velocity to within the nearest inch of desired sheet length whence the fine correction mode automatically takes over from the coarse correction mode to finally shift the ratio relationship within the acceptable tolerance range of the desired sheet length.

A principal feature comprising this invention is the provision of a sheet length control system wherein the coarse correction mode and fine correction mode provide a fully automatic average sheet length control wherein fine sheet length correction is automatically obtained immediately following major coarse correction, with fine sheet length corrections made initially for sheet-to-sheet variations from the preset desired sheet length after which inhibiting means is interposed for a selected number of cutoff operations of the processing apparatus to permit the processing apparatus to "settle down" to determine if further fine sheet length correction is desirable and expedient within an acceptable tolerance. In this connection, initial fine sheet correction is always sufficient to completely correct for sheet length error into the acceptable tolerance range, such as within one-fourth inch or one-eighth inch of the desired sheet length. The signal produced by the fine sheet length correction mode for correcting the sheet length error is characterized in magnitude of the sheet length error to correct the actual sheet length being cut to correspond to the predetermined desired sheet length value within an acceptable tolerance. Thus, the duration or period of the correction signal for a sheet length error is proportional to the magnitude in actual sheet length error and also compensates for nonlinearity of the variable speed transmission over the sheet length range as further referred to below. The appropriate correction period is automatically selected by the circuit logic requiring no reading in or information by operating personnel except the setting of desired sheet length value. Such a control system takes away the possible option for human error in attempting to correct the cutoff apparatus in any manner for a given sheet length error.

Another feature comprising this invention is the quick but accurate changing from one sheet length to another during a production run change wherein, after the new sheet length has been obtained by adjustment through the variable speed transmission to within an acceptable coarse change range, such as, within plus or minus one inch, the fine sheet length correction mode automatically goes into operation to bring the desired sheet length value within an acceptable sheet length tolerance range. The web fabricating machinery will remain in operation during coarse correction but the feeding machinery, that is, the web feeding belts and the double facer, are stopped so that the web of material is not fed into the cutoff apparatus. The control system may signal the operator when coarse correction has been completed at which time the operator can manually re-engage the clutch to the feeding machinery to commence the production run. In this manner, incorrect sheet lengths from a moving web of material are not produced which would be wasted. An interlock may be provided in the control system to prevent the operator from re-engaging the clutch until coarse correction has been completed.

Coarse correction may be obtained by utilizing programmed tape means in the form of a tape reader control operative to adjust the variable speed transmission through its adjusting motor and motor control to bring about the correct input to output ratio corresponding to the desired velocity ratio relationship of the cutter knives relative to the moving web of material to within an acceptable coarse change tolerance of the desired sheet length, after which comparator circuit means is operative to disengage the tape reader control to permit fine sheet length correction through the variable speed transmission adjusting motor control and the fine correction mode. Such a tape reader control not only accomplishes the coarse correction in an efficient and fast manner but also is highly accurate in performing the initial adjustment leaving little to be done to complete sheet length change by the fine correction mode portion of the sheet length control

system. The unique feature in using the tape reader control in the coarse correction mode is its ability to accurately calibrate to within close tolerance the actual sheet length desired for cutoff.

Another feature comprising the present invention is the utilization of a "fluke error" detection circuit which is designed to inhibit any sheet length adjustment to be made during a period in which a large or severe slip of the moving web of material is experienced in the double facer. Such severe slippage is termed a "fluke error" herein and generally requires correction in the double facer by the operator of the equipment. Such severe slippage can be caused by the slipping of the moving web of material between the sheet board feed-belts or excessive brake tension of the rolls in driving the feed-belt. It is undesirable that the sheet length control system make a sheet length correction for such a large error in slippage of the web since they are not usually repetitive type errors. It is the main purpose of a sheet length control system to only correct for errors that are repetitive and show a specific tendency away from the desired and predetermined sheet length value.

Another feature comprising this invention is the provision of a number of correction zones of increasing magnitude from an OK or acceptable tolerance range which represent either a greater or lesser magnitude in sheet length error from the desired, preselected sheet length value.

During a production run of processing sheet board, sheet-to-sheet variations usually yield a pattern of random errors. The width of the band of such a pattern of errors depends upon various factors, the most important being the inherent heterogeneities in the variable speed transmission. In order to maintain average sheet length, an imaginary OK or acceptable tolerance range is selected from which a series of out of tolerance zones or correction zones, representative in a captive nature of the error band pattern, are created within which positive sheet length correction can be made if an error should fall in any one of the correction zones. The prime aim is to keep the band of sheet length errors centered within the acceptable tolerance zone. No positive correction or positive inhibiting means is necessary in the acceptable tolerance zone and the fine correction mode is not responsive to sheet length variations falling in this zone. If the errors in sheet length are out of the acceptable tolerance zone, the sheet length control promptly shifts the pattern of errors and then makes corrections in response to the magnitude of any subsequent error, that is, if subsequent errors fall within the next error band outside the acceptable tolerance band, no correction is made unless the errors occur more than twice in a consecutive manner. If the error in sheet length is outside the error band limits, a correction is made immediately. This is an important feature of the invention as previously indicated in a different manner in the beginning of this summary.

Means are provided to inhibit the inner such tolerance zone adjacent to the OK or acceptable tolerance range for a preselected number of cutoff operations after a correction for sheet length error falling within the inner tolerance zone has been completed by the sheet length control system fine correction mode. This inhibiting feature in the most inner tolerance zone provides a dampening effect to permit the mechanical operation of the cutoff apparatus to "settle down" a sufficient amount of time before further corrections are made due to possible errors of sheet length falling again within the inner band tolerance zone. Such a dampening feature prevents continual corrections being made from one innermost tolerance zone into the other innermost tolerance zone and, thus, prevents the control system from overcorrecting caused by continually correcting for frequent sheet length errors falling within these inner band tolerance zones.

Other objects and advantages appear hereinafter in the following description and claims.

The accompanying drawings show, for the purpose of exemplification without limiting the invention or the claims thereto, certain practical embodiments illustrating the principles of this invention wherein:

pare the signal received from the storage memory 22 with that of the programmed tape reader 37 to determine whether the sheet length indicated by these signals is the same or different, and how much they are different in their value as representative in inches. The MYLAR tape is generally indicated diagrammatically at 38 in FIG. 1 and is driven by the roller guide 40 of the programmed tape reader 37. The tape reader 41 is of the brush type and depending upon the aligned arrangements of openings 42 on the MYLAR tape 38 as arranged in consecutive order, the tape reader 41 will indicate a value which is indicative of a specific value of sheet length.

A programmed tape reader suitable for use in the coarse correction mode is manufactured by the Industrial Timer Corporation of Parsippany, New Jersey.

The programmed tape reader 37 is connected by shaft 43 to the transmission adjuster 15 through the electric clutch as indicated at 44. The clutch 44 is operated by the actuator 45, which may be electric solenoid mechanism. The actuator is placed into operation by the coarse comparator 35 when the signal from the storage memory 22 as compared to the sheet length position of the MYLAR tape 38 in connection with the programmed tape reader 37 are not the same and are in excess of a comparative value difference of plus or minus 4 inches. Under such conditions the comparator 35 operates the solenoid actuator 45 through comparator control line 46 in order to insure that the clutch 44 is engaged and set to be driven by the transmission adjusting motor 16 through its output shaft 47 and then shaft 43 of the transmission adjuster 15. The operation of the programmed tape reader 37 will become more apparent as further explanation is made in connection with the operation of the complete control system.

The control line 46 from the comparator 35 is also connected to the reverse flip-flop 48 and the forward flip-flop 50 to set these flip-flops for operation, depending upon the selection made by the bistable multivibrator or start error flip-flop 60 in removing the inhibition from either of these flip-flops 48 and 50 along the respective lines 74 and 63.

From the foregoing, it can be readily seen that the programmed tape reader 37 simulates the position of the variable speed transmission 10 with respect to its output to input gear ratio. Thus, for any position of the transmission adjuster 15 in adjusting the variable speed transmission, the programmed tape reader 37 is able to indicate by electrical signal to the coarse comparator 35 the output to input gear ratio of the variable speed transmission. By the same token, a new setting on the thumbwheel dials indicated at 18 will permit the coarse comparator to sense the difference between the new sheet length setting and that read by the programmed tape reader 37 so that the coarse comparator 35 will then through control line 46 permit engagement of the clutch 44 as well as set the forward and reverse flip-flops 50 and 48 and, as will be explained hereinafter, permit the operation of the transmission adjusting motor 16 in order to adjust the transmission adjuster 15 while at the same time operate the programmed tape reader 37 to bring into proper adjustment to the output to input ratio relationship of the variable speed transmission 10 for a sheet length value in coincidence with the desired sheet length setting on the dials of the thumbwheel setting 18.

Reference is now made in FIG. 1 to the CR relay 51 which is provided with normally closed contacts 52 and 53 and normally opened contacts 54 and 55. Normally closed contact 52 will permit the knife digitizer 23 to present its pulse to the AND gate buffer 27. By the same token, normally closed contact 53 will permit the web digitizer 56 operated by the roller 57 on the moving web of prefabricated sheet board 1 to present its signal to the up counter 36. The CR relay 51 is energized to close its contacts 54 and 55, while opening contacts 52 and 53, when the coarse correction mode is to be placed into operation. Thus, in operation of the programmed tape reader 37 in conjunction with its coarse comparator 35 and the storage memory 22, the CR relay 51 is energized so that no knife pulses are received from the pulse digitizer 23 and by the same token, no pulses are received from the web

digitizer 56 since, under normal circumstances, no sheet board 1 is moving from the feedbelts 2 and 3 at the time a coarse correction is being made. This is to permit operation of the sheet length control system to provide for the new change in sheet length through the coarse correction mode without the needless waste of prefabricated sheet board. To this end, a web simulative digitizer indicated at 58 is used to simulate the effect of the web digitizer 56 as if prefabricated sheet board were actually moving into the cutoff apparatus. Web simulative digitizer 58 is coupled to the input shaft 12 of the variable speed transmission 10 by means of the gearing 61 and 62 and produces, upon rotation of the input shaft 12, a train of pulses which, in this specific embodiment, are representative of 32 pulses per simulated sheet board inch. The web digitizer 56 is capable of producing a train of pulses when the prefabricated sheet board 1 is moving from the feedbelts 2 and 3 also of 32 pulses for every inch of prefabricated sheet board passing under the web digitizer roller 57.

With the CR relay 51 energized, normally opened contact 54 will be closed permitting the train of pulses received from web simulative digitizer 58 to be fed along line 49 into the up counter 36. In setting a new coarse correction, therefore, the web simulative digitizer 58 represents electronically, a series of pulses indicative of the passing of prefabricated sheet board as if such sheet board were being counted by the web digitizer 56. With main drive motor 5 in operation and clutch mechanism 6 in its disengaged position so that the feedbelts 2 and 3 are not in operation, the main drive motor 5 will operate the variable speed transmission 10 to rotate the cutter knife carrier 7. Because the tape reader has been programmed relative to the variable speed transmission 15, the coarse correction mode is in a position capable of sensing simulative signals representative of the output to input shaft ratio of the variable speed transmission 10 which in relationship corresponds to the desired sheet length to be cut set on the dials of the thumbwheel setting 18.

The up counter 36 is a counting unit which consists of a series of flip-flop circuitry capable of counting up to a given number in the several hundreds and therefore consists of a decade counter unit comprising hundreds, tens, units and sixteenths while the range comparator consists of a series of comparison gates comprising exclusive OR gates. The up counter 36 is also provided with a sixteenth counter which includes a count divider which uniformly divides the 32 pulses per inch of time received from the web simulative digitizer 58 or web digitizer 56 into one-half the amount thereof so that the sixteenth counter actually receives every other pulse. Therefore, the up counter 36 is capable of indicating up to a desired hundredth unit and any one-sixteenth of a unit or multiple thereof the amount of simulative passage per unit time of prefabricated sheet board if the same were actually moving from the feedbelts 2 and 3.

The range comparator 34 continually receives the output of the up counter 36 receiving the train of pulses from the web simulative digitizer 58 when the CR relay 51 is in its energized position until the up counter 36 is cleared by a delayed knife pulse TP4. The network comprising the range comparator 34 receives the selected sheet length value from the storage memory 22 and compares this with the up counter sheet length value, and if the difference is more than a comparable plus or minus four inches, a signal is sent along line 39 by the range comparator to set the start error flip-flop 60 which is a bistable multivibrator.

At this point it should be noted that AND gate 75 to error counter 80 is operative since the pulses from digitizer 58 are received along line 76 and the inhibit is removed from AND gate 75 by a signal along line 69 from the start error flip-flop 60. The fine sheet correction mode will actually be placed in operation continually seeking to make corrections through the forward or reverse control 66 or 88 in an attempt to make the necessary coarse correction. However, the operation of the coarse comparator 35 in priming either one of the flip-flops 48 or 50 at their respective inputs 64 or 65 will permit operation

of either of these flip-flops, if their other respective inputs at 71a and 73 or 72a and 59 are also primed. The operation of one of these flip-flops will, in turn, override the correcting function the error band selector 90 since the correction signal from these flip-flops is of long duration sufficient to bring the selector 90 is only producing correction signals representative of the greatest error magnitude that it can make correction for, which in the particular embodiment disclosed in FIG. 3 has been selected as plus and minus 4 inches as will be explained in more detail hereinafter.

Mention was made of priming inputs 71a and 72a which are connected by the respective lines 71 and 72 to the respective outputs of the AND gates 91 and 96. As will be more evident later, the AND gates 91 and 96 represent the sheet length error bands of greatest sheet length error magnitude in operation of the fine sheet length correction mode. When the coarse correction mode is in operation and overriding the functioning of the error band selector 90 and the coarse change is greater than the largest single sheet length error magnitude for which the selector is capable of producing a correction signal, for example, a correction pulse representative of plus four inches with respect to the AND gate 91, a signal is produced along either of the respective lines 71 or 72 to the respective inputs 71a or 72a of the flip-flop. Thus, the flip-flop 48 or 50 will be set to operate the respective reverse control 88 or forward control 66 when all of the inputs 71a, 73 and 64 of either reverse flip-flop 48 or the inputs 72a, 59 and 65 in the case of forward flip-flop 50 are all primed or set. As soon as the coarse correction has been sufficient enough to bring the coarse change within the bounds of the fine sheet length error band, the prime will be removed from either of the inputs 71a or 72a depending, of course, on the direction of the coarse change, that is, whether it was of increasing or decreasing magnitude of sheet length and the operation of respective control 88 or 66 by the flip-flop 50 or 48 will cease. Further sheet length correction will be automatically assumed by the error counter 80 and error band selector 90 with the CR relay being de-energized.

Reference is again made to the range comparator 34 which compares the count in storage memory 22 with the output count value of the up counter 26 between clearing TP4 knife pulses to determine if the storage memory sheet length value is higher or lower than the pulsing rate of the web simulative digitizer 58. The signal on line 39 is indicative of the magnitude and direction of the sheet length value and operates the start error flip-flop 60 to take away inhibit of either the reverse flip-flop 48 or the forward flip-flop 50 depending upon whether the sheet length value in the storage memory 22 is higher or lower than the set rate of digitizer 58. For example, if the up counter 36 produces a signal under the value in the storage memory 28, a sheet length of high value is being called for and the range comparator will produce a signal to the start error flip-flop 60 which will operate to produce a signal on the output line 63 and set the forward flip-flop 50 through input 59 to permit forward flip-flop 50 to operate from supply line 70. At the same time, the programmed tape reader 37 together with the information received from the storage memory 22 will have indicated to the coarse comparator 35 that the sheet length value in the storage memory 22 is higher than that registered on the programmed tape reader 37 at this given time. Therefore control line 46 will receive a signal from comparator 35 to the inputs 64 and 65 of the reverse flip-flop 48 and forward flip-flop 50. Since both flip-flops 48 and 50 have a prime or setting signal on line 46 to their inputs 64 and 65, only one such reverse or forward flip-flop 48 and 65 will be placed in operative condition, since as indicated above, an output has been received on line 63 from the start error flip-flop 60 to the forward flip-flop 50 to take away the inhibition thereof. At the same time, as also previously indicated, the operation of error counter 80 through AND gate 96 (because a longer sheet length is being called for and assuming it is in excess of a 4 inch change) will prime input 72a. All three in-

puts 72a, 59 and 65 have been primed setting forward flip-flop 50. Therefore, forward flip-flop 50 will be placed in operative connection to the forward motor control 66 through line 79 to operate the transmission adjusting motor 16 in the necessary direction to commence to make correction of the output to input shaft ratio of the variable speed transmission.

It should be noted that each of the flip-flops 48 and 50 are provided with an input indicated respectively at 67 and 68 and connected to line 70 from the normally open contact 55 which, when closed, provides a positive voltage supply to the respective flip-flop set to operate. In the above mentioned illustration, it has been previously mentioned that the CR relay 51 is in its energized position and therefore normally open contact 55 will be closed to permit an input to the forward flip-flop 50 when this flip-flop has been set at its input 65 and inhibition removed from inputs 59 and 72a.

From the foregoing example, it can be seen that the forward control 66 will continue to operate through the forward flip-flop 50 until the adjustment to the variable speed transmission is such that the output to input ratio is representative of a sheet length value within plus or minus four inches of the desired sheet length value held in storage in the storage memory 22. The range comparator 34 having placed in operation the start error flip-flop 60 to operate the forward flip-flop 48 through line 74, the start error flip-flop 60, as previously mentioned, will also release the inhibiting of AND gate 75 to error counter 80 to permit error counter 80 to receive the train of pulses from the web simulative digitizer 58 of 32 pulses per unit time through web simulative digitizer line 76. Thus, when start error flip-flop 60 imposes a signal on AND gate 75, the train of pulses from web simulative digitizer over line 76 permits AND gate 75 to operate and, thus, permits the train of pulses to enter the error counter 80.

When coarse correction has been made within the range of the error band of the fine sheet length correction mode, that is, within a plus 4 inches, the priming of input 72a of flip-flop 50 will be removed as well as input 65 will be reset by coarse comparator preventing further operation of flip-flop 50.

The error counter 80 represents a portion of the fine sheet length correction mode and contains a plurality of output terminals 81 through 86 which become activated according to the number of web simulative pulses accumulated in the counter since it was last cleared by the delayed clearing pulse TP4 through clearing line 77 to the clear terminal 78 of the error counter 80. Error counter 80 is a decade type flip-flop counter network which is incapable of producing any output if the present sheet length value and the simulated or actual sheet length value are the same within an acceptable tolerance. Therefore, no correction can be initiated through the AND gates 91 through 96 to the error band selector 90. However, if the count in the error counter 80 does not match that of the preselect sheet length value, then a knife pulse TP3 received through line 87 will remove the inhibit from all of the AND gates 91 through 96 depending upon the magnitude of the error in the error counter 80.

The error counter 80 is only concerned with error differences of plus or minus 4 inches from the desired sheet length value and therefore is said to perform the function of the fine sheet length adjustment or correction mode. As shown in FIG. 1, six correction zones have been set up as represented by the number of AND gates 91 through 96. Three of the correction zones are for short errors in sheet length, that is, within a minus 4 inch tolerance or within any other desired correction zone tolerances. For purposes of explanation, let it be assumed that there is an OK or acceptable tolerance zone of a quarter inch. Output 83 from error counter 80 could represent a minus ½ inch out-of-tolerance whereas output 82 and 81 respectively are indicative of a minus 1 inch and minus 4 inch out-of-tolerance zone. On the other hand, output 84 of error counter 80 is representative of a plus ½ inch out-of-tolerance zone and outputs 85 and 86 are representative of plus 1 inch and plus 4 inch out-of-tolerance zones, respectively. If range comparator 34 determines that

there is more than a plus or minus 4 inch difference between the unit values of up counter 36 and storage memory 22, then comparator 35 also sensing this difference in value will operate the respective reverse flip-flop 48 or forward flip-flop 50 to in turn operate the reverse motor control 88 or forward motor control 66 and override the correcting function of error counter 80 that it may impose through the AND gates 91 through 96 to the error band selector 90. However, when the comparator 35 has permitted adjustment, as in the case of the example discussed, through the forward flip-flop 50 and the forward motor control 66 to the transmission adjusting motor 16 to within a plus or minus 4 inch band or range, comparator 35 will cease to operate and disengage the clutch 44 while at the same time error counter 80 will automatically take over the error count and, through the error band selector 90, operate either the forward control 66 or the reverse control 88 to fine adjust, through transmission adjusting motor 16, the transmission adjuster 15 to within the acceptable tolerance zone of sheet length value to be cut by the cutter blades 8 of the cutoff apparatus. Thus, the function of the reverse and forward flip-flops 48 and 50 is to make immediate and fast but continuous correction to the variable speed transmission 10 through its transmission adjusting motor 16, through the reverse and forward motor controls 88 and 66, overriding the correcting function of the error counter 80 of the fine sheet length adjustment mode until the adjustment made to the variable speed transmission 10 is within plus or minus 4 inches of the desired preset sheet length on the thumbwheel setting 18, at which time the knife pulse TP3 on line 87 removes the inhibit from any one of the AND gates 91 through 96 permitting further functional operation of the transmission adjusting motor 16 for specific but different time durations or intervals as predetermined in the error band selector 90. When the error difference is within the plus or minus 4 inch range, comparator 35 will prevent operation of the reverse and forward flip-flops 48 and 50 by resetting inputs 64 and 65.

In the operation of the coarse correction mode, explained above, the operation of flip-flop 48 is like that of flip-flop 50. The start error flip-flop 60 will permit the removal of an inhibit signal on input 73 of reverse flip-flop 48 whenever it is determined by the range comparator 34 that the count difference between the up counter 36 and the storage memory 22 is lower than the minus 4 inch error band so that at the same time comparator 35, through control line 46, removes the inhibit from input 64 of reverse flip-flop 48 while the inhibit at input 71a is removed by AND gate 91 through line 71. As a result, all inputs 71a, 73 and 64 are primed and flip-flop 48 is set to permit operation of the reverse motor control 88 and thus adjust the variable speed transmission to produce an output to input shaft ratio relationship indicative of the desired sheet length value within a plus or minus of a 4 inch band. In reality, coarse comparator 35 ceases to operate upon reaching the nearest whole inch of preset sheet length value in comparing the signal received from the programmed tape reader 37 as compared to the storage memory 22. The start error flip-flop 60 having removed the inhibit from AND gate 75 to permit operation of the error counter 80 and the short AND gates 91, 92 and 93, in conjunction with the knife pulse TP3 received on line 87 permitting further correction through the reverse and forward motor controls 66 and 88 in adjustment of the variable speed transmission somewhere within the plus and minus 4 inch error band of sheet length until the variable speed transmission is adjusted to within the acceptable tolerance range for sheets to be cut by the revolving blades 8.

After coarse correction has been obtained as described, CR relay 51 is de-energized so the signal from pulse digitizer 23 is placed on line 121 after the signal has been properly shaped and power amplified, thence on line 87 to remove the inhibition from any one of the AND gates 91 through 96 to permit a signal at any one of the outputs of these AND gates if the error counter 80 produces at any of its outputs 81 through 86 an output signal indicative of sheet length error from desired sheet length during a production run. The signal will proceed

through the selected AND gate 91 through 96 into the error band selector 90. The function of the error band selector 90 will be explained hereinafter in more detail in connection with FIG. 3 which shows a typical embodiment of an error band selector which may be constructively used in the fine sheet length adjusting mode. The error band selector 90 comprises a series of one shot multivibrators which are pulse shaper circuits and produce a correction signal indicative of the magnitude of error coming from any one of the AND gates 91 through 96. The error band selector 90 is an important feature comprising the sheet length control system when operating in its fine sheet length adjusting or correction mode.

A more detailed explanation will be made in regard to FIG. 3 with respect to the reverse and forward controls 88 and 66 to the transmission adjusting motor 16.

To the fine sheet length correction mode, comprising the error counter 80 together with the AND gates 91 through 96 and the error band selector 90, the sheet length control system as shown in FIG. 1 is also provided with three other unique circuitry devices as generally indicated in block form as the inner band inhibitor 101, the fluke error inhibitor 102 and the detect sheet length size circuit 103. Each of these inhibitor and detection circuits will now be explained separately in detail.

The inner band inhibitor 101 which performs a unique feature in the operation of the fine sheet length correction mode, in taking cognizant of the mechanical inherent heterogeneities involved in the operation of the cutoff apparatus and the variable speed transmission 10. The inner band inhibitor 101 performs the function of inhibiting operation of inner outputs 83 and 84 of the error counter 80 which are the inner band correction zones and, as mentioned above, are representative of the plus or minus $\frac{1}{2}$ inch error correction zone in this particular embodiment. In the embodiment of FIG. 3, they are the $\frac{1}{2}$ inch correction zones as will be made known later. It is desirable that an inhibiting signal be placed on the inner band outputs 83 and 84 of the error counter 80 when a correction has already just been made previously through the inner correction zones, since these zones are adjacent to the acceptable tolerance range of the actual sheet length being cut and a large amount of sheet length errors will likely appear within these zones. The inner band inhibitor 101 actually is a counter and counts only knife pulses TP3 received on line 87 through AND gate 104. The inner band inhibitor 101 is set when either of the inner error bands represented by the outputs 83 and 84 have just been previously placed in operation. Then the inner band inhibitor will be triggered down to zero by the next two consecutive knife pulses TP3 on line 87. Thus, the inner band inhibitor 101 does not operate to inhibit the inner band outputs 83 and 84 when it is in its zero position so that the error band selector receiving an output from either of the inner band AND gates 93 or 94 may normally function. When an error signal does appear in the $\frac{1}{2}$ inch band correction zone, operation of the AND gates 93 and 94 by the knife pulse TP3 will operate the error band selector 90 to bring about the $\frac{1}{2}$ inch correction adjustment through either of the motor controls 88 and 66 while at the same time a signal on line 99 from either of these inner band correction zones will set the inner band inhibitor counter to a count of 2. For the duration of the next two knife pulses TP3, the inner band inhibitor will be reduced to a count of zero and this countdown is introduced to the inner band inhibitor by a high signal appearing at this time at the output 106 thereof on line 107 to the input of the AND gate 104 which removes the inhibition from the AND gate and permits the passage of the knife pulses TP3 through the AND gate 104 into the inner band inhibitor 101. By the same token, the inverter 108 applies an inhibiting signal (zero) to the outputs 83 and 84 of error counter 80, that is, to the inner band error correction zones and their respective gates 93 and 94. This inhibition remains on these gates 93 and 94 until the counter of the inner band inhibitor 101 goes to zero on the next two consecutive knife pulses TP3, at which time the signal is removed from the output 106 of the inner band inhibitor to inhibit operation of AND gate 104 and also

through inverter 108 puts a high on line 105 to again permit the operation of the inner band error correction zones through error counter outputs 83 and 84 to AND gates 93 and 94. From the foregoing, it can be seen that a dampening effect is placed upon the fine sheet length correction mode through the use of the inner band inhibitor 101 to permit only a ½ inch error correction by the error band selector 90 for any three consecutive knife pulses TP3. However, it should be carefully understood that if on the second consecutive knife pulse TP3 the error counter 80 would indicate an error sheet length value in excess of the inner band error correction zones, such as the plus 1 inch error correction zone indicated by the output 85 of error band counter 80, then operation of the AND gate 95 would be permitted, which in turn would produce a correction signal from error band selector 90 to reverse control 88 to make the necessary correction to the variable speed transmission 10, since there is no inhibiting signal from the inner band inhibitor 101 to AND gate 95 and, for that matter, any of the other AND gates other than AND gates 93 and 94 of the inner band error correction zones as previously indicated. However, the knife pulse TP3 would represent one of the two needed countdown pulses to remove the inhibiting function of inhibitor 101.

Since frequently sheet length errors will fall within the acceptable sheet length inner band error correction zone, the inner band inhibitor 101 performs the function of inhibiting excessive consecutive corrections with respect to errors falling within this zone, since this error zone is very small in extent as compared to the other correction zones and it may not be necessary from a practical standpoint to make inner band sheet length error corrections to the output to input shaft ratio of the variable speed transmission 10 on consecutive knife pulse TP3 since, in a majority of cases, the initial adjustment made to the variable speed transmission 10 on the inner band error correction zone most generally is sufficient.

The fluke error inhibitor 102 presents another unique circuit function in the operation of the sheet length control system comprising this invention. As can be seen from FIG. 1, the fluke error detection circuit is connected to the web digital pulse line 76 as well as the web simulative pulse digital line 49. The fluke error inhibitor 102 comprises a series of separate digital counters which may be said to be connected back to back, wherein each of the separate counters accumulate their respective pulses received from the web digitizer 56 and the web simulative digitizer 58. When the counters accumulate their respective pulses which are nearly equal in amount, this would indicate that there is no extreme or severe slippage in the double facer. Obviously if the digital counting from the web digitizer 56 is much less than that of the web simulative digitizer 58, then there has been some slippage of the sheet board 1 as it is being pulled from the double facer by means of the feedbelts 2 and 3. When this condition occurs, that is, when there is excessive pulses in the counter counting the web digitizer 56 pulses over that of the counter counting the web simulative digitizer 58 pulses, a flip-flop circuit in the fluke error inhibitor 102 is set and inhibits the error band selector 90 through its output line 110 from making any corrections through the transmission adjusting motor 16 to adjust the shaft ratio relationship of the variable speed transmission 10. The next delayed knife pulse TP4 will clear the above mentioned flip-flop circuit in order to permit the defined sheet length adjusting mode to operate once again and make any sheet length corrections within the plus or minus inch band if deemed necessary on the next cutoff operation. Thus, the fluke error inhibitor 102 compares by counting the pulses received on pulse line 76 to those received on line 49. If the pulse on line 76 are exceeded by the pulses received on pulse line 49, then the fluke error inhibitor will produce an inhibit signal along line 110 to inhibit the operation of the error band selector 90. The fluke error inhibitor circuit may be made to produce an inhibit signal on line 110 for any degree of slippage of the sheet board 1. From a practical standpoint, when slippage of one-half inch or greater occurs of the sheet board 1 being

pulled by the feedbelts 2 and 3, the fluke error inhibitor 102 will inhibit the operation of the error band selector 90 from making any variable speed transmission adjustments through the transmission adjuster 15. The ½ inch limitation is chosen for the simple reason that the double facer normally should never slip more than one-half inch in a repetitive manner; otherwise, this is an excellent indication that there is something wrong in the operation of the double facer and therefore it is impractical to make fine sheet length adjustment to the cutoff apparatus. Such slippage usually occurs only once over a long period of time during the production run and therefore corrections should not be made because the next consecutive sheet to be cut off by the cutoff apparatus will not have slipped and therefore may be a sheet length within the OK or acceptable tolerance zone. An alarm or annunciator may be provided in connection with the fluke error inhibitor 102 to indicate to operating personnel that the double facer is not functioning properly.

The third of the unique circuitry supplementing the fine sheet length adjusting mode is termed the detect sheet length size circuit shown at 103. In principle, the detect circuit 103 performs a function germane to the operation of the error band selector 90 basically due to the inherent mechanical characteristics of the variable speed transmission 10 of the Reeves type. In this connection, reference is made to FIG. 5 wherein there is illustrated a curve 111 showing sheet length in inches versus time necessary for adjustments to be made to the transmission adjuster 15, varying the output to input gear ratio of the Reeves variable speed transmission 10. As can be seen from the curve 111 in FIG. 5, the nature of the transmission adjuster for the Reeves transmission is such that more time is necessary for changing from one sheet length to another sheet length principally below the 90-inch coordinate as compared to any sheet length adjustment from one sheet length to another above 90-inch coordinate. In this latter connection, it will be noted that the curve becomes very steep above the 90-inch coordinate and therefore less time is necessary for changing of sheet length, say from 110 inches to a sheet length of 140 inches as compared to a sheet length adjustment from 20 inches to 50 inches, even though their respective sheet length changes differ exactly 30 inches in both cases. As a result, the detect circuit 103 is provided to receive from storage memory 22 along line 112 sheet length information from which the detect circuit determines whether the preselected sheet length made on the thumbwheel setting 18 is above or below the 90-inch coordinate as shown in FIG. 5. The 90-inch coordinate is chosen as the point of division because, as shown in FIG. 5, the curve 111 commences to proceed at a very steep rate therefrom as compared to that portion of the curve 111 below the 90-inch coordinate.

As previously mentioned, the error band selector 90 has the capability for each of the provided sheet length error correction zones, as represented by the AND gates 91 through 96, to produce a correction signal along the correction signal along the correction lines 113 or 114 of sufficient duration corresponding to the magnitude of sheet length error to operate the transmission adjusting motor 16 through the reverse and forward motor controls 88 and 66 to adjust the transmission adjuster 15 a sufficient degree to bring the sheet length back into the acceptable tolerance zone. The function of the detect circuit 103 is to affect this time duration capacity of the error band selector 90 in order to insure a longer correction period if the sheet length is below 90 inches but cause a change in the correction signal time period or duration to be a much shorter time period when the preselected sheet length being cut is over 90 inches. Other sheet length control systems of the prior art, such as U.S. Pat. No. 3,324,751, have provided for adjustment in connection with the duration or time period of the correction signal to the motor controls for the transmission adjusting motor because of the inherent mechanical nonlinearity in the adjustment of the Reeves type variable speed transmission. However, the detect circuit 103 provides an automatic means for making this selection of time

duration with respect to the correction signal. In this regard, it should be obvious to those skilled in the art that the detect circuit 103 need not necessarily break the period of correction into two segments as indicated at 115 and 116 in FIG. 5. Obviously, there may be multiple segments such as five segments in which the detect circuit would automatically change with respect to each such segment along the curve 111 depending upon the desired sheet length, the period of duration of the correction signal to correspond to the nonlinearity in adjustment of the Reeves type variable speed transmission as exemplified by the curve 111.

Further explanation will be made in connection with the operation of the detect circuit 103 together with the error band selector 90 in connection with FIG. 3 hereinafter.

Reference is now made to FIG. 1 in connection with counter 117 which is conditioned to receive the train of pulses from the web digitizer 56 when the CR relay 51 is in its normal unenergized position with contact 53 closed. Counter 117 is of the digital type and in counting web digitizer pulses, that is, 32 pulses for every inch of sheet board 1 passing under the web digitizer 56, it presents the counted output on output line 118 to the AND gate 120. However, AND gate 120 inhibits the signal on line 118 from passing until a knife pulse TP3 occurs along the line 121 which removes the inhibiting of AND gate 120 to permit the output count on line 118 to be presented to the storage unit 122. Thus it can be seen that counter 117 counts a train of pulses indicative of a sheet length passing under the web digitizer 56 between consecutive knife pulses TP3 and presents this information through AND gate 120 to storage 127 wherein there is provided a series of flip-flop circuits which store the value in a memory network in order to permit decimal decoding of the information stored therein through the decode unit 123. The decode unit 123 is a series of AND gates which are nine in number. The purpose of the decode 123 is to take the digital information in storage, obtained from the pulse received from the counter 117, and convert the same into analytical form, which may then be sent along line 124 to the display readout 125 on the control panel 117 where the information is fed to a series of lamps which visually display the analytical numeral of sheet length cut by the blades 8 for a revolution of the carrier 7. The lamps used in the display readout 125 are a series of lamp cathodes connected in series with a biasing resistor which in turn is connected to the collector of a transistor. The transistors are each connected to the output of an inverter which operate as drivers to turn off or on the transistor by consecutively placing or removing the bias from the base of the transistor. In normal operation the inverters impose a bias on each of the transistors so that all the cathodes representing each of the lamps are lit. However, when a signal is received from any of a series of seven OR gates at the output of the decode unit 123, the inverter is caused to turn off its respective cathode lamp. When one or more cathode lamps are turned off in this manner, the arabic numeral will appear at the display readout 125. It should be understood that there are only seven such inverters, transistors and cathode lamps since when all the cathode lamps are lit they represent the numerical form of the number "8". Thus, by using the inverters as drivers for the transistors to turn off the cathode lamps to produce the desired numeral or integer, it is made possible to eliminate a ninth circuit necessary for operation of the readout lamps.

As shown in FIG. 1, the control panel includes a short lamp 126, a long lamp 127 and a good lamp 128. The short lamp 126 would be connected to operate from any of the outputs of AND gates 91, 92 and 93, whereas the long lamp 127 would be connected to operate from any of the outputs from AND gates 94, 95 and 96 to, respectively, indicate a short or long correction being made by the transmission adjusting motor 16 to the transmission adjuster 15. Where there is no correction being made through the error band selector 90, by necessity, this must be a good sheet, and therefore the good lamp 128 will be lit indicating it to the operating personnel at the control panel 17. The operation of the short lamp 126 and long lamp 127 is more specifically shown in connection with FIG. 3.

Reference is now made to FIG. 2, wherein there is shown the sheet length control system of FIG. 1 except with a different means and method of performing the coarse correction mode. In FIG. 1 the coarse correction is accomplished by the programmed tape reader 37 in cooperation with the comparator 35 to operate the reverse flip-flop 48 or forward flip-flop 50 to operate the respective reverse control 88 or the forward control 66 to make the necessary sheet length adjustment when changing from one sheet length to another. However, in FIG. 2 there is provided the knife simulative digitizer 130 coupled to the output shaft 13 of the variable speed transmission 10 by means of the gearing 131 and 132 to produce a generative train of pulses to the AND gate buffer 27 when the CR relay 51 is in its energized position closing contact 133. It will be noted that in FIG. 2, CR relay 51 has an extra contact 133. Without the passage of sheet board 1 from the double facer either by means of disengaging the clutch mechanism 6 or cutting the sheet board well in advance of the double facer, the CR relay 51 can be operated to place the sheet length control system in the coarse correction mode thereby permitting the knife simulated digitizer 130 to place its signal into the buffer gate 27, pulse shaper 128 and thence the driver 30 to produce a simulated knife pulse along line 121 which then proceeds along to the fine sheet length adjustment mode by way of pulse line 87 as well as pulse line 97. In the meantime the train of pulses received from the web simulative digitizer 140 is directed along pulse line 49 through now closed contact 54 of the CR relay 51 to pulse line 76 and thence to the up counter 36 wherein the pulses are counted up and then directed to the range comparator 34 to compare the numerical value of these pulses with those in representative value in the storage memory 22 before the up counter 36 is cleared by a pulse along the delayed pulse line 77 received through AND gate 31, shaper 32 and its driver 33. When the range comparator makes the determination that the change in sheet length is more than a predetermined value, which is represented in actual sheet length as being more or less than 4 inches, the range comparator through line 39 will remove the inhibiting of start error flip-flop 60 which in turn, because of the nature of the direction of the sheet length change determined by range comparator 34, will remove the inhibit from either the reverse flip-flop 48 or the forward flip-flop 50. The respective reverse or forward flip-flop 48 or 50 will then be permitted to operate its respective reverse or forward control 88 or 66 to permit operation of the transmission adjusting motor 16 to make the proper output to input shaft ratio change through the transmission adjuster 15 of the variable speed transmission 10.

At the same time, it should be noted that the inhibiting of AND gate 75 has been removed by the start error flip-flop 60 to permit the web simulative digitizer signal appearing on pulse line 76 line 76 to enter the error counter 80.

As explained in the sheet length control system of FIG. 1, the coarse correction is obtained to the nearest whole inch of desired new sheet length by the coarse correction mode after which operation of the fine sheet length adjusting mode is automatically commenced and takes over the operation from the reverse and forward flip-flops 48 and 50 and at the same time the CR relay 51 is de-energized to bring into operation of the knife digitizer 23 and the web digitizer 56 as previously explained.

Mention should be made of the fact that knife simulative digitizer 130 is of a different nature than knife digitizer 23. While knife digitizer 23 produces one pulse for every revolution of the knife blades 8, knife simulative digitizer 130 produces 18 such pulses for every revolution of the shaft 13 which is representative of one revolution of the knife blades 8. If web simulative digitizer 140 is producing 32 pulses per inch as explained above in the embodiment of FIG. 1, with respect to digitizer 58 then its output in time relationship with knife simulative digitizer 130 will be actually 32 pulses for every one-eighteenth inch of simulated sheet board. To explain it in other terms, the output to input shaft ratio of transmission 10 is represented by the output of digitizer 130 over that of digitizer 140. However, with digitizer 130 operating 18 times

faster than normal, that is, representative of 18 knife cuts within the time period of one knife cut as represented by digitizer 23 when in actual operation, then coarse correction can be obtained 18 times faster than the time required for sheet length change through operation of the fine sheet length adjustment or correction mode.

In summary, therefore, it will be seen that in reality knife simulative digitizer 130 in relation to web simulative digitizer 140 is working at a rate of 18 times faster than that of knife digitizer 23 so that coarse corrections are made 18 times faster than could be provided by the fine sheet length control systems comprising the error counter 80, AND gates 91 through 96 and the error band selector 90. However, upon de-energizing CR relay 51 the system is switched into the fine sheet length adjustment mode operation to permit corrections for sheet length error within the pattern band of errors, preferably within a plus and minus 4 inches of sheet length error.

It should be noted that when the CR relay 51 is de-energized, operation of the error band selector 90 also imposes an inhibiting signal along line 134 therefrom to inhibit operation of either the reverse or forward flip-flops 48 or 50.

Reference is now made to FIG. 3 which in fact represents in detail the operation of the error band selector 90 as well as the reverse or forward controls 88 or 66 for the transmission adjusting motor 16. The embodiment shown in FIG. 3 is only with respect to the one-half of the representative band of errors appearing for short sheet length error in connection with the band of correction zones. Thus, the error counter short 80S in FIG. 3 represents that portion of error counter 80 in FIGS. 1 and 2 acceptable for counting short sheet length errors wherein the web digitizer 56 has not counted sufficient pulses to represent the desired preset length because of an early occurrence of a knife pulse TP3 along pulse line 87 to any one of the AND gates 91, 92 or 93 in FIGS. 1 and 2.

In practical application, the correction zones are established, as shown in the Table I below.

TABLE I

adjusting motor 16 in a reverse direction to make the necessary adjustment to the transmission adjuster 15.

Line 193 from OR gate 190S is also connected to triac 201 through biasing resistance 202 to illuminate the short lamp 126 as previously explained in connection with FIG. 1. Triac 201 performs the function of a switching device. Thus, for any correction signal, no matter its time duration that appears at the output of OR gate 190S, the short indicating lamp 126 will be illuminated to indicate to operation personnel that a short error sheet length adjustment is being made through motor 16. The same is true in connection with long indicating lamp 127 wherein any signal appearing at the output of OR gate 190L is directed through line 194 to operate triac 203 to permit completion of a circuit through resistance 204 and thus illuminate long indicating lamp 127. As indicated, triacs 201 and 203 act as switching devices to open and close the circuits operating the short and long indicating lamps 126 and 127.

The last portion of operation of the error band selector 90 involves the operation of the contact 171c through 175c by the relays represented in the form of the relay coils 177 and 178. Relay coils 177 and 178 operate on 120 volts AC and are energized by a signal from the output of detect 90 circuit 103. Coil 177 operates to open contacts 171c through 173c whereas relay coil 178 upon being energized is connected to open contacts 174c through 176c. It can be seen that upon the detect circuit 103 sensing a sheet length in excess of 90 inches, the relay coils 177 and 178 will be energized to open the respective contacts 171c through 176c in order to decrease the CR time constant of the pulse shaper 171 through 176 since as previously mentioned in connection with FIG. 5 the time duration necessary for sheet length error correction is much shorter for sheets above 90 inches as compared to sheet length less than 90 inches. By removing the condensers 171a through 176a upon operation of the contacts 171c through 176c, the time constant in each of the shapers 171 through 176 is reduced since only the condensers 171b through 176b remain in the circuit of the shapers.

It is also within the contemplation of this invention to substitute in lieu of the coils 177 and 178 and their respective contacts, six additional one shot multivibrator circuits that would be identical to pulse shapers 171 through 176 but without condensers 171a through 176a to be operative for sheet length errors for sheet length production runs in excess of 90 inches. A logic circuit 103 would discriminate select one of the two series of six pulse shapers to operate depending upon whether sheet length size is over or under 90 inches.

Reference is now made to FIG. 4 in order to explain the operation of the sheet length control system comprising this invention with respect to sheet-to-sheet variations of consecutive sheet boards of desired preselected length "X" cut by the knife blades 8. The example shown in FIG. 4 is for purposes of explanation and therefore in a general sense does not represent the actual occurrence of sheet length error during a production run since space for such a representation is not practical, as well as the fact that explanation should be limited to the simple example explaining the operation of the fine sheet length correction mode, particularly the operation of the inner band inhibitor 101, fluke error inhibitor 102 and the error band selector 90.

As mentioned above, in connection with Table I, there are 12 correction zones, six for short error sheet length and six for long error sheet length. In FIG. 4 there is shown only five such correction zones in case of long sheet errors and short sheet errors, although a 4-inch correction zone could also be provided. The OK or acceptable tolerance range as indicated at 205 is one-fourth inch in width and sheets falling within this zone are acceptable. However, if sheet lengths fall outside this acceptable tolerance zone 205, but within 4 inches short and long correction zones, then correction for sheet length error proportional to the amount of the error is made by the fine sheet length correction mode.

Sheet length cut is represented by the dots numbered 1 through 30 and sheet corrections made are indicated by the arrows and "0" in the OK tolerance range 205.

Operation of the $\frac{1}{8}$ inch inner band inhibitor 101 is represented by the solid lines 206, inhibiting operation of the fine sheet length correction mode for two consecutive knife pulses TP3 after an initial $\frac{1}{8}$ inch correction has just been made as shown at the top of FIG. 4 in connection with sheet 3.

The fine sheet length correction mode makes a correction when an error in the length of sheet 1 occurs outside the acceptable tolerance band 205 which causes an error input to be generated as for example, a $\frac{1}{8}$ inch short error which produces a signal at output 162 of the error counter short 80S of FIG. 3. The knife pulse TP3 activates AND gate 152 which in turn activates shaper 172. Assuming that sheet lengths over 90 inches are being cut by the cutoff apparatus, detect circuit 103 is activated to energize relay coils 177 and 178 and thus opening contact 172c. Shaper 172 at its output produces a correction pulse of specific duration along line 182 to OR gate 190S. The time duration of the pulse is of sufficient length to make a $\frac{1}{8}$ inch correction to bring the sheet back within the acceptable tolerance zone 205 as represented by the arrow leading from sheet 1 and ending in an "0". The correction having been made, acceptable tolerance has been achieved as indicated by the next sheet cut by the cutoff apparatus, that is, sheet 2 in FIG. 4. Sheet 3 is out of tolerance and falls in the $\frac{1}{8}$ inch short error band and activates the error counter short 80S at its output 161 and upon coincidence of the knife pulse TP3, AND gate 151 is placed into operation so that pulse shaper 171 can produce a correction signal along line 181 to OR gate 190S to make the necessary correction through motor 16 to operate the variable speed transmission adjuster 15 a sufficient duration of time to bring the next sheet length properly within the acceptable tolerance zone 205. As can be seen in connection with sheet 4, its sheet length is still within the one-eighth inch short error band most likely because of the fact that the cutoff apparatus has not sufficiently "settled down" which is borne out by the fact that sheet 5 is properly within the OK or acceptable tolerance zone 205. It can be seen, therefore, that correction of sheet 4 would have been undesirable and most likely would have undesirably thrown sheet 5 within the $\frac{1}{8}$ inch long error band or zone. But operation of the inner band inhibitor 101, as indicated by the inhibiting zone lines 206, has prevented correction of sheet 4, the inner band inhibitor inhibiting operation of the $\frac{1}{8}$ inch error band for the next two cutoff cycles, being sheets 4 and 5.

Sheet 6 is within the acceptable tolerance range 205 whereas sheet 7 appears in the $\frac{1}{8}$ inch long zone so that the fine sheet length correction mode makes the necessary correction as exemplified by the arrow leading from sheet 7 to "0." Again, the inner band inhibitor 101 is placed into operation inhibiting correction within that $\frac{1}{8}$ inch error band or zone for the next two consecutive cutoff cycles provided that the next two sheet length errors are not outside the $\frac{1}{8}$ inch long error band. Therefore, sheet 8 appearing in this band is not corrected by the control system. But note that a sheet 9 correction is made by the fine sheet length adjustment mode because the error is outside the $\frac{1}{8}$ inch long error band after initial correction by the first knife pulse in any given set of three consecutive knife pulses TP3 where in correction was made under the first knife pulse of such a set. If sheet 10 had been in any correction zone outside the acceptable tolerance zone 205, correction would have been allowed and made by the fine sheet length correction mode.

Sheets 11 and 12 being in the acceptable tolerance zone 205, no correction is necessary; however, on sheet 13, a correction is found necessary, which is similar to the correction made in connection with sheet 1. Sheet 14 falls within the short $\frac{1}{8}$ inch error band and there follows a sheet length correction of $\frac{1}{8}$ inch increase to correct for this sheet length error trend. However, it can be seen that sheet 15 is in the short $\frac{1}{8}$ inch error zone or band like sheet 13. Correction is made to sheet 15 through pulse shaper 172 of FIG. 3 since this sheet length error is outside the inner $\frac{1}{8}$ inch error zone or band and, thus, the inner band inhibitor 101 has no effect in this connection on the operation of the fine sheet length correction mode. Sheet 16 it will be noted, is within the short $\frac{1}{8}$

inch error zone but no correction is made since inhibitor 101 is still in operation, as indicated by the inhibiting zone lines 206, with the third knife pulse TP3 occurring in this two-step countdown inhibitor.

Upon examination of sheet 17 it would appear that correction of sheet 16 in the $\frac{1}{8}$ inch short error band would have been undesirable since sheet 17 appears in the $\frac{1}{8}$ inch long error band. Since the inner band inhibitor 101 now is not in operation due to three consecutive knife pulses TP3 having occurred as represented by sheets 14, 15 and 16, correction is made by the fine sheet length correction mode with respect to sheet 17. With this correction, sheet 18 is again back in the acceptable tolerance zone 205. It can be seen from this example in connection with sheets 16 and 17 why the inner band inhibitor 101 becomes important. If correction had been made to sheet 16, it would most likely have been an overcorrection placing sheet 17 further out in the long sheet correction zones and possibly after correction placing the next sheet after sheet 18 at the time of cutoff either in the $\frac{1}{8}$ inch or $\frac{1}{4}$ inch short error correction zones.

Sheet 19 all of a sudden appears with a long error length zone in excess of two inches. The fluke error inhibitor 102 will prevent correction by the error band selector 90 since obviously sheet 19 is not indicative of repetitive error trend. More likely it is caused by slippage of the sheet board 1 in the double facer so that the web simulative digitizer 58 does not correspond to the web digitizer 57. Thus, fluke error inhibitor 102 inhibits any correction signal from issuing out of error band selector 90. The next delayed knife pulse TP4 will clear fluke error inhibitor and allow the error band selector 90 to make any corrections necessary on the next consecutive sheet to be cut. With respect to sheet 20, it is in the 1 inch short error band indicating that a correction is necessary. Although this type of error may not ordinarily occur, it is illustrative of the operation of fine sheet length correction mode. Correction will be made upon the cutoff of sheet 20 as indicated in FIG. 4 to bring the sheet length in one single step back into the acceptable tolerance zone 205. Now at this time, it should be noted that sheet 21, being in the $\frac{1}{8}$ inch short error band makes it appear that there actually exists a trend of errors. Correction is then made for sheet 21 falling in the short $\frac{1}{8}$ inch error zone followed by further correction with respect to sheet 22 falling within the long $\frac{1}{8}$ inch error zone which again brings into play the inner band inhibitor 101. Note now that sheet 23 is in the short $\frac{1}{8}$ inch error zone but no correction is made by the fine correction mode since the inner band inhibitor 101 is brought into operation. As a result, the next "correctable" sheets, sheets 25 and 26, are within the acceptable tolerance zone 205. Sheet 24 in the long 1 inch sheet correction zone is obviously a fluke error and fluke error inhibitor 102 preventing selector 90 from making any correction.

It is doubtful if a fluke error would occur in the large short sheet correction zones this would require the web of material to be moving faster than the double facer which is highly unlikely.

From the foregoing discussion in connection with sheets 20, 21, 22, 23, 25 and 26, it can be seen that the fine sheet length adjustment or correction mode functions to make corrections for sheet length errors immediately while at the same time with the operation of the inner band inhibitor 101 permits the cutoff apparatus to "settle down" with a minimal amount of hunting or sheet length correction back and forth across the acceptable tolerance zone 205 and thus minimize, on the average during a production run, production of a large number incorrect sheets more than desirable or that can be tolerated by a customer.

Sheet 24 at the time of cutoff represents a severe slippage in the double facer as was the case in connection with sheet 19. As mentioned, the fluke error inhibitor 102 prevents any correction by the error band selector 90. Severe slippage in the double facer is shown by the fact that sheet 25 at the time of the cutoff is in the OK or acceptable tolerance zone 205. By the same token, sheet 26 is also in the acceptable zone. Thus it

can be seen from all the foregoing that for the best average sheet length within the limits of the cutoff apparatus is obtainable by fine sheet length correction mode in combination with the inner band inhibitor 101 and the fluke error inhibitor 102.

With the influence of the inner band inhibitor 101 removed, sheet 27 appears in the $\frac{1}{8}$ inch long error band and therefore correction is made through the error band selector 90 which makes the next necessary correction. The correction having been made, sheet 28 is within the acceptable tolerance zone but sheet 29 being barely outside the acceptable tolerance zone with any correction through the fine sheet length correction mode is inhibited by the inner band inhibitor 101 as indicated by the inhibiting zone lines 206. The influence of the inner band inhibitor 101 having been removed after the occurrence of cutoff of sheet 29, correction can continue for sheet length corrections outside of the acceptable tolerance zone 205. However, in the example shown, the next consecutive sheet, sheet 30, is within the acceptable tolerance zone.

It should be understood that FIG. 4 is not truly representative of the normal operation of corrugated board cutoff apparatus since in the usual case, sheet errors occur in a given pattern either too short of too long in length. However, it can be readily seen that the operation of the fine sheet length correction mode comprising this invention is designed to take into consideration the inherent heterogeneities found in a cutoff apparatus of the kind herein employed, particularly in respect to the variable speed transmission of the Reeves type. Actually, the correction mode has a built-in multiple dampening feature that prevents hunting and overcorrection by the control system and thus makes more effective immediate sheet length corrections that should be made to the operation of the processing apparatus to which the control is to be applied.

The effective control system accomplished is immediate correction for sheet length error in a single step and in the case of the smallest sheet length errors just outside tolerance, inhibition by the control system is made to determine if an initial small sheet length error correction made was sufficient before attempting any further corrections for such errors.

I claim:

1. In a processing apparatus having cutting means for cutting sheets of uniform length from a moving web of material fed to the apparatus, a sheet length control system for presetting and maintaining the desired sheet length within an acceptable tolerance as compared to a preset, predetermined sheet length value comprising

digitizer means for producing pulses the repetitive rate of which is indicative of the rate of movement of the web of material,

digitizer means for producing a pulse signal indicative of each coincidental cutoff of sheet length by said cutting means,

counter gating means connected to receive said signals for time relation comparison to produce an error signal indicative of whether and only if the sheet length cut is shorter or longer than said predetermined sheet length value,

error band selective means connected to said counter gating means, and having a series of discrete correction bands each of predetermined correction signal output corresponding to a discrete corrective adjustment for sheet length, one of said bands representing various short sheet length correction adjustments and the other group of said bands representing various long sheet length correction adjustments, said error signal received from said counter gating means operative to produce a correction signal from selective of said bands the correction signal output of which is characteristic of the error magnitude in sheet length, and

means responsive to said correction signal for correcting the sheet length to corresponding to said predetermined sheet length value within said acceptable tolerance.

2. In a processing apparatus having cutting means for cutting sheets of uniform length from a moving web of material fed to the apparatus, a sheet length control system for presetting and maintaining the desired sheet length within an acceptable tolerance as compared to a preset, predetermined sheet length value comprising digitizer means for producing pulses the repetitive rate of which is indicative of the rate of movement of the web of material, digitizer means for producing a pulse signal indicative of each coincidental cutoff of sheet length by said cutting means, counter gating means connected to receive said signals for time relation comparison to produce an error signal indicative of whether and only if the sheet length cut is shorter or longer than said predetermined sheet length value, error band selective means connected to said counter gating means to receive said error signal for producing a correction signal characteristic of the error magnitude, means responsive to said correction signal for correcting the sheet length to correspond to said predetermined sheet length value within said acceptable tolerance, and inhibiting means connected to said error band selective means to inhibit operation thereof for a selected passage of said cutoff pulse signals immediately after a correction in sheet length has been made through said responsive means.

3. The sheet length control system of claim 2 characterized in that said inhibiting means is operative to inhibit said error band selective means for selective of said cutoff pulse signals with respect to the innermost error bands of said error band selective means.

4. The sheet length control system of claim 1 characterized in that said error band selective means comprises a series of one shot multivibrators, the output of each of which corresponds in correction signal length to the error magnitude progressively from said acceptable tolerance.

5. The sheet length control system of claim 4 characterized by means selective to vary the signal length of said multivibrators dependent upon the magnitude of the desired sheet length.

6. In a processing apparatus having cutting means for cutting sheets of uniform length from a moving web of material fed to the apparatus, a sheet length control system for presetting and maintaining the desired sheet length within an acceptable tolerance as compared to a preset, predetermined sheet length value comprising digitizer means for producing pulses the repetitive rate of which is indicative of the rate of movement of the web of material, digitizer means for producing a pulse signal indicative of each coincidental cutoff of sheet length by said cutting means, counter gating means connected to receive said signals for time relation comparison to produce an error signal indicative of whether and only if the sheet length cut is shorter or longer than said predetermined sheet length value, error band selective means connected to said counter gating means to receive said error signal for producing a correction signal characteristic of the error magnitude, means responsive to said correction signal for correcting the sheet length to correspond to said predetermined sheet length value within said acceptable tolerance, said error band selective means comprising a series of one shot multivibrators, the output of each of which corresponds in correction signal length to the error magnitude progressively from said acceptable tolerance, and inner band inhibiting means to inhibit for selective of said cutoff pulse signals the operation of the innermost of said one shot multivibrators after correction has been made through either one of said inner band multivibrators by said responsive means.

7. In a processing apparatus having cutting means for cutting sheets of uniform length from a moving web of material fed to the apparatus, a sheet length control system for presetting and maintaining the desired sheet length within an acceptable tolerance as compared to a preset, predetermined sheet length value comprising digitizer means for producing pulses the repetitive rate of which is indicative of the rate of movement of the web of material, digitizer means for producing a pulse signal indicative of each coincidental cutoff of

sheet length by said cutting means, counter gating means connected to receive said signals for time relation comparison to produce an error signal indicative of whether and only if the sheet length cut is shorter or longer than said predetermined sheet length value, error band selective means connected to said counter gating means to receive said error signal for producing a correction signal characteristic of the error magnitude, means responsive to said correction signal for correcting the sheet length to correspond to said predetermined sheet length value within said acceptable tolerance, and inhibiting means connected to said error band selective means to detect normally nonrepetitive sheet length error magnitudes of large value to inhibit the operation of said error band selective means.

8. The sheet length control system of claim 1 characterized by delayed pulse means from said cutting means digitizer means to clear said counter gating means sequentially after the occurrence of each of said cutoff pulse signals.

9. The sheet length control system of claim 1 characterized by a coarse correction system to adjust transmission means driving said cutting means for initially presetting the desired sheet length to be cut from the moving web of material.

10. The sheet length control system of claim 9 characterized by comparator means included in said coarse correction system to drive motor control means included in said responsive means to adjust said transmission means in a manner to operate said cutting means to cut a sheet length of preselected value.

11. The sheet length control system of claim 10 characterized by programmed tape means connected to said comparator means and responsive to changes in adjustment to said transmission means to permit said comparator means to operate said motor control means until said transmission means is adjusted to substantially correspond to the preselected sheet length value.

12. In a processing apparatus having cutting means for cutting sheets of uniform length from a moving web of material fed to the apparatus, a coarse correction system to adjust transmission means during said cutting means for initially presetting the desired sheet length to be cut during a production run comprising

storage memory means to retain a preselected sheet length value,

programmed tape means indicative of the sheet length value adjustment within said adjustable transmission means,

coarse comparator means connected to said storage memory means and said programmed tape means to detect the differential magnitude of the preselected sheet length value as compared to the set sheet length value in said adjustable transmission means,

and means responsive to said detected differential magnitude for adjusting said transmission means to have a set sheet length value substantially corresponding to that of the preselected sheet length value.

13. The processing apparatus of claim 12 characterized in that said responsive means includes motor control means to adjust said transmission means in a proper manner conductive toward changing said set sheet length value to correspond to said preselected sheet length value.

14. The method of maintaining selected uniform processed sheet length in processing sheets from a moving web of material fed to a processing apparatus by maintaining a given ratio between sequential operation of the processing apparatus relative to the rate of movement of the web of material to the processing apparatus comprising the steps of

a. digitally sensing each time the processing apparatus is initiated to process a sheet length producing a train of pulses,

b. digitally sensing the rate of movement of the web of material fed to the processing apparatus producing a train of pulses,

c. comparing the digitally produced train of signals to a preselected sheet length,

- d. producing an error signal proportional to the magnitude of the difference between the processed sheet lengths and the preselected sheet length within a given acceptable tolerance,
- e. feeding the error signal into an error band selective means provided with a series of discrete correction bands each having a predetermined correction signal output,
- f. producing a correction signal selective from one of the correction bands of the error band selective means indicative of the appropriate correction necessary to said ratio,
- g. and applying the correction signals to the processing apparatus to correct the ratio between sequential operation

of the processing apparatus relative to the rate of movement of the web of material to the processing apparatus to produce processed sheet lengths substantially identical with the preselected sheet length.

15. The method of claim 14 characterized by the step of inhibiting correction of said ratio for at least one operation of the processing apparatus where the difference in magnitude between the processed sheet lengths and the preselected sheet length is in the correction band just outside of the acceptable tolerance and where the immediately previous correction made in the processing apparatus involved the same correction band.

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