The present invention relates to pre-printed corrugated board fabrication and automatic cut-off control method and apparatus, enabling extremely high quality printing to be applied to one of the liners of the corrugated board prior to the fabrication of the board and automatically aligning the cut-off position with the terminations of each printed pattern when the corrugated board is cut to length for use as boxes, display stands, games, and the like. By means of the method and apparatus of the present invention a continuous pre-printed paper web, or so-called liner, having a high quality of printed material thereon, is fed into a corrugated board combiner so as to form an outside face of the finished corrugated board. While the corrugated board is being cut to length, the printed designs appearing on the outside face of the corrugated board are maintained accurately centered in the cut-off pieces and cumulative error in the location of successive cuts is eliminated.

More particularly, the present invention relates to the method and apparatus for fabricating pre-printed corrugated board and automatically controlling the instantaneous rate of feed of the corrugated board from the delivery end of the drying and cooling section of a double-facer type corrugated combiner to maintain the cut-off correctly aligned with a pre-printed design on the corrugated board and advantageously eliminate cumulative error.

Corrugated board has been widely used for many years because of its high strength, light weight and many other desirable characteristics. However, there is one important problem in the field of corrugated board which has been troubling the field for many years without solution. This problem is the relatively low quality of printing which has heretofore been forced upon the industry by the characteristics of corrugated board. Double faced corrugated board is formed by a pair of spaced sheets called liners, with a corrugating medium between them. The crests of the corrugating medium support the liners along spaced narrow areas with the liners spanned across from crest to crest. Any attempt to print fine on the liners causes the spanned portions of the liners to sag away from the printing dies and leaves an uneven impression which is commercially unsatisfactory.

Prior to the present invention printing on corrugated board has been done by rubber printing dies which are abraptly struck against the liner during the printing process. In this way the impression is made before the linen has any substantial opportunity to sag. However, the resulting equality of printing and the designs which can be obtained are far short of those life-like qualities obtainable with lithographic, gravure and other high quality types of printing processes.

Among the many advantages of the present invention are those resulting from the fact that it enables the utilization of these high quality types of printing processes to be applied on a continuous web which is later used to form the outside liner of the finished corrugated board. In the combining process described as embodying the present invention, this previously printed web is unwound from the unwind stand of the double-facer section of a corrugated combiner. The pre-printed liner is combined with a corrugating medium and another liner and forms a continuous corrugated board which is fed through the glue drying and cooling section of the combiner. It is then cut into lengths for use in boxes, display stands, games, and the like.

During the printing process, a series of spaced marks are applied to the liner for registering the location of the cuts with respect to the repetitions of the pre-printed design. In the method and apparatus described as illustrative of the present invention these register marks are evenly spaced and a plurality of these marks are provided for each repetition of the design. As used herein the term “repetitive design” is intended to include a plurality of separate designs printed one after another, sometimes called a “blotch print,” as well as a continuous pattern with a repeat unit in it.

These register marks are suitably scanned and the combiner is automatically controlled to assure that the positions of the cuts fall between successive repetitions of the pre-printed design. All of the pieces of the corrugated board are advantageously cut to substantially the same length and cumulative error between the positions of successive cuts and the repetitive pre-printed material are eliminated.

Previous attempts have been made to utilize pre-printed liners in corrugated board, but these attempts have not been commercially successful. The pre-printed material was undesirably scuffed in the corrugated combiner machine and the cut-off location did not remain in aligned synchronism with the pre-printed material. As a result, cumulative error crept into the operation. The cuts fell into the middle of the pre-printed designs, rendering the final product a total waste from a commercial point of view.

In prior attempts to control the location of the cuts with respect to the pre-printed material on the corrugated board, the control action has been applied to the cut-off knives. This has been unsuccessful commercially for several reasons. Corrugated board is relatively rigid and stiff. Thus, the cutting knives must be moving at the same speed as the corrugated board being fed past them during the instant when the cut is made. If the knives are too slow, the corrugated board jams against them crushing and crumpling the leading edge of the cut pieces, weakening the corrugated board and spoiling it for commercial use. If the knives move too fast with respect to the corrugated board, they pull and tear at the leading edge of the cut pieces, leaving a jagged cut which is commercially unsatisfactory.

In order to obtain the desired synchronism between the motion of the knives and the corrugated board, the knives are driven at varying rates of speed, during different portions of each cutting cycle. At the instant of cut, the knives move most swiftly. Then the knives are slowed down relative to the velocity of the corrugated board so as to delay their motion and to allow a suitable period of time to elapse before the next cut is made. The amount of delay in knife motion is increased in order to increase the length of the pieces being cut. Corrugated combiners in use today include eccentric drives or stroke drives which are adjustable and which produce the desired speed of the knives with respect to the speed of the corrugated board at the instant of cutting. These knife drives provide for adjustment of the knife speed and the delay in the knife motion so as to cut off the corrugated board in the desired lengths.

In prior attempts to control the location of the cuts with respect to the pre-printed material on the corrugated board those in the field have attempted to control the operation of knives so as to position the cuts at the desired places on the corrugated board feeding out of the
In the fabricated combiner, however, the variations in knife speed and the stresses introduced into the mechanism as a result of these variations introduced errors and caused slippage and backlash to occur which prevented commercially successful control.

In the corrugated combiner described as illustrative of the present invention the corrugated board is fed from the uncut-face-facer through a glue drying and cooling section which is more than 100 feet long. In the drying and cooling section the rigid corrugated board is fed along a straight path and moves at a velocity up to about 600 feet per minute (i.e., about 7 miles per hour) depending upon the rate of production. The mass of rigid corrugated board passing along this straight path at this relatively high velocity is substantial, and thus a substantial momentum is involved.

In order automatically to align the position of the cuts with respect to the pre-printed design, we advantageously control the instantaneous rate of feed of the corrugated board from the cooling and drying section. As the cutting knife tends to cut behind the desired position with respect to the preprinted pattern, the corrugated board being fed out from the delivery end of the drying and cooling section is slowed down with respect to the remainder of the corrugated board in the combiner so as to maintain proper positioning of the cut. As the knives tend to cut ahead of the desired position, the corrugated board being fed from the delivery end of the drying and cooling section is speeded up relative to the remainder of the corrugated board in the machine to maintain proper positioning of the cut. All cumulative error is eliminated.

We have found that the tremendous length of straight rigid corrugated board in the drying and cooling section provides a highly significant and important longitudinal resiliency for control purposes without damaging the resiliency in the finished product. The method and apparatus of the present invention enable the utilization of this longitudinal resiliency for controlling the instantaneous delivery rate from the drying and cooling section automatically to obtain the desired registry of the cut-off position with respect to the pre-printed design. Thus, from moment to moment the instantaneous delivery rate is changed as required, while the average rate of feed of the stiff corrugated board through the drying and cooling section remains constant.

In effect, when the position of the cut tends to move ahead of the desired registry location, the delivered end of the corrugated board being fed through the drying and cooling section is automatically stretched longitudinally to bring the pre-printed pattern into registration with the cut-off knife. When the position of the cut tends to drop behind the desired place on the pre-printed pattern, the delivered end of the corrugated board is compressed longitudinally to maintain alignment.

Among the many further advantages of the method and apparatus of the present invention are those resulting from the fact that the control action is applied to regulate the instantaneous delivery rate so as to accelerate or decelerate the end portion of the corrugated board. This automatic control of the positioning of the cut-off is obtained without changing the speed of the corrugated combiner as a whole. Thus, advantageously the large moment of the whole mass of the corrugated board in the drying and cooling section is not affected for its velocity remains substantially constant, except for the changes in the velocity of the delivered end of the corrugated board which are made as required. These instantaneous changes in delivered speed advantageously provide and maintain proper cut-off registry without any ill effect upon the highly desirable commercial qualities of the finished product.

The drive mechanism for the knives is powered directly from the prime mover, thus eliminating slippage, backlash, and alternating stresses from the control mechanism due to the variable speed of the knives.

In the fabrication method described, the pressure upon the corrugated board over a major portion of its length in the drying section of the combiner is reduced. This reduces any tendency to scuffing of the pre-printed surface. The initial and final pressures on the corrugated board are held at a high value to reduce any tendency for creepage of the pre-printed liner with respect to the crests of the corrugating medium and thus assure a good glue bond in the finished product.

In this specification and in the accompanying drawings, are described and shown methods and apparatus embodying the present invention and various modifications thereof are indicated, but it is to be understood that these are given for purposes of illustrating and not as limiting the invention and the manner of applying the method and apparatus in practical use so that they may modify and adapt it in various forms, each as may be best suited to the conditions of a particular use.

The various objects, aspects, features and advantages of the present invention will be more fully understood from a consideration of the following specification in conjunction with the accompanying two sheets of drawings, in which:

FIGURE 1 is a side elevational view of a double facer corrugated board combiner embodying the present invention, with portions of the mechanism shown simplified and broken away for illustrative purposes;

FIGURE 2 is a plan view, shown on enlarged scale, of the delivery end of the drying and cooling section of the combiner and of the automatic cut-off control apparatus, being taken along the line 2-2 in FIGURE 1 looking down;

FIGURE 3 is an elevational view, shown partly in section and on further enlarged scale, of a reversing gear and differential control and motor for instantaneously varying the delivery velocity, this view being taken along the line 3-3 in FIGURE 2; and

FIGURE 4 is a perspective view of the underneat face of a pre-printed corrugated board being fed from the delivery end of the drying and cooling section of the combiner past a photo-electric scanner on its way to the cutting knives and also showing a schematic circuit diagram of electrical circuits utilized to regulate and drive the motor control of the differential.

As illustrated in FIGURE 4, the continuous corrugated board 8 includes a liner 10 of heavy paper stock forming its upper face, a second pre-printed liner 12 of heavy paper stock forming its lower face, and a corrugated medium 14 between them with its crests glued to the inside surfaces of the two liners. The pre-printed liner 12 is printed in a suitable printing press, for example such as a web-fed lithographic press or other press, such as a gravure press, so as to provide a desired high quality in the printed product. The liner 12 may be clay-coated or otherwise treated prior to the printing operation so as to produce the desired pleasing background appearance of the surface on which to apply the printed material.

A series of evenly spaced registration marks 15 and 16 of color contrasting sharply with the color of the background are applied along one edge of pre-printed liner at predetermined positions with respect to the printed material. A plurality of these registration marks are printed for each repetition of the pattern along the length of the corrugated board. For example, as shown, there are four repeating marks for each repetition of the pattern along the length of the board. It is not necessary that any of these marks actually be located in the desired positions where the transverse cuts are to be made, but the marks should be as evenly spaced as possible. They should bear predetermined positions with respect to the printed material which remain constant for each repetition of the pattern along the length of the corrugated board.

The registration marks 16 nearest the cut-off positions
are considered as being the cut-off marks and those marks which are intermediate are for the purpose of continuously minimizing error in positioning of the corrugated board with respect to the subsequent cut-off positions and are considered as being "helper" marks.

In most instances it is desirable to position the cut-off marks 16 exactly at the desired positions for the cuts so that the operator is aided in determining at a glance whether the operation is proper. As shown, the corrugated board is going to be cut off transversely at a first position indicated by the dashed line 17 as being aligned with a first cut-off mark 16 and then next will be a cut-off along a second transverse line 18 aligned with a second cut-off mark 17, and then along a third transverse line 19, and so forth.

Usually three “helper” marks between each cut-off mark are adequate. The number of helper marks may be reduced when the lengths of the cut-off pieces are below 40 inches, for it is usually not desirable to position the registration marks 15 and 16 more closely together than about 10 inches, unless the combiner will be run at a somewhat reduced speed. When the lengths of the cut pieces exceed about 100 inches it is usually advantageous to increase the number of helper marks so as to position the marks not substantially farther apart than 25 or 30 inches. For example, in cutting to lengths of 200 inches, seven helper marks can be used to advantage with each cut-off mark.

For purposes of illustrating a typical application it is assumed that the pre-printed corrugated board is going to be formed into boxes with the printed material on the outside surface. The printed subject matter is divided into two parts side-by-side across the width of the corrugated board. A longitudinal slotting knife divides the corrugated board along a longitudinal line 20 between these two designs just prior to the formation of the transverse cuts 17, 18, and 19, as will be explained in detail further below. The relative thickness of the corrugated board is shown increased out of proportion slightly to illustrate the structure more clearly.

The scanner 22 focuses a beam of light from a lamp 23 onto the path travelled by the registration marks 15 and 16. These marks contrast in color with the background of the printed material, so that as each mark passes the scanner a variation in the amount of reflected light changes the conductivity of the photoelectric tubes 24 of the Type 5892 type. Each registration mark should have sufficient length, i.e., in the direction of scan so as to assure triggering of the control circuit at the highest production rates. The widths of these marks, i.e., in a direction perpendicular to the edge of the corrugated board should be sufficient to assure that they remain within the scanning path in spite of slight lateral shifting of the corrugated board during production. For example, registration marks from 9/32 to 3/8 of an inch long and at least 1/16 of an inch wide are usually quite satisfactory.

Directing attention to FIGURES 1 and 2, it is seen that the double-faced corrugated combiner generally includes a single-facer, or single-backer, unit 25, wherein the corrugating medium 14 is glued to the first liner 10. It also includes a double-facer, unit 26 wherein the second pre-printed liner 12 is glued to the other side of the corrugating medium. Then the corrugated board is fed in a straight line through a drying and cooling section 27, having a length of at least 100 feet.

The cut-off knives comprise a pair of counter-rotating cylinders 28 and 29 which are geared together to rotate in synchronism. A pair of shear blades, not shown, are fixed to these two rotating cylinders and mate with each other upon each rotation of the cylinders 28 and 29 so as to shear the corrugated board off cleanly between them when the shear blades and corrugated board are moving at the same speed during the instant of cut. The knife cylinders 28 and 29 are driven through an eccentric type drive located within the housing 30. This drive is manually adjustable and produces the desired cyclic speed up and delay in the movement of the knife cylinders, as discussed above. This type of eccentric drive is well known in the industry and so it is not described in detail here.

As shown in FIGURE 1, the scanner unit 22 is positioned to scan the pre-printed face of the corrugated board after the corrugated board has left the delivery end of the drying and cooling section 27 and before it reaches the knives. From the output end of the combiner machine, the cut-off pieces 32 and 33 from the two sides of the board are fed and conveyed to a pair of side delivery conveyors 34 and 35, respectively, where they are fed into positions for the next production steps.

In operation, the first liner 10 is unwind from a roll 36 on an unwind stand 38 and fed past smoothing and guiding rollers 39 and 40 and over a steam-heated drying roller 42 into the single-facer unit 25. At the same time the corrugating medium 14 is unwind from a roll 44 on an unwind stand 45 and fed under a smoothing roller 46 and over a steam-heated drier roller 47 and past further smoothing and tensioning rollers 48 and also into the single-facer unit 25. A suitable quantity of moisture is supplied by a steam manifold 49 to the medium 14 just prior to being corrugated.

In order to corrugate the medium 14, it passes between a pair of mating corrugating rollers 50 and 51. Starch glue solution carried in a tank 52 is picked up by a pair of engaging transfer rollers 53 and 54. The glue is applied to the roller 54 to the crests of the corrugating medium as it moves under the corrugating roller 51 where it is supported against the roller 51 by a plurality of arcuate fingers 55. The liner 10 is pressed firmly against the gluey crests of the corrugating medium and combined with it by a presser roller 56. This forms the single-faced corrugated material 58 which is flexible and is guided by rollers up to an overhead conveyor or bridge 60 where a substantial length of the single-faced material lies in festoons drying. From the bridge 60 the material 58 passes down under a steam-heated drier roller 62 and into the double-facer unit 26.

The pre-printed second liner 12 is unwind from a roll 64 on an unwind stand 65 which supplies the double-facer unit 26. The pre-printed liner is initially wound in the roll 64 so that its printed face is toward the axis of the roll. As shown in FIGURE 1, the pre-printed liner 12 passes over a smoothing roller 66 and under a steam-heated drier roller 68 and through tensioning and smoothing rolls 70 in the double-facer with the pre-printed surface toward the underside. As it leaves the double-facer, the pre-printed liner moves upwardly and over a guide roller 72 where it converges with the single-faced material 58 at the entrance to the long drying and cooling section 27 of the machine.

Starch glue solution is supplied in a tank 74 and is picked up by a pair of engaging transfer rolls 75. The upper transfer roll applies the glue to the exposed ridges of the corrugating medium on the web of material 58 after the web 58 has been guided down around a roller 76 and under a smaller tensioning and smoothing roller 78.

In order to gelatinize and dry the starch glue, the drying and cooling section 27 includes a series of steam-heated chests 80 having smooth upper surfaces over which passes the pre-printed face of the corrugated board.

These chests extend for a length of about fifty feet. Heat is thus transferred into the corrugated board.

For holding the board 8 firmly down into contact with these heating chests, an upper heavy canvas feed belt 81 is provided extending the full length of the section 27.

This feed belt 81 is driven by a large drive roller 82 at the delivery end of the section 27. A certain degree of longitudinal elasticity exists along the length of said belt 81. A tensioning roller 83 wraps the belt substantially around the draw roller, and a plurality of smaller rollers 84 support the upper part of the belt as it returns to the reversion...
For the purpose of controlling the motion of the pre-printed liner 12 in the drying and cooling section, a drive is applied to the roll 64 exerting a drag force of between 90 and 120 pounds on the liner 12 as it enters between the belt 81 and the roller 72.

In order to control the pressure applied by the belt 81 against the corrugated board a series of weighted rollers are arranged to bear down on the inside of the belt 81 over the steam chests. The relative pressure applied by these weighted rollers is adjusted by means of manually adjustable eccentric cam 88 engaging the upper arms of L-shaped levers whose lower arms carry these weighted rollers.

It is advantageous to apply an initial maximum pressure on the corrugated board for an initial short distance, for example, for the first two or three feet just after the pre-printed liner has converged with the single-faced material 58. This initial heavy pressure assures a firm contact between the gusset ridges of the material 58 and the liner 12 and prevents relative skidding between them. Also, it provides good initial heat transfer so as to commence gelatinizing the glue.

For the next portion of the travel over the heat chests a distance of about 25 feet or about one-half of the total length of the heat chests, the weighted rollers 87 are lifted from contact with the belt 81 so that only the weight of the belt 81 is applied to the corrugated board. In effect, the corrugated board just skims over the surface of the heat chests. We have found that this method of an initial high pressure for two or three feet immediately after the convergence of the pre-printed liner with the single-faced material 58, followed by a low pressure for about 25 feet or about one-half of the distance over the heat chests minimizes any tendency to scuff the pre-printed surface 12 while at the same time causing the required gelatinizing action to occur in the starch glue.

To obtain the gelatinizing action, the steam chests 80 along their low pressure or skimming path are operated quite hot, at a temperature in the range from 300° F. to 315° F. for a production rate of about 300 feet per minute and is increased up to 325° F. for a production rate of 500 feet per minute.

Along the remainder of the travel over the heat chests 80 substantially all of the weight rollers 87 are applied to press the corrugated board firmly against the heat chests. The heat chests in this second half are operated at a lower temperature in the range from 230° F. to 290° F. depending upon production speed in the range from 250 feet per minute up to 500 feet per minute. This lower temperature together with the high pressure transfers sufficient heat to the corrugated board to set the glue while at the same time avoiding any undue tendency to soften the pre-printed material or to cause scuffing of it.

Beyond the end of the last heat chest a lower feed belt roller 89 and a second heavy canvas feed belt 90 driven by a large draw roller 92 and having a tensioning roller 93. A certain degree of longitudinal elasticity also exists along the length of this belt. A plurality of manually adjustable levers 94 carry transverse rollers which support the lower feed belt and adjust the pressure applied to the corrugated board between the feed belts 81 and 90. The corrugated board 8 travels a distance of the order of 50 feet or more between these two belts. They extract heat from the corrugated board while maintaining it under pressure, thus completing the setting of the glue.

Initially after travelling out from between the draw rollers 82 and 90 at the delivery end of the drying and cooling section, the corrugated board passes over a spur porting roller 95 and under a longitudinal slitting and creasing roller 96 and then over the scanner. These slitting and creasing rollers are adjusted as desired for the ultimate product. The creases help in folding the board into boxes.

The drive for the draw rollers 82 and 92 and also for the cut-off knife cylinders 28 and 29 includes a prime mover 98 which is belt-coupled to a main drive shaft 100. This prime mover is controlled by a master production speed control. For example, it is desirable to use a shunt motor 90 of approximately 75 H.P. operated by a Ward Leonard motor-generator type speed control. The drive shaft 100 drives a Reeves-type adjustable ratio pulley and belt set 101 within a housing 102. This Reeves drive in turn operates a right-angle bevel gear 103 which rotates a second drive shaft 104 extending across the machine so as to turn the eccentric drive 30 for the knives 28 and 29.

In order to sense the relative positions of the knives 28 and 29 with respect to the relative position of each pre-printed pattern, a selector switch unit 105 has a rotatable contact 106 which is driven by a part of the machine having a predetermined motion with respect to the operation of the knives. As shown this contact 106 is driven from the shaft 104 by a positive drive 107. The shaft 104 rotates at a substantially constant average speed for each given setting of the Reeves drive and a given speed of the prime mover and makes one rotation for each cycle of the cutting knives. This positive drive 106 may include any suitable positive drive arrangement such as gears or chains and sprockets. It is required that the rotatable contact 106 make one rotation for the passage of each registration mark past the scanner 22 and also that the contact make an integral number of rotations for each knife cycle. For example, with three helper marks between each cut-off mark, the contact 106 rotates four times for each knife cycle, i.e. four times for each rotation of the shaft 104. As shown, a gear train 108 drives a sprocket chain 109 to produce the desired four rotations of the contact for each knife cycle.

The other end of the drive shaft 100 extends into a differential case 110 and operates a pair of reversing gears 111 and 112 which turn a bevel gear drive 113 of a differential 114. A pair of idler bevel gears 115 drive this drive gear 113 to a driven bevel gear 116 fixed to a shaft 117 which drives a right-angle gear unit 118. The shafts 100 and 117 turn in the same direction. A normally engaged clutch 119 feeds power to the right angle gear unit to the two draw rollers 82 and 92. When it is desired to speed up or slow down the instantaneous rate at which corrugated board is fed out from between the draw rollers 82 and 92, a control motor 120 is energized and drives a chain drive 121 which turns a worm gear 122. The worm gear in turn moves a nular differential gear 123 carrying the idler gears 115.

This differential gearing and chain drive are arranged such that about fifty revolutions of the motor 120 produce a differential motion of the worm gear between the input and output shafts 100 and 117. The motor 120 is reversible, and as described herein, is a three phase 220 volt, 60 cycle, 1 H.P. induction motor having a speed of about 1725 r.p.m.

An amplifier and control circuit for controlling this motor 120 is housed within a case 126 conveniently located near the selector switch 105, and as shown in FIGURE 4 this amplifier and control circuit 126 includes all of the circuit components shown in FIGURE 4 except a solenoid-operated reversing switch 128 which is positioned adjacent to this control motor. A power supply 132 is energized from 110 volt, 60 cycle power mains through a suitable fuse and an on-off switch 131. This power supply includes a step-up transformer having suitable voltage windings for energizing the tube heater circuits and a selector switch 23, and rectifier and filter circuits for supplying the direct positive and negative voltages. It supplies a well-filtered positive voltage from a terminal 134 through a connection indicated as B+ and through a plate load resistor 135 to the anode of an amplifier pentode 156. Its cathode is connected to the
appearing thereacross when they are de-energized. Condensers 213 and 214 associated with the motor energizing contacts are for the purpose of minimizing sparking at the contacts.

When the registration marks are light colored with respect to a darker background, then the abrupt reduction of reflected light the mark has passed the scanner causes a negative pulse of voltage to be coupled through the condenser 183 to the amplifier control grid. That is, the control action is triggered by the contrast at the trailing edge of the mark instead of the leading edge of the mark. As explained further below, provision is made for shifting, or “zeroing” in the position of the cut-off with respect to the cut-off marks 16, so that it is immaterial whether the contrast at the leading or trailing edge of the registration marks produces the control action.

In view of the somewhat erratic but small dimensional changes which may occur in the corrugated board as it is being dried and cooled, it is usually found desirable to space the brushes 188 and 190 farther apart than the width of the insulating sector 189. In this way a certain desirable amount of latitude or “dead space” in the selector switch is obtained which allows for such minor deviations in the positions of the registration marks as results from dimensional changes during drying and cooling of the board. In many instances these dimensional changes tend to offset one another. Thus, the various helper marks may deviate slightly in position, and yet the cut-off is correctly positioned. Any consistent deviations which begin to accumulate are immediately sensed and automatically corrected. The dead space adjustment is obtained by changing the spacing of the two brushes. By moving them farther apart the amount of latitude or dead space is increased and by moving them closer together it is decreased.

It is usually desirable to operate with as much dead space as possible while still maintaining the variations in cut-off position within commercially acceptable tolerances. As shown, a manually rotatable knob 210 acting upon an arcuate rack adjusts the dead space by shifting the brush 190 with respect to the other brush.

In order to produce the desired adjustment or “zeroing” of the cut-off position with respect to the cut-off marks 16, both of the brushes are carried in insulated relationship on a rotatable mounting disk (not shown) so that they can be simultaneously moved concentrically about the axis of the arcuate embodiment of their spacing, but shifts their orientation with respect to the axis of the rotatable contact and produces a corresponding shift in the orientation of the cut-off position with respect to the cut-off marks 16.

It is usually found most satisfactory to adjust the sensitivity controls 164 and 174 to the minimum amount of sensitivity which will allow proper response to the registration marks. In this way the circuit is prevented from accidentally responding to glue marks, dirt marks, or the like which may occasionally lie in the scanning path.

The purpose of the pairs of relay contacts 168 and 190 is to ground the brush leads 191 and 192 immediately after either of the gas tubes 157 or 161 has been triggered. In this way the control of the gas-tubes is made independent of motion of the rotatable contact subsequent to the firing of the gas-tube.

In order to control the length of time during which the Thyatrons remain in conduction after being fired, and thus, to control the number of revolutions of the motor 120 upon each energization, the time-delay control circuit including the triode 142 is utilized. As explained above this triode is normally in full conduction. Its grid is returned to ground through an adjustable resistor 212 having its movable contact connected to ground through a resistor 214. A capacitor 216 couples the grid to the cathode 218, which in turn is connected to the top of the common cathode resistor 158. Upon firing of either of the gas tubes 157 or 161, a relatively large current flows through this cathode resistor 158 thus applying a large positive voltage to the cathode 218. Initially, the grid of the triode also is driven positive because of the coupling capacitor 216, and thus the triode remains in full conduction. However, the capacitor 216 charges through the time-delay circuit 213, which occurs until the grid becomes progressively more negative with respect to the cathode 218 and cuts off the conduction in the triode 142.

This allows the contacts 150 to open, removing anode voltage from the Thyatrons and thus stopping energization of the motor 120. By moving the adjustable contact downward along the resistor 212 the time-constant of the circuit is increased so as to provide for a longer delay before the control motor is de-energized. That is, more corrective action occurs upon energization of the motor, and vice versa.

In general it is desirable to adjust the time-delay control for the minimum amount of time-delay which can maintain the registration desired under the conditions of operation. The reason for this is the erratic nature of dimensional changes in corrugated board occurring during drying and cooling. If the time-delay is adjusted to a larger value than necessary the motor 120 tends to “hunt” back and forth about the desired position of registry. That is, it continuously over-corrects and reverses back and forth, placing an undue strain upon the apparatus.

In order to enable the operator manually to control the advance and retard, a pair of thumb buttons are provided (not shown). One of these closes a pair of contacts in parallel with the contacts 167 and 168, respectively. The other closes a pair of contacts in parallel with the contacts 169 and 170, respectively. Also, for indicating to the operator when the advance or retard circuits are being actuated, suitable pilot lights may be arranged to flash whenever the relays 152 or 154 are energized.

When properly adjusted with a desirable time-delay setting and the proper amount of dead space in the selector switch the control action is smooth and accurate. Small and commercially unimportant dimensional variations are accepted without any needless actuation of the corrective action, but any tendency toward cumulative error is immediately sensed and prevented. The intermediate “helper” marks are advantageous in enabling the apparatus to sense any trend toward cumulative error and thus to correct the trend before the cut-off mark is reached.

From the foregoing it will be understood that the illustrative embodiment of the pre-printed corrugated board fabrication and cut-off control methods and apparatus of the present invention described above are well suited to provide the advantages set forth, and since many possible embodiments may be made of the various features of this invention and as the method and apparatus herein described may be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense and that in certain instances, some of the features of the invention may be used without a corresponding use of other features, all without departing from the scope of the invention.

What is claimed is:

1. The method of producing corrugated board having a pre-printed design on at least one liner thereof and being cut into lengths with the cut-off position properly registered with respect to the pre-printed design, comprising the steps of printing a repetitive design on a continuous web of material adapted to form one of the liners of the corrugated board, each repetition of said pre-printed design including a plurality of evenly spaced register marks, applying said pre-printed liner to one side of a corrugating medium with the pre-printed design on the outside surface and applying a continuous web of material to the other side of said corrugating medium to form the other liner of the corrugated board and applying glue material...
common return circuit or grounded neutral connection 137 of the supply 132. A separately filtered positive direct voltage is supplied from a terminal 138 through a lead 139 and through a time-delay relay winding 140 to the anode of a time-delay tube 142. The purpose of this time-delay circuit is to limit the period of time during which the control motor is energized, as will be explained further below. A terminal 144 supplies a suitable low voltage through a connection indicated at X to the scanner lamp 23. Another terminal 146 supplies a very well-filtered negative voltage through a connection indicated as C— and through a photo-tube load resistor 147 and a lead 148 to the cathodes of the photodiode cells 24. 

In operation, the triode 142 is normally in full conduction, thus maintaining the relay contacts 150 closed so that a positive voltage is supplied to a lead 151 connected to a “retard” relay winding 152 and is supplied by a lead 153 to an “advance” relay winding 154. The other side of the retard winding 152 is connected through a current-limiting resistor 156 to the plate of a gas-filled Thyatron tube, type 2050, having its cathode connected through a common cathode resistor 158 to ground. The retard relay winding 152 and the gas tube 157 form part of a “retard” circuit, indicated generally at “R,” which actuates the motor relay 128 to energize the control motor 120 so as to retard the rotation of the draw rollers 82 and 92 with respect to the knives, as explained in detail further below. The advance winding 154 is connected through a resistor 160 to the plate of an “advance” Thyatron 161 having its cathode connected to this common resistor 158. The relay winding 154 and the gas tube 161 form part of an “advance” circuit, generally indicated at “A,” which causes the motor relay 128 to increase the speed of the draw rollers 82 and 92 with respect to the knives, as explained in detail further below. 

Normally, these advance and retard Thyatrons are non-conducting, so that their respective associated pairs of relay contacts 167, 168, and 169*, 170 are held open. Capacitors 155 and 157* are connected across the relay windings 152 and 154, respectively, to prevent high voltages from appearing across them when the windings are de-energized. 

In order to control these Thyatrons, the pentode 136 is normally conducting, so that its anode is normally at a relatively low voltage due to the conduction of current through and resultant voltage drop in the plate load 135. This low voltage is fed through first and second resistor coupling circuits, respectively to the control grids of the advance and retard Thyatrons. The first coupling circuit includes an isolating resistor 162 connected to a series resistor 163 in series with a potentiometer 164 in turn connected through an adjustable resistor 165 to a negative terminal 166 of the power supply. The adjustable contact 168* on the potentiometer 164 is connected by a lead 169 to the control grid of the retard Thyatron and normally supplies a negative voltage to this grid to prevent the Thyatron 157 from firing. This adjustable contact 168* is used to adjust the sensitivity of the retard circuit. That is, by moving this contact toward the right along the potentiometer, a less negative voltage is applied to this grid and thus the tube 157 is more easily thrown into an ionized condition by changes in the current through the amplifier tube 136. Moving it to the left reduces the sensitivity. 

The second coupling circuit includes an isolating resistor 172 in series with a resistor 173 connected through a second sensitivity control potentiometer 174 and a adjustable resistor 175 to the grid of the advance Thyatron 127 which provides a negative terminal 166. A movable contact 178 on this potentiometer is connected by a lead 179 to the control grid of the advance gas tube 161 and controls the sensitivity of the advance circuit. A mechanical connection 180 gages these two sensitivity controls together so that the sensitivity of the advance and retard circuits may be manually adjusted to corresponding settings. The adjustable resistors 165 and 175 are used to balance the operation of the two circuits A and R. 

For purposes of explaining the method and apparatus for registering the cut-off positions, assume that the cut-off position is properly aligned. In such case, each time one of the registration marks 15 or 16 passes the scanner, its contrasting color causes a change in the amount of reflected light striking the photo-tubes 24. For example, assume that these marks are separated with the background. Then the reflected light striking the photo-tubes is reduced, reducing their conductivity. As shown, the photo-tubes are connected between the resistor 147 and the ground circuit, a reduction in their conductivity causes the lead 148 to become more negative, thus feeding a pulse of negative voltage through the lead 182 and through a coupling condenser 183, and across a grid return resistor 184 shunted by a capacitor 185 to the control grid of the amplifier 136. 

This negative pulse momentarily reduces the amount of current conducted through the amplifier 136, thus causing its anode to become less positive. This condition, in turn, is capable of applying a more positive voltage through the two coupling circuits 162—163—164—168—169 and 172—173—174—175—176 to the respective grids of the gas tubes. However, because the drive shaft 164 is properly positioned at this instant of time as assumed above, then a pair of contact brushes 188 and 190 each are grounded by the conductive portion of the rotary contact 106. A portion of the rotatable contact 106 is cut away and is replaced by an inserted sector 189 of insulating materials. But when the knives are properly oriented with respect to each registration mark, this insulating sector 189 lies midway between but does not engage either brush 188 or 190, just as is indicated in FIGURE 4. 

The contact brush 188 is connected by a lead 191 to the junction of resistors 162 and 163 and grounds this junction so as to prevent this positive voltage pulse from firing the retard gas tube. Similarly, the brush 190 is connected by a lead 192 to the junction of resistors 172 and 173 and grounds this junction to prevent firing of the advance gas tube. 

If the cut-off position begins to drop behind the desired point, then the rotating contact 166, which is driven in a counterclockwise direction by the shaft 144 as indicated by the arrow, begins to fall behind the position indicated in FIGURE 4. Then the insulating sector 189 engages and insulates the brush 188 from ground so that the positive voltage pulse fed through the resistor 162 to the lead 169 can trigger the tube 157. As a result, the pairs of contacts 167 and 169 are closed, and a 110 volt circuit is completed from a power line 194 through the contacts 167 and by a lead 195 through a motor control relay winding 196 back to the other power line 198. Energization of the winding 196 closes the pairs of motor contacts 199 and 200, thus energizing the motor 120 from the three-phase power mains 201, 202, and 203 in such direction as to retard the instantaneous delivery rate of the corrugated board 8. In this way the cut-off is brought back into registry. 

Whenever the cut-off position tends to move ahead of the desired location on the corrugated board, the brush 190 engages the insulating sector 189 at the same time that a registration mark causes a negative pulse to reach the grid of the amplifier tube 136. Thus, the advance gas tube is fired, closing the pairs of contacts 169 and 170. A circuit is completed from the power main 199 through the contacts 169* and a lead 265 and through the other motor control relay winding 206 to the power main 198. The pairs of contacts 207 and 208 are closed, reversing two of the phases in the motor 120 and increasing the rate of delivery of the corrugated board so as to maintain the cut-off position in register.
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between each of said liners and the corrugating medium, feeding said juxtaposed liners and corrugating medium along a relatively straight elongated path while applying pre-printed glue along at least a portion of said path, whereby to glue said juxtaposed liners and corrugating medium into a rigid corrugated board, the feeding of said juxtaposed liners and said corrugating medium along said path being at a substantially constant speed over an initial portion thereof, delving said corrugated board out of said path, cyclically cutting off lengths of said corrugated board soon after being delivered from said path, said cyclic cutting operations being repeated at predetermined fixed periods of time, sensing the positions of said evenly spaced register marks with respect to the said cyclic cutting operation, and varying the speed of the corrugated board as it is being delivered from said path, thereby to maintain the cut-off position in predetermined relationship with respect to predetermined ones of said register marks while maintaining the speed of the corrugated board over the initial portion of said path substantially constant, the differential in speed between the initial portion of the path and the delivery end being accommodated by longitudinal resiliency in the corrugated board.

2. The method of producing corrugated board having a pre-printed design on at least one liner thereof and being cut into lengths with the cut-off position properly registered with respect to the pre-printed design comprising the steps of providing a repetitive design on a continuous web of material adapted to form one of the liners of the corrugated board, each repetition of said pre-printed design including a characteristic at a predetermined orientation with respect to the design, applying said pre-printed liner to one side of a corrugating medium with the pre-printed design toward the outside surface and applying a liner to the other side of said corrugating medium and applying glue material between each of said liners and the corrugating medium to form a corrugated board configuration, feeding said juxtaposed liners and corrugating medium along a relatively straight elongated path while applying pressure against the liners and while heating said glue along at least a portion of said path, whereby to glue said juxtaposed liners and corrugating medium into a rigid corrugated board, the feeding of said juxtaposed liners under said corrugating medium along said path being at a substantially constant speed over an initial portion thereof, feeding said corrugated board out of said path, cyclically cutting off lengths of said corrugated board soon after leaving said path, sensing the position of said evenly spaced register marks with respect to the said cyclic cutting operation, varying the speed of the corrugated board as it is being fed from said path to maintain the cut-off position in predetermined relationship with respect to said characteristic, while maintaining substantially constant the speed of the corrugated board in said initial portion of the straight path.

3. The method of producing corrugated board having a pre-printed design on at least one liner thereof and being cut into lengths with the cut-off position properly registered with respect to the pre-printed design, comprising the steps of printing a repetitive design on a continuous web of material adapted to form one of the liners of the corrugated board, each repetition of said pre-printed design including a plurality of evenly spaced register characteristics, forming a corrugating medium and applying a first liner to one face of said corrugating medium and gluing it thereto to form single-faced corrugated material, applying said pre-printed liner to the other face of said corrugating medium with the pre-printed design toward the outside and applying glue material between the inside surface of the pre-printed liner and the corrugating medium, maintaining said pre-printed liner juxtaposed with said corrugating medium of the single-faced corrugated material and feeding them along a relatively straight elongated path while applying pressure against the pre-printed liner to hold it firmly against the corrugating medium, applying heat to said glue material along at least an initial portion of said elongated path, thereby to form a glued bond between said pre-printed liner and said corrugating medium to form pre-printed corrugated board, the feeding of said juxtaposed liner and said corrugating medium along said path being at a substantially constant rate of speed over a major portion of said path, feeding said pre-printed corrugated board out of said path while cyclically cutting off lengths of said corrugated board soon after it leaves said path, sensing the position of said evenly spaced register marks with respect to said cyclic cutting operation, and varying the speed of the corrugated board in the last portion of said path as it is being fed out from said path to maintain the cut-off position in predetermined relationship with respect to pre-selected ones of said register characteristics.

4. The method of producing corrugated board as claimed in claim 3 and wherein the pre-printed liner is bonded to the corrugating medium by an initial relatively high pressure which is applied between the pre-printed liner and the corrugating medium for a short distance along said path holding said pre-printed liner firmly pressed against a heat supplying surface, thereafter continuing said pre-printed liner further along said path while skimming adjacent to said heat supplying surface and while a relatively low pressure is applied to said pre-printed liner, thereafter applying a pressure intermediate said high and low pressures to said pre-printed liner while finishing its travel along said heat supplying surface, and during the final portion of said path clamping said pre-printed liner and the single-faced corrugated material between a pair of surfaces moving synchronously therewith, said latter surfaces having longitudinal resiliency.

5. Apparatus for producing corrugated board having a pre-printed design on at least one liner thereof and for cutting the corrugated board into lengths properly registered with respect to the pre-printed design, said apparatus including a single-facer unit arranged to apply a first liner to a corrugating medium, a double-facer unit adapted to apply the pre-printed liner to the other face of the corrugating medium to form corrugated board, said pre-printed liner having a plurality of evenly spaced register marks theron, means defining a heated surface extending along an initial portion of a relatively supporting belt for feeding said corrugated board along said relatively straight path, said supporting belt holding said corrugated board against said heated surface with the pre-printed liner engaging said heated surface and with the other being pressed by said supporting belt, said supporting belt extending beyond the limits of said heated surface and defining a further extension of said relatively straight path, a second supporting belt adapted to engage the pre-printed liner of the corrugated board after leaving said heated surface, a common drive mechanism, a cut-off knife driven at regularly repeated cycles by said common mechanism, and a pair of draw rollers each within a respective one of said continuous belts at the ends spaced farthest from said heated surface and nearest to said cut-off mechanism, said draw rollers being driven by said common drive mechanism, a differential between said common drive mechanism and said draw rollers, a control motor coupled to said differential for changing the speed of said draw rollers with respect to said common drive mechanism, a control device including a first sensing mechanism arranged to scan the pre-printed liner to sense said evenly spaced register marks, a second sensing device responsive to a plurality of predetermined conditions during each cycle, a said control circuit coupled to said motor and responsive jointly to said first and second sensing means for controlling said differential
control motor, thereby to change the speed of said draw rollers with respect to said common drive mechanism.

6. Apparatus as claimed in claim 5 wherein said control circuit includes means for varying the latitude in said second sensing means, and for varying the sensitivity of said first sensing means, and an adjustable time-delay circuit arranged to control the relative length of time during which the control motor is energized upon the actuation of said two sensing means at the same time.

7. Apparatus for producing pieces of corrugated board having a pre-printed design on at least one liner thereof and wherein the pre-printed design is in proper registry with the pieces, said apparatus including a single-facer unit arranged to apply a first continuous liner to a continuous corrugating medium to form single-faced material, a double-facer unit adapted to apply a continuous pre-printed liner to the other side of the corrugating medium with glue therebetween, said pre-printed liner having a repetitive design and a plurality of register marks thereon for each repetition of the design, a pair of feed belts defining a relatively straight path and adapted to hold said single-faced material against said pre-printed liner while feeding them together along said straight path, a pair of draw rollers at the delivery end of said path and driving said feed belts, a common drive mechanism having an element rotating at substantially constant speed, a cut-off knife driven by said element, said draw rollers being driven by said common drive mechanism, a differential between said common drive mechanism and said draw rollers, a control motor coupled to said differential for controlling the relative speed of said draw rollers with respect to said constant speed element, a scanning device arranged to scan the pre-printed liner to sense the register marks thereon, a sensing device responsive to the rotation of said element and a control circuit under the joint control of said scanning and sensing devices and controlling said differential control motor.

8. Apparatus as claimed in claim 7 wherein said cut-off knife moves at varying speeds with respect to said rotating element and produces one cut for each rotation of said element, said register marks being evenly spaced and during normal operation a predetermined number of said marks passing said scanning device for each rotation of said element.

9. Apparatus as claimed in claim 7 and wherein said feed belts have longitudinal resiliency and the speeding up and slowing down of said draw rollers is accommodated by the resiliency of said belts and by the longitudinal resiliency of said corrugated board in said straight path, whereby said corrugated board in said straight path is actually stretched slightly or compressed slightly along its length to maintain registration with the cut-off knife.

10. Apparatus for producing pieces of corrugated board having a pre-printed design on a liner in proper register with respect to each piece comprising means for supplying a continuous web of material having a pre-printed "repetitive design" thereon, means for supplying a continuous web of corrugating medium and for assembling a continuous length of corrugated board by applying said pre-printed web to said corrugating medium with adhesive therebetween, a pair of counter-revolving feed belts adapted to feed said assembled corrugated board while holding said pre-printed liner in engagement with said corrugating medium thereby to bond them together, said assembled corrugated board being discharged from between said feed belts, a common drive mechanism for said apparatus, a pair of drive rollers for said respective feed belts located near the position where said corrugated board is discharged from between said feed belts, a differential drive mechanism coupled between said common drive mechanism and each of said drive rollers for varying the speed of said belt drive rollers with respect to said common drive mechanism, motor means for actuating said differential, cut-off mechanism driven by said common drive means for cutting said corrugated board into pieces, and a control circuit responsive to the relative position of said cut-off mechanism with respect to the position of said "repetitive design" and being connected to said motor means for controlling said motor means for varying the speed of said belt drive rollers, thereby to maintain the feed of the "repetitive design" on said corrugated board in synchronism with respect to said cut-off mechanism for maintaining said design in register with the cut pieces.

References Cited in the file of this patent

UNITED STATES PATENTS

1,837,841 Swift .......................... Dec. 22, 1931
2,007,266 Barker ..................... July 9, 1935
2,052,255 Shoults ..................... Aug. 25, 1936
2,078,496 Jaffe ......................... Apr. 27, 1937
2,249,190 Thompson ................... July 15, 1941
2,249,820 Gulliksen .................. July 22, 1941
2,262,362 Gulliksen .................. Nov. 11, 1941
2,707,027 Brown ...................... Apr. 26, 1955