CROSS FOLDER WITH SHEET ELEVATING MEANS

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ABSTRACT OF THE DISCLOSURE

A folding apparatus for articles such as sheets or the like has a lead-in conveyor communicating with a plurality of article conveyors in overlying relationship. Buckling folding means associated with the two uppermost conveyors effect a quarter fold in a conveyed article in the course of moving on said uppermost conveyors.

A cross-folder folds such quarter-folded article transversely to the initial folds while moving over a third conveyor. The cross-folder comprises counter-rotating pinch rolls disposed beneath an article-support platform on which a quarter-folded article is deposited by the third conveyor. Said third conveyor comprises spaced continuous belt portions adjustable positionable from a position above to a position below the plane of the supporting surface of the platform when an article on said third conveyor passes thereon. Means for creating a blast of compressed air urges the central axial portion of an article disposed on said platform onto said pinch rolls between two belts whereby a cross fold is effected when an article is disposed over said pinch rolls. The cross-folded article is carried into engagement with two additional buckling folder means which effect additional half-folds parallel to the cross fold as the article is discharged from the apparatus onto a stacking conveyor.

This invention relates to a folding apparatus, and more particularly pertains to apparatus adapted to automatically cross-fold flatwork, such as bed sheets and the like. This application is a continuation-in-part of my copending application Ser. No. 416,815, filed Dec. 8, 1964, now abandoned.

Various machines have been devised for the automatic folding of flatwork. Some employ conveyors in conjunction with gripping means which hold and raise the leading sheet edge as the remainder of the sheet is carried therebeneath. At the appropriate instant the leading edge is dropped upon the terminal edge of the sheet whereby the sheet is buckled upon itself and folded in half.

Other known folding means utilize pinch rolls in combination with a wedging blade or means for delivering an air blast which functions at the appropriate instant, i.e., when the middle of the sheet is opposite the bite of the pinch rolls. The wedging blade or blast forces the middle of a sheet into the opposed rotating rolls which grip the sheet and fold the same as the sheet passes there-through.

Other machines may employ a combination of means for folding sheets, as does the folder disclosed in Kamberg and Roberts' copending application Ser. No. 454,335, filed Jan. 21, 1965 (now Patent No. 3,260,518, issued July 12, 1966), which employs both pinch rolls and buckling-type folding devices for effecting multiple folds in small laundry pieces, such as pillow cases and towels.

In one embodiment of a folding apparatus made in accordance with this invention, a large item of flatwork, such as a bed sheet, is moved by conveyors into engagement with buckling means, such as are disclosed in my Patent No. 3,094,321, pinch rolls, or a combination of the latter two folding means, until the sheet is folded twice into quarters. The quarter-folded sheet which is carried on a conveyor in a direction transverse to the folds made may then be cross-folded. The latter fold is effected by directing a blast of air against the sheet axis equidistant from the sheet lateral ends as the sheet passes over the bite of a pair of oppositely rotating pinch rolls disposed beneath a longitudinal opening in the conveyor. The sheet is cross-folded in two in the course of passing between the pinch rolls.

To enable the entire sheet to properly pass through the pinch rolls, it had heretofore been necessary to stop the everly conveying apparatus as the sb-et was forced into the bite. Roll stoppage was necessary to prevent the opposed lateral end portions of the quarter-folded sheet from being carried forward as the pinch rolls were in the process of effecting cross-folding of the central sheet portion. Continual movement of the lateral ends result in uneven folds, damaged sheets and even damaged apparatus. The stopping and starting of the conveyor up to 900 times per hour was a strain that frequently led to early deterioration of the conveyor driving means.

In accordance with the invention an article, which may already be folded in half or quarter-folded, is automatically cross-folded without any starting and stopping of the article conveyor means heretofore occurring during the cross-folding operation.

It is an object of this invention, therefore, to provide a folding apparatus for continuously quarter-folding and cross-folding a large piece of flatwork without stopping and restarting the conveying apparatus on which the flatwork is disposed.

It is another object of this invention to provide an apparatus for automatically effecting two cross folds in a large piece of flatwork.

It is a further object of this invention to provide a folding apparatus for automatically effecting four separate folding operations in a large piece of flatwork without the use of any complex measuring means for actuating a folding mechanism, and wherein movement of a foldable article into engagement with various apparatus components actuates the folding elements thereof.

It is yet another object of this invention to provide a compact folding apparatus, in which the parts thereof are readily accessible, for effecting a plurality of folds arranged transversely to each other in a foldable article.

The above and other objects of this invention will become more apparent from the following description when read in the light of the accompanying drawings and appended claims.

In one embodiment of this invention, a folding apparatus is provided with three vertically aligned, substantially horizontal conveyors in which the center conveyor runs in a direction opposite to the other two. The conveyors are arranged so that a folded sheet dropping from each of the upper two conveyors is engaged by the conveyor beneath. The upper two conveyors have arranged thereover, transversely to the directions of conveyor movement, folding elements. The folding elements of the successive conveyors buckle the unfolded and once-folded sheet respectively upon itself to form a quarter-folded sheet which drops from the end of the second conveyor.

Disposed beneath a longitudinal opening in the third conveyor means composed of spaced continuous tapes moving about spaced roller means which rotate counterclockwise rotating pinch rolls which are arranged parallel to the direction of third conveyor movement. Interposed between conveyor tapes straddling the pinch rolls are smooth-surfaced support rods arranged substantially parallel to and slightly below the normal level of the conveyor tapes. One roller about which the third conveyor tapes rotate and move is adjustably positionable in the vertical plane and is automatically lowered when the quarter-folded sheet is disposed over the pinch rolls.
As the folded sheet moves over the bite of the pinch rolls, an air blast from an overlying air tube forces the sheet center into the pinch rolls and the third conveyor tapes concomitantly drop below the level of the smooth support rods depositing the sheet thereon. The sheet may then be pulled between the pinch rolls without the ends being carried forward by the third conveyor tapes, thereby avoiding wrinkling and jamming of the sheet in the rolls.

The once cross-folded sheet is then guided onto an underlying fourth conveyor leading to the apparatus exterior. The latter conveyor is preferably disposed at substantially right angles to the upper three conveyors. Folding elements, such as are employed with the upper two conveyors may be employed with the fourth conveyor to effect a second cross fold as the sheet exits the machine.

As an alternative to lowering the third conveyor tapes, the smooth support rods may be adjustably positionable in the vertical plane while the tapes remain in a fixed plane, as will hereinafter be explained in greater detail.

As a second alternative, the support rods may be fixedly positioned relative to the third conveyor tapes and slightly raised above the plane thereof. The leading edges of the rods may be upwardly inclined so that momentum given to the carried article by the conveyor may be inadequate to drive such article onto the support rods. The tautness resulting in the quarter-folded sheet after the center portion is engaged by the pinch rolls may be sufficient to enable the flatwork to completely clear the spaced conveyor tapes. A high-speed apparatus to be described incorporates still another means for depositing a foldable article over two pinch rolls, as will also hereinafter be explained in greater detail.

For a more complete understanding of this invention, reference will now be made to the drawings wherein:

FIGURE 1 is a fragmentary side elevational view, partly broken away and partly schematic in nature, of one embodiment of folding apparatus of this invention;

FIG. 2 is a fragmentary perspective view illustrating the relationship between four conveyor members of the apparatus of FIG. 1;

FIG. 3 is a fragmentary side elevational view, partly schematic in nature, of elements employed in effecting folds as a foldable article is carried on three of the conveyors in FIG. 2;

FIGS. 4 and 5 are perspective views of a foldable member illustrating the initial stages wherein the member is folded upon itself;

FIG. 6 is a fragmentary perspective view of a foldable member after it has been quarter-folded and cross-folded once upon itself;

FIG. 7 is a fragmentary elevational view illustrating the pinch rolls utilized in conjunction with the third conveyor of FIG. 2, as well as a portion of the lowermost conveyor of the apparatus of FIG. 1;

FIG. 8 is a fragmentary side elevational view similar to FIG. 1 of a folding apparatus made in accordance with this invention adapted to operate at high speed;

FIG. 9 is a fragmentary exploded view illustrating the ribbon elevating cylinders and associated parts utilized in the apparatus embodiment of FIG. 8;

FIG. 10 is a fragmentary elevational view taken along line 10--10 of FIG. 11;

FIG. 11 is an enlarged fragmentary sectional view, partly in elevation, illustrating a conveyor arrangement and stacking means which may be employed in the apparatus of FIG. 8 to effect two cross folds and automatic stacking of a foldable article following passage through the pinch rolls; and

FIG. 12 is a fragmentary perspective, schematic in nature, illustrating the relationship between the conveyors and rolls of FIG. 11.

As the folded sheet moves over the bite of the pinch rolls, an air blast from an overlying air tube forces the sheet center into the pinch rolls and the third conveyor tapes concomitantly drop below the level of the smooth support rods depositing the sheet thereon. The sheet may then be pulled between the pinch rolls without the ends being carried forward by the third conveyor tapes, thereby avoiding wrinkling and jamming of the sheet in the rolls.

The once cross-folded sheet is then guided onto an underlying fourth conveyor leading to the apparatus exterior. The latter conveyor is preferably disposed at substantially right angles to the upper three conveyors. Folding elements, such as are employed with the upper two conveyors may be employed with the fourth conveyor to effect a second cross fold as the sheet exits the machine.

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For a more complete understanding of this invention, reference will now be made to FIG. 1 wherein a folding apparatus 10 made in accordance with the teachings of this invention is illustrated. The folder 10 is adapted to fold large pieces of flatwork, such as bed linens and the like, into quarters by first folding the piece in two and subsequently folding the halved piece into quarters along folding axes transversely disposed to the sheet longitudinal axis. The quarter-folded sheet is then folded twice along axes disposed at right angles to the folds initially made. The resulting sheet is thus folded into quarters along transverse folding axes and the resulting folded piece twice-folded again along axes transversely disposed to the initial folding axes.

The apparatus 10 of FIG. 1 employs spaced side plates 12 which are maintained in fixed, spaced relationship by means of transverse brace members, ends 19 thereof being illustrated in FIG. 1. Also spanning the interval between the opposed sides 12 of the apparatus 10 are roller 16 and 15, more clearly seen in FIG. 2, which cooperate with rollers 20 and 22, as shown in FIG. 2, for purposes of enabling spaced tapes 24 to define a continuous upper conveyor 26.

It will be noted from FIG. 1 that the initial portion of conveyor 26 may be upwardly inclined and disposed exteriorly of the side walls 12 of the apparatus 10 beneath a discharging conveyor 28 of an ironer, whereby ironed flatwork may be passed directly into the folder 10.

As is apparent from FIGS. 1 and 2, a conveyor 30 is disposed beneath upper conveyor 26 and moves over rollers 32 and 34. Conveyor 30, similarly to conveyor 26, is composed of spaced tapes 24. A third conveyor 36 is disposed beneath the upper two conveyors 26 and 30 and moves over rollers 38 and 40. It will be noted from FIGS. 1 and 2 that the upper surface of the conveyor 30 moves to the left in a direction opposite to the direction of movement of the conveyors 26 and 36. It will be further noted from FIGS. 1 and 2 that the conveyors are substantially horizontally disposed. Also, conveyors 30 and 36 are arranged relative to their overlying conveyors so that the folded article dropping from such overlying conveyors is engaged thereby and carried in a direction opposite to the direction of movement of the overlying conveyors.

It will be seen from FIG. 1 that roller 18 comprising the drive roller for the tapes of upper conveyor 26 is keyed to a large sprocket 42, whereas drive roller 34 for conveyor 30 is rotatable with sprocket 44, and drive roller 40 for conveyor 35 is rotatable with sprocket 46. The three sprockets 42, 44 and 46 are of decreasing size whereby drive chain 48, driven by sprocket 50 rotatable with wheel 52, which is in turn driven by motor 54, is able to drive conveyors 26, 30 and 35, respectively, at increasing rates of speed.

Progressively increasing conveyor speed is desirable since a foldable member in the course of dropping from conveyor 26 to conveyor 39 may be pulled from the conveyor 26 by the more rapidly moving tapes of conveyor 39. This pulling action obviates wrinkling in the course of moving from conveyor to conveyor and assures tautness in the foldable member as it drops from an upper to a lower conveyor. Associated with each of the upper conveyors 26 and 30 is a system of elements for engaging a leading edge of a piece of flatwork moving over each of the conveyors and dropping it automatically upon the terminal edge so as to fold in half the flatwork piece engaged thereby. Such folding elements are more clearly seen in FIG. 3.

In the course of moving on conveyor 26, the leading edge L of a sheet S deflects arm 56 of electric switch 58 illustrated in FIG. 3. This deflection closes the normally open switch 58, but does not activate any apparatus until another switch in series therewith is also closed. In an alternate folder construction, arm 56 of switch 58 upon engagement with a foldable article energizes a circuit which instantaneously raises fingers 69, normally in the lowered position. Subsequent engagement with switch arm 64 would then lower the fingers, as well as clamp
bar 94. Such an arrangement permits small pieces placed on conveyor side portions which do not engage switch arm 56 to pass over the apparatus conveyors without activating the associated folding stations which require closure of switch 58 to function.

At deflecting switch actuator 56 of the illustrated embodiment, the leading edge L of a sheet S is driven up inclined, transversely aligned fingerlike members 60, which are secured to a pivot bar 62. The transverse alignment of the fingers 60 is more apparent in FIG. 2. After proceeding up the inclined fingers 60, the leading edge of the sheet piece engages conveyor 36 and deflects arm 64 of switch 66 from its normal position, thereby closing the same which is connected in series with switch 58.

The closing of the switch 66 completes an electrical circuit energizing a coil in a conventional four-way solenoid valve 70, illustrated in FIGS. 1 and 2, which is in communication with a compressed air supply by means of a line 72. Energization of the valve coil moves a spring-biased valve within the device so as to allow compressed air to flow into the bottom portions of air cylinders 74 and 76 through lines 73 and 80, respectively. The pistons in the cylinders instantly move upwardly; clevis 82 and piston rod 84 pivotally move link 86 in an upwardly direction. The latter link is pivotally connected to arm 88 fixedly secured to transverse bar 90 from which spaced fingers 92 project to engage transverse clamp bar 94, more clearly seen in FIG. 2.

Simultaneously with the latter movement of the piston and associated parts in cylinder 74, piston rod 96 of cylinder 76 moves upwardly with clevis 98 to pivotally move arm 100 attached to pivot bar 62, to which inclined fingers 60 are secured. Thus, simultaneously, clamp bar 90 is pivoted downwardly into engagement with the upper surface of arm 102, which is fixedly positioned over uppermost conveyor 25 while inclined fingers 60 are dropped. The leading edge L of the sheet S may then be clamped in position on surface 102 as the remainder of the sheet passes therebeneath.

When the terminal edge T of the sheet becomes disengaged from actuator arm 56 of switch 58, the switch is opened and the electrical circuit energizing the coil in solenoid 70 is broken, reversing the air passage, and allowing the clamp bar 94 to rise together with the fingers 60. As the clamp bar rises, the released leading edge L of the sheet S drops upon the terminal edge T of the sheet S, thereby forming a half fold.

It may be desired to have a slight delay in the raising of the inclined fingers 60 after the clamp bar 94 has risen, to prevent engagement of the fingers 60 with the trailing sheet edge. This may be accomplished by placing a valve on the air escape line of cylinder 76 so that fingers 60 rise more slowly than clamp bar 94. FIG. 3 illustrates a sheet member just after the leading edge L is dropped onto the terminal edge T of the sheet following release by the clamp bar 94.

It is apparent from FIGS. 1 and 2 that precisely the same folding elements of FIG. 3 are employed in conjunction with conveyor 30 which is moving to the left in FIG. 1. Precisely the same folding operation is effected on conveyor 30 as was above described with respect to conveyor 26. The sheet, following the folding operation on conveyor 30, is quarter-folded and has the appearance of sheet S2 illustrated in FIG. 3.

The quarter-folded sheet, similar to sheet S2, drops from the terminal edge of conveyor 30 onto the initial edge portion of conveyor 36 and is carried to the right by the tapes 24 thereof in the manner indicated in FIGS. 1 and 2. In the course of passing to conveyor 36, the sheet is inverted whereby the terminal or selvage edges of the sheet, instead of being on the bottom, as illustrated in FIG. 5, are now on top of the quarter-folded sheet as it moves to the right on the conveyor 36. It will be noted from FIG. 2 that a longitudinal opening is provided in the conveyor 36 by the omission of a center tape 24.

Disposed beneath this longitudinal opening is a pair of oppositely-rotating pinch rolls 104 and 106 which rotate clockwise and counterclockwise, respectively, as illustrated in FIG. 2. The pinch rolls 112, the other roll being spring biased toward the driven roll. Such an arrangement facilitates passage of thick, folded articles between the pinch rolls.

As will be more clearly seen from FIG. 1, the pinch rolls may be driven by means of gear 54 which also drives the upper three conveyors 26, 30 and 36, by means of rotating shafts 118 and 120 which are connected by means of a universal joint 122. Shaft 120 is rotatably driven by motor 54 through gear box 124, which is driven off of motor 54 through belt 126. Shafts 118 and 120 are supported in bearings disposed in vertical supports 128 and 130, as is more clearly shown in FIG. 1.

It is the purpose of the pinch rolls 104 and 106 to cross fold a piece of flatwork, such as sheet S2 of FIG. 5, which has been already quarter-folded. The center of the quarter-folded flatwork piece moving over conveyor 36 is driven into the bite of the pinch rolls 104 and 106 by means of compressed air emanating from air tube 134, more clearly seen in FIGS. 1 and 7. The compressed air is not discharged through the air tube 134 until the quarter-folded flat piece is properly located relative to the underlying pinch rolls.

The compressed air passing into the air tube 134 may be admitted by means of a solenoid valve at the instant that the quarter-folded sheet moving over the pinch rolls trips a switch actuator, such as actuator 136 of switch 138 illustrated in FIG. 7. The air jets from air tube 134 drive the central portion of the quarter-folded sheet into the bite of the pinch rolls, enabling the pinch rolls to engage the sheet and drive it downwardly onto a S-shaped deflector 140, such as is illustrated in FIG. 7. The sheet is next deposited on a fourth conveyor 142 also composed of tapes 24 which are driven to the left, over rollers 143 and 145, as illustrated in FIG. 2, and substantially right angles to the overlapping three conveyors.

It will be noted from FIG. 6 that the selvage edges of a cross-folded piece are desirably inwardly disposed and hidden from view when the apparatus 10 is employed.

It will be appreciated that if the quarter-folded flatwork piece carried by conveyor 36 continues to move as it is engaged by the pinch rolls following the air discharge from tube 134, the opposed lateral ends of the sheet will continue to move while the center portion is being driven through the pinch rolls. The latter relative movement between the various sheet portions prevents an even, desired fold from being formed and will create wrinkles, if not tearing of the sheet, and jamming of the rolls.

It had heretofore been the practice to stop the conveyor disposed over the pinch rolls until the cross fold effected by the pinch rolls had been completed. The repeated stopping and starting of the conveyor motive means invariably led to early failure of such means. In the illustrated machine 10, a desired cross fold is assured without stopping conveyor 36 moving over pinch rolls 104 and 106. This is made possible by removing the quarter-folded sheet from the tapes 24 of conveyor 35 in the course of driving a folded article through the pinch rolls to effect the cross fold.

The quarter-folded article may be removed from the tapes of conveyor 36 by means of smooth, transversely aligned support rods 144, more clearly seen in FIGS. 1, 2 and 7. If the weight of the quarter-folded article is proper and the article is sufficiently stiff, it may be driven onto the support rods 144 by conveyor 36. The impetus given
to the quarter-folded article by the conveyor 36 may drive the article up the inclined leading portions of the support rods 144, or when heavy quarter-folded articles are to be cross-folded which are unable to be driven onto the support rods 144, the tapes 24 of conveyor 36 may be dropped below the level of the support rods at the appropriate instant after the quarter-folded article has been carried by conveyor 36 over the support rods. The dropping of the tapes may be effected by means of pivotal bearings 146 mounted on the supporting side walls 12 of the apparatus 10.

As shown in FIG. 1, bearing 146 is able to pivot about bearing pivot 148 by means of a piston and cylinder unit 150. The position of the piston therein being regulated by solenoid valve 152. In accordance with the position of the valve in solenoid valve 152, the air in cylinder 150 is regulated to either extend or retract piston and connected rod 154 of cylinder 150. The latter movement regulates the position of the bearings 146 and the roller 40 of conveyor 36, which conveyor is either above or below the level of the support rods 144.

In the normal course of operation, the solenoid valve 152 is spring-biased into a position which enables air to pass into the bottom of cylinder 150 so that the bearing for roller 40 of conveyor 36 is moved to position the roller above the level of the support rods 144. When the quarter-folded sheet strikes switch actuator 136 of switch 138, a circuit is closed energizing the coil in solenoid valve 152, reversing the air flow therein so that the piston (not shown) and rod 154 of cylinder 150 are lowered simultaneously with the discharge of air through the switch 134 leaving the quarter-folded sheet supported on the support rods 144 above the level of the tapes 24 of conveyor 36. The sheet now being free of the conveyor 36, the pinch rolls 104 and 106 may efficiently cross fold a sheet member having opposed end portions supported on the support rods as the sheet is driven onto the deflectors 140 and through the pinch rolls. The cross fold is effected substantially instantaneously by the rapidly rotating rolls, and the conveyor 36 is immediately raised after the sheet has lost contact with switch actuator 136.

As an alternative to varying the relationship between the support rods 144 and the tapes 24 of conveyor 36, the support rods may be moved in the vertical plane relative to the conveyor 36 which is allowed to remain stationary. A cylinder 150a and a solenoid valve 152a are illustrated in FIG. 1, which are adapted to function in precisely the same manner as cylinder 150 and solenoid valve 152 previously described.

The coil in solenoid valve 152a is normally spring-biased into a position forcing the level of the support rods 144 to be normal to the level of conveyor 36. Upon energizing the coil in valve 152a, the coil is energized so as to reverse the flow of air in cylinder 150a, forcing air into the bottom of the cylinder, thereby raising the support rods 144 above the level of the upper surface of conveyor 36. The framework supporting the pinch rolls and support rods 144 may be supported at the reciprocally movable end by means of twin cylinders 150a mounted on opposed walls 12 of the apparatus 10, while opposed transverse channel 156 (see FIG. 1) may be pivotally mounted at opposed end limits in the straddling walls 12 of the apparatus 10, 12 of the apparatus 10.

If a second cross fold of the large flatwork piece is desired, a set of folding elements, such as are illustrated in FIG. 3, may be placed in the path of the article moving over the fourth conveyor 142, as illustrated in FIG. 7. The leading right edge of the once cross-folded article may be engaged by the folding elements previously described with respect to the folding elements of conveyors 26 and 20. A second cross fold is thereby formed in the article prior to discharging the same out of the side of the apparatus 10 opposite to that illustrated in FIG. 1. Control switches may be employed to energize specific folding operations if the size of the article being folded so warrants.

The above-described apparatus of FIGS. 1, 2, 3 and 7 is adapted to effect a maximum of four folds. In normal practice, a sheet which is discharged from the apparatus 10 is again cross-folded by an attendant in the course of lifting the foldable article along the article middle from a discharge platform disposed at the end of the discharge conveyor 142. The attendant, after lifting the folded article, deposits the same, now folded five times, in a stack. The maximum speed of operation previously described is governed by the speed of the attendant in folding and stacking the discharged folded items.

The apparatus 11 of FIG. 8 is adapted to automatically fold a sheet or similar foldable items five times, effecting three cross folds, and automatically arranged the same in next vertical stacks of desired height. The apparatus described in FIGS. 8 through 12 needs no full time attendant; since the speed thereof is not dependent upon human dexterity, it may operate much faster than the apparatus of FIG. 1. In the following description, rolls, conveyors and other components having the same relative position in apparatus 11 as in apparatus 10 will bear the same identifying numeral, plus the subscript "a."

With the increased conveyor speed of apparatus 11, the tendency for a foldable article to "fly-off" at the conveyor ends is proportionately increased. It will be seen from FIG. 8 that curved guide fingers 160 mounted on transverse bar 162 and extending through the tapes of conveyor 30a to a position adjacent the end of conveyor 26a are employed to facilitate the movement of the halved sheet from conveyor 26a to conveyor 30a. Bar 162 may be mounted in the opposed side walls of the folder 11.

Utilized in conjunction with fingers 160 is a driven roll 164, which with spaced guide fingers 160 engaging the periphery of roll 164, functions as a pinch roll in cooperation with roll 18a of conveyor 26a. It will be seen from FIG. 8 that fingers 160 extend between the rings 161 disposed on roll 164 as well as between the tapes of conveyor 30a. Roll 164 is rotatably driven more rapidly than roll 18a, thereby tensioning and preventing wrinkling of the engaged portions of a halved foldable article as it leaves conveyor 26a to engage underlying conveyor 30a while traveling at a high rate of speed. FIG. 12 readily discloses the roll disposition of the various conveyors employed in the apparatus 11.

To prepare a rapidly-moving, foldable article for a second folding operation by means of the folding elements, identical to those shown in FIG. 3, which are also used in conjunction with conveyors 26a and 30a, a squeeze roll 166a rotatably engaging the moving tapes of conveyor 30a, as well as short tapes 165 extending about filler roll 167, is employed. Thereby the tapes 165 which taper to the surface of conveyor 30a may be held in the air from the leading right edge or elongate "bubble" of the rapidly moving foldable article carried by the tapes of conveyor 30a.

The flat leading edge allows the article to be readily lifted by fingers 60a, held, and dropped by the folding elements 94a and 102a in the manner earlier described, in the process of effecting a second transverse fold. To most
efficiently reduce the leading-edge bubble of the foldable article, the tapes of conveyor 30a and the tapes 165 should have the same speed. Curved guide fingers 168 secured to transverse bar 170 mounted in the apparatus side walls are disposed adjacent the terminal end of conveyor 30a to facilitate passage of a quarter-folded article to underlying conveyor 36a.

If it is desired to by-pass the folding stations of the apparatus 11 after that utilized in conjunction with conveyor 30a, pivot by-pass plate 172 mounted on transverse bar 174 may be employed. When pivoted into a lowered position, the outer edge of conveyor 36a is substantially coplanar with the tapes of conveyor 26a which are retained in such horizontal position with the assistance of guide rollers 175. The latter rollers also function to provide room for squeeze roll 166 and its cooperating idler 167 beneath conveyor 26a. A by-passed article will slide over the plate 173, over auxiliary by-pass plate 176, onto table 178, fragmentarily illustrated. When plate 172 is pivoted upwardly into the position illustrated in FIG. 8, a foldable item will pass onto the conveyor 30a.

FIG. 8 also illustrates a modified arrangement for moving the upper article-conveying surface of conveyor 36a relative to an auxiliary-support rod 144a. Such an arrangement includes the use of pivotal ribbed-lifting cylinders 180 and 180a, which are welded or otherwise fixedly secured to pivotal transverse supporting bars or channels 182 or 182a. The cylinders 180 and 180a may be pivoted into an upper position, as illustrated in FIG. 8, wherein they slide (or rotatably, if rollers are substituted for fixed cylinders) engage the undersurfaces of the tapes 24 of conveyor 36a. The hollow cylinders 180 and 180a may also comprise solid rods.

Each embodiment of the tape-supporting elongate member should have smooth, outer surfaces to facilitate slidable engagement with the moving surface of conveyor 36a. Because of the slack normally found in long continuous tapes, such as those illustrated, the cylinders are able to slidably engage and elevate the tapes of conveyor 36a above the plane of the article-support rods 144a, although the normal planar disposition of the tapes of conveyor 36a is below the level of support rods 144a.

Keyed, or otherwise secured to pin 188 of bar 152 on which cylinder 189 is mounted, is a radial arm 190 which is connected by link 194 to elevators 196 of piston rod 198, see FIGS. 8 and 9. Rod 198 is reciprocally movable in cylinder 210. Compressed air flow into cylinder 210 and the resulting piston displacement is controlled by solenoid valve 202, which may be mounted on wall 12a of apparatus 11, as illustrated in FIG. 8. Valve 202 is in an electrical circuit with a switch, such as switch 138a disposed over pinch rolls 104a and 106a (only roll 106a being seen in FIG. 8) employed in apparatus 11.

When arm 136a of switch 138a is tripped by a quarterfolded sheet carried on the raised tapes of conveyor 36a, a circuit is closed energizing the solenoid of valve 202 and reversing the air flow into cylinder 210. The air flow reversal extends piston rod 198 pivoting the member 190 clockwise, as viewed in FIG. 8, whereby tubular member 190 is lowered from its normal raised position to a position below the level of rods 144a. Also keyed or otherwise suitably attached to pin 188 of bar 182 is a radial arm 204, see FIG. 9, which is pivotally connected to elongate connecting arm 206. Arm 206, fragmentarily illustrated in FIGS. 8 and 9, is pivoted to an arm 208 at an opposed arm 180, keyed or otherwise secured to pin 210 of supporting bar 182a on which cylinder 180a is mounted. Thus, the piston 198 of cylinder 200 simultaneously moves the ribbon-engaging cylinders 180 and 180a.

Simultaneously with the lowering of the folded article onto the rods 144a, an air blast from air bar 134a forces the folded article to the bight of pinch rolls 104a and 106a, which function in the manner previously described with respect to rolls 104 and 106.

It will be noted from FIG. 8 that spaced rubber grommets 205 are mounted on rods 144a. These grommets prevent forward slidable movement of the foldable article when deposited onto the rods 144a from the rapidly moving tapes of conveyor 36a.

After the folded article receives an air blast from air bar 134a, see FIG. 11, the same is cross-folded as it is driven between the countercurrently rotating pinch rolls 104a and 106a, as indicated by the arrows in FIG. 11. In the modified apparatus 11, illustrated in FIGS. 8 through 12 pinch roll 104a is spring-loaded, so as to move laterally with respect to fixedly positioned pinch roll 106a. This lateral movement enables the pinch rolls to accommodate folded articles of varying thicknesses and substantially eliminate jamming of pinch rolls which could lead to damaged foldable articles, and in some instances damaged apparatus.

It will be noted from FIG. 11 that a series of spaced tapes 212 are rotatably driven by the positively-driven pinch roll 106a which is in turn driven through chain or belt 214, which rotatably engages sprocket or pulley 216 of gear box 218. Motor 220 drives the output shaft and pulley 216 of the gear box 218. The driven belt 214 rotates pulley 222, which is rotatable with pinch roll 106a.

Idler roll 224 cooperates with pinch roll 106a for purposes of supporting the tapes 212. The tapes 212 are disposed intermittently along the length of pinch roll 106a.

The once-cross-folded article discharged from the conveyor belts 212, after passing through the pinch rolls of apparatus 11, is driven onto conveyor 226 employing spaced tapes 24 similarly to conveyor 142 illustrated in FIG. 2 in the apparatus embodiment 10. It is apparent from FIG. 11 that the upper tape portions of conveyor 226 drive the leading bight edge of the once crossfoldable article into the crossfolded article with the folding elements 69a, 102a and 94a, together with the remaining folding elements illustrated in the folding station illustrated in FIG. 3, whereby the once cross-folded article is crossfolded a second time.

The conveyor 226 has the tapes thereof arranged in desired position at one conveyor end by means of rotating driving roll 228 having a pulley 230 engaging the driving belt 214. The tapes of conveyor 226 also rotatably engage roll 232 and auxiliary guide rolls 234 and 236. It will be seen from the fragmentary view of FIG. 10 that roll 232 has rubber rings 238 rotatably engaging the end portions thereof (only one end portion being illustrated in FIG. 10). The latter rubber rings rotatably engage rubber rings 240 which are of smaller diameter and secured at spaced intervals about the periphery of guide roll 242.

It will be seen from FIGS. 10 and 11 that interposed between the guide roll 242 and the roll 232 of conveyor 226 are a plurality of curved guides 244 affixed at the lower end limits to transverse support bar 246. The rubber rings 238 drive the smaller rings 240 at a greater surface speed thereby tending to eliminate wrinkling of the foldable article which has been twice cross-folded at this stage. The article is driven between the rolls 242 and 252 over the fingers 244 onto underlying conveyor 248 also employing spaced tapes 24, similarly to the remaining conveyors.

Whereas the upper tape portions of conveyor 226 are driven to the left, as illustrated in FIG. 11, the upper portions of conveyor 248 are driven to the right. As a result of the engagement between the drive belt 214 and pulley 250 driven to driving roll 252 of the conveyor 248. Cooperating with driving roll 252 is idler roll 254 disposed at the opposed conveyor end limit. It will be noted from FIG. 11 that the auxiliary rolls 234 and 236 associated with conveyor 226 are rotatably engaged with each other to provide a second cross-folding-station similar to that illustrated in FIG. 3. The latter station serves to provide a third cross-fold in the foldable article being driven through the apparatus 11.
It will be seen from Fig. 11 that the single continuous drive belt 214 also engages a roll 256 and tensioning pulley 255 mounted on pivotal arm 260, which is biased by means of a spring 262 in a manner to take up slack which would otherwise be in the belt 214. It is apparent from Fig. 11 that sprocket members may be substituted for the pulleys and a chain may be substituted for the belt 214.

Following passage through the folding station associated with conveyor 248, the foldable article has been quarter-folded and in addition cross-folded three times. Such article may then be discharged from the interior of the apparatus 11 by means of discharge conveyor 262, the tape ordinarily being forcibly mounted on roll 264 at one conveyor end and at the opposed end on rolls 266, 268 and 290. Drive belt 214 may engage pulley 270 rotatably mounted with roll 264, whereby the latter roll is positively driven.

Plate 272 facilitates passage of the folded article from conveyor 248 to conveyor 262. If it is not desired to automatically stack articles being discharged from the apparatus 11, for instance when small articles are passed through the machine without being processed in each and every folding station, a pivotal by-pass plate 274 mounted on bar 278 may be pivoted downwardly into the dotted line position of Fig. 11. In this position foldable articles pass directly onto conveyor 256, belts thereof being rotatably mounted on rolls 282 and 284, and pass over guide fingers 256 onto discharge table 258 where an attendant may further process the folded article merely placing the same in a cart or other receptacle.

It is desirable to automatically stack foldable articles which are being processed by the cross folder 11, the article passing over conveyor 262 is conveyed beneath by-pass plate 274, which is normally in the elevated position. The article is then carried over the tape portions of conveyor 262 disposed between roller 268 and guide roller 290. Other tapes 24 rotatably mounted about rolls 292 and 294 cooperate with the right-hand terminal portions of the tapes defining conveyor 262 to squeeze the foldable articles in the course of driving the same onto stacking platform 296 similar to that disclosed in Kamberg and Roberts application Ser. No. 434,335. Rolls 292 and 294 may be driven by means of a belt-chain-Engaging sprockets attached to the latter two rolls, as well as a pulley or sprocket attached to and driven by roll 268 of the conveyor 262. If desired, an auxiliary motor may be employed to drive a separate belt or chain which engages sprockets attached to the rolls 292 and 294. Variations of conveyors 266 and 268 illustrated in Fig. 11, may be journalled in bearings mounted in side walls W (see Fig. 8) transversely disposed to the longitudinal axes of the various rolls.

The automatic stacking station comprising the right-hand portion of Figs. 11 and 12 utilizes spaced fingers 298 and 300, which are fixedly secured to transverse bars 302 and 304, respectively. The latter bars are engaged at opposed end limits by pairs of rods 308 and 310, respectively. The connecting rods 310 are reciprocally movable in sleeves 312 disposed in the side walls 314, which also support the overlapping tail 268. Connecting rods 308 are supported by spaced sleeves 316 and 318. Sleeve 318 is mounted in a box-like housing 320 mounted on wall 322. Opposed wall 324 is apertured for reciprocal movement of the fingers 298 comprising a portion of the stacking platform 296.

The fingers 300 of platform 296 and the rod 310 connected thereto are reciprocally moved by piston rod 326 which is reciprocally movable in cylinder 328. Passage of air into the latter cylinder is controlled by solenoid valve 336. Piston rod 336 is connected to connecting rod 338 by means of clevis 339; connecting rod 338 is reciprocally connected to piston rod 326 by means of a clevis 340.

In the normal course of operation of the automatic stacker illustrated in Fig. 11, the folded article, which is driven across the fingers 298 and 300, engages switch arm 312 of switch 344. Switch 344 closes a circuit which magnetically attracts the valve of solenoid valve 346 so that air is passed into cylinder 348 thereby instantaneously lowering a tamping bar 350 to engage the foldable article at the precise instant that the article engages stop plate 352 on which cylinder 348 is mounted.

The tamping bar 350 is preferably mounted on a rubber pad secured to the piston rod extending from the cylinder 348. In the course of its downward travel, the tamping bar 350 may engage a switch mounted on wall 352 and break the circuit energizing the coil in valve 346 so that the air passage into cylinder 348 is reversed, withdrawing the tamping bar into the position illustrated.

In the course of its upward movement, tamping bar 350 may strike a second switch on wall 352 which energizes coils in the solenoid valves 336 and 338 so that the air passage into the air cylinders 334 and 338, respectively, is reversed. The piston rods 332 and 336 then extend, separating the fingers 298 and 300 of the platform 296.

Since the foldable article, by virtue of the position of switch 344 relative to the platform 296, is always stopped at precisely the same spot on the platform 296, the folded articles fall into precisely the same spot on the underlying conveyor 358. The tamping bar prevents bouncing of the foldable articles varying distances from stop plate 352, thereby insuring a neat vertical stack beneath. If the foldable articles are driven at certain speeds and composed of soft materials, bouncing may not be a problem and the tamping bar eliminated.

The conveyor 358 comprises a plurality of tapes 24 mounted on opposed rolls 360, one being illustrated in Fig. 11. The pintles of the rolls 360 may be mounted in bearings disposed in opposed supporting walls 324 and 342. A pulley 362 may be mounted on one end limit of a solenite 361 of roll 360 (see Fig. 12), and the latter pulley may be driven by a belt 364 which also engages the output pulley of a gear box 366.

An electric counter 368 may receive impulses each time actuator 378 of switch 380 is contacted by bar 304 in the course of opening the platform 296. After a predetermined number of revolutions have been received by counter 368, a relay 370 may be closed which energizes the circuit energizing motor 367. Gear box 366 in addition to driving drive belt 364 also drives wheel 372 having a projecting pin 374 mounted thereon which is adapted to strike an arm of limit switch 376 in the course of its rotation. The striking of the switch 376 will break the circuit energizing the motor 367, thereby resulting in only a limited, desired energization of the motor 367 and rotational movement of the belts of the conveyor 358.

Each time that the fingers 298 and 300 are driven apart by their controlling piston and air cylinders, bar 304 engages actuator 378 of switch 380 (see Fig. 11) so as to break the circuit energizing the solenoids in the valves 336 and 338. The latter break in the circuit will reverse the flow of air into the cylinders 334 and 338 by way of the cylinder-controlling solenoids so as to return the fingers 298 and 300 to the platform-defining position illustrated in Fig. 11.

The automatic stacker of Fig. 11 is merely illustrative of one form of automatic stacker which may be employed with the apparatus 11. In view of the extreme speed in which the apparatus 11 may function, an attendant would be unable to process foldable articles discharged by such apparatus. Accordingly, it is intended that the automatic stacker, such as is illustrated in Fig. 11, or other auto-
matic stacking means, be employed with the apparatus 11. It is seen, therefore, from the foregoing description that a folding apparatus adapted to fold a foldable item as many as fifteen times has been provided which is composed of simple and inexpensive parts. As above described, various apparatus embodiment may be employed for removing a foldable article from belt tapes when approaching the vicinity of pinch rolls adapted to form the first cross fold in a foldable article. The provided apparatus while performing its various functions and effecting various folds occupies a minimum of space and effects its folds in a precisely the article center, the center of the article being determined without the need for complex measuring devices which are expensive and subject to failure. The folding operations above described take place as a result of engagement of the foldable article in the course of being forced into engagement with the various folding elements. Also in the apparatus embodiment above described the foldable article is always discharged with the selvage edge of the article innermost and hidden from view, thereby presenting an item of pleasing appearance. Without further elaboration, the foregoing will so fully explain the character of my invention that others may, by applying current knowledge, readily adapt the same for use under varying conditions of service, while retaining certain features which may properly be said to constitute the essential items of novelty involved, which items are intended to be defined and secured to me by the following claims.

I claim: 1. In a folding apparatus, the combination comprising an endless conveyor composed of spaced flexible belts, means spaced lengthwise of said belts for simultaneously engaging the upper run of said belts, a support having an upper support surface disposed adjacent to said upper run and intermediate the belt-engaging means, and means supporting said belt-engaging means for parallel, arcuate movement between a position in which said belt-engaging means maintain the upper run of said belts deflected above the uppermost portions of said support, and another position in which the upper run of said belts is permitted to descend below the uppermost portions of said support.

2. In a folding apparatus, the combination comprising an endless conveyor composed of spaced flexible belts, support elements disposed between said belts and defining a support, means spaced lengthwise of said belts for simultaneously engaging the upper run of said belts, and means supporting the belt-engaging means for parallel arcuate movement between a position in which said belt-engaging means maintain the upper run of said belts deflected above the uppermost portions of said support, and another position in which the upper run of said belts is permitted to descend below the uppermost portions of said support, and another position in which the upper run of said belts is permitted to descend below the uppermost portions of said support.

3. In a folding apparatus, the combination comprising an endless conveyor having a plurality of spaced flexible belts, a plurality of support elements disposed between said spaced belts and defining a support, means spaced lengthwise of said belts for moving the upper run of said belts, means for actuating said belt-moving means whereby the belt portions interposed between said belt-moving means are moved in a plane substantially parallel to the lower run of said belts, and means supporting said belt-moving means for arcuate movement between a position in which said belt-moving means maintain the upper run of said belts deflected above the uppermost portions of said support, and another position in which the upper run of said belts is permitted to descend below the uppermost portions of said support.

4. In a folding apparatus, the combination comprising an endless conveyor of spaced flexible belts, support elements disposed between said belts and defining a support, means spaced lengthwise of said belts for simultaneously engaging the upper run of said belts, and means supporting the belt-engaging means for parallel arcuate movement between a position in which said belt-engaging means maintain the upper run of said belts deflected above the uppermost portions of said support, and another position in which the upper run of said belts is permitted to descend below the uppermost portions of said support, and another position in which the upper run of said belts is permitted to descend below the uppermost portions of said support.

5. In an apparatus for folding sheets or the like, the combination comprising an endless conveyor having a plurality of spaced, flexible belts for conveying a sheet or the like, support elements defining a support disposed in substantially parallel relationship with the upper run of said belts, means spaced lengthwise of said belts for simultaneously moving the upper run of said belts, and means supporting said belt-moving means for parallel arcuate movement between a position in which said belt-moving means maintain said run deflected above the uppermost portions of said support, and another position in which said run of said belts is permitted to descend below the uppermost portions of said support whereby a sheet or the like may be deposited on said support when carried thereover by said belts, folding means disposed parallel to said belts and having an opening interposed between the spaced edges of two adjacent belts, and means for forcing a sheet or the like disposed on said support into said folding means, the forcing means being oppositely disposed to said folding means.

6. The apparatus of claim 5 in which friction-creating stop means are disposed on said support elements for desired positioning of a sheet or the like relative to said folding means when a foldable article is deposited by said conveyor onto said support.

7. The folding apparatus of claim 5 in which a sheet or the like engaged by said folding means initially engages a first conveyor and at least one transverse folding means disposed in the path of such sheet or the like while conveyed on said first conveyor whereby such sheet or the like is transversely folded prior to engaging said folding means; said transverse folding means engaging the leading edge portion of a sheet or the like and depositing the same on substantially the terminal edge of such sheet or the like while carried by said first conveyor.

8. The folding apparatus of claim 5 in which a sheet or the like passing and engaging said conveyor into engagement with at least one transverse folding means while on a third conveyor whereby the sheet or the like is again folded; said transverse folding means engaging the leading edge of a sheet or the like and depositing the same on the terminal edge of said sheet or the like while carried by said third conveyor.

9. The folding apparatus of claim 5 in which means for initiating the dropping of said upper run of said belts is disposed in the normal path of movement of a sheet or the like while on said conveyor.

10. The apparatus of claim 5 in which said folding means comprises counter-rotating pinch rolls and the forcing means comprises a tube directing compressed air at a support portion oppositely disposed to the bite of said pinch rolls.

11. In a folding apparatus, the combination comprising constantly moving conveyor means for moving foldable articles in one direction of movement, said conveyor means having a continuous longitudinal opening therein; means for folding a foldable article along a foldline substantially parallel to said direction of movement disposed beneath the longitudinal opening in said conveyor means and adapted to rapidly pull a foldable article beneath said conveyor means; article-support means disposed slightly
above the level of said conveyor means and adapted to support spaced portions of a foldable article as such foldable article is being folded by the folding means; said support means being disposed over said folding means and adapted to receive foldable articles thereon from the constantly-moving conveyor means moving thereby; said article-support means and said conveyor means being in fixed relative positions, the initial edge portions of the support means being inclined upwardly in the direction of conveyor means movement whereby a foldable article may be driven by said conveyor means onto said support means.