

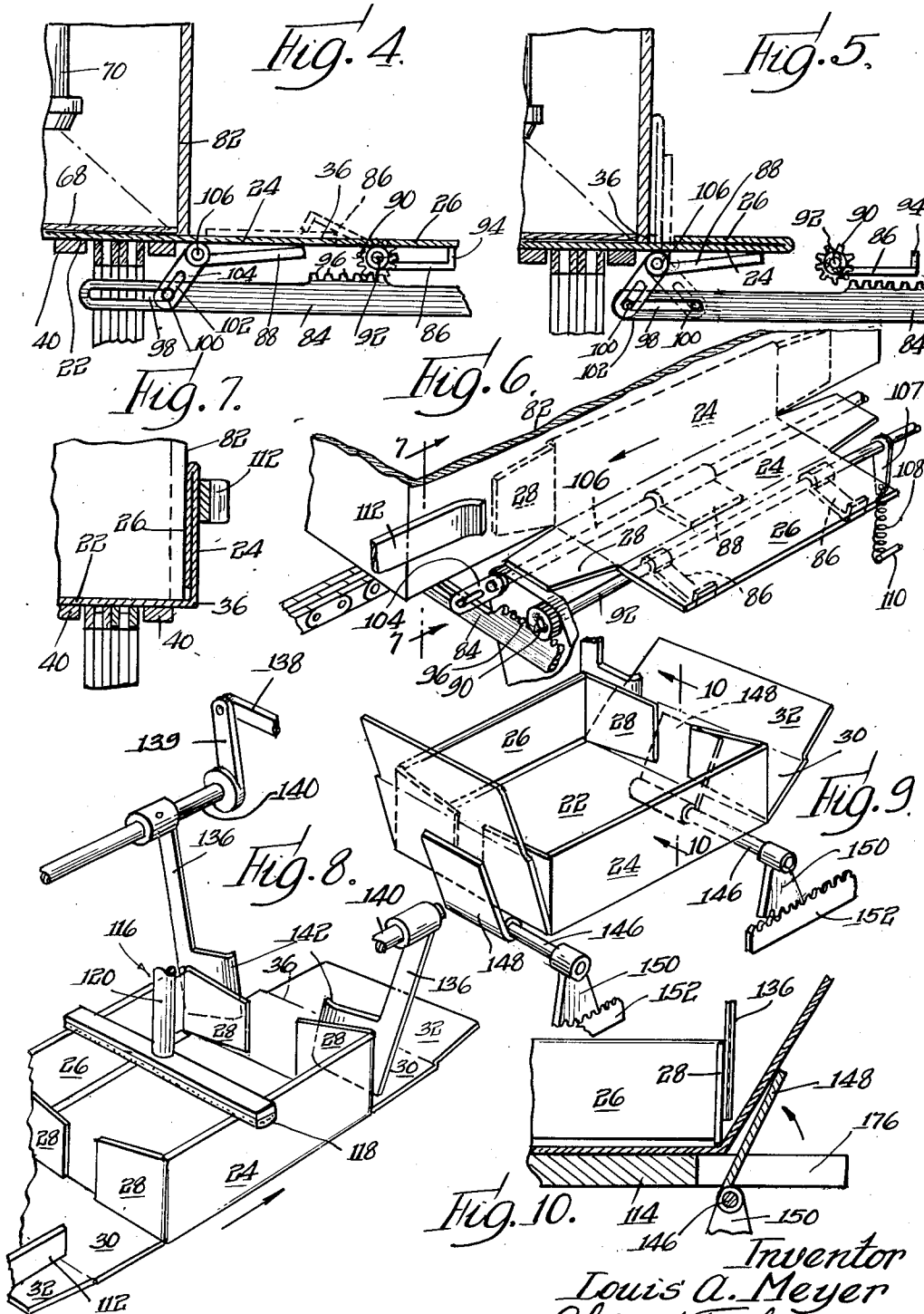
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L. A. MEYER
BOX FORMING MACHINE

3,013,477

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4 Sheets-Sheet 2



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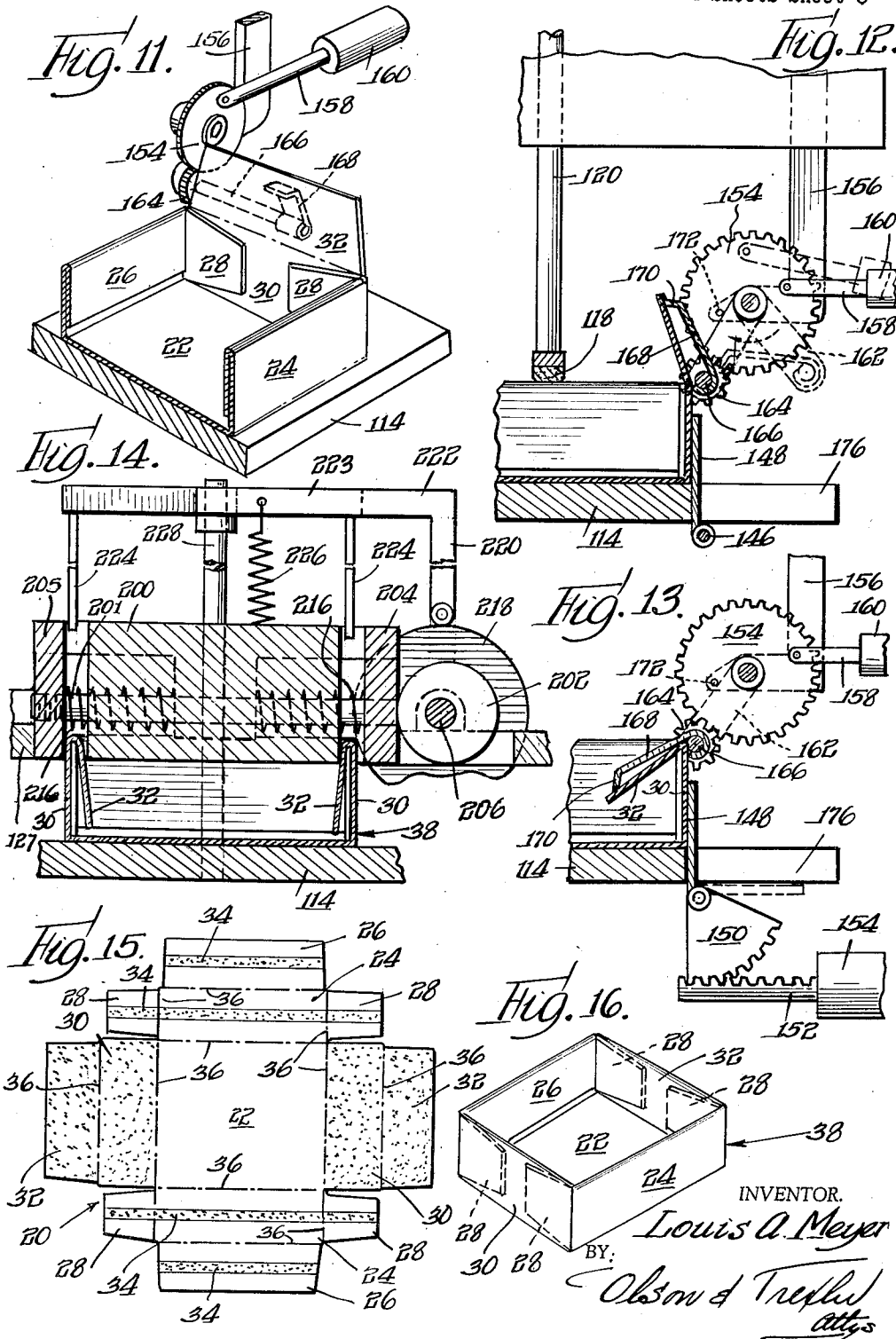
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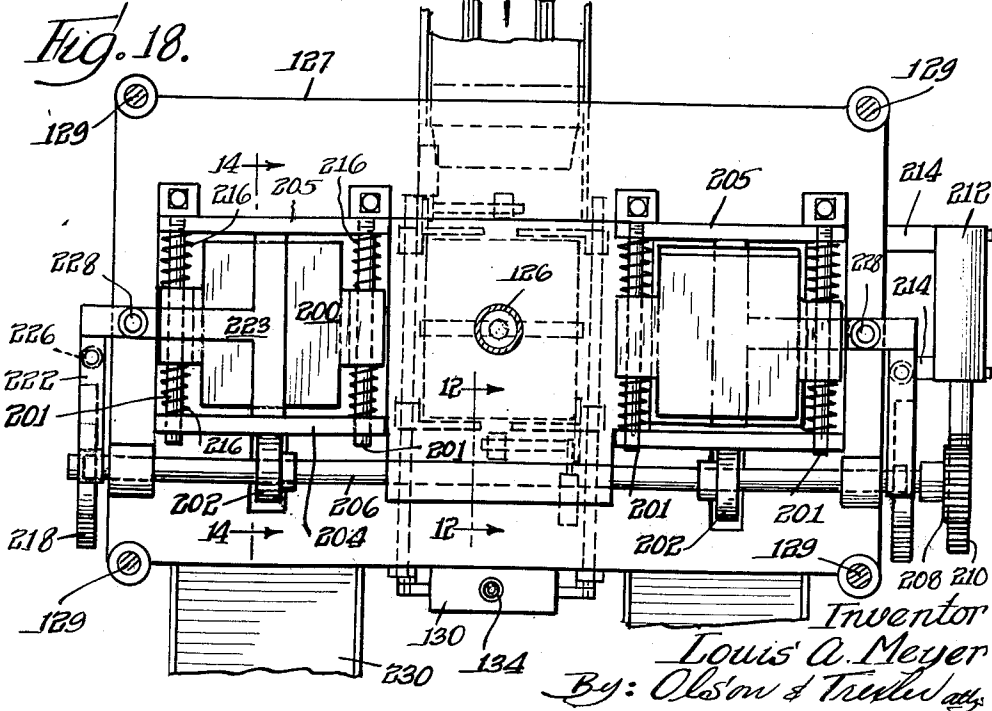
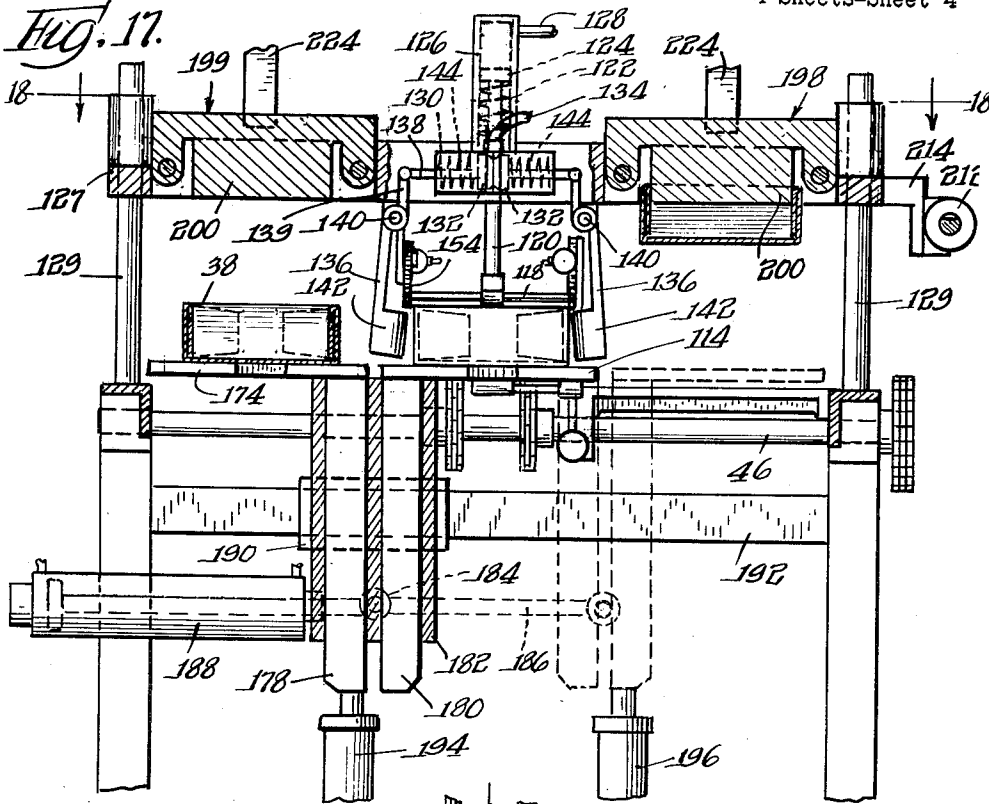
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BOX FORMING MACHINE

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4 Sheets-Sheet 4



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BOX FORMING MACHINE

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9 Claims. (Cl. 93—49)

This invention relates to a box forming machine and more particularly to an improved machine for forming boxes of the set up variety.

Machines commonly used for forming boxes of the set up variety from pre-cut blanks are generally too large and take up too much floor space. This is particularly true of box forming machines used to form double side wall boxes. In addition, the box forming process is too slow in these machines. Frequently one or two stages of the box forming procedure are much slower than the accompanying stages, causing a slowdown in operating speed of the entire machine.

An object of this invention is to provide a box forming machine of small size that will occupy a minimum of floor space.

Another object of this invention is to provide a box forming machine of high production capacity.

It is a further object of this invention to provide a box forming machine in which the slowest steps in forming have been greatly speeded up to obviate the need for slowing down the entire machine.

It is an additional object of this invention to provide a box forming device wherein the various forming operations are performed at successive stations upon the box blank to result in a completely formed box in minimum time with minimum use of floor space.

In addition, it is an object of this invention to provide a machine for forming boxes having double side walls, double end walls, and reinforcing tabs, which machine is of extraordinarily simple construction.

Other and further objects and advantages of the present invention will be apparent from the following description when taken in connection with the accompanying drawings wherein:

FIG. 1 is an elevational view partially in section taken substantially along line 1—1 in FIG. 2 showing the box forming machine.

FIG. 2 is a plan view partially in section taken substantially along line 2—2 in FIG. 1 showing the box forming machine.

FIG. 3 is an enlarged cross-sectional view of the box forming machine, taken along line 3—3 of FIG. 1.

FIG. 4 is an enlarged partial cross-sectional view taken substantially along line 4—4 in FIG. 2 showing the mechanisms for forming the side walls of the box.

FIG. 5 is a partial cross-sectional view corresponding to FIG. 4 showing the side forming mechanisms in different positions of operation.

FIG. 6 is a partially cut away perspective view corresponding to FIGS. 4 and 5 showing the side forming mechanisms and the beginning of the next box forming stage.

FIG. 7 is a partial cross-sectional view taken along line 7—7 in FIG. 6.

FIG. 8 is a perspective view of a cut away portion of the machine showing the mechanisms employed to fold in the tabs of the side segments of the box.

FIG. 9 is a perspective view of a cutaway portion of the machine showing the mechanisms employed to fold in the tabs of the side segments of the box.

FIG. 10 is a partial sectional view in elevation taken substantially along line 10—10 in FIG. 9.

FIG. 11 is a perspective view of a cut away portion of the machine showing the mechanisms for forming the double end wall of the box.

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FIG. 12 is an elevational view of a portion of the machine corresponding to FIG. 11 and taken along line 12—12 in FIG. 18.

FIG. 13 is a partial sectional view corresponding to FIG. 12 but showing the mechanisms in different operating positions.

FIG. 14 is a sectional view of the final pressing stage of this machine taken along line 14—14 in FIG. 18.

FIG. 15 is a plan view of the box blank showing latex strips on the side wall segments and adhesive sprayed on the end segments of the box.

FIG. 16 is a perspective view of the fully formed box.

FIG. 17 is a cross-sectional view taken substantially along line 17—17 in FIG. 1.

FIG. 18 is a partial plan view taken substantially along line 18—18 in FIG. 17 showing the pressing mechanisms and movable platforms of the final stage.

Before referring to the machine in greater detail it is thought that it would be helpful to refer first to FIGS. 15 and 16, showing the blank and the box respectively. The blank comprises a flat stamped-out section of cardboard, and is identified by the numeral 20. As will be appreciated, the principles of the invention are equally applicable to other materials, and the blank could be made of plastic, for instance, and could even be made of metal, and spot welded, rather than glued. However, the blank contains a rectangular bottom section 22, with a pair of rectangular side walls 24 along the opposite longitudinal edges thereof. The sidewalls are provided along their outer longitudinal edges with rectangular flaps 26. End tabs 28 are provided on the opposite ends of the side walls.

The blank 20 is further provided at its opposite ends with end walls 30. End flaps 32 are provided on the end walls. Latex strips 34 have been coated on the side walls 24, the rectangular flaps 26, and the end tabs 28. The latex in the strips 34 will stick only to other latex coatings and to nothing else, but two such latex coatings will stick to each other on contact with substantially no pressure required. The strips 34 on the rectangular flaps 26 are positioned so as to abut the strips 34 on the rectangular sidewalls 24 when the flaps are bent over to form double sidewalls for the box. The blank 20 is preferably prescored as indicated by the broken lines at 36 in FIG. 15, and also shown in various sectional views through the blank, such as FIGS. 10 and 12.

When the blank has been completely folded to its final shape, it results in a box 38 shown in FIG. 16, which box has double side walls, double end walls, and reinforcing tabs or corners. The particular dimensions of the box depend on the final requirements, and the machine is adjustable and is adapted to accommodate any of a great number of sizes of blanks to produce boxes of corresponding size.

The box forming machine comprises a series of tracks or rails 40, intermittently extending throughout approximately two thirds of the machines' length, along which the blanks are moved. Three horizontal shafts 42, 44 and 46 extend laterally beneath the tracks 40. Sprocket wheels 48 are keyed to the shafts 42, 44 and 46 and two parallel pairs of chains 50 and 52 are mounted on the sprocket wheels 48 so as to have their upper reaches extend parallel to and slightly below the tops of the rails 40. The shafts 42, 44, and 46 are journaled in suitable bearings in suitable side frame members 54. A drive belt 56, driven by a motor 58, drives a wheel 60 which is fixed on the end of the shaft 44, thereby driving the chains 50 and 52 in a generally clockwise direction as viewed in FIG. 1. Each of the chains 50 and 52 is provided with a pair of lugs 62 protruding outwardly from the chains 50 and 52. It is within the contemplation of

the invention that a greater or lesser number of lugs might be used.

A magazine 64 (see FIGS. 1 and 2) is provided above the chains 50 to support a stack of the box blanks 20. The magazine is provided with an edge discharge slot or opening 66 at its bottom right corner as viewed in FIG. 1, and the lugs 62 on the chains 50 are adapted to pick up a blank for each half revolution of the chains 50, and to slide the blank from the magazine into position over the next pair of chains 52 and under a template 68. The template 68 overlies the bottom portion 22 of the blank while two spray nozzles 70 spray glue or other adhesive material on the top surfaces of the end walls 30 and end flaps 32. The nozzles 70 are connected to a glue supply through suitable tubes 72 and 74. The tubes 72 and 74 feed the liquid adhesive to the nozzles by gravity flow. The nozzles 70 spray only when air pressure is supplied to them through suitable connecting tubes 76, which tubes 76 provide air passages from a valve 78 to the nozzles 70. Constant high pressure is maintained in another tube 80 connected to the opposite side of the valve 78. When the valve 78 is opened the pressure is transmitted to the nozzles 70 and the glue is sprayed. The valve is timed by suitable timing means to be opened only while the blank is in its temporarily stationary position beneath the template 68. The nozzles 70 are inoperative at all other times.

A housing 82 is provided for the nozzles 70 and comprises a rectangular box-like structure. The housing 82 has an outside width dimension virtually equal to the width of bottom section 22, so that no glue is sprayed on the side walls 24, flaps 26, or end tabs 28.

Simultaneously with the glue spraying operation just described, the folding mechanisms illustrated in FIGS. 4, 5, and 6 act to fold the flaps 26 against the side walls 24 and to bend the resulting double wall sections vertically upward. The bends occur along the prescored lines 36. Identical mechanisms are provided on either side of the spraying housing 82 to accomplish this bending. The mechanisms on one side are described as follows:

A horizontal laterally extending rack 84 (see FIGS. 4-6) is laterally movable as by suitable pneumatic piston means 85 (see FIG. 2). The rack 84 is suitably timed to function only while the blank is stationary beneath the template 68. A pinion gear 90 is mounted on a shaft 92 by means of a one way clutch mechanism. The one way clutch mechanism permits the gear 90 to drive the shaft 92 in a counter-clockwise direction as viewed in FIGS. 4 and 5, but the gear 90 turns freely on the shaft 92 when driven in a clockwise direction as viewed in FIGS. 4 and 5. Two levers 86 are affixed to the shaft 92 and are provided with conveniently bent tip portions 94 for engagement with the underside of the side flap 26 of the blank 20. The rack 84 is provided with a limited number of teeth 96 for engaging the gear 90. The inward end portion of the rack 84 is provided with a horizontal slot 98 in which a pin 100 rides horizontally during the side folding operations. The pin 100 also rides in a slot 102 on an arm 104 which extends upwardly from the rack 84 to a rock shaft 106. A laterally extending arm portion 88 is mounted on the rock shaft 106 so as to be engageable with the underside of the side wall 24.

The piston 85 first pulls the rack 84 laterally outward, causing the teeth 96 to rotate the gear 90 in a counter-clockwise direction, thereby rotating the levers 86 counter-clockwise and forcing the flap 26 to bend at its score line 36 and fold over against the top portion of the side wall 24. During this first folding operation, the slot 98 merely slides by the pin 100 and does not pivot the arm 104 until the pin 100 abuts the inward edge of the slot 98 (see FIG. 5). The flap 26, upon abutting the side wall 24, sticks firmly thereto through the adhesion of the strips of latex 34 one to another.

The teeth 96 then pass laterally outward of the gear 90 freeing the gear 90 from engagement with the teeth 96. A radial prong 107 (see FIG. 6) is also attached to the shaft 92 and is connected at its radially outward end to a spring 108 which is appropriately fastened to the frame at its other end 110. The spring 108 is cocked by the counterclockwise rotation of the shaft 92 during the above described folding operation, and when the gear 90 is freed of engagement with the teeth 96 the spring acts to rotate the shaft 92 and the levers 86 clockwise to their original position, thereby clearing the side wall 24 and the flap 26 for upward folding by the arm portion 88.

As the rack 84 is pulled further laterally outward the pin 100, now at the inward end of the slot 96, is forced to move with the rack 84. The pin 100, through its engagement in the slot 102, causes the arm 104 to pivot counterclockwise. The arm 104 acts through the rock shaft 106 to cause the arm portion 88 to pivot counterclockwise, thereby forcing the double wall 24 and 26 to bend at the score line 36 into a vertically upward position (as shown by the broken lines in FIG. 5). The side of the housing 82 acts as a backstop for the upwardly folded side.

A pair of chain lugs 62 is then brought into abutment with the left end of the blank 20, and the chains 52 move the blank 20 to the right (FIG. 1) and out from beneath the template 68. As the blank 20 is so moved, the forward tab 28 is trapped by a curved bar 112 positioned adjacent to the side of the housing 82 so as to channel the movement of the upturned side of the blank 20.

As the blank 20 begins to move from under the template, the piston 85 returns the rack 84 laterally inward towards its initial position (as shown in FIG. 4). The arm portion 88 is rotated clockwise to its initial position and the teeth 96 of the rack 84 engage the gear 90 whereby to rotate it in a clockwise direction. However, the one way clutch mechanism connecting the gear 90 to the shaft 92 allows the gear 90 to turn freely on the shaft 92 and the position of the levers 86 are unchanged as the rack moves inwardly. The folding mechanisms just described are then in position to fold the next blank.

Another pair of lugs 62 on the chains 52 pushes the blank 20 onto a platform 114. The curved bars 112 and the rails 40 terminate (see FIG. 2) and a plunger, generally designated by a numeral 116, descends onto the top of the side portions of the blank to hold them in their upright positions. The plunger 116 comprises a horizontal bar 118 having a resilient pad on its underside which engages the side portions 24 and a vertical rod portion 120 extending upwardly from said bar 118. The rod 120 terminates at its upper end in a piston 124 (FIG. 17) which fits snugly in a pneumatic cylinder 126 and is driven by air pressure introduced to the cylinder through a tube 128. The pneumatic cylinder 126 forces the plunger 116 down as soon as the blank 20 reaches the platform 114.

As the piston 124 is forced down it cocks a spring 122 disposed beneath the piston 124 within the cylinder 126. When the folding operations which are performed while the blank 20 rests on the platform 114 have been completed as hereinafter described, the pressure in the cylinder 126 is released. The spring 122 then returns the piston upwardly whereby to disengage the bar 118 from the blank 20.

The cylinder 126 is mounted in the center of a large horizontal plate 127 (FIG. 18) which overlies the platform 114, the final folding mechanisms hereinafter described, and the entire final folding and pressing stages of the machine. The plate 127 is rectangular and is adjustably mounted on four posts 129 which extend upwardly from the floor.

A horizontal cylinder 130, containing two opposing

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pistons 132 and connected near its center to a pressure pipe 134, is mounted in the plate 127 across the centerline of the machine. Each piston 132 is connected to a corresponding outwardly extending coaxial rod 138. Each rod 138 is pivotally connected through a depending intermediate rod 139 to a corresponding longitudinal shaft 140 (see also FIG. 8). Two levers 136 depend from each shaft 140 adjacent to the front and rear ends of the blank 20. The levers 136 are caused to rotate inwardly as pressure is supplied to the cylinder 130 through the pipe 134 whereby to separate and move laterally outwardly the pistons 132.

The levers 136 are provided with paddle-like lower end portions 142 that engage the end tabs 28 on the inward swing of the arms 136 whereby to bend the tabs 28 perpendicularly inward about their scored inner edges 36. When the pressure is released from the cylinder 130 the pistons 132 are returned to their original positions by the action of two springs 144 which are disposed within the cylinder 130 so as to oppose the pressure strokes of the pistons 132.

Before the arms 136 are fully retracted from contact with the tabs 28 the end folding mechanisms next described will have folded the end walls 30 upwardly sufficiently far to prevent the tabs 28 from rebounding toward their original parallel alignment.

A pair of horizontal shafts 146 extends laterally beneath the front and back edges of the blank 20 (see FIGS. 9-13). Pivotable flippers or plate means 148 are mounted on the shafts 146, and normally are in substantially horizontal position. A segment gear 150 extends downwardly from each of the shafts 146. The segment gears 150 engage a corresponding pair of racks 152 which are horizontally movable as by appropriate pneumatic pistons 154. As the racks 152 rotate the segment gears 150, the flippers 148 are caused to bend up the end wall 30 and end flap 32 to a vertical position.

The mechanisms for forming the double end walls are best illustrated in FIGS. 11-13. A relatively large sun gear 154 is rotatably mounted on an arm 156 which extends downwardly from the machine frame. A connecting rod 158 is secured to the gear for rotation thereof, and may be actuated by suitable means such as a pneumatic cylinder 160. An arm 162 is mounted coaxially with sun gear 154, and extends radially therefrom. This arm is rotatable independently of the sun gear 154. A relatively small planet gear 164 is fixed on a shaft 156 and pivotally mounted at the end of the arm 162, the planet gear 164 meshing with the sun gear 154. A flap folding arm 168 is secured at the center line of the machine on the shaft 166, and conveniently has an inwardly directed tip 170.

The gears 154 and 164, and the arm 162 are positioned to the side of the path of travel of the box blank 20; and the rest position of the shaft 166 and flap folding arm 168, as shown in dashed lines in FIG. 12, is such that the end wall 30 and end flap 32 can be moved up without engaging these parts. A torsion spring (not shown) acts between the planet gear and arm 162 to resist rotation of the gear 164. According, when the sun gear 154 is pivoted by the connecting rod 158, the arm 162 rotates with the sun gear. When the arm 168 engages the flap 32, resistance to further pivoting the arm 162 is provided. In addition, a positive stop 172 preferably is provided on the depending arm 156. Pivoting of the arm 162 according is arrested, and the planet gear 164 is therefore rotated in a counterclockwise direction as shown in the drawings. This causes the flap folding arm 168 to bend the flap 32 down from a vertical position as shown in FIG. 11, through the angular position of FIG. 12, and down to the folded position of FIG. 13 and preferably to a further position wherein the flap is in still closer proximity to the end wall 30. Reverse rotation of the sun gear 154 causes the parts to move in the opposite direction back to the rest position.

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The arm 148 is rotated to its rest position after the end folding operation just described has been completed.

When the end folding mechanisms have retracted, the platform 114 on which the box 38 is supported is displaced laterally and replaced by a second platform 174 (FIG. 17) which platform 174 immediately receives the next box from the chains 52.

The movements of the platforms and the final pressing operation are best illustrated in FIGS. 17 and 18. The platforms 114 and 174 are of identical size and shape, each being substantially rectangular with rectangular notches 176 provided along their front and rear edges to accommodate the end folding mechanisms (see FIG. 2). The platforms 114 and 174 are parallel and adjacent to one another. Leg portions 178 and 180 depend from the adjacent portions of the platforms 174 and 114 respectively. The depending legs 178 and 180 are slidably mounted in vertical slots in a frame 182. The frame 182 is connected at 184 to a laterally extending connecting rod 186 which is driven as by a suitable hydraulic or pneumatic cylinder 188. The frame 182 is slidably mounted through suitable mounting means 190 on a laterally extending guide bar 192 which extends across the entire width of the machine (see FIG. 17).

A pair of suitable hydraulic or pneumatic cylinders 194 and 196 is mounted vertically in alignment with the outwardmost positions of the depending arms 178 and 180 respectively. As soon as the folded box 38 has been displaced laterally by its platform 114 or 174, the corresponding cylinder 194 acts to move the depending leg 178 of said platform 114 or 174 vertically upward whereby to engage said box 38 in pressing means 198 or 199 respectively.

The pressing means 198 and 199 act to press the end flaps 32 against the end walls 30 to secure said flaps to said walls through their adjacent adhesively coated surfaces. Each pressing means comprises a rectangular core 200 (see also FIG. 14) a front plate 204 and a rear plate 205. The core 200 and the front plate 204 are slidably mounted on a pair of horizontal shafts 201 which are mounted in the plate 127 so as to extend parallel to the sidewalls 30 of the box. The shafts 201 fixedly engage the rear plate 205 which is fixedly mounted on the plate 127. Four helical springs 216 are disposed coaxially on the shafts 201 so as to act in compression between the front plate 204 and the core 200 and between the rear plate 205 and the core 200. The front and rear end walls of the box 38 are received between the core and the front plate 204 and rear plate 205 respectively. The springs maintain the proper spacing between the core and the plates.

When the box has been received by the pressing means, a cam 202 bears against the front plate 204 to press the front end wall of the box against the core 200. The core, in turn, presses the rear end wall against the rear plate 205. The cam 202 is mounted on a horizontal shaft 206 which is rotatably driven by a rack 208 (FIG. 18) and pinion 210 arrangement, the rack being driven as by pneumatic cylinder 212 which is mounted to the frame 127 by brackets 214. After a short pressing time, the cam 202 rotates to allow the springs 216 to return the front plate 204 and the core 205 to their rest positions.

A second cam 218, also mounted on the shaft 206, bears upwardly on an arm 220 which depends from a horizontal bar 222. A horizontal T-shaped extension 223 of the bar 222 is disposed above the core 200. Two ejector rods 224 depend from the extension 223 and are aligned vertically above the end walls of the box. Upon completion of the pressing stage, the cam 218 rotates to permit a spring 226 to force the bar 222, the extension 223, and the depending ejector rods 224 downwardly. The lower ends of the rods 224 are thereby caused to strike the tops of the end walls of the pressed box whereby to eject it downwardly out of engagement with the pressing means.

The extension 223 is slidably mounted on a vertical post

228 for stability. The post 228 is fixedly mounted on the frame 127. The spring 226 acts in tension between the extension 223 and the frame 127 below and is attached thereto at its upper and lower ends respectively.

The ejected box falls into a chute 230 and slides away from the machine. During the pressing operation just described, the platform 114 or 174 that carried the box 38 to the pressing position returns downwardly without the box and moves laterally to its central position to receive another partly folded blank 20 for the end folding operations. When the box is ejected from the press, the platform is not below the press, so the box falls past the platform into the chute below.

The platforms continue to shuttle back and forth and move up and down to supply boxes to the two pressing means 198 and 199 from the end forming position. The pressing means handle alternate boxes as they leave the single folding assembly line.

It will now be apparent that I have disclosed a complete box forming machine having a dual pressing section that will operate approximately twice as fast as the orthodox single pressing section. Since the pressing operation is generally the slowest step in the box forming process all preliminary stages of the present box forming machine can be operated at greatly increased speed. The boxes are disposed of by the pressing section much more rapidly than in the standard box forming machine. Production capacity is greatly increased with only a slight increase in mechanism and use of floor space.

Various changes in structure will no doubt occur to those skilled in the art, and will be understood as forming a part of this invention in so far as they fall within the spirit and scope of the appended claims.

The invention is claimed as follows:

1. A box forming machine comprising a plurality of box folding mechanisms for folding a box blank into box form, conveyor means for moving said box blanks between successive positions in which said mechanisms act, first and second box pressing means each including a stationary forming block for receiving said folded box blank, and terminal platform means for moving alternate box blanks respectively into engagement with said first and second pressing means.

2. A box forming machine comprising a plurality of box folding mechanisms for folding a succession of box blanks into double walled boxes, conveyor means for moving said box blanks into successive positions respectively adjacent said mechanisms, all of said folding mechanisms acting on each box in succession, and terminal duplicate pressing means for pressing the double walls of said boxes, each of said duplicate pressing means acting on separate boxes after said boxes have been completely folded, wherein said pressing means remain stationary and further including movable platform means for moving said boxes into engagement with said pressing means.

3. A box forming machine comprising continuously moving conveyor means, means on said continuously moving conveyor means for intermittently moving a box blank along a straight-through path from one to another of a series of blank folding stations, a plurality of box folding mechanisms positioned adjacent said stations for completely folding said blanks, a pair of final forming stations respectively offset laterally of said path on opposite sides thereof adjacent the terminal end thereof, similar box forming mechanisms including a stationary forming block and pressing means at each of said final stations, and means for laterally moving alternate, completely formed box blanks from said conveyor means respectively to said final stations.

4. A box forming machine as set forth in claim 3 wherein the means for laterally moving said box blanks comprises a pair of platforms which are laterally movable as a unit and individually movable vertically upward.

5. A box forming machine as set forth in claim 3 wherein

in the means for laterally moving said box blanks comprises a laterally movable frame having two vertical guideways and a pair of horizontal platforms, said platforms including downwardly extending leg means slidably mounted in said guideways whereby to permit individual vertical movement of each of said platforms.

6. A box forming machine as set forth in claim 3 wherein the means for laterally moving said box blank 5 comprises a plurality of normally coplanar platforms, which platforms are successively positioned to receive box blanks from said movable conveyor means, said platforms moving said box blanks to the respective final forming stations.

7. A box forming machine comprising continuously movable conveyor means, means on said conveyor means for intermittently moving a box blank from one to another of a series of blank folding stations, said conveyor means comprising supporting means on which the box blanks are supported and a series of endless flexible means having upper reaches substantially on a level with said supporting means, said endless flexible means having projections thereon engageable with said blanks, there being at least one such flexible means for each of said stations, a pair of blank folding members on opposite sides of said conveyor means at one of said stations and pivotally mounted about horizontal axes parallel to said conveyor means, said blank folding members being pivotable from a substantially horizontal position upwardly and toward one another whereby to bend portions of said blank and to form side walls of a box, a housing having vertical walls parallel to said conveyor means and disposed adjacently inward of said side walls, and glue spraying means disposed within said housing between said vertical walls of said housing, said glue spraying means spraying glue on predetermined portions of said box blanks simultaneously with the folding action of said folding members.

8. A box forming machine comprising a plurality of box folding mechanisms for folding the sidewalls of a box blank into vertically upward position, said sidewalls including front and back tab portions, a pair of horizontal shafts parallel to said sidewalls and spaced upwardly and outwardly therefrom, a plurality of depending arm portions mounted on said shafts and disposed laterally outwardly of said tabs, said depending arms being pivotable inward and engageable with said tabs whereby to fold said tabs perpendicularly inwardly relative to said sidewalls, said box forming machine further including a vertical plunger rod and a horizontal bar attached to the lower end thereof, said horizontal bar engaging the tops of said sidewalls with a resilient pad affixed to said bar whereby frictionally to retain said sidewalls in a vertical position while said tabs are being folded inwardly.

9. A box forming machine comprising folding means for forming a box blank into a double-walled box form, said box form being maintained by a plurality of adhesively joined box surfaces, stationary pressing means for securing said adhesively joined surfaces including a pair of rectangular cores engageable with said formed box blanks and plate means for compressing the walls of said formed box blanks laterally against said cores, and terminal platform means for moving said box blanks from said folding means into engagement with said pressing means, said platform means including a pair of adjacent slabs, each of said slabs corresponding with a said core, said slabs being jointly movable in a horizontal plane and independently movable in a vertical plane.

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