United States Patent [19]

Norton

[11] **3,861,672**

[45] **Jan. 21, 1975**

[54] **SHEET MATERIAL HANDLING APPARATUS AND METHOD**

[75] Inventor: **Robert K. Norton,** Twinsburg, Ohio

[73] Assignee: **Harris-Intertype Corporation,** Cleveland, Ohio

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[21] Appl. No.: **429,032**

[52] **U.S. Cl.** **271/203,** 271/204

[51] **Int. Cl.** **B65g 37/00**

[58] **Field of Search** 271/201, 202, 203, 204, 271/205, 206

[56] **References Cited**

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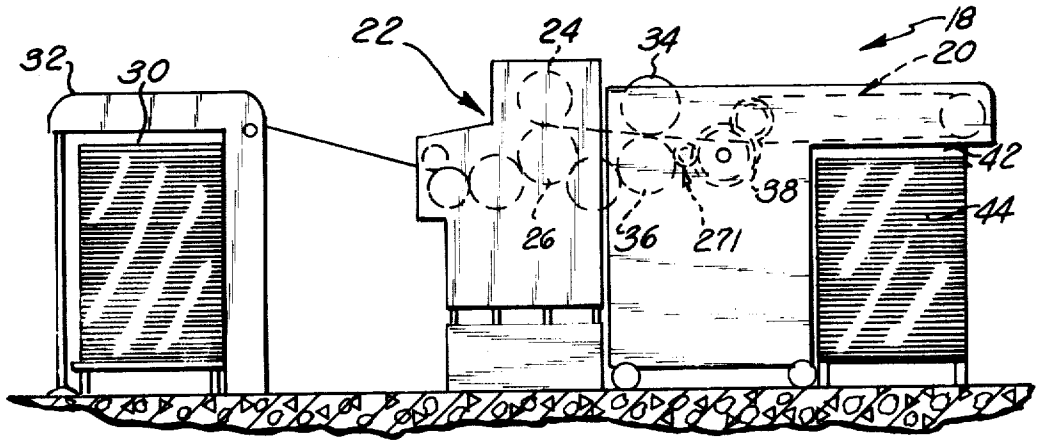
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Primary Examiner—M. Henson Wood, Jr.
Assistant Examiner—D. W. Keen

[57] **ABSTRACT**

An improved sheet slowdown method and apparatus are advantageously utilized in association with a cutter and creaser having working cylinders which are effective to process a complete sheet upon each revolution of the working cylinders. To reduce deceleration forces, the sheet slowdown apparatus includes a plurality of sets of grippers which are effective to transport, slow down and release a sheet during two revolutions of the working cylinders. Thus, a first sheet is engaged at the pickup station by a first set of grippers, moved at a constant speed toward the receiving station by the first set of grippers, decelerated to a very low speed, and then released by the first set of grippers at the receiving station. As this is occurring, a second or next succeeding sheet is delivered to the pickup station. A second set of grippers engages the second sheet at the pickup station and moves it toward the receiving station at a constant speed while the first set of grippers is decelerating the preceding sheet. To enable the two sets of grippers to function in this manner, an improved drive arrangement is provided to vary the speed of movement of one set of grippers relative to the speed of movement of the other set of grippers. This enables one set of grippers to move at a constant speed while another set of grippers is either being decelerated prior to releasing a sheet at the receiving station or accelerated after releasing a sheet.

31 Claims, 16 Drawing Figures



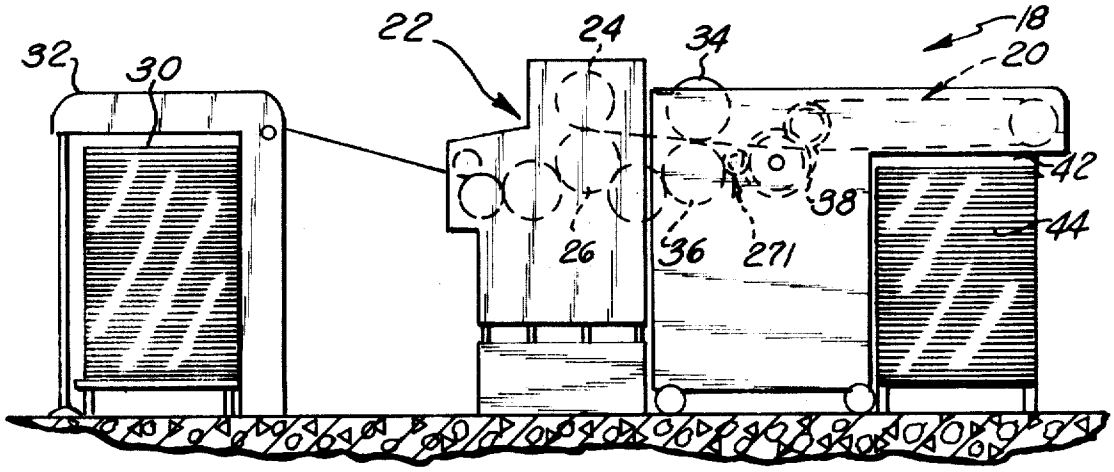

32
30
22
24
34
18
20
42
44
38
26
36
271

FIG. 1

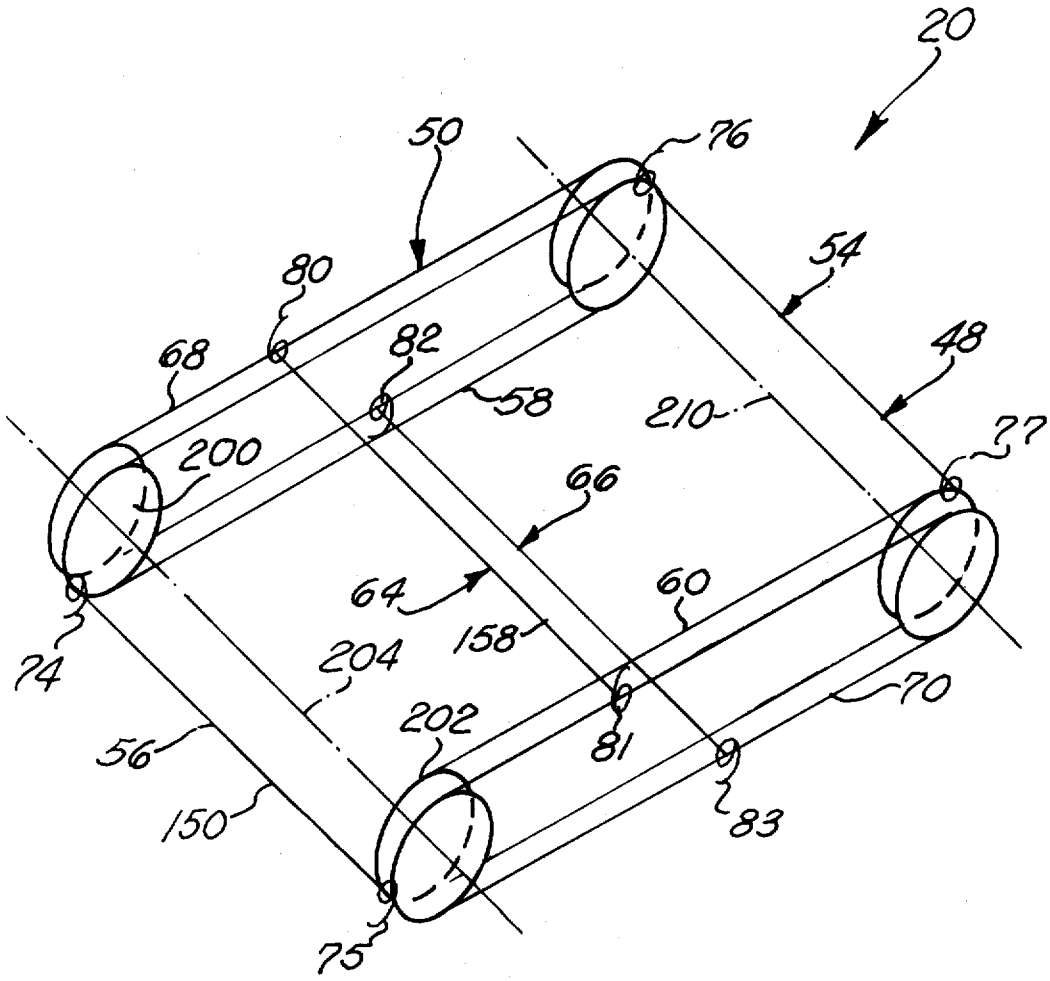

20
50
76
80
54
68
82
48
58
210
200
77
66
64
60
74
158
204
70
202
56
81
150
83
75

FIG. 2

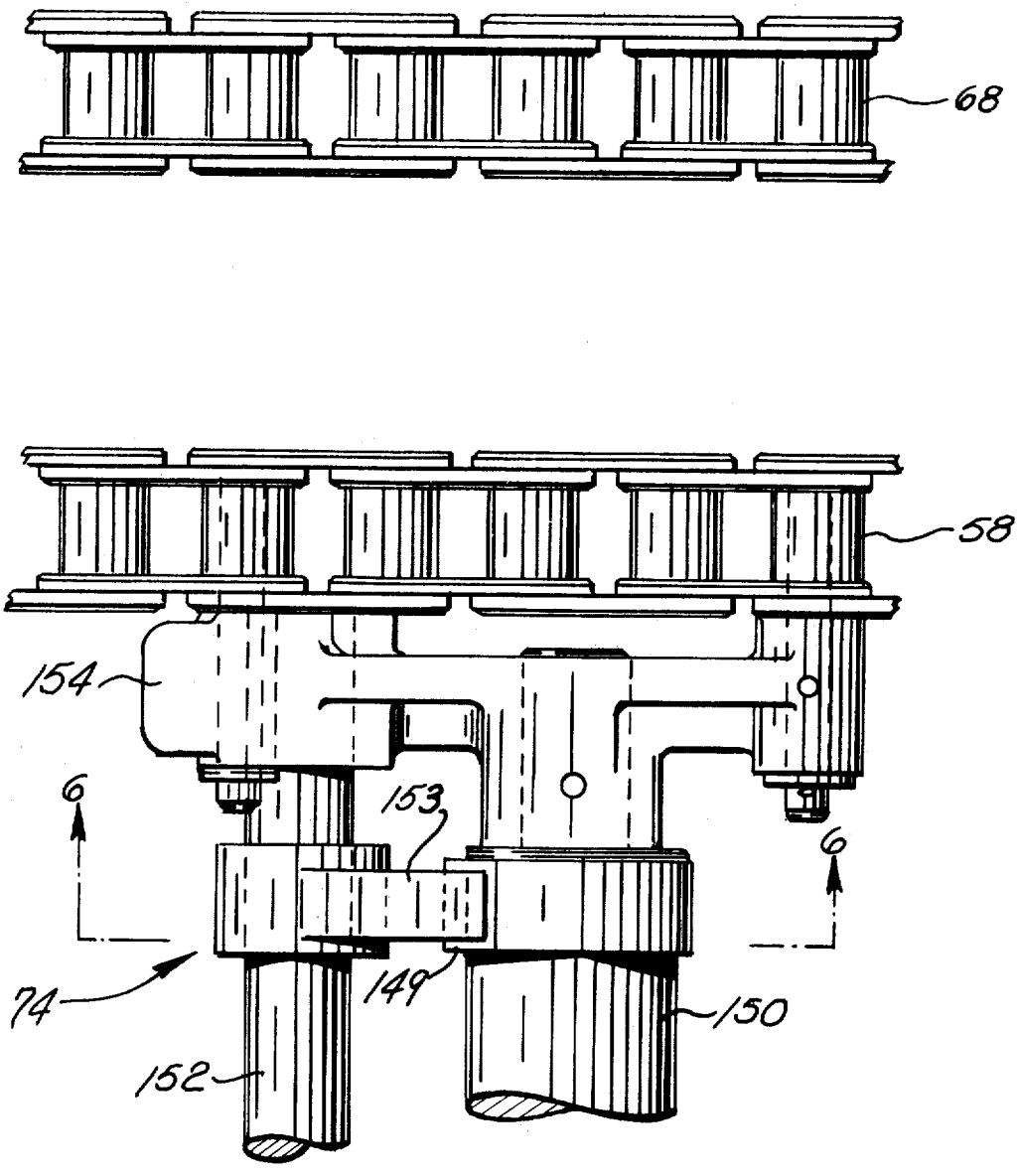


FIG. 3

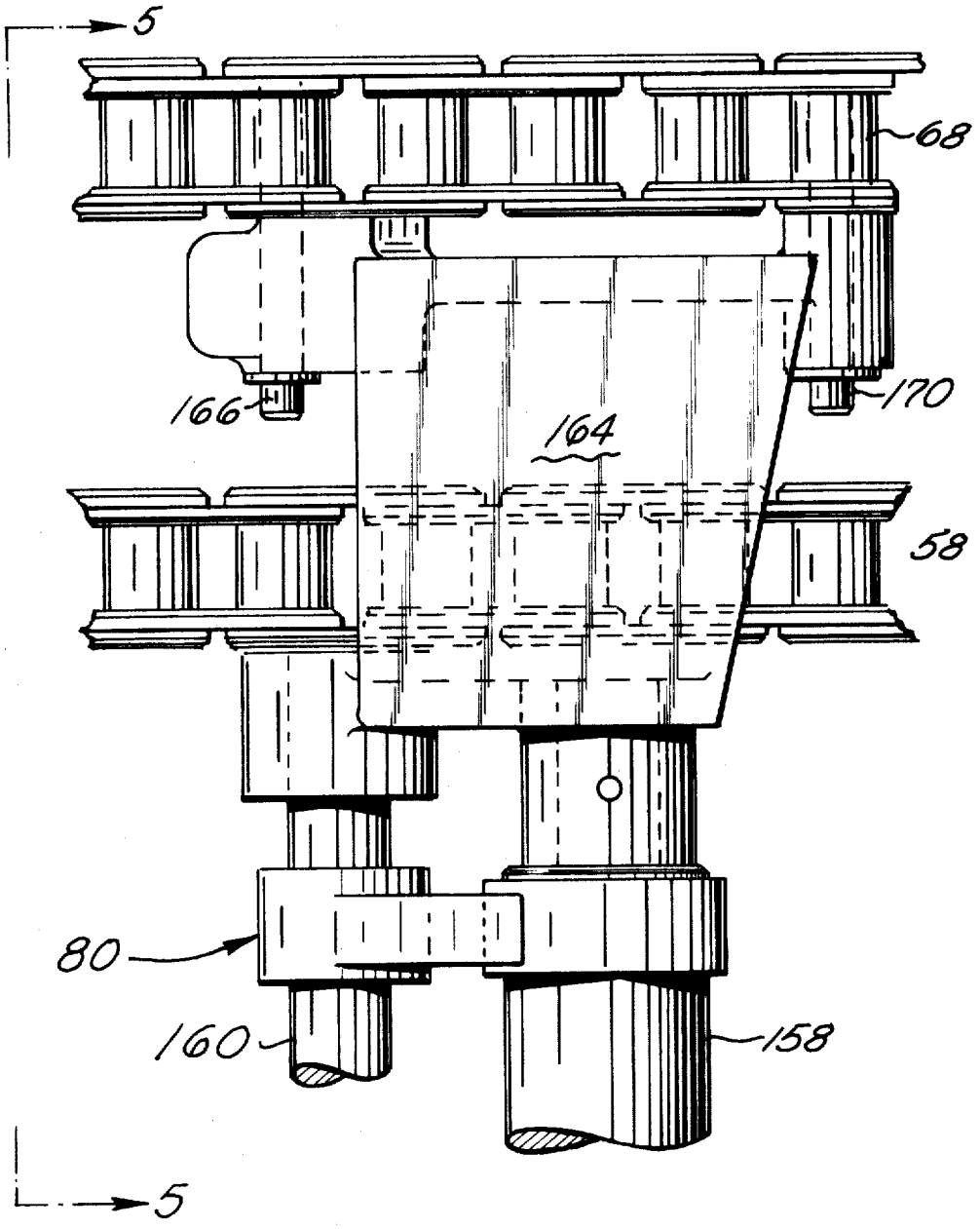


FIG. 4

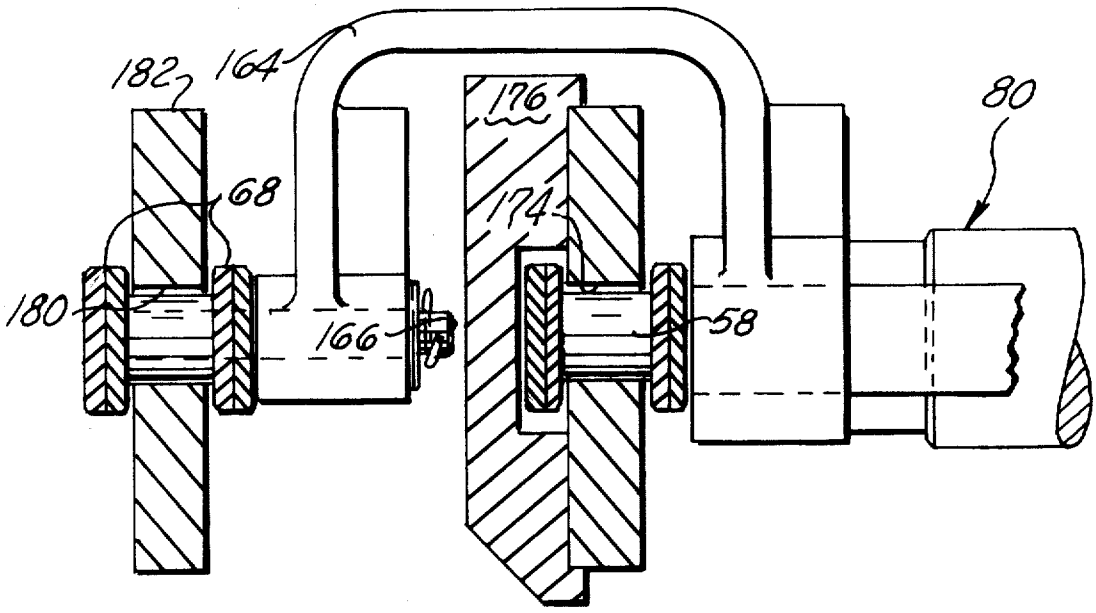


FIG. 5

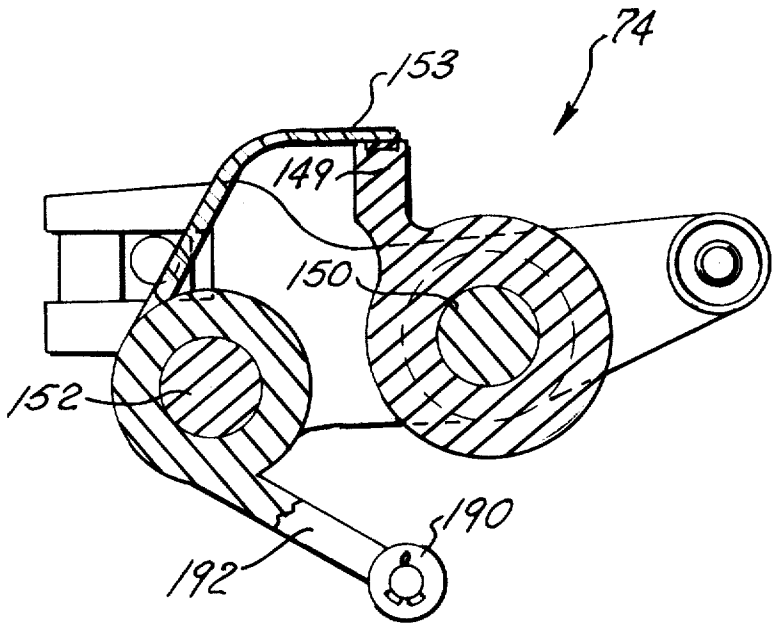


FIG. 6

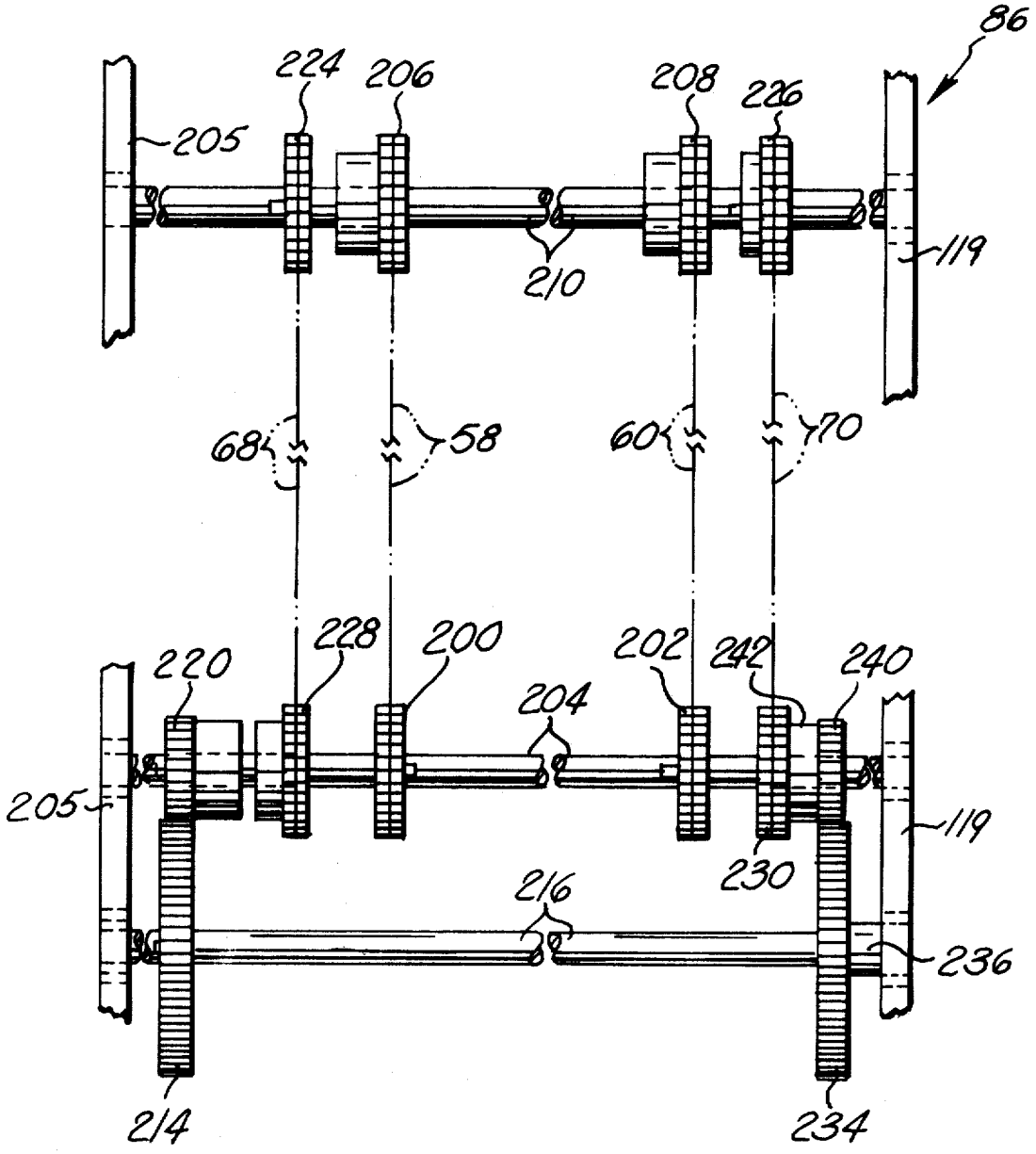

86
224
206
208
226
205
210
119
68
58
60
70
228
200
202
242
240
220
204
205
119
230
216
236
214
234

FIG. 7

FIG. 8

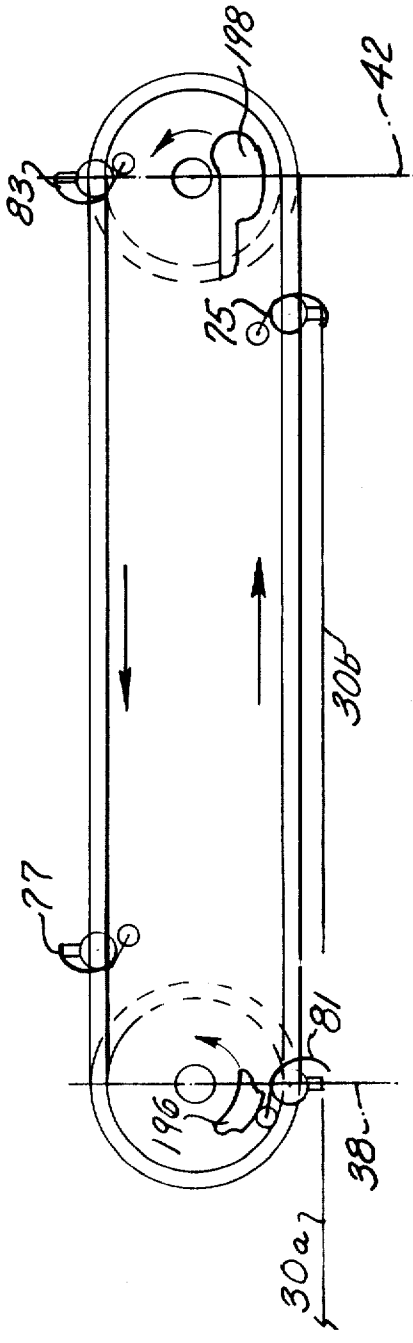


FIG. 9

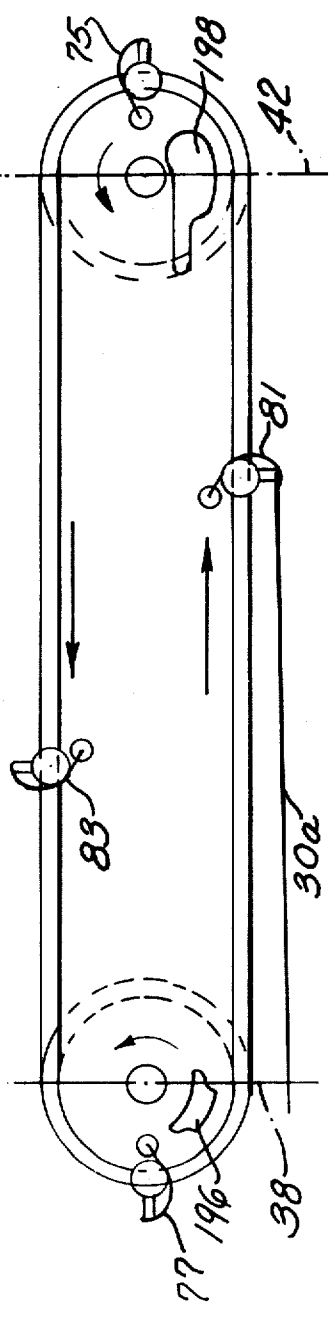
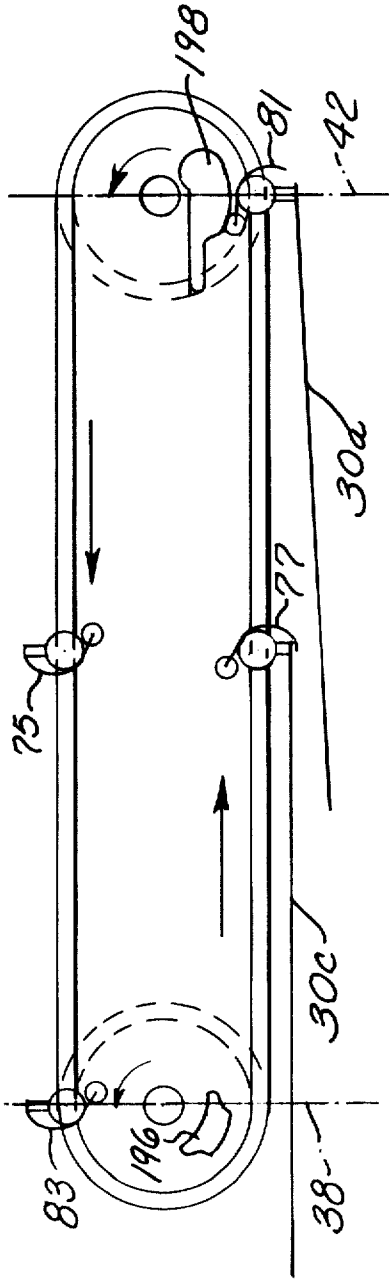


FIG 10



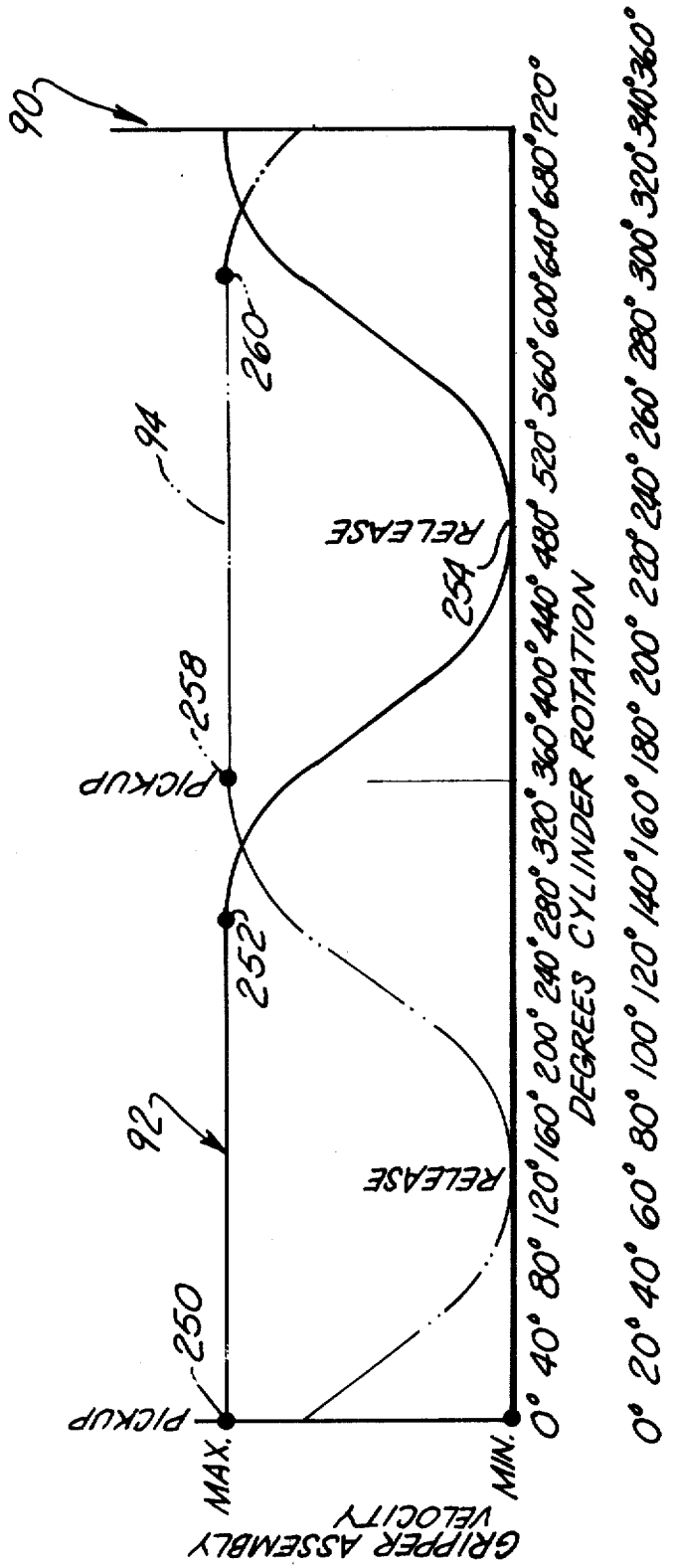

90
260
94
RELEASE
254
PICKUP
258
252
92
RELEASE
250
PICKUP
MAX.
MIN.
GRIPPER ASSEMBLY VELOCITY
0° 40° 80° 120° 160° 200° 240° 280° 320° 360° 400° 440° 480° 520° 560° 600° 640° 680° 720°
DEGREES CYLINDER ROTATION
0° 20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340° 360°
DEGREES CAM FOLLOWER DRIVE ROTATION

FIG. 11

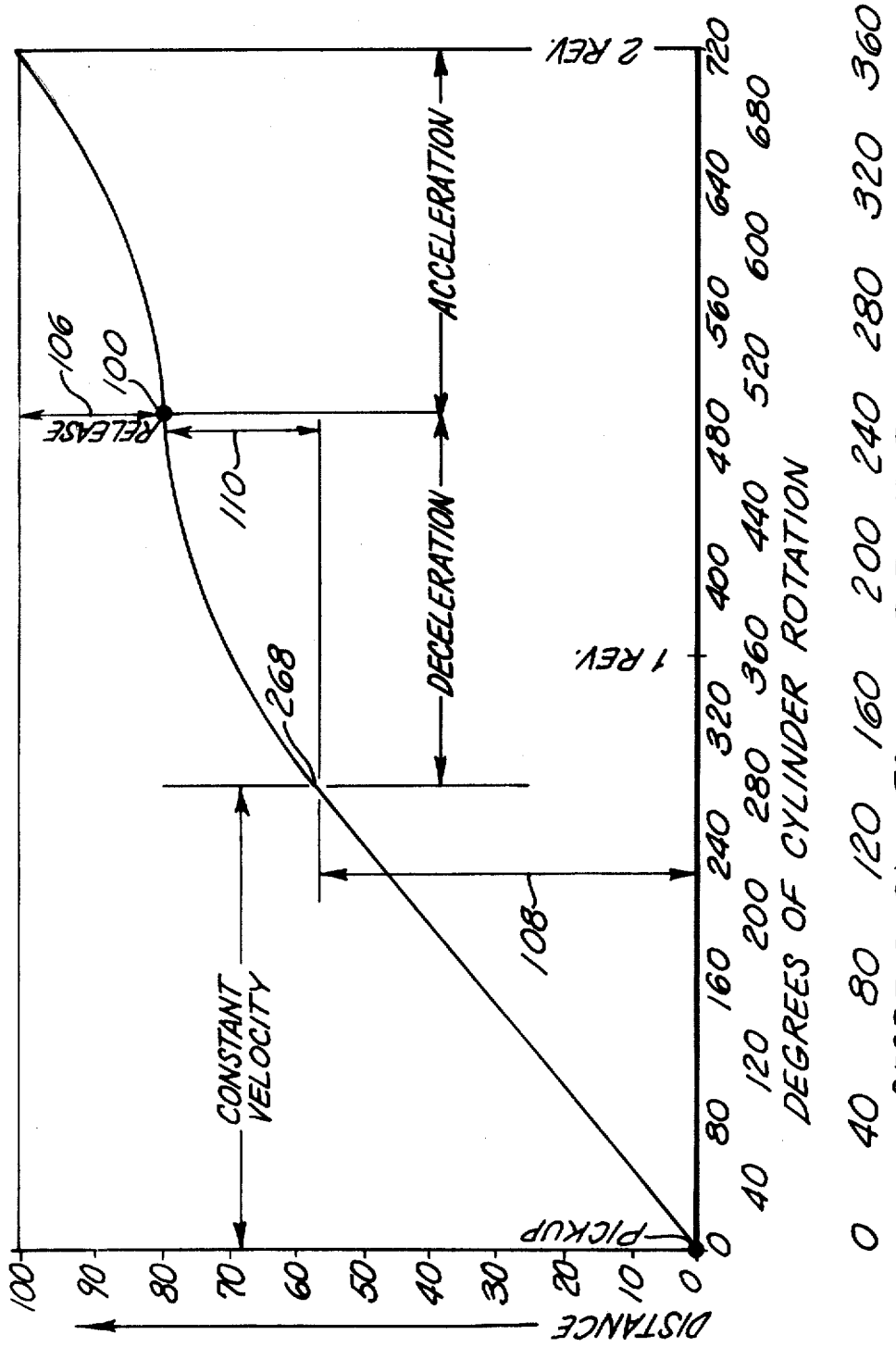

DISTANCE
100 90 80 70 60 50 40 30 20 10 0
PICKUP
RELEASE
106
100
110
268
108
CONSTANT VELOCITY
DECELERATION
ACCELERATION
1 REV.
2 REV.
0 40 80 120 160 200 240 280 320 360 400 440 480 520 560 600 640 680 720
DEGREES OF CYLINDER ROTATION
0 40 80 120 160 200 240 280 320 360
DEGREES CAM FOLLOWER DRIVE ROTATION

FIG. 12

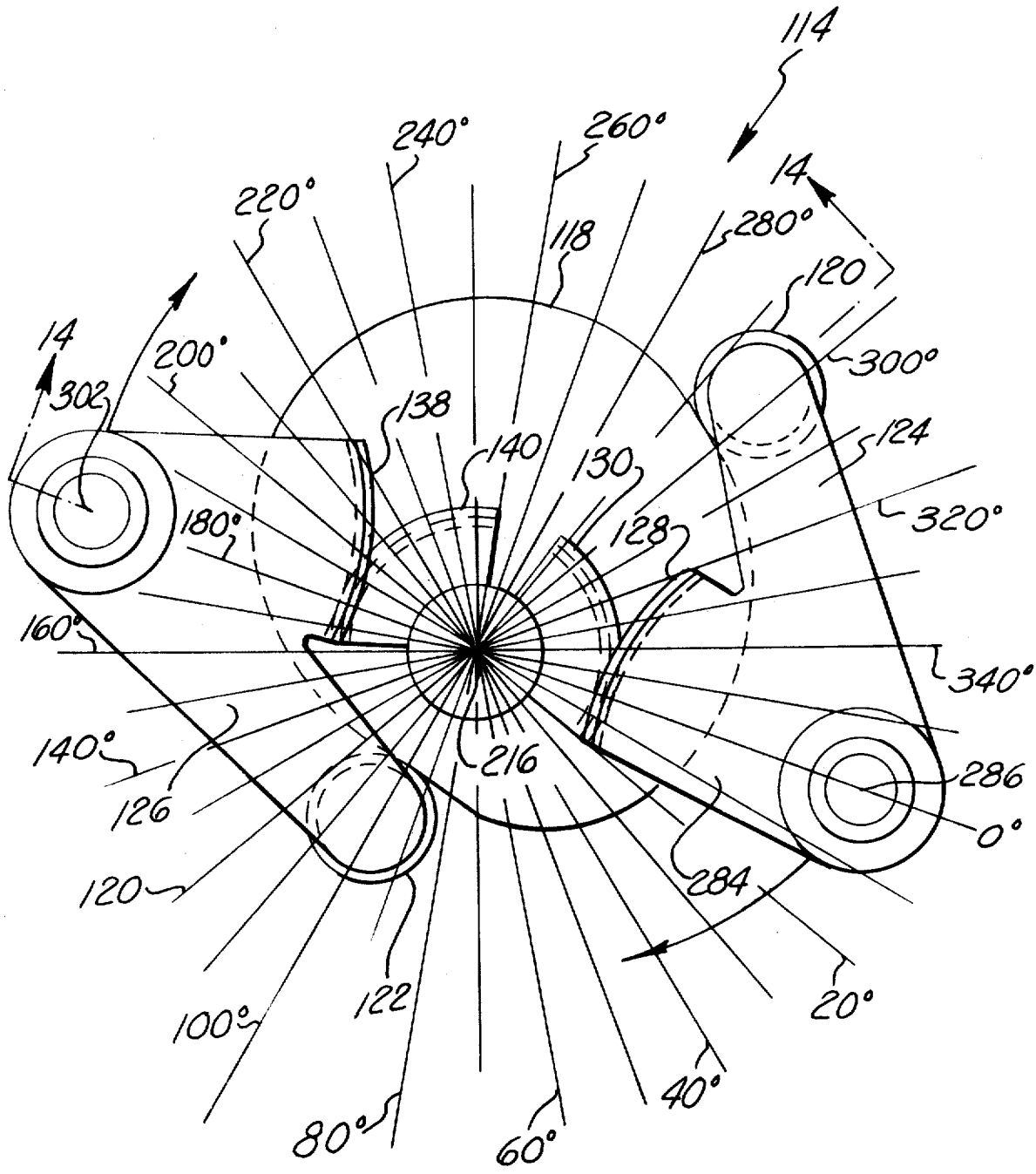

114
240°
260°
220°
118
280°
14
120
14
200°
300°
302
138
140
130
124
180°
128
320°
160°
340°
140°
216
286
126
0°
120
284
100°
122
20°
40°
80°
60°

FIG. 13

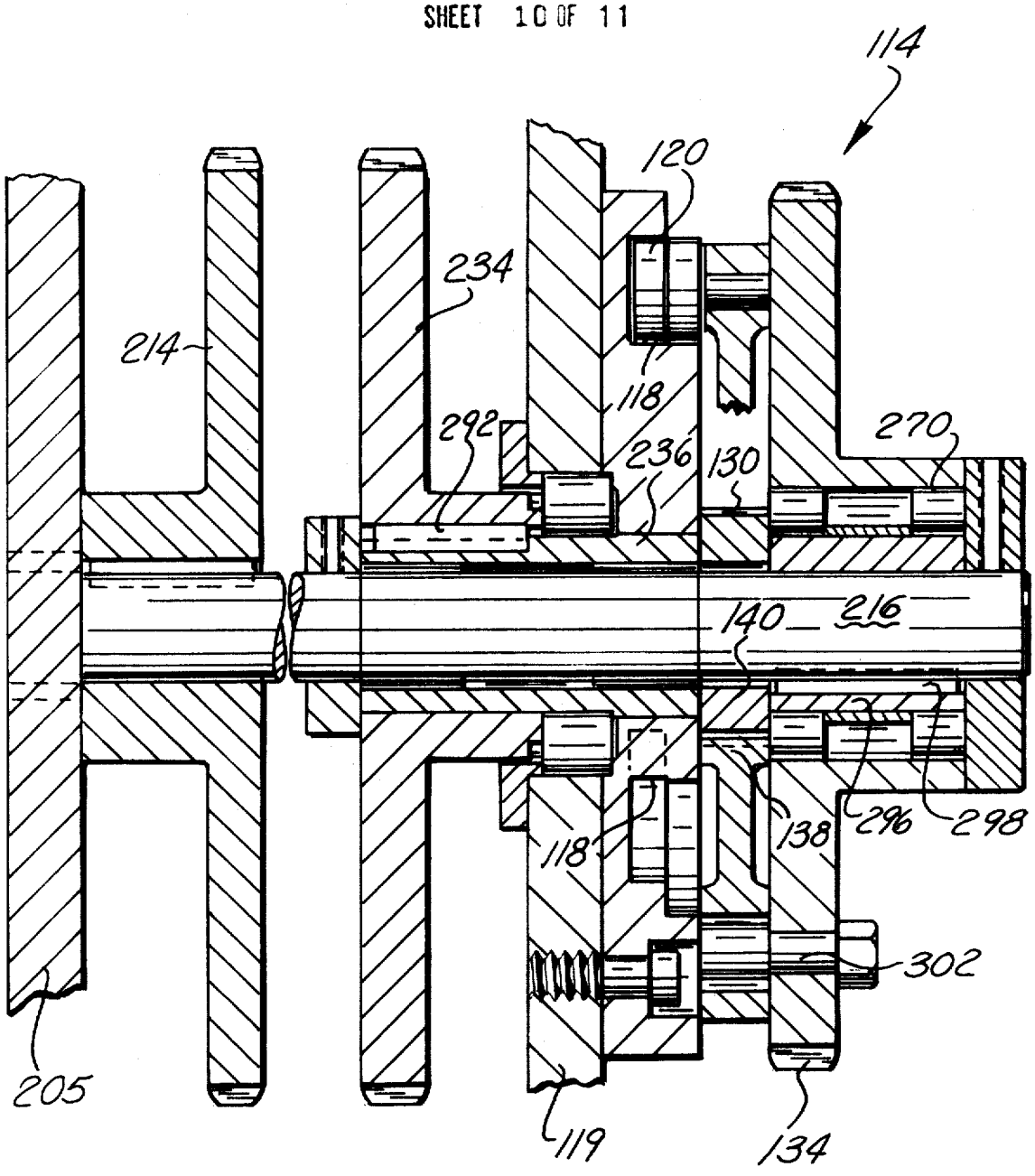

114
120
234
214
118
292
270
236
130
140
216
296
298
138
118
302
205
119
134

FIG. 14

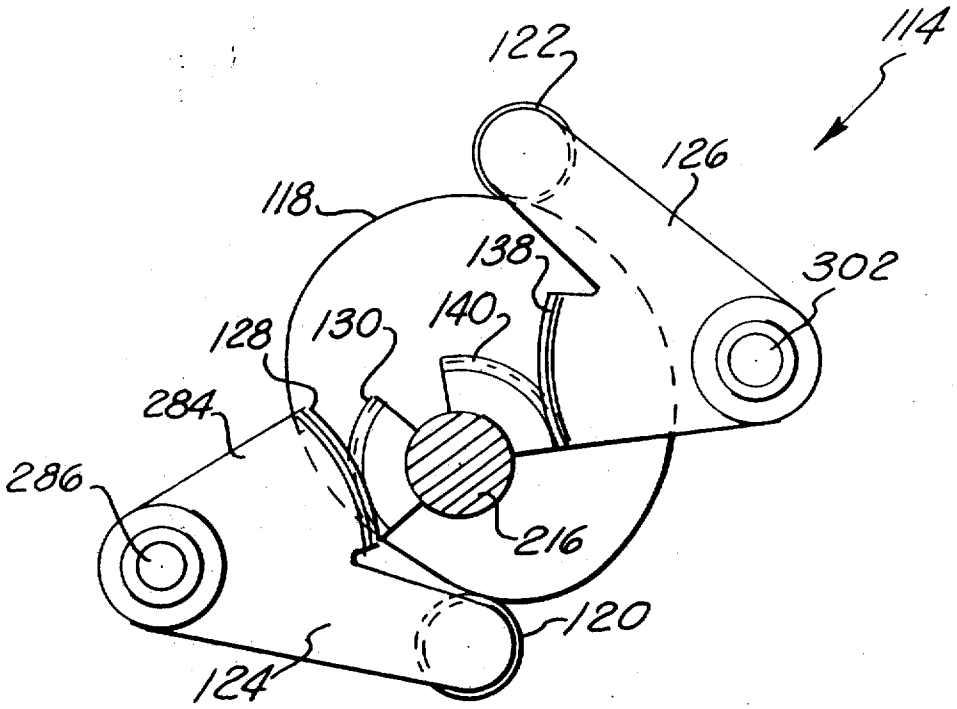

114
122
126
118
138
302
128
130
140
284
286
216
120
124

FIG. 15

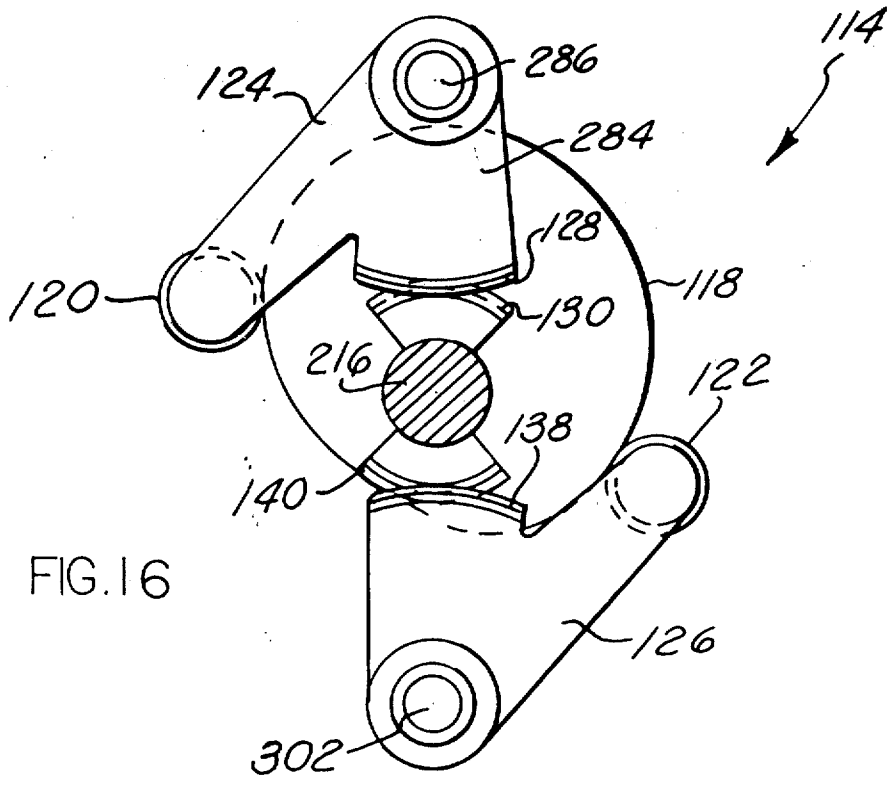

114
124
286
284
128
118
120
130
216
122
138
140
126
302

FIG. 16

SHEET MATERIAL HANDLING APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

This invention relates generally to a sheet handling apparatus and method and more specifically to an improved sheet slowdown apparatus and method.

Cartons have been manufactured from large sheets by cutting a sheet into carton blanks which are interconnected by narrow tabs. To prevent rupturing or breaking of the weak tabs, it is desirable to slow down or decelerate the sheets at a relatively low rate. In order to reduce the rate of deceleration, it is necessary to provide a relatively long period of time in which to decelerate each sheet in turn from the sheet feed speed to a relatively low speed at which it is deposited at a receiving station.

A known sheet slowdown apparatus for use in decelerating sheets which have been cut to form carton blanks is disclosed in U.S. Pat. No. 3,730,517. This known sheet handling apparatus includes a first or main conveyor which grips a sheet and moves it at a constant speed to a transfer station. At the transfer station a second or slowdown conveyor engages the sheet and decelerates it. The grippers of the slowdown conveyer are interconnected by a chain so that each slowdown gripper is decelerated to a low speed, opened to release an engaged sheet, and then accelerated back to the speed of the main conveyor during the time period between the arrival of the leading edge of one sheet at the transfer station and the arrival of the leading edge of a next succeeding sheet. The time period which elapses between arrival of the leading edges of successive sheets at the transfer station dictates the rate at which the grippers and the engaged sheet must be decelerated prior to depositing the sheet at the receiving station and the rate at which the grippers must be accelerated back to the speed of the main conveyor.

SUMMARY OF THE PRESENT INVENTION

The present invention provides a new and improved sheet slowdown method and apparatus which enables each sheet in turn to be decelerated over a relatively long period of time. This is accomplished by engaging a sheet at a pick up station with a gripper assembly of a first set of grippers, moving the gripper assembly and engaged sheet toward a receiving station, and decelerating the gripper assembly and engaged sheet during a period of time which is greater than the period of time between the arrival of the leading edges of succeeding sheets at the pickup station. To this end, the improved sheet material slowdown apparatus includes a plurality of sets of grippers which can be moved relative to each other so that a gripper assembly of one set of grippers and an engaged sheet can be decelerated while a next succeeding sheet is being moved at a constant speed by a gripper assembly of another set of grippers. An improved drive arrangement is advantageously utilized to provide the relative movement between gripper assemblies of one set of grippers and gripper assemblies of another set of grippers.

Accordingly, it is an object of this invention to provide a new and improved method and apparatus for sequentially moving sheets from a pickup station to a receiving station over a relatively long period of time to enable each sheet to be decelerated in turn at a relatively low rate.

Another object of this invention is to provide a new and improved sheet material handling method and apparatus for sequentially moving sheets from a pickup station to a receiving station under the influence of a drive assembly which is effective to move a leading sheet and a gripper assembly of a first set of grippers at a first speed while effecting movement of a next succeeding sheet and a gripper assembly of a second set of grippers at a second speed which is different than the first speed.

Another object of this invention is to provide a new and improved method and apparatus for sequentially moving sheets of material from a pickup station to a receiving station and wherein the speed of movement of one gripper is varied relative to the speed of movement of another gripper by varying the operating speeds of drive assemblies connected with the grippers.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and features of the present invention will become more apparent upon a consideration of the following description taken in connection with the accompanying drawings wherein:

FIG. **1** is a schematic illustration of a sheet material handling apparatus having a sheet slowdown assembly which is constructed and operated in accordance with the present invention;

FIG. **2** is a schematic illustration of the sheet slowdown assembly utilized in the sheet material handling apparatus of FIG. **1**;

FIG. **3** is an enlarged plan view of a portion of the sheet slowdown assembly of FIG. **2** and illustrating the relationship between inside and outside gripper drive chains and a gripper which is connected with the inside drive chain, the view being taken looking downwardly toward a horizontal upper run of the drive chains;

FIG. **4** is a plan view, generally similar to FIG. **3**, illustrating the relationship between the inside and outside drive chains and a gripper which is connected with the outside drive chains, the view being taken looking downwardly toward a horizontal upper run of the drive chains;

FIG. **5** is a sectional view, taken generally along the line **5—5** of FIG. **4**, illustrating the manner in which a mounting assembly for connecting a gripper with the outside drive chain extends across or spans the inside drive chain;

FIG. **6** is a sectional view, taken generally along the line **6—6** of FIG. **3**, illustrating the construction of one gripper assembly;

FIG. **7** is a schematic plan view illustrating the relationship between input gears and drive sprockets for moving the inside and outside drive chains;

FIG. **8** is a schematic illustration depicting the engaging of the leading end portion of a sheet at the pickup station and the decelerating of a preceding sheet;

FIG. **9** is a schematic illustration, generally similar to FIG. **8**, illustrating movement of the sheet which was engaged at the pickup station in FIG. **8** at a constant speed toward a receiving station;

FIG. **10** is a schematic illustration, depicting the releasing at the receiving station of the sheet engaged at the pickup station in FIG. **8** and the movement of a next succeeding sheet at a constant speed;

FIG. 11 is a graph depicting the variations in the velocity of movement of the grippers connected with the inside and outside drive chains;

FIG. 12 is a graph depicting the distances through which a gripper is moved at a constant speed, decelerated, and accelerated; FIG. 13 illustrates a drive assembly for moving the inside and outside drive chains and the gripper assemblies relative to each other, the drive assembly being shown in a position corresponding to the gripper positions illustrated in FIG. 8;

FIG. 14 is a sectional view, taken generally along the line 14—14 of FIG. 13, further illustrating the construction of the drive assembly;

FIG. 15 is an illustration, generally similar to FIG. 13, illustrating the drive assembly in a position corresponding to the gripper positions illustrated in FIG. 9; and

FIG. 16 is an illustration, generally similar to FIG. 13, illustrating the drive assembly in a position corresponding to the gripper positions illustrated in FIG. 10.

DESCRIPTION OF ONE SPECIFIC PREFERRED EMBODIMENT OF THE INVENTION

General Description

A sheet material handling apparatus 18 constructed in accordance with the present invention is illustrated in FIG. 1 and includes an improved sheet slowdown apparatus 20. The sheet slowdown apparatus 20 receives sheets from a rotary machine 22, in the present instance a cutter and creaser, having rotatable working cylinders 24 and 26. The working cylinders 24 and 26 are effective to cut carton blanks in sheets 30 supplied from a pile elevator 32. The carton blanks are interconnected by relatively weak or narrow tabs so that the sheet continues to move through the apparatus 18 as a unit even though the cutter and creaser 22 formed a plurality of carton blanks in the sheet.

Each time the working cylinders 24 and 26 rotate through one complete revolution a sheet is advanced by broke stripping cylinders 34 and 36 to a pickup station 38. The leading edge of each of the sheets is engaged in turn at the pickup station' 38 by the sheet slowdown apparatus 20. The engaged sheet is then moved to a receiving station 42 where it is deposited on a pile or stack 44.

In accordance with one feature of the present invention, the sheet slowdown apparatus 20 is effective to decelerate a leading sheet as it approaches the receiving station 42 while a next succeeding sheet is being moved at a constant speed. To enable two sheets to be simultaneously moved at different speeds by the sheet slowdown apparatus 20, the sheet slowdown apparatus includes two independently operable sets of grippers, that is an inside set of grippers 48 and an outside set of grippers 50 (FIG. 2). The inside set of grippers 48 includes two subsets of grippers 54 and 56 which are interconnected by a pair of drive chains 58 and 60. The outside set of grippers 50 includes two subsets of grippers 64 and 66 which are interconnected by outer drive chains 68 and 70.

Each of the subsets of grippers 54, 56, 64 and 66 includes a pair of gripper assemblies. Thus, the inner subset of grippers 56 includes two gripper assemblies 74 and 75 which are connected with the inner drive chains 58 and 60. The inner subset of grippers 54 is spaced half way around the chains 58 and 60 from the other inner subset of grippers 56. The inner subset of grippers 54 includes two gripper assemblies 76 and 77 which are connected with drive chains 58 and 60. The two chains 58 and 60 maintain a predetermined path length distance between the gripper assemblies 74 and 75 and the gripper assemblies 76 and 77.

Similarly, the outer subset of grippers 64 includes a pair of gripper assemblies 80 and 81 which are of the same construction as the gripper assemblies 74 and 75. The other outer subset of grippers 66 is spaced halfway around the chains 68 and 70 from the outer subset of grippers 64. The outer subset of grippers 66 includes two gripper assemblies 82 and 83. The chains 68 and 70 maintain a predetermined path length distance between the gripper assemblies 80 and 81 and the gripper assemblies 82 and 83.

The inside grippers 54 and 56 are movable relative to the outside grippers 64 and 66 to enable a sheet engaged by one set of grippers to be moved relative to a sheet engaged by the other set of grippers. To enable relative movement to occur between the inside and outside sets of grippers 48 and 50, a gripper chain drive arrangement 86 (see FIG. 7) is constructed so as to enable relative movement to occur between the inside drive chains 58 and 60 and the outside drive chains 68 and 70. Since relative movement can occur between the gripper drive chains, the different sets of grippers can be moved relative to each other.

The manner in which the different sets of grippers move relative to each other is illustrated schematically in FIG. 8 through 10. An outside gripper assembly 81 is illustrated schematically in FIG. 8 as being operated from an open condition to a closed position to engage a sheet 30*a* at the pickup station 38 while moving at the same speed at which the sheet is fed to the pickup station from the working cylinders 24 and 26 and the stripping cylinders 34 and 36. A preceding sheet 30b and inside gripper assembly 75 is illustrated schematically in FIG. 8 as being decelerated immediately prior to releasing of the sheet 30b at the receiving station 42.

Continued operation of the sheet slowdown apparatus 20 moves the gripper 81 and the sheet 30*a* along a horizontal path toward the receiving station 42 at a constant speed equal to the speed at which a sheet is fed to the pickup station 38 from the working cylinders 24 and 26. As the gripper 81 moves toward the receiving station 42 from the position shown in FIG. 9, the gripper is decelerated. When the gripper 81 reaches the position shown in FIG. 10, it is traveling at a predetermined minimum speed and opened to release the sheet 30*a* at the receiving station 42. It should be noted that while the outside gripper assembly 81 is being decelerated, the inside gripper assembly 77 engages a next succeeding sheet 30*c* at the pickup station 38 and moves the sheet 30*c* toward the receiving station 42 at a constant speed equal to the sheet feed speed from the working cylinders 24 and 26.

As a sheet 30*a* is moved from the pickup station 38 to the receiving station 42, the velocity of the outside grippers 64 and 66 are varied in the manner depicted in the graph 90 (FIG. 11) by the curve 92. As the velocity of the outside grippers 64 and 66 are being varied in the manner illustrated by the curve 92, the velocity of the inside grippers 54 and 56 are being varied in the manner illustrated by the curve 94 in FIG. 11. This results in each of the gripper assemblies being moved in turn along a forward path from the position occupied by the gripper assembly 81 in FIG. 8 to the position occupied by the gripper assembly 83 in FIG. 8 in the man-

ner depicted graphically in FIG. 12. Similarly, each of the gripper assemblies is moved in turn along a return path from the position occupied by the gripper assembly 83 in FIG. 8 to the position occupied by the gripper assembly 81 in FIG. 8 in the manner depicted graphically in FIG. 12.

Accordingly, after the gripper 81 has been opened to release the sheet 30*a* at the receiving station 42, the gripper 81 and the gripper 83, which are interconnected by the outside drive chain 70, are accelerated along an arcuate path length through a distance indicated at 106 in FIG. 12. When the gripper 83 reaches the pickup station 38, it is moving at a speed equal to the sheet feed speed of the cutter and creaser 22. The gripper 83 is operated to engage a sheet at the pickup station 38 and is moved at sheet feed speed along a horizontal path length through the distance indicated at 108 in FIG. 12. When the gripper 83 reaches the position in which the gripper 81 is shown in FIG. 9, the gripper 83 is decelerated as it continues to move along a horizontal path length, through the distance indicated graphically at 110 in FIG. 12, to the receiving station 42.

A gripper drive arrangement 114 for varying the speed of movement of the inside and outside grippers 54, 56, 64, and 66 in the manner depicted by the curves 92 and 94 in the graph 90 is illustrated in FIGS. 13 and 14. The drive arrangement 114 includes a stationary cam 118 which is fixedly connected to a side frame member 119. The cam 118 is engaged by cam followers 120 and 122 (FIG. 13). The cam followers 120 and 122 are disposed on follower arms 124 and 126 which are rotated about shaft 216 on an input gear 134. The input gear 134 is rotated at a rate which is equal to half of the rate at which the working cylinders 24 and 26 are rotated. An input gear segment 128 is connected with the cam follower 120 and cooperates with an output gear segment 130 to either accelerate or decelerate the outside sets of grippers 64 and 66. Similarly, an input gear segment 138 connected with the cam follower 122 cooperates with an output gear segment 140 to either accelerate or decelerate the inside sets of grippers 54 and 56.

The drive arrangement 114 is illustrated in FIG. 13 in a position in which the outside grippers 64 are positioned so that the gripper assembly 81 is being operated to engage the sheet 30*a* at the pickup station 38 in the manner illustrated schematically in FIG. 8. The drive arrangement 114 is illustrated in FIG. 15 in a position corresponding to the position of the gripper assembly 81 in FIG. 9. Finally, the drive arrangement 114 is shown in FIG. 16 in a position corresponding to the position of the gripper assembly 81 in FIG. 10.

Gripper Mounting

The inside set of grippers 48 is connected with the inside drive chains 58 and 60 for movement therewith relative to the outside set of grippers 50 which is connected with the outside drive chains 68 and 70. The post 149 of the left (as viewed in FIG. 2) inside gripper 74 is connected with post of the right (as viewed in FIG. 2) inside gripper 75 by a horizontal main connector bar 150 (see FIGS. 2, 3 and 6). In addition, an actuator bar 152 extends between a gripper finger 153 of the gripper assembly 74 and a gripper finger of the gripper assembly 75. The actuator bar 152 is rotatably mounted on a base 154 (see FIG. 3) which is fixedly connected with the main connector bar 150 and the inside chain 58. The gripper assembly 75 is connected with the inside chain 60 in the same manner as is illustrated in FIG. 3 in association with the gripper assembly 74. Therefore, upon movement of the two inside chains 58 and 60, the two gripper assemblies 74 and 75 are moved together along parallel paths.

The gripper assemblies 76 and 77 of the other inside subset of grippers 54 are connected with the inside chains 58 and 60 at locations spaced half of a chain length from the locations at which the gripper assemblies 74 and 76 are connected with the chains 58 and 60. The gripper assemblies 76 and 77 are connected with the inside chains 58 and 60 in the same manner as the gripper assemblies 74 and 75. Therefore, the two subsets of grippers 54 and 56 are maintained the same distance apart around the inside chains 58 and 60 and are moved at the same speed as the inside chains.

The outside subsets of grippers 64 and 66 are fixedly connected with the outside chains 68 and 70 for movement therewith. The outside gripper assembly 80 is connected with the outside gripper assembly 81 by a horizontal main connector bar or rod 158 (FIGS. 2 and 4) which extends parallel to the connector bar or rod 150 interconnecting the gripper assemblies 74 and 75. In addition, a rotatable actuator rod or bar 160 extends between the outside gripper assemblies 80 and 81 and is parallel to the connector rod 158.

The outside gripper assembly 80 is connected with the outside chain 68 by a bridge or spanner piece 164 which extends across the inside chain to the outside chain in the manner depicted in FIGS. 4 and 5. It should be noted that the spanner piece 164 is fixedly connected with the chain 68 by suitable pins 166 and 170 (FIG. 4) and does not engage the inside chain 58. Therefore, the inside chain 58 is free to move relative to the outside chain 68.

The inside chain 58 is supported for movement along a guide track 174 (FIG. 5) by a member 176 which is connected with the frame or base of the sheet slowdown apparatus. Similarly, the outside chain 68 is mounted for movement along a guide slot or track 180 formed in a support member or bar 182 which extends parallel to the support member 176 and is also connected with the frame of the sheet slowdown apparatus 20. Although only the mounting arrangement for the outside gripper assembly 80 has been illustrated in FIGS. 4 and 5, it should be noted that the other outside gripper assemblies 81, 82 and 83 are connected with the associated one of the outside chains 68 and 70 in the same manner. It should also be understood that although only the support arrangement for the upper runs of the chains 58 and 68 has been illustrated in FIG. 5, the upper and lower runs of all the gripper chains are supported in the same manner.

The gripper assembly 74 is of a known construction and includes the post 149 (FIG. 6) which is fixedly connected with the main support or connector bar 150. A gripper finger 153 is fixedly connected with the rotatable actuator shaft 152. Upon engagement with a roller 190 on an actuator arm 192 with a cam member 196 at the pickup station 38 (see FIG. 8) or a cam member 198 at the receiving station 42, the actuator arm 192 is pivoted in a counterclockwise direction (as viewed in FIG. 6) to move the gripper finger 153 away from the post 149 against the influence of a biasing spring (not shown) to open the gripper assembly 74. The rotatable actuator shaft 152 interconnects the gripper assemblies

74 and 75 so that upon opening of the gripper assembly 74, the gripper assembly 75 is also opened.

The other inside gripper assemblies 76 and 77 are simultaneously operated from the closed condition to the open condition by the cam 196, as the gripper assemblies approach the pickup station 38. The gripper assemblies 76 and 77 are then operated to the closed condition by their biasing springs as they move away from the pickup station to grippingly engage the leading end portion of a sheet between the gripper fingers 153 and posts 149 in a known manner. The gripper assemblies 76 and 77 are opened to release a sheet at the receiving station 42. The outside gripper assemblies 80–83 move along paths which are coincident with the paths of movement of the inside gripper assemblies 74–77. Therefore cams 196 and 198 are also effective to actuate the outside gripper assemblies.

Although the construction of only the gripper assembly 74 has been shown in FIG. 6, it should be understood that the gripper assemblies 75–77 and 80–83 are of the same construction as the gripper assembly 74 and are operated between the open and closed conditions in the same manner. Although it is contemplated that many different types of known gripper assemblies could be used, the construction of one specific preferred known type of gripper assembly is more fully illustrated in U.S. Pat. No. 3,730,517.

The chain drive assembly 86 (see FIG. 7) is effective to move the inside chains 58 and 60 at the same speed and to vary the speed of movement of the inside chains relative to the speed of movement of the outside chains 68 and 70 while moving the two outside chains at the same speed. Thus, the inside chains 58 and 60 extend around a pair of drive sprockets 200 and 202 which are fixedly keyed to a horizontal drive shaft 204 rotatably mounted on side frame members 119 and 205. The chains 58 and 60 extend from the drive sprockets 200 and 202 to a pair of idler sprockets 206 and 208 which are rotatably mounted on a horizontal shaft 210. The shaft 204 is driven by an inut gear 214 which is keyed to a horizontal drive shaft 216 and is disposed in meshing engagement with a drive gear 220 which is keyed to the shaft 204. Therefore, upon rotation of the input shaft 216, the input gear 214 is rotated to drive the gear 220. Rotation of the gear 220 rotates the shaft 204 and the two drive sprockets 200 and 202 to drive the inside chains 58 and 60 at the same speed.

The two outside chains 68 and 70 extend around a pair of drive sprockets 224 and 226 which are keyed to the shaft 210 on which the idler sprockets 206 and 208 are rotatably mounted. The two outside chains 68 and 70 extend from the drive sprockets 224 and 226 to a pair of sprockets 228 and 230. An input gear 234 for effecting movement of the drive chains 68 and 70 is fixedly connected with a sleeve 236 which is rotatably mounted on the shaft 216. The gear 234 is disposed in meshing engagement with a drive gear 240 formed on a sleeve 242 which is rotatably mounted on the shaft 204 and is fixedly connected with the sprocket 230.

Upon rotation of the input gear 234, the gear 240 is rotated to rotate the sproket 230. This causes the chain 70 to move and rotate the drive sprocket 226 which is fixedly keyed to the shaft 210. Rotation of the shaft 210 with the drive sprocket 226 results in rotation of the drive sprocket 224 and movement of the chain 68 in unison with the chain 70.

It should be noted that the drive sprockets 200 and 202 for the two inside chains are fixedly connected with the shaft 204 and are rotatable relative to the sprockets 228 and 230 connected with the outside drive chains 68 and 70. Similarly, the drive sprockets 224 and 226 for the outside chains 68 and 70 are fixedly connected with the shaft 210 and are rotatable relative to the sprockets 206 and 208 connected with the inside chains 58 and 60. Therefore, if the speed of rotation of the input gear 214 for the inside chains 58 and 60 is varied relative to the speed of rotation of the input gear 234 for the outside chains 68 and 70, the inside chains 58 and 60 will be accelerated or decelerated relative to the outside chains. Similarly, if the speed of rotation of the input gear 234 is varied relative to the speed of rotation of the input gear 214, the outside chains 68 and 70 will be either accelerated or decelerated relative to the inside chains 58 and 60. Thus, the mounting arrangement for the chains and gripper assemblies is such that a sheet engaged by one set of grippers, for example the inside set of grippers 48, can be decelerated as it approaches the receiving station 42 while a next succeeding sheet which is engaged by another set of grippers, for example the outside set of grippers 50, is being moved at a constant speed toward the receiving station 42.

When on set of grippers 48 or 50 is moved relative to another set of grippers, the path length distance between gripper assemblies in the two sets of grippers is varied. Thus, when the inside set of grippers 48 is being decelerated and the outside set of grippers is moving at a constant speed, the path length distance between the inside gripper assembly 75 and the outside gripper assembly 81 is decreased (see FIGS. 8 and 9). However, the chains 58, 60, 68, and 70 maintain the path length distance between gripper assemblies in each set of grippers constant.

Gripper Movement

The sheet slowdown apparatus 20 is effective to move each sheet received in turn from the cutter and creaser assembly 22 at the pickup station 38 to the receiving station 42. To prevent the rupturing or tearing of the relatively weak tabs sheet is decelerated over a relatively long period of time. This is accomplished by engaging the leading edge portion of a sheet at the pickup station 38 with grippers which are moving at the same surface speed at which the sheet is fed to the pickup station from the cutter and creaser 22. The grippers continue to move the engaged sheet at the same speed toward the receiving station 42. When the grippers are approaching the receiving station 42, the grippers are decelerated to a relatively slow speed and may even be stopped for an instant of time. The sheet is then released at the receiving station.

The time period during which the sheet is moved at a constant speed and decelerated is greater than the time period between the arrival of the leading edge portions of successive sheets at the pickup station 38. This means that before a sheet is released at the receiving station 42 by one set of grippers, the leading edge of the next succeeding sheet has been engaged at the pickup station 38 by another set of grippers. As the leading sheet is decelerated, the next succeeding sheet is moved away from the pickup station at a constant speed.

The sheet 30a is conveyed from the nip between the working cylinders 24 and 26 in the cutter and creaser

22 to the broke stripping cylinders 34 and 36 which feed the sheet to the pickup station 38. The stripping cylinders 34 and 36 are driven by a gear train at the same surface speed as the working cylinders 24 and 26. Therefore, the sheet feed rate or speed of movement of the sheet is maintained constant as it moves from the nip between the working cylinders 24 and 26 to the pickup station 38.

At the pickup station 38, the outside grippers 64 engage the leading edge portion of the sheet 30a in the manner illustrated schematically in FIG. 8. Thus, the gripper assembly 81 is opened by engagement of its actuator arm with the cam 196 as the gripper assembly approaches the pickup station 38. As the gripper assembly 81 reaches the pickup station 38, it is moving at a speed which is just slightly less than the speed at which the sheet 30a is approaching the pickup station so that leading end of the sheet moves into the open gripper assembly 81. At this time the open gripper assembly 81 is accelerated to the sheet feed speed so that it moves at the same speed as the sheet 30*a*. As the gripper assembly 81 and sheet 30*a* move away from the pickup station 38, the gripper assembly 81 is operated from the open condition illustrated schematically in FIG. 8 to the closed condition to grippingly engage the leading end portion of the sheet 30*a*. Of course, the gripper assembly 80 of the outside grippers 64 (see FIG. 2) is also opened and closed to engage the leading end portion of the sheet 30*a* at the pickup station 38.

Once the leading end portion of the sheet 30*a* has been engaged at the pickup station 38, the gripper assembly 81 is moved at a constant speed which is equal to the speed at which the sheet 30*a* is fed from the working cylinders 24 and 26 and stripping cylinders 34 and 36. When the trailing end of the sheet 30*a* has been moved to the pickup station and is clear of the nip between the stripping cylinders 34 and 36, the gripper assembly 81 is in the position illustrated in FIG. 9. Of course, the triling end of a somewhat shorter sheet would be advanced further than the trailing end of the sheet 30*a* when the gripper assembly 81 reaches the position shown in FIG. 9.

It should be noted that as the gripper assembly 81 is moving toward the receiving station 42 at a constant speed with the sheet 30*a*, the preceding sheet 30*b* is being decelerated to a minimum speed by the inside set of grippers 56. In fact, as the gripper assembly 81 is moving at a constant speed from the pickup station 38 toward the position shown in FIG. 9, the gripper assembly 75 is opened to deposit the preceding sheet 30*b* at the receiving station 42. During continued constant speed movement of the gripper assembly 81 toward the position shown in FIG. 9, the gripper assembly 65 is accelerated as it moves away from the receiving station 42.

Once the gripper assembly 81 has moved at a constant speed to the position indicated schematically in FIG. 9, the gripper assembly 81 is decelerated. Thus, as the gripper assembly 81 moves from the position shown in FIG. 9 to the position shown in FIG. 10 the speed of movement of the gripper assembly is decreased. As the gripper assembly 81 approaches the receiving station 42 at a very slow minimum speed, the gripper assembly 81 is operated to the open condition (see FIG. 10). As this occurs, the sheet 30*a* is deposited on the pile 44 at the receiving station 42.

While the gripper assembly 81 is being decelerated from the position shown in FIG. 9 to the position shown in FIG. 10, the leading end of the next succeeding sheet 30*c* arrives at the pickup station 38. As the leading end of the sheet 30*c* arrives at the pickup station 38, grippers 54 of the inside set of grippers 48 are moved to the pickup station 38 and engage the leading end portion of the sheet 30*c* while moving at sheet feed speed. Since the gripper assembly 81 and the sheet 30*a* are being decelerated at a relatively slow rate, the gripper assembly 77 of the inside grippers 54 approaches the outside gripper assembly 81 as the inside gripper assembly 77 moves the sheet 30*c* away from the pickup station 38 at a constant speed. It should be noted that the leading end of the sheet 30*c* moves into a lapped relationship with the trailing end of the sheet 30*a*.

After the gripper assembly 81 has been opened to deposit the sheet 30*a* at the receiving station 42, it is moved away from the receiving station and accelerated to the sheet feed speed as the gripper assembly 83 of the other outside set of grippers 66 approaches the pickup station to engage the sheet which immediately follows the sheet 30*c*. Thus, the inside and outside grippers 54, 56, 64, and 66 are alternately moved in turn to the pickup station to engage the leading end of each sheet and move the sheet to the receiving station 42. The deceleration rate of each sheet in turn is relatively low. In fact, the sheet 30*a* is moved at a constant speed and decelerated over a period of time which is greater than the period of time required for the working cylinders 24 and 26 to cut and crease the next succeding sheet 30*c*. This results in the arrival of the leading end of a next succeeding sheet 30*c* at the pickup station 38 before the preceding sheet 30*a* is deposited at the receiving station 42. This low deceleration rate tends to minimize breakage of the tabs interconnecting the carton blanks.

The velocity of the outside gripper assembly 81 in moving from the pickup station 38 to the receiving station 42 and away from the receiving station is illustrated by the curve 92 in FIG. 11 as a function of the degrees of rotation of one of the working cylinders 24 or 26. Thus, it is assumed that the working cylinder 24 is in a zero degree rotational position when the gripper assembly 81 is at the pickup station 38. At this time, the gripper assembly 81 has obtained its maximum velocity which is equal to the speed at which the sheet 30*a* is fed to the pickup station 38. This is represented by the point 250 on the curve 92 of the graph 90.

As the gripper assembly 81 moves away from the pickup station 38, the engaged sheet 30*a* and the gripper assembly are moved at a constant speed equal to the speed at which sheets are moved through the cutter and creaser 22. This constant speed is maintained until the gripper assembly 81 reaches the position shown schematically in FIG. 9 and indicated by the point 252 on the curve 92. The gripper assembly 81 is then decelerated until it has a minimum speed at the position shown in FIG. 10. The gripper assembly 81 is then opened to release or deposit the sheet 30*a* at the receiving station 42. The point at which the sheet 30*a* is released is indicated by the point 254 on the curve 92.

As the sheet 30*a* is moved from the pickup station 38 (indicated at 250 on the curve 92) to the receiving station 42 (indicated at 254 on curve 92), the cylinders 24 and 26 are rotated through approximately 500°. Thus, the working cylinders 24 and 26 are rotated through

more than a complete revolution as the sheet **30***a* is moved from the pickup station **38** to the receiving station **42.** Therefore, more time is utilized to move the sheet from the pickup station to the receiving station than is required for operating on the sheet with the working cylinders **24** and **26.** This provides a relatively long period of time in which the sheet can be slowed or decelerated from the sheet feed speed indicated by the point **252** to the stop condition indicated by the point **254.**

Since more than a complete revolution is required to move the sheet **30***a* from the pickup station to the receiving station, the next succeeding sheet **30***c* has moved to the pickup station **38** and is engaged by the inside grippers before the sheet **30***a* is released at the receiving station **42.** The velocity of the inside grippers **54** is indicated by the curve **94** in FIG. **11.** Thus, after the working cylinders **24** and **26** have rotated through 360° from the point at which the leading edge of the sheet **30***a* is engaged at the pickup station **38,** the leading edge of the next succeeding sheet **30***c* is at the pickup station **38** and is engaged by the grippers **54.** The point at which the sheet **30***c* is engaged at the pickup station **38** is indicated by the point **258** on the curve **94** in FIG. **11.** It should be noted that at the time the leading edge of the sheet **30***c* is engaged at the pickup station **38,** the outside grippers **64** have been decelerated to a speed which is less than the sheet feed speed.

As the succeeding sheet **30***c* is moved at a constant speed from the pickup station **38** toward the receiving station **42,** the outside grippers **64** are decelerated and actuated to release the sheet **30***a*. The speed of the inside grippers is decreased as the inside grippers **54** move away from the point indicated at **260** on the curve **94.** At this time, the outside grippers **64** are being accelerated back to the sheet feed speed. Of course, as the outside grippers **64** are being accelerated back to sheet feed speed, the opposite outside grippers **66** are approaching the pickup station **38** to engage a sheet which next succeeds the sheet **30***c*. Thus, the gripper assembly **83** will have moved from the position indicated in FIG. **10** to a position closely adjacent to, but short of, the pickup station **38.** Finally, after the working cylinders **24** and **26** have rotated through 720° or two revolutions from their position when the leading edge of the sheet **30***a* was engaged at the pickup station **38,** the outside grippers **66** move to the pickup station **38** to engage a sheet which next succeeds the sheet **30***c*.

During continued operation of the cutter and creaser **22,** each subset of grippers **54, 56, 64** and **66** is repetitively moved in turn from the pickup station **38** to the receiving station **42.** Thus, each sheet is engaged in turn at the pickup station **38,** moved at a constant speed, decelerated, and deposited at the receiving station. The time for deceleration of each sheet in turn is equal to approximately 210° of rotation of the work cylinders **24** and **26.** Thus, each sheet is decelerated during more than one half of a revolution of the work cylinders **24** and **26.** In addition, it should be noted that at no time are the gripper assemblies moved at a speed which is greater than the sheet feed speed. Thus, the substantially constant speed at which the gripper assemblies are moved, which is equal to sheet feed speed, is the maximum speed obtained by the gripper assemblies.

The relative distances through which the sets of grippers are moved at a constant speed, decelerated and accelerated are indicated graphically in FIG. **12.** Thus, when a sheet is picked up by the origin in FIG. **12,** it is moved at a constant speed through a distance **108,** which is greater than the length of the sheet, to a point indicated at **268** in FIG. **12.** The sheet is then decelerated through a distance **110** until it is released at a point indicated at **100** in FIG. **12.** The gripper assembly is then accelerated through a distance **106** back to pickup speed so that the next set of grippers connected with the same drive chain are moving at sheet feed speed to engage a sheet at the pickup station **38.**

Gripper Drive Mechanism

The drive mechanism **114** is operable to move the inside set of grippers **48** and the outside set of grippers **50** relative to each other to enable one of the sets of grippers to move at a constant speed while the other set of grippers is being decelerated or accelerated in the manner previously explained. The drive mechanism **114** has an input gear **134** (see FIG. **14**) which is rotatably mounted on bearings **270** and is driven through a drive train **271** (see FIG. **1**) at a rotational speed which is equal to one half of the rotational speed of the working cylinders **24** and **26.** Thus, for every two revolutions of the working cylinders **24** and **26** the gear **134** is driven through one complete revolution.

The cam followers **120** and **122** (see FIG. **13**) are mounted on the input gear **134** at locations which are 180° apart and are moved through one revolution about the stationary cam **118** each time the working cylinders **24** and **26** move through two complete revolutions. As the cam follower **120** moves about the stationary cam **118,** the gear segments **128** and **130** are actuated to either accelerated or decelerate the outside set of grippers **50** so that they move with the velocity indicated by the curve **92** in FIG. **11.** Similarly, the cam follower **122** cooperates with the cam **118** to actuate the gear segments **138** and **140** to accelerate and decelerate the inside set of grippers **58** in the manner indicated by the velocity curve **94** in FIG. **11.**

The two gripper velocity curves **92** and **94** have a maximum velocity which is greater than a velocity corresponding to the clockwise (as viewed in FIG. **13**) speed of rotation of the input gear **134.** In addition, the two gripper velocity curves have a minimum velocity which is less than a velocity corresponding to the clockwise (as viewed in FIG. **13**) speed of rotation of the input gear **134.** The increase in the velocity of the gripper assemblies over the velocity corresponding to the speed of rotation of the input gear **134** is obtained by inward movement of the cam followers **121** and **122** and counterclockwise rotation of the gear segments **128** and **138** (as viewed in FIG **13**). This movement of the gear segments **128** and **138** advances the output gear segments **130** and **140** in the clockwise direction (as viewed in FIG. **13**) relative to the input gear **134.** Similarly, the decrease in the velocity of movement of the gripper assemblies to a velocity below the velocity corresponding to the speed of rotation of the input gear **134** is obtained by outward movement of the cam followers **120** and **122.** This results in a retarding of clockwise movement of the output gear segments **130** and **140** (as viewed in FIG. **13**).

The cam follower **120** and the arcuate gear segments **128** and **130** are connected with the drive gear **234** through the sleeve **236** (see FIGS. **7** and **14**). The gear

segments **128** is mounted on the input gear **134** through a segment arm **284** which is pivotally connected by a pin **286** to the input gear **123.** If there was no relative movement between the gear segments **128** and **130,** the rotation of the input gear **134** and gear segments **128** about the center of the shaft **216** would effect rotation of the chain drive gear **234** at the same rotational speed as the input gear. This is because the gear segment **128** is disposed in meshing engagement with the gear segment **130.** The gear segment **130** is in turn integrally formed with the sleeve **236** which is fixedly connected with the gear **234** by a key **292.**

Since the input gear **134** and gear segments **128** are rotated in a clockwise direction (as viewed in FIG. **13**) about the center of the shaft **216,** if the gear segment **128** moves in a counterclockwise direction (as viewed in FIG. **13**) about the pivot connection **286** with the input gear **234,** the speed of rotation of the gear segment **130** in a clockwise direction (as viewed in FIG. **13**) in increased. This results in an increase in the speed at which the gear **234** and outside drive chains **68** and **70** are driven. Similarly, if the gear segment **128** is moved in a clockwise direction about the pivot connection **286,** the speed of clockwise rotation of the output gear segment **230** is reduced to thereby decrease the rotational speed of the gear segment **130** and the speed at which the gear **234** is driven. Of course, this effects a decrease in the speed at which the outside gripper chains **68** and **70** are moved.

Similarly, the gear segments **138** and **140** cooperate to either increase or decrease the speed of rotation of the gear **214** and the speed of movement of the inside gripper drive chains **58** and **60.** The gear segment **140** is integrally formed with a sleeve **296** (FIG. **14**) which is fixedly connected with the shaft **216** by a key **298.** Since the chain drive gear **214** is also fixedly keyed to the shaft **216** (see FIG. **7**), the rate of rotation of the gear **214** can be varied by varying the speed of rotation of the gear segment **140.** When the gear segment **138** is pivoted in a counterclockwise direction (as viewed in FIG. **13**) about a pivot pin **302,** the speed of rotation of the output gear segment **140** in a clockwise direction is increased to thereby increase the speed of rotation of the gear **214** and the speed of movement of the inside gripper drive chains **58** and **60.** Similarly, if the gear segment **138** is moved in a clockwise direction about the pivot pin **302** (as viewed in FIG. **13**), the speed of rotation of output gear segment **140** in a clockwise direction is decreased to thereby decrease the speed at which the gear **214** is rotated with a resulting decrease in the speed of movement of the inside gripper chains **58** and **60.**

Since the input gear **134** is rotated at one half the rotational speed of the working cylinders **24** and **26,** the pivot connections **286** and **302** are rotated in a clockwise direction (as viewed in FIG. **13**) at a rotational speed which is euqal to one half of the rotational speed of the working cylinders.

To effect movement of the outside grippers **64** and **66** at a constant speed equal to sheet feed speed, it is necessary for the cam follower **120** to move inwardly at a constant rate, that is in a counterclockwise direction (as viewed in FIG. **13**) about the pivot connection **286,** to advance the output gear segment **130** in a clockwise direction (as viewed in FIG. **13**). Since the speed of the outside sets of grippers **64** and **66** remains constant as they move from the point indicated at **250** to the point indicated at **252** on the curve **92** (FIG. **11**), the cam follower **120** moves inwardly at a constant rate during the first 140° of rotation of the input gear **134** about the cam **118.** As this occurs, the cam follower **120** moves from the position shown in FIG. **13** to the position shown in FIG. **15.** This 140° of rotation of the cam follower **120** about the stationary cam **118** corresponds to 280° of rotation of the working cylinders **24** and **26.**

When the outside sets of grippers **64** and **66** are to be decelerated from the point indicated at **252** to the point indicated at **254** on the curve **92** in FIG. **11,** the cam follower **120** is moved inwardly at a decreasing rate until the minimum diameter portion of the cam **118** is engaged by the cam follower **120.** At the instant when this occurs, the gear segment **130** is rotating at the same rotational speed as the input gear **134.** Further deceleration of the outside grippers **64** and **66** requires that the cam follower **120** moves outwardly, that is to pivot in a clockwise direction (as viewed in FIGS. **13** and **15**) about the pivot connection **286** to reduce the speed of rotation of the gear segment **130** in a counterclockwise direction. This retarding of counterclockwise rotation of the gear segment **130** effects a further deceleration of the outside grippers **64** and **66** until they reach the minimum velocity condition represented by the point **254** in FIG. **11.**

It should be understood that the speed of rotation of the outside chain sprockets **230, 226, 224** and **228** (FIG. **7**) varies as a direct function of variations in the speed of rotation of the gear segment **130.** Therefore, when the speed of counterclockwise (as viewed in FIG. **13**) rotation of the gear segment **130** about the central axis of the shaft **216** is reduced, the velocity of the outside drive chains **68** and **70** is reduced. Of course, this results in a reduction in the velocity at which the outside set of grippers **50** are driven.

The velocity of the outside set of grippers **50** is decreased from sheet feed speed, indicated at the point **252** in FIG. **11,** to a minimum velocity which is substantially zero velocity, indicated by the point **254** in FIG. **11,** during **110** degrees of rotation of the input gear **134.** This moves the cam follower **120** from the position shown in FIG. **15** to the position shown in FIG. **16.** Thus, when the outside gripper **81** moves from the pickup station **38** (FIG. **8**) to the receiving station **42** (FIG. **10**), the input gear and cam follower **120** move through **250** degrees from the position shown in FIG. **13** to the position shown in FIG. **16.** As this is occurring, the working cylinders **24** and **26** are rotated through 500°.

As the outside grippers **64** and **66** and outside chains **68** and **70** are accelerated from the minimum velocity condition, that is the point indicated at **254** on the curve **92** in FIG. **11,** back toward sheet feed speed, the rate at which the cam follower **120** is moved outwardly, that is pivoted in a clockwise direction about the connection **286,** is gradually decreased until the cam follower **120** engages the maximum diameter portion of the cam **118.** At the instant when this occurs, the gear segment **130** is rotating at the same speed as the input gear **134.** The cam follower **120** then begins to move inwardly to again accelerate the gear segment **130** in a clockwise direction (as viewed in FIG. **13**). The rate of inward movement of the cam follower **120** increases until the velocity of the outside chains **68** and **70** and

set of grippers **50** reach a speed which is equal to sheet feed speed.

The cam follower **122** cooperates with the cam **118** to effect operation of the gear segments **130** and **140** to either accelerate or decelerate the inside sets of grippers **54** and **56** in the same manner as previously explained in connection with the cam follower **120** and gear segments **128** and **130.** It should be noted that the connection **302** associated with the cam follower **122** is 180° out of phase with the pivot connection **286** for the cam follower **120.** This results in the speed of movement of the outside grippers **64** and **66** being varied in the manner indicated by the curve **92** in FIG. **11** while the speed of movement of the inside grippers **54** and **56** is varied in the manner indicated by the curve **94** in FIG. **11.**

In view of the foregoing description, it can be seen that the sheet slowdown apparatus **20** enables each of the sheets **30** in turn to be decelerated over a relatively long period of time. This is accomplished by engaging a sheet **30** at the pickup station **38** with a gripper assembly, moving the gripper assembly toward a receiving station **42,** and decelerating the gripper assembly during a time period which is greater than the period of time between the arrival of succeeding sheets at the pickup station. To enable one sheet of material to be moved away from the pickup station at a constant speed while another sheet of material is being decelerated, the inside set of grippers **48** and outside set of grippers **50** are movable relative to each other. The gripper drive assembly **114** includes a plurality of cam followers and gear segments which cooperate in such a manner as to effect the desired relative movement between the inside set of grippers **48** and the outside set of grippers **50.**

Although the sheet slowdown apparatus **20** has been disclosed herein in association with a cutter and creaser **22,** it is contemplated that the sheet slowdown apparatus could be used in other environments. For example, the sheet slowdown apparatus could be utilized in association with printing press having working cylinders which are rotated to print on each of a plurality of sheets in turn. In addition, it should be understood that the specific construction of the grippers and their mounting assemblies could be varied from the illustrated construction. Of course, the gripper chains **58, 60, 68** and **70** could be replaced by other known devices which are capable of moving the grippers and maintaining a predetermined path distance between the grippers of each set of grippers. It is contemplated that the construction of the drive mechanism **114** and the manner in which it is connected with the gripper drive chains could be varied if desired. It is further contemplated that the specific manner in which the velocity of the grippers is varied could be changed from that represented by the curves **92** and **94** in FIG. **11.** In fact, the curves **92** and **94** should be considered as merely illustrating one specific preferred manner in which the velocity of the grippers could be varied.

It should be further understood that additional grippers could be added to each set of grippers such that each gripper and the sheet engaged thereby would travel through almost two cycles of the motion as illustrated in FIG. **12** before releasing the sheet at the receiving station **42** to provide a point substantially midway between the pickup and receiving stations at which the sheet would be stationary to permit an additional operation to be performed on the sheet prior to delivery of the sheet at the receiving station.

Having described one specific preferred embodiment of the invention, the following is claimed:

1. An apparatus for sequentially operating on sheets of material and depositing each of the sheets of material in turn at a receiving station, said apparatus comprising a first set of grippers, said first set of grippers including a plurality of spaced apart gripper assemblies, means for supporting said gripper assemblies of said first set of grippers for sequential movement along a path extending between the pickup station and the receiving station, means for maintaining a predetermined path length distance between said gripper assemblies of said first set of grippers, a second set of grippers, said second set of grippers including a plurality of gripper assemblies disposed along the path and interspersed between gripper assemblies of said first set of grippers, means for maintaining said predetermined path length distance between said gripper assemblies of said second set of grippers, means for enabling variations to occur in the path length distance between gripper assemblies of said first set of grippers and gripper assemblies of said second set of grippers, means for sequentially operating said gripper assemblies to sequentially engage sheets of material at the pickup station and to sequentially release the engaged sheets of material at the receiving station, and drive means for sequentially moving said gripper assemblies along the path, said drive means including means for varying the speed of movement of said gripper assemblies of one of said sets of grippers relative to the speed of movement of said gripper assemblies of the other of said sets of grippers.

2. An apparatus as set forth in claim **1** wherein said drive means includes means for decreasing the speed of movement of said first set of grippers along the path while maintaining the speed of movement of said second set of grippers along the path substantially constant to thereby decelerate a leading sheet engaged by said first set of grippers relative to a next succeeding sheet engaged by said second set of grippers.

3. An apparatus as set forth in claim **1** wherein said means for maintaining a predetermined path length distance between each of said gripper assemblies of said first set of grippers includes first chain means for interconnecting said gripper assemblies of said first set of grippers, said means for maintaining a predetermined path length between said gripper assemblies of said second set of grippers including second chain means for interconnecting said gripper assemblies of said second set of grippers, said drive means including means for moving said first and second chain means and means for varying the speed of movement of said first and second chain means relative to each other.

4. An apparatus as set forth in claim **3** wherein said means for moving said first and second chain means includes a first sprocket disposed in meshing engagement with said first chain means and a second sprocket disposed in meshing engagement with said second chain means, said first and second sprockets being disposed in a coaxial relationship, said means for varying the speed of movement of said first and second chain means including means for varying the speed of rotation of one of said sprockets relative to the speed of rotation of the other of said sprockets.

5. An apparatus as set forth in claim **1** wherein said drive means includes a rotatable input member, means

for rotating said input member at a substantially constant speed, a first rotatable output member connected with said first set of grippers, a second rotatable output member connected with said second set of grippers, and means for varying the speed of rotation of said first and second output members relative to each other and to said input member.

6. A sheet material handling apparatus for sequentially slowing down and depositing at a receiving station sheets of material engaged at the pickup station, said apparatus comprising first and second gripper assemblies each of which is operable from an open condition to a closed condition to sequentially grip sheets of material at the pickup station and operable from the closed condition to the open condition to sequentially release gripped sheets of material at the receiving station, support means for supporting said first and second gripper assemblies for movement along a path extending between the pickup and receiving stations and for enabling said first and second gripper assemblies to move relative to each other along the path, control means for effecting operation of said first and second gripper assemblies in turn from their open conditions to their closed conditions to sequentially grip sheets of material at the pickup station, for enabling said first and second gripper assemblies to remain in the closed condition as they move in turn from the pickup station to the receiving station and for sequentially effecting operation of said first and second gripper assemblies from the closed condition to the open condition to sequentially release gripped sheets of material at the receiving station, first drive means for moving said first gripper assembly along the path from the pickup station to the receiving station, second drive means for moving said second gripper assembly along the path from the pickup station to the receiving station, and means for varying the speed of operation of one of said drive means relative to the speed of operation of said other drive means to vary the speed of movement of one of said gripper assemblies along the path relative to the speed of movement of the other of said gripper assemblies along the path.

7. An apparatus as set forth in claim 6 wherein said means for varying the speed of operation of one of said drive means relative to the speed of operation of the other of said drive means includes means for decreasing the speed of operation of said first drive means to decrease the speed of movement of said first gripper assembly along the path while maintaining the speed of operation of said second drive means and the speed of movement of said second gripper assembly along the path substantially constant to thereby decelerate a leading sheet engaged by said first gripper assembly relative to a next succeeding sheet engaged by said second gripper assembly.

8. An apparatus as set forth in claim 7 wherein said means for varying the speed of operation of one of said drive means relative to the speed of operation of the other of said drive means includes means for increasing the speed of operation of said first drive means to increase the speed of movement of said first gripper assembly after operation of said first gripper assembly to the open condition to release the leading sheet at the receiving station and for maintaining the speed of operation of said second drive means and the speed of movement of said second gripper assembly substantially constant during at least a portion of the time period in which the speed of operation of said first drive means and the speed of movement of said first gripper assembly are being increased.

9. An apparatus as set forth in claim 6 wherein said first drive means includes first chain means for effecting movement of said first gripper assembly, said second drive means include second chain means for effecting movement of said second gripper assembly, said means for varying the speed of operation of one of said drive means relative to the speed of operation of the other of said drive means including means for varying the speed of movement of said first and second chain means relative to each other.

10. An apparatus as set forth in claim 6 wherein said first drive means includes a first sprocket disposed in meshing engagement with said first chain means, said second drive means includes a second sprocket disposed in meshing engagement with said second chain means, said first and second sprockets being disposed in a coaxial relationship, said means for varying the speed of movement of said first and second chain means including means for varying the speed of rotation of one of said sprockets relative to the speed of rotation of the other of said sprockets.

11. An apparatus as set forth in claim 6 wherein said means for varying the speed of operation of one of said drive means relative to the speed of operation of the other of said drive means includes means for decreasing the speed of movement of said one gripper assembly while maintaining the speed of movement of said other gripper assembly substantially constant and for decreasing the speed of movement of said other gripper assembly while maintaining the speed of movement of said one gripper assembly substantially constant.

12. An apparatus as set forth in claim 6 wherein said means for varying the speed of operation of one of said drive means relative to the speed of operation of the other of said drive means includes a rotatable input member, means for rotating said input member at a substantially constant speed, a first rotatable output member connected with said first drive means, a second rotatable output member connected with said second drive means, and means for varying the speed of rotation of said first and second output members relative to each other and to said input member.

13. An apparatus as set forth in claim 12 wherein said means for varying the speed of rotation of said first and second output members relative to each other includes a cam, a first cam follower disposed in engagement with said cam, first gear means for connecting said first cam follower with said first output member, a second cam follower disposed in engagement with said cam, and second gear means for connecting said second cam follower with said second output member, said cam and first and second cam followers being movable relative to each other to effect operation of said first and second gear means to thereby vary the speed of rotation of said first and second output members relative to each other.

14. An apparatus as set forth in claim 13 wherein said first gear means includes a first arcuate gear segment connected with said first cam follower and a second arcuate gear segment connected with said first output member and disposed in meshing engagement with said first gear segment, said first cam follower being movable under the influence of said cam to effect relative movement between said first and second gear seg-

ments, said second gear means including a third arcuate gear segment connected with said second cam follower and a fourth arcuate gear segment connected with said second output member and disposed in meshing engagement with said third gear segment, said second cam follower being movable under the influence of said cam to effect relative movement between said third and fourth gear segments.

15. A sheet material handling apparatus for sequentially slowing down and depositing at a receiving station sheets of material received at a pickup station from a machine having at least one rotatable cylinder which operates on each of the sheets in turn while they are moving at a predetermined speed, said apparatus comprising a first gripper assembly, means for operating said first gripper assembly to engage a leading sheet at the pickup station, first chain means for moving said first gripper assembly along a path extending between the pickup and receiving stations, means for operating said first gripper assembly to deposit the leading sheet at the receiving station, a second gripper assembly, means for operating said second gripper assembly to engage a trailing sheet at the pickup station, second chain means spaced apart from said first chain means for moving said second gripper assembly along a path extending between the pickup and receiving stations, means for operating said second gripper assembly to deposit the trailing sheet at the receiving station, first drive means for decelerating said first chain means, said first gripper assembly and the leading sheet prior to depositing of the leading sheet at the receiving station, and second drive means for moving said second chain means, said second gripper assembly and the trailing sheet at the predetermined speed along a portion of the path during deceleration of said first chain means, said first gripper assembly and the leading sheet.

16. An apparatus as set forth in claim **15** wherein said first drive means includes means for accelerating said first chain means and said first gripper assembly after depositing the leading sheet at the receiving station and during movement of said second chain means, said second gripper assembly and the trailing sheet at the predetermined speed.

17. An apparatus as set forth in claim **15** further including a rotatable input shaft, means for rotating said input shaft at a speed which varies as a function of the speed of rotation of the machine cylinder, said first drive means including a rotatable output shaft connected with said first chain means and said first gripper assembly, and means for transmitting drive forces from said input shaft to said output shaft to effect rotation of said output shaft and for varying the speed of rotation of said output shaft relative to the speed of rotation of said input shaft to effect movement of said first chain means and said first gripper assembly at the predetermined speed and to effect deceleration of said first gripper assembly.

18. An apparatus as set forth in claim **17** wherein said second drive means includes a second rotatable output shaft connected with said second chain means and said second gripper assembly, and means for transmitting drive forces from said input shaft to said second output shaft to effect rotation of said second output shaft and for varying the speed of rotation of said second output shaft relative to the speed of rotation of said input shaft to effect movement of said second chain means and said second gripper assembly at the predetermined speed and to effect deceleration of said second chain means and said second gripper assembly.

19. An apparatus for sequentially operating on sheets of material and depositing each of the sheets of material in turn at a receiving station, said apparatus comprising a first set of grippers, said first set of grippers including a plurality of spaced apart gripper assemblies, means for supporting said gripper assemblies of said first set of grippers for sequential movement along a path extending betw4en the pickup station and the receiving station, means for maintaining a predetermined path length distance between said gripper assemblies of said first set of grippers, a second set of grippers, said second set of grippers including a plurality of gripper assemblies disposed along the path and interspersed between gripper assemblies of said first set of grippers, means for maintaining said predetermined path length distance between said gripper assemblies of said second set of grippers, means for enabling variations to occur in the path length distance between gripper assemblies of said first set of grippers and gripper assemblies of said second set of grippers, means for sequentially operating said gripper assemblies to sequentially engage sheets of material at the pickup station and to sequentially release the engaged sheets of material at the receiving station, and drive means for sequentially moving said gripper assemblies along the path, said drive means including means for moving said gripper assemblies of said first set of grippers at a substantially constant predetermined speed along spaced apart first portions of the path, for decelerating said gripper assemblies of said first set of grippers along spaced apart second portions of the path, and for accelerating said gripper assemblies of said first set of grippers along spaced apart third portions of the path, said drive means for moving the plurality of gripper assemblies of said second set of grippers at a substantially constant predetermined speed along at least part of said first portions of said path during movement of said gripper assemblies of said first set of grippers along at least parts of said second and third portions of the path, for decelerating said gripper assemblies of said second set of grippers along at least part of said second portions of the path during constant speed movement of said gripper assemblies of said first set of grippers along at least part of said first portions of the path, and for accelerating said gripper assemblies of said second set of grippers along at least part of said third portions of the path during constant speed movement of said gripper assemblies of said first set of grippers along at least part of said first portions of the path.

20. An apparatus as set forth in claim **19** wherein said drive means is effective to sequentially move said gripper assemblies of said first and second sets of grippers along said second portions of the path in a period of time which is at least half as great as the period of time between the arrival of the leading edge portions of successive sheets of material at the pickup station.

21. An apparatus as set forth in claim **19** wherein said means for maintaining a predetermined path length between said gripper assemblies of said first set of grippers includes first chain means for interconnecting said gripper assemblies of said first set of grippers, said means for maintaining a predetermined path length between said gripper assemblies of said second set of grippers includes second chain means for interconnecting

said gripper assemblies of said second set of grippers, said second chain means being spaced apart from and extending parallel to said first chain means.

22. An apparatus as set forth in claim **19** wherein said drive means includes first means operable to move said gripper assemblies of said first set of grippers along the path, second means operable to move said gripper assemblies of said second set of grippers along the path, and control means for effecting constant speed operation of said first means during movement of said gripper assemblies of said first set of grippers along said first portions of the path, for decreasing the speed of operation of said first means during movement of said gripper assemblies of said first set of grippers along said second portions of the path, and for increasing the speed of operation of said first means during movement of said gripper assemblies of said first set of grippers along said third portions of the path, said control means further including means for effecting constant speed operation of said second means during movement of said gripper assemblies of said second set of grippers along said first portions of the path, for decreasing the speed of operation of said second means during movement of said gripper assemblies of said second set of grippers along said second portions of the path, and for increasing the speed of operation of said second means during movement of said gripper assemblies of said second set of gripper assemblies along said third portions of the path.

23. An apparatus for sequentially operating on sheets of material and deposting each of the sheets of material in turn at a receiving station, said apparatus comprising a rotatable cylinder means for performing a work operation on each sheet of material in turn at a predetermined sheet feed rate, means for sequentially conveying sheets of material from said cylinder means to a pickup station at the predetermined sheet feed rate, a first set of grippers, said first set of grippers including a plurality of spaced apart gripper assemblies, means for supporting said gripper assemblies of said first set of grippers for sequential movement along a path extending between the pickup station and the receiving station, a second set of grippers, said second set of grippers including a plurality of gripper assemblies disposed along the path and interspersed between gripper assemblies of said first set of grippers, means for sequentially operating said gripper assemblies to sequentially engage sheets of material at the pickup station and to sequentially release the engaged sheets of material at the receiving station, and drive means for sequentially moving said gripper assemblies along the path, said drive means including means for moving said gripper assemblies of said first set of grippers at a substantially constant predetermined speed along spaced apart first portions of the path, for decelerating said gripper assemblies of said first set of grippers along spaced apart second portions of the path, and for accelerating said gripper assemblies of said first set of grippers along spaced apart third portions of the path, said drive means being effective to move said gripper assemblies of said first set of grippers along said first and second portions of the path in a period of time which is greater than the period of time between the arrival of leading edge portions of successive sheets of material at the pickup station during operation of said conveyer means to convey sheets of material to the pickup station at the predetermined sheet feed rate, said drive means including means for moving the plurality of gripper assemblies of said second set of grippers at a substantially constant predetermined speed along said first portions of said path, for decelerating said gripper assemblies of said second set of grippers along said second portions of the path and for accelerating said gripper assemblies of said second set of grippers along said third portions of the path, said drive means being effective to move said gripper assemblies of said second set of grippers along said first and second portions of the path in a period of time which is greater than the period of time between the arrival of leading edge portions of successive sheets of material at the pickup station during operation of said conveyer means to convey sheets of material to the pickup station at the predetermined sheet feed rate.

24. An apparatus as set forth in claim **23** further including means for enabling variations to occur in the path length distance between gripper assemblies of said first set of grippers and gripper assemblies of said second set of grippers.

25. An apparatus as set forth in claim **24** further including means for maintaining a predetermined path length distance between each of said gripper assemblies of said first set of grippers and means for maintaining said predetermined path length distance between said gripper assemblies of said second set of grippers.

26. An apparatus as set forth in claim **23** wherein said drive means includes first chain means for interconnecting said gripper assemblies of said first set of grippers, second chain means interconnecting said gripper assemblies of said second set of grippers, said first chain means being spaced apart from and extending parallel to said second chain means, means for driving said first and second chain means, and means for varying the speed at which one of said chain means is driven relative to the speed at which the other of said chain means is driven.

27. An apparatus as set forth in claim **23** wherein said drive means includes a rotatable input member which is rotated at input speed which varies as a function of variations in the sheet feed rate, a first rotatable output member connected with said first set of grippers and said input member, means for rotating said first output member under the influence of forces transmitted from said input member and for varying the speed of rotation of said first output member between a maximum rotational speed which is greater than said input speed and a minimum rotational speed which is less than said input speed, means for effecting movement of said gripper assemblies of said first set of grippers along said first portions of the path during rotation of said first output member at its maximum rotational speed, for effecting movement of said gripper assemblies of said first set of grippers along said second portions of the path during deceleration of said first output member from its maximum rotational speed to its minimum rotational speed, and for effecting movement of said gripper assemblies of said first set of grippers along said third portions of the path during acceleration of said first output member from its minimum rotational speed to its maximum rotational speed, a second rotatable output member connected with said second set of grippers and said input member, means for rotating said second output member under the influence of forces transmitted from said input member and for varying the speed of rotation of said second output member be-

tween a maximum rotational speed which is greater than said input speed and a minimum rotational speed which is less than said input speed, and means for effecting movement of said gripper assemblies of said second set of grippers along said first portions of the path during rotation of said second output member at its maximum rotational speed, for effecting movement of said gripper assemblies of said second set of grippers along said second portions of the path during deceleration of said second output member from its maximum rotational speed to its minimum rotational speed, and for effecting movement of said gripper assemblies of said second set of grippers along said third portions of the path during acceleration of said second output member from its minimum rotational speed to its maximum rotational speed.

28. A method of sequentially transferring sheets of material from a pickup station to a receiving station said method comprising the steps of providing a first set of grippers which includes a plurality of spaced apart gripper assemblies, providing a second set of grippers which includes a plurality of spaced apart gripper assemblies, moving the gripper assemblies of the first set of grippers along a path extending between the pickup station and the receiving station, maintaining a predetermined path length distance between the gripper assemblies of said first set of grippers as they move along the path, moving the gripper assemblies of the second set of grippers along the path simultaneously with movement of the gripper assemblies of the first set of grippers along the path, maintaining a predetermined path length distance between the gripper assemblies of the second set of grippers as they move along the path, varying the path length distance between the gripper assemblies of the first set of grippers and the gripper assemblies of the second set of grippers as the gripper assemblies move along the path, sequentially operating the gripper assemblies to sequentially engage sheets of material at the pickup station and to sequentially release the engaged sheets of material at the receiving station, and varying the speed of movement of the gripper assemblies of one of the sets of grippers relative to the speed of movement of the gripper assemblies of the other set of grippers.

29. A method as set forth in claim **28** wherein said step of varying the speed of movement of the gripper assemblies of one of the sets of grippers relative to the speed of movement of the gripper assemblies of the other set of grippers includes the step of decreasing the speed of movement of the first set of grippers while maintaining the speed of movement of the second set of grippers substantially constant.

30. A method as set forth in claim **28** further including the steps of operating a gripper assembly of the first set of grippers to release the leading sheet of material at the receiving station and thereafter increasing the speed of movement of the first set of grippers relative to the speed of movement of the second set of grippers.

31. A method of sequentially transferring sheets of material from a pickup station to a receiving station said method comprising the steps of engaging a leading sheet of material at the pickup station with a first gripper assembly, operating a first drive assembly to move the first gripper assembly and the leading sheet of material along a path to the receiving station, engaging a next succeeding sheet of material at the pickup station with a second gripper assembly, operating a second drive assembly to move the second gripper assembly and the engaged sheet of material along the path to the receiving station while performing said step of operating the first drive assembly to move the first gripper assembly and the leading sheet of material along the path, and varying the speed of operation of one of the drive assemblies relative to the speed of operation of the other drive assemblies to vary the speed of movement of one of the gripper assemblies and engaged sheet of material relative to the speed of movement of the other of the gripper assemblies and the engaged sheet of material while simultaneously moving both of the gripper assemblies and both of the sheet of material along the path toward the receiving station.

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