United States Patent [19]

Miles

[11] **3,856,061**

[45] **Dec. 24, 1974**

[54] **METHOD OF CUTTING LUMBER TO RANDOM OR SPECIFIED CLEAR LENGTHS**

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[73] Assignee: **Edward Hines Lumber Co.,** Hines, Oreg.

[22] Filed: **Jan. 8, 1973**

[21] Appl. No.: **321,787**

Related U.S. Application Data

[62] Division of Ser. No. 214,011, Dec. 30, 1971.

[52] **U.S. Cl.** **144/312,** 83/71, 83/371, 83/326, 83/39

[51] **Int. Cl.** **B27b 1/00**

[58] **Field of Search** ..... 144/312, 326 R, 3 R, 3 N; 83/371, 71, 39

[56] **References Cited**

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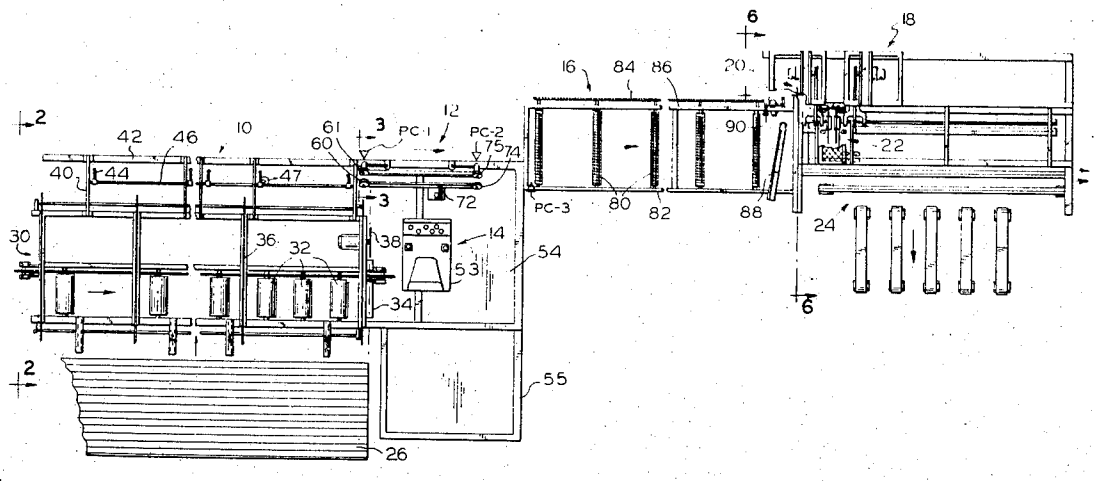
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Primary Examiner—Donald R. Schran
Attorney, Agent, or Firm—Klarquist, Sparkman, Campbell, Leigh, Hall & Whinston

[57] **ABSTRACT**

A piece of lumber is fed flat to the infeed end of a marking station, tilted on edge and driven endwise into the marking station where defects in the piece are detected and marked with a retroreflective material. The marked piece moves to a defect-cutting station where it is driven endwise past a pair of defect-cutting saws until a marked defect is sensed between the saws to stop movement of the piece and actuate the saws to remove the defective section. The clear piece downstream of the saws is measured and, if longer than a minimum length range, diverted to a cut-to-length saw station. If within the minimum length range, it is diverted to a "core block" sort. If shorter than the minimum range, it is diverted to junk. The piece upstream of the saws is measured and diverted in the same manner as the downstream piece except that upstream pieces longer than the minimum length range resume travel past the defect saws. Long-length sensors at the defect station determine if a piece contains any one of several specified defect-free long lengths and if so, set a stop downstream of the defect saws corresponding to the longest specified clear length sensed and then actuate only one of the defect saws to cut the piece to such length when the piece reaches the set stop. Such piece is then diverted directly to a sorting station. Random length clear pieces transferred to the cut-to-length station are pressed against a series of depressible stop-sensors determining various specified lengths, driven endwise over the stop-sensors past a length saw until one of the stop-sensors is released, then driven in reverse against the released stop. The length saw then strokes to cut the piece to specified length, after which the piece is sorted according to length as determined by the released stop-sensor.

13 Claims, 15 Drawing Figures



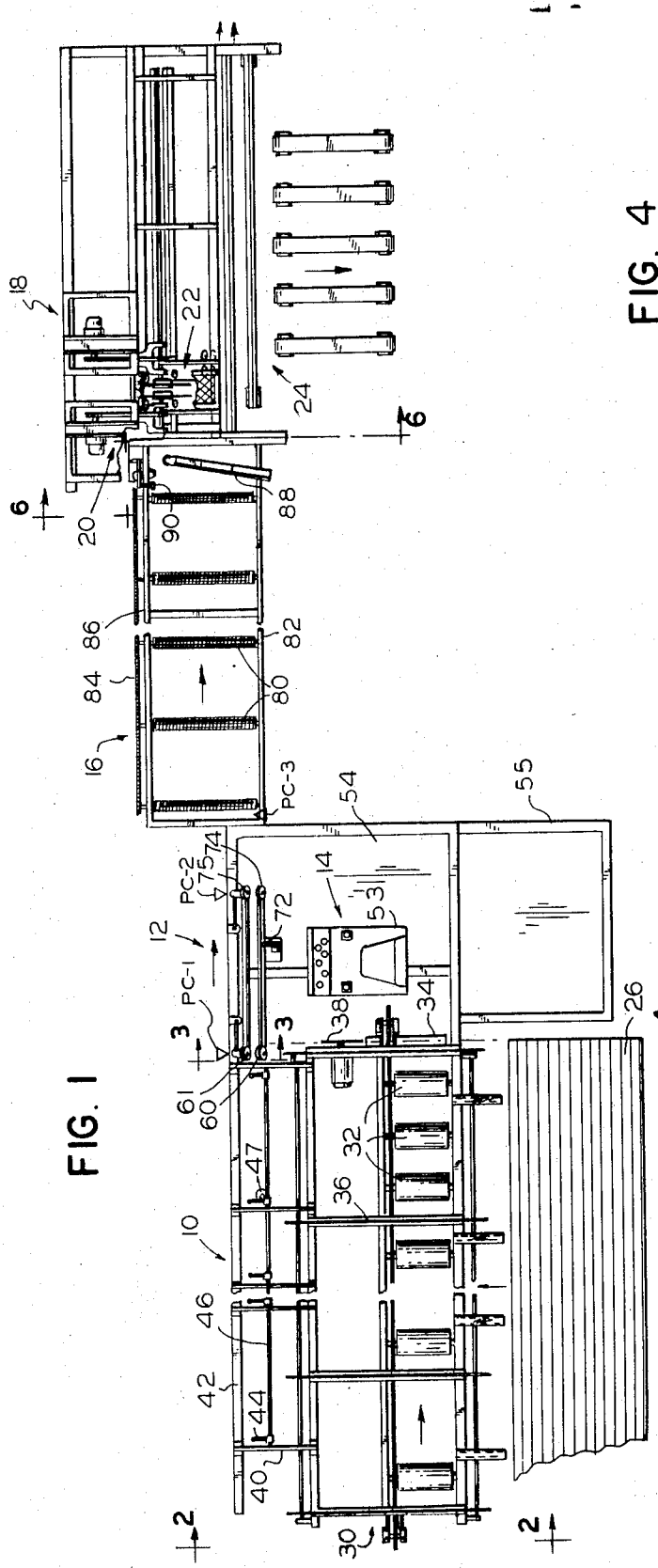


FIG. 1

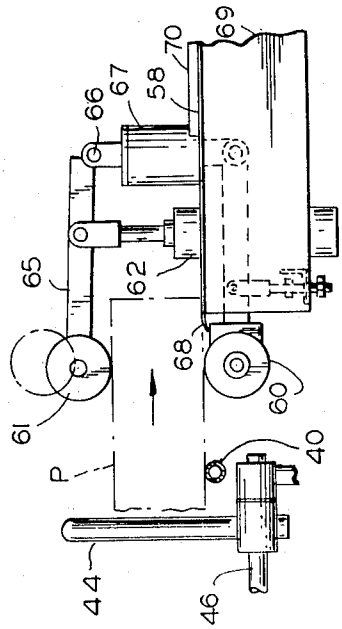


FIG. 4

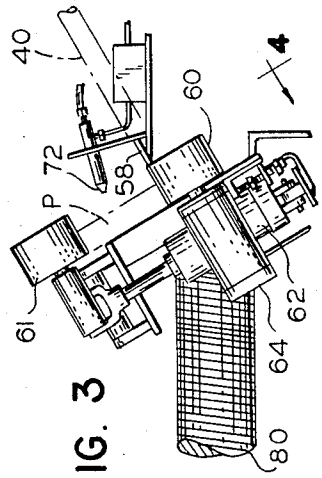


FIG. 3

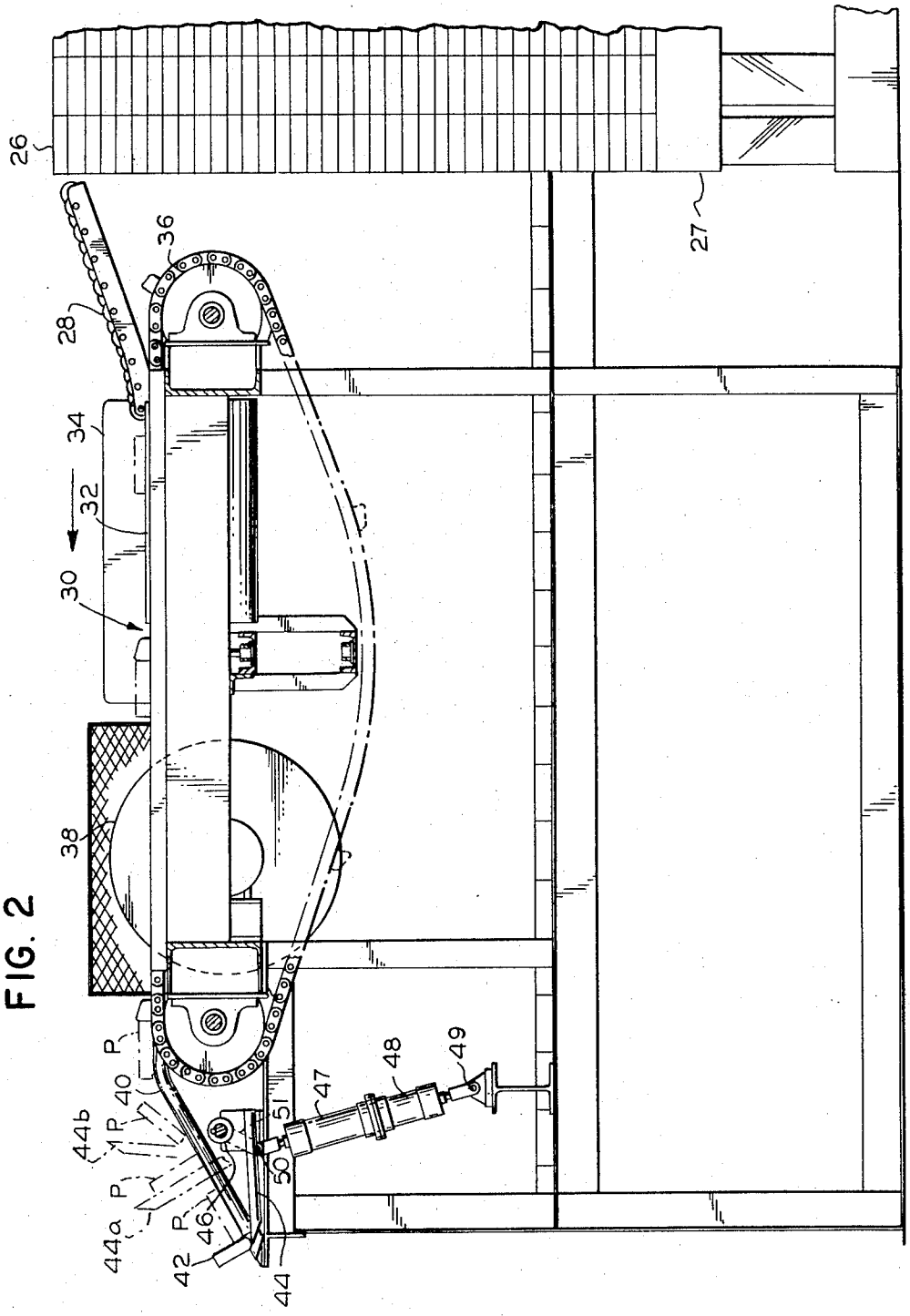


FIG. 2

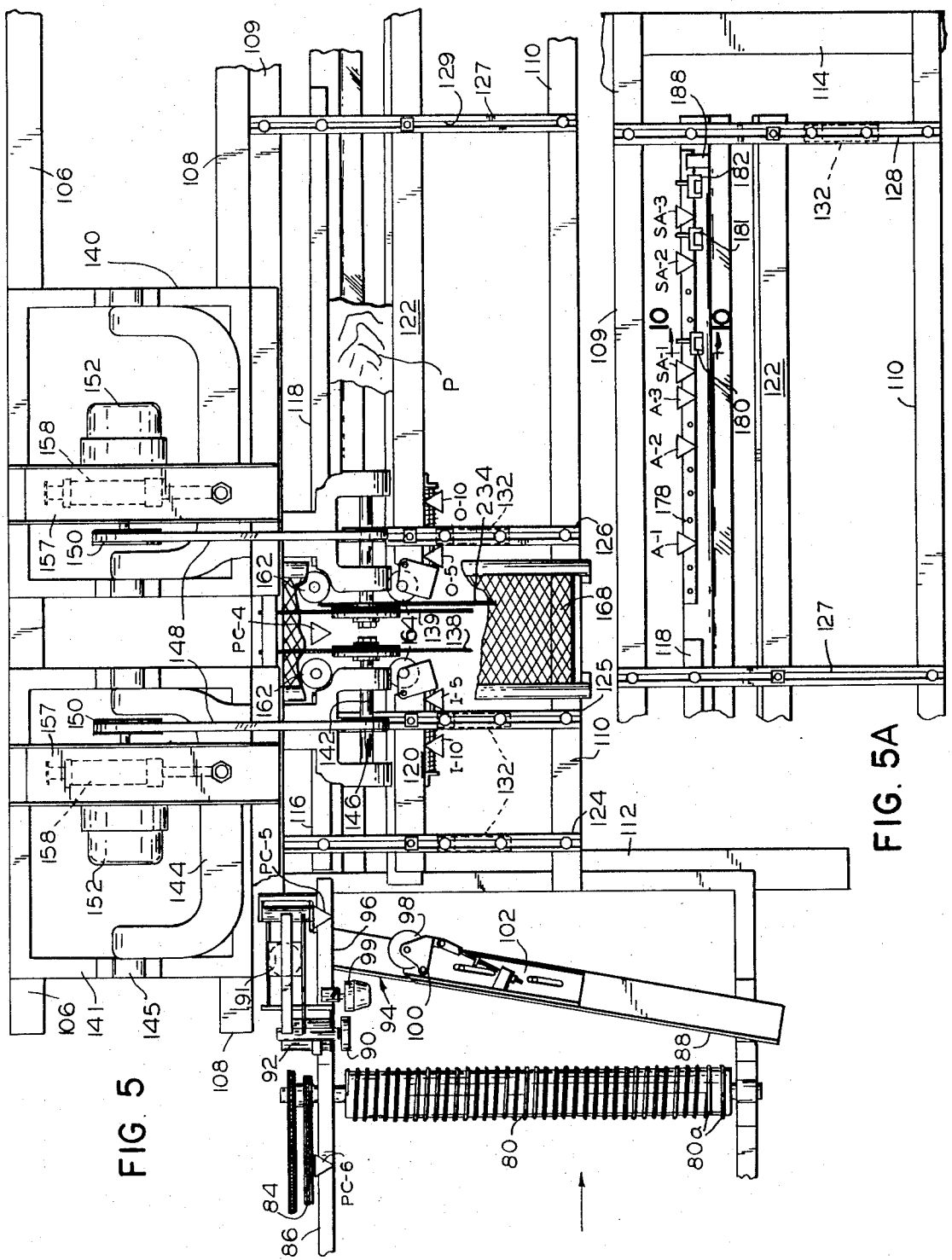

106
108
109
110
129
127
140
122
P
118
152
158
157
150
162
148
PC-4
64
139
138
O-10
234
132
O-5
126
168
I-5
125
142
120
I-10
146
116
124
112
PC-5
144
141
145
191
96
98
102
99
94
100
90
92
88
80
80a
84
PC-6
86
114
188
182
181
SA-2
SA-3
SA-1
A-3
A-2
A-1
178
180

FIG. 5

FIG. 5A

FIG. 10

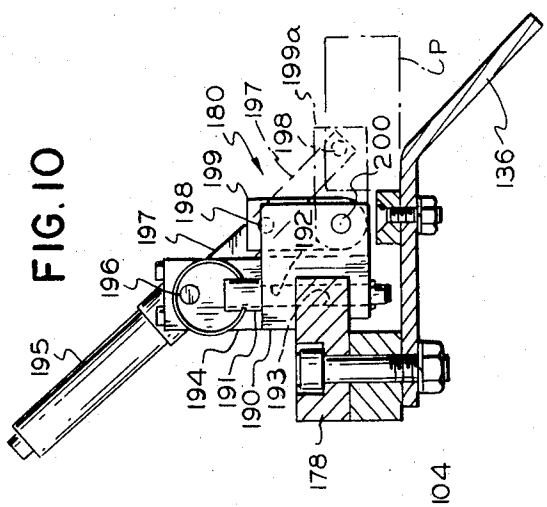

P
199a
180
197
198
199
200
192
136
196
197
198
195
194
191
190
193
178

FIG. 6

284
104
24
16
P
80
22
224
274a
274b
270
274c
274d
275
279
278
281
276
280
282
236
238
237
18
20
110
112
250
251
132
124
138
168
170
I-10
120
134
202
146
144
142
164
136
116
206
PC-4
162
176
166
109
108
148
156
158
152
150
145
153
154
106
157
159
141
226
248
286
288
272
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242
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211
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204
209
212

FIG. 8

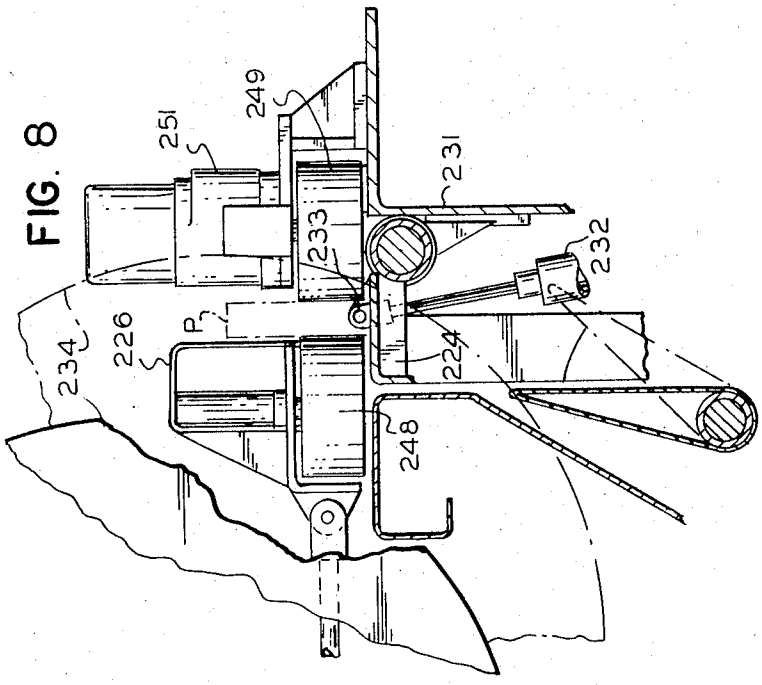


FIG. 9

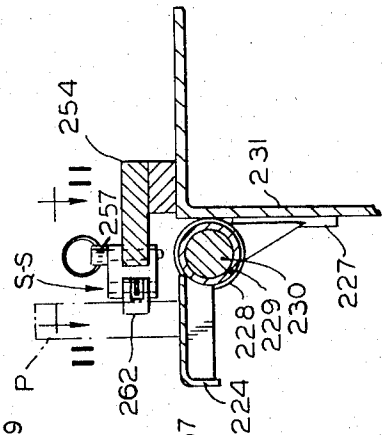


FIG. 11

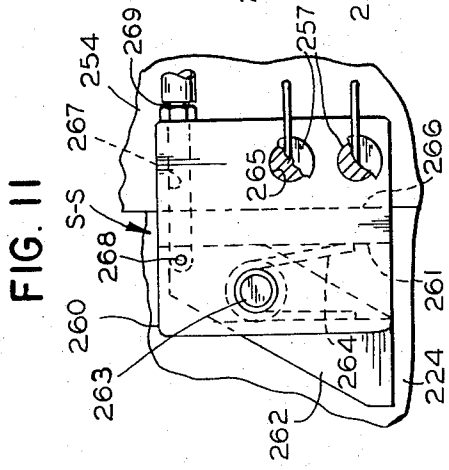


FIG. 7

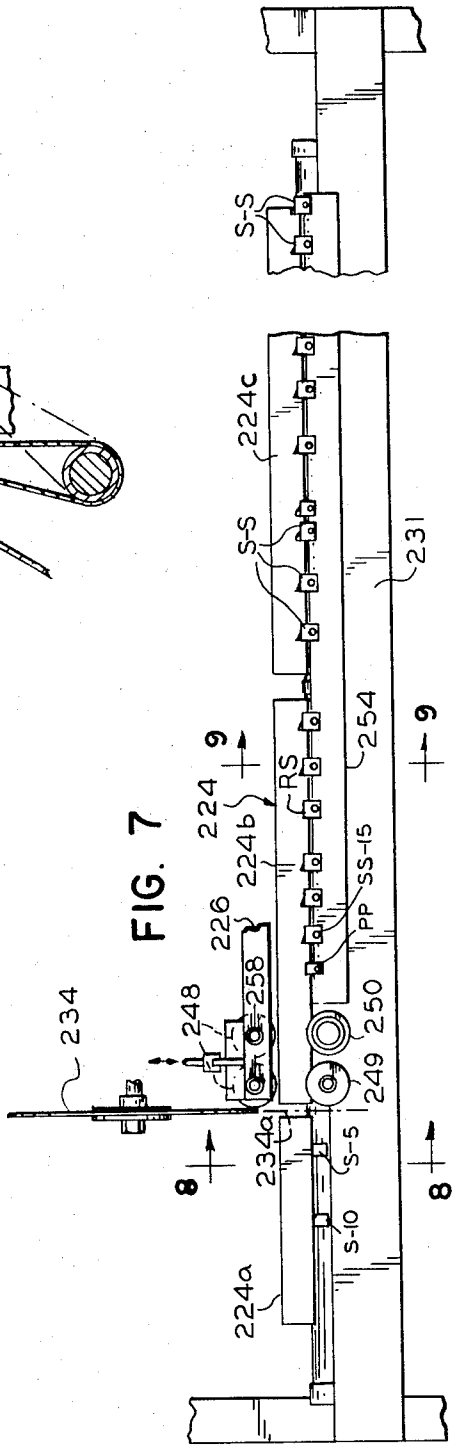


FIG. 12

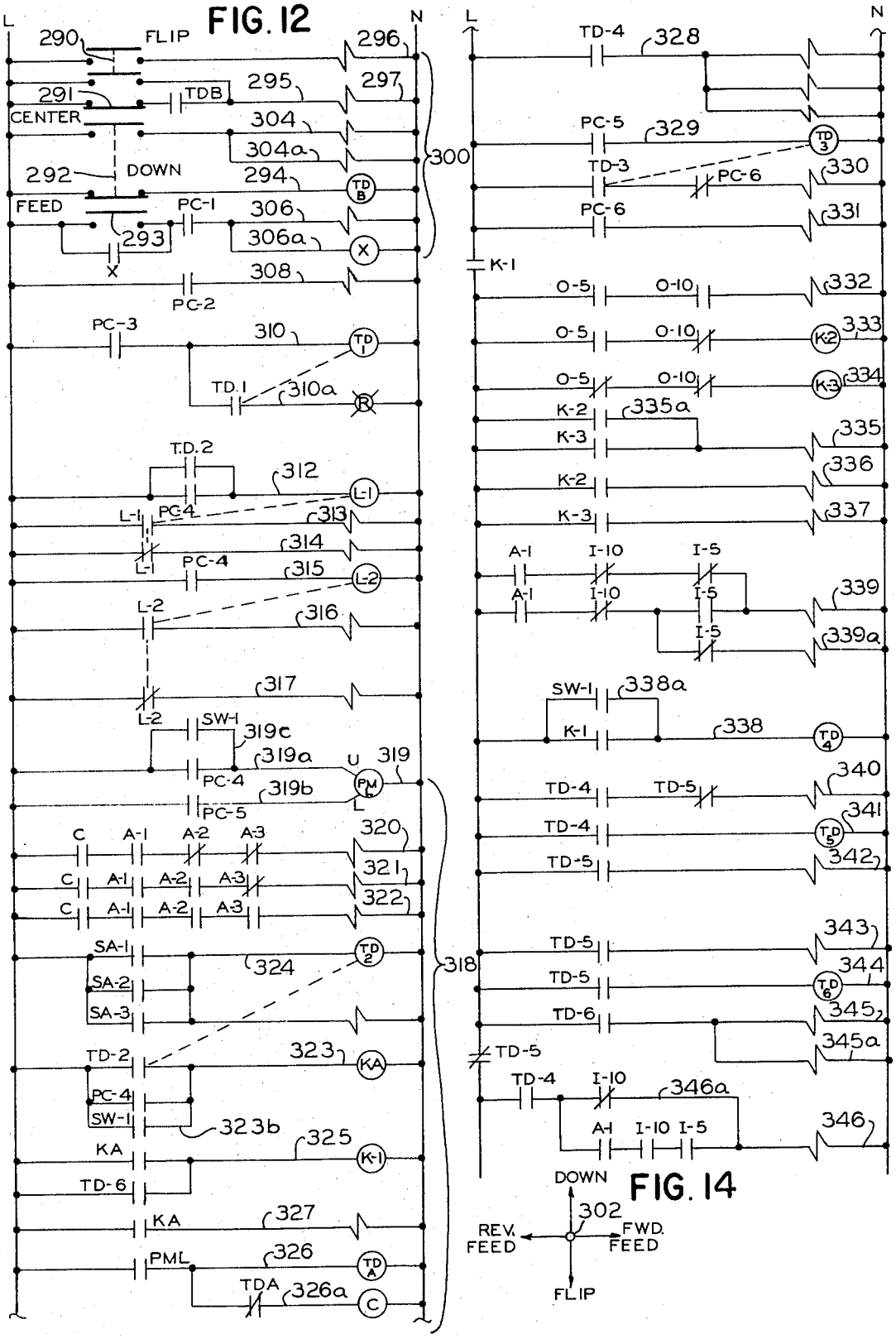
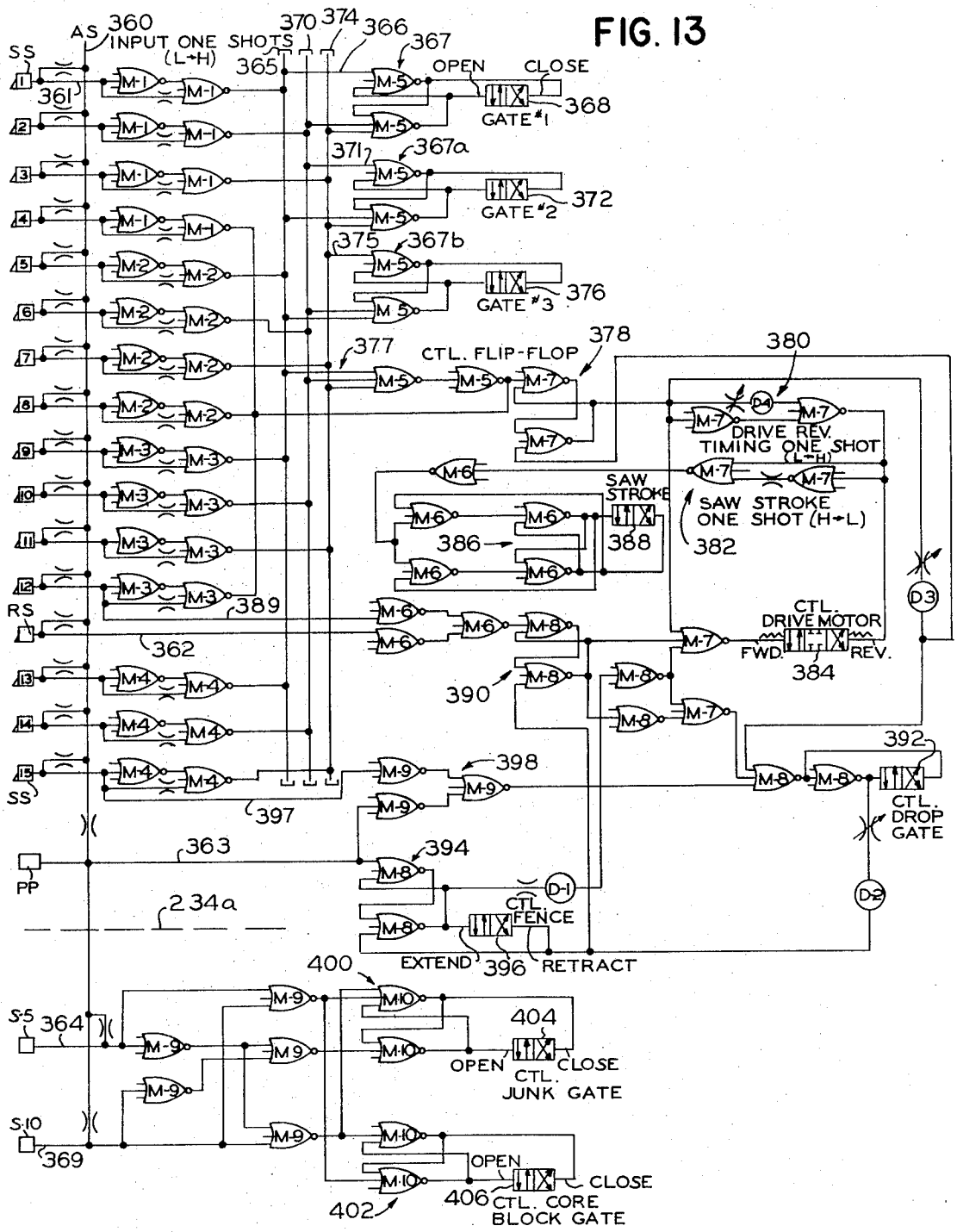

L
N
290
FLIP
296
291
TDB
295
297
CENTER
304
304a
300
292
DOWN
294
TD B
FEED
PC-1
306
306a
293
X
308
PC-2
PC-3
310
TD 1
TD.1
310a
T.D.2
312
L-1
PC-4
313
314
315
L-2
316
317
SW-1
319c
319a
319
U
PM L
319b
320
C
A-1
A-2
A-3
321
322
SA-1
SA-2
SA-3
TD 2
324
318
TD-2
323
KA
PC-4
SW-1
323b
325
K-1
TD-6
327
PML
326
TD A
TDA
326a
C
TD-4
328
PC-5
329
TD 3
TD-3
330
PC-6
331
K-1
O-5
O-10
332
K-2
333
K-3
334
335a
335
336
337
A-1
I-10
I-5
339
339a
SW-1
338a
338
TD 4
340
TD-5
341
TD 5
342
343
344
TD 6
345
345a
346a
346

FIG. 14

DOWN
302
REV. FEED
FWD. FEED
FLIP

FIG. 13


AS
360
INPUT ONE SHOTS
(L→H)
370
374
366
367
365
OPEN
CLOSE
GATE #1
368
361
371
367a
GATE #2
372
375
367b
GATE #3
376
377
CTL. FLIP-FLOP
378
380
DRIVE REV. TIMING ONE SHOT (L→H)
SAW STROKE
SAW STROKE ONE SHOT (H→L)
382
386
388
389
RS
362
CTL. DRIVE MOTOR
FWD.
REV.
384
390
392
CTL. DROP GATE
398
397
SS
363
PP
394
234a
CTL. FENCE
EXTEND
396
RETRACT
400
S-5
364
404
OPEN
CLOSE
CTL. JUNK GATE
S-10
369
OPEN
CLOSE
406
CTL. CORE BLOCK GATE
402
D1
D2
D3
D4

METHOD OF CUTTING LUMBER TO RANDOM OR SPECIFIED CLEAR LENGTHS

This application is a division of my prior co-pending application Ser. No. 214,011, filed Dec. 30, 1971, for Method and Apparatus for Cutting Lumber to Random or Specified Clear Lengths.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the cutting and sorting of lumber to random or specified clear lengths.

2. Description of the Prior Art

Heretofore the removal of defects from lumber and the cutting of the resulting clear pieces to one of several specified clear lengths with a minimum of waste has been largely a manual, trial-and-error operation. For example, in one typical prior system, each of ten saws manned by twenty people is equipped with a set of some twenty manually operated stops spaced at varying distances from the saw to determine various specified lengths. Each person takes a piece of lumber, inspects it, then using one of the saws cuts the piece on opposite sides of any defect to remove the defective section. Thereafter the same person places each resulting random length clear piece against a manually set one of the several stops estimated to be the one that will cut the longest specified clear length from such piece with a minimum of waste. However, if the operator errs in his estimate, he must clear the set stop and set other stops until the one stop is set that will produce the longest possible specified length from the piece. In practice, an operator must re-estimate and reset stops for a given piece approximately 50 percent of the time, thereby losing valuable production time. Thus as presently practised, the upgrading of low-grade defect-containing lumber by cutting it to specified clear lengths is a costly, time-consuming operation, particularly with the high labor costs involved.

SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for removing defects from lumber and cutting the lumber to random or specified clear lengths with a minimum of labor and at a high rate of production exceeding that possible with the aforementioned prior method. The invention eliminates the human guesswork and trial-and-error estimation of the longest specified clear length in a given piece of lumber involved with the prior method. The invention also eliminates the manual setting and resetting of stops.

A basic feature of the invention is the separation of the defect- and length-cutting operation into two separate steps, including a defect-cutting step carried out at a first cutting station and a cut-to-length step carried out at a subsequent cutting station.

A further basic feature of the invention is the use of each individual piece of lumber to carry its own information necessary to trigger various machine operations in proper sequence, thereby eliminating the need for costly computer or memory systems to operate the apparatus.

Another feature of the present invention is a built-in sorting system which sorts pieces according to length from length sensings made at the defect- and length-cutting apparatus.

According to another feature of the invention, various specified clear lengths in a board are sensed automatically and these sensings used to operate various elements of the apparatus as required to position the board for cutting, to cut the board to a specified length and to sort pieces according to length.

A more specific feature of the invention is the marking of defects in a board with a retroreflective material which can be sensed to initiate machine functions which either remove the defect from the board or cut the board to a specified long clear length.

In another specific aspect of the invention, boards containing at least one of several specified long, clear lengths can be detected, positioned and cut automatically to the longest possible one of the specified lengths at the defect-cutting station and then diverted to a corresponding sorting station without passing through the cut-to-length station.

A prototype apparatus of the invention is designed to process 15,000 board feet per day using from one to three persons, thereby giving a production rate per person of from 5,000 to 15,000 board feet. This should be compared to the 1,500 board feet per person capable of being produced using the typical prior system previously described.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the present invention will become more apparent from the following detailed description which proceeds with reference to the accompanying drawings, wherein:

FIG. **1** is a plan view of an overall system in accordance with the invention;

FIG. **2** is a vertical sectional view on an enlarged scale taken approximately along the line **2—2** of FIG. **1** showing the infeed end portion of the apparatus of FIG. **1**;

FIG. **3** is a vertical section taken approximately along the line **3—3** of FIG. **1** showing the details of the marking station portion of the apparatus;

FIG. **4** is a view taken along the line **4—4** of FIG. **3** showing an infeed portion of the marking station in plan;

FIG. **5** is a plan view of the sorting section of the apparatus of FIG. **1**;

FIG. **5A** is a continuation of FIG. **5** showing a plan view of an outfeed portion of the defect-cutting station;

FIG. **6** is a view taken approximately along the line **6—6** of FIG. **5** showing the sawing and sorting sections of the apparatus in elevation;

FIG. **7** is a plan view of the cut-to-length station as viewed along the line **7—7** of FIG. **6** rotated to a horizontal plane and with other portions of the apparatus removed for clarity;

FIG. **8** is a partial sectional view taken along the line **8—8** of FIG. **7** on an enlarged scale;

FIG. **9** is a sectional view taken along the line **9—9** of FIG. **7** on an enlarged scale;

FIG. **10** is a view taken along the line **10—10** of FIG. **5–A** showing one of the pop-out stops;

FIG. **11** is a view taken along the line **11—11** of FIG. **9** showing one of the stop-sensors;

FIG. **12** is a circuit diagram of the electrical sensing and control system of the apparatus;

FIG. 13 is a circuit diagram of the pneumatic-fluidic sensing and control system of the apparatus; and

FIG. 14 is a diagram of a manual control stick portion of the control system.

DETAILED DESCRIPTION

GENERAL ASSEMBLY

With reference to the drawings, FIG. 1 shows the overall apparatus, including an infeed section **10**, a marking station **12** just downstream from the infeed section where defects are marked, and an operator's station **14** alongside the marking station. A transfer section **16** transfers marked lumber from the marking station **12** to a cutting and sorting section **18**. At the cutting and sorting section, marked defects are first detected and cut from pieces at a defect-cutting station **20** after which the resulting random-length clear pieces are dropped to a cut-to-length station **22** and then to a sorting section **24** where the pieces are sorted to length.

INFEED SECTION

Referring to FIGS. **1** and **2**, pieces from a stack of lumber **26** on a scissors lift **27** at the head of the infeed section are fed onto a declining skate wheel section **28** leading to a zero trim table **30**. Pieces roll down the skate wheels **28** onto a series of driven ending rolls **32** which drive the pieces endwise against an ending bumper **34**. Lug chains **36** push one piece at a time from the ending rolls through a zero trim saw **38** and onto a declining skidway comprising a series of skid rails **40**. Each piece P slides down the rails in a flat condition to a stop **42** at the bottom of the skidway. As each piece arrives at the stop, it has its right-hand end as viewed in FIG. **1** referenced in the same position as every other piece with respect to the infeed end of the marking station **12** regardless of the length of the piece because of the zero-referencing action of the zero trim table.

At the lower end of the skidway, means are provided for turning each board on edge and for flipping it completely over. Such means includes a flipper arm assembly comprising a series of flipper arms **44** mounted at spaced intervals along a common shaft **46**. As clearly shown in FIG. **2**, the flipper arms in their inactive positions lie below a piece of lumber P at the bottom of the skid rails. The flipper arm assembly is actuated by a tandem pair of air cylinders **47, 48** pivoted to the frame of the machine at **49** and pivoted at **50** to a crank arm **51** of shaft **46**. Upon extension of cylinder **47**, arm **44** pivots to an inclined position **44*a*** to lift a piece P on edge as shown. Upon extension of both cylinders **47, 48**, arm **44** is pivoted to a near vertical position **44*b*** to flip a piece P completely over to its opposite face. The flipper assembly is controlled from the operator's station **14**. There the operator, positioned in a seat **53** on a platform **54**, overlooks the flipper assembly and can flip a given board so that its most defective face will be tilted toward the operator as it passes through the marking station **12**.

If desired, the zero trim table can be eliminated and additional skate wheels or other means provided for feeding pieces of lumber manually one at a time onto the skid rails **40** for manipulation by the flipper arms.

Lumber from stack **26** can be fed automatically to the skate wheels using automatic lumber feeder devices common in the industry. Alternatively, a second person can be stationed at the stack on an extension **55** of the operator's platform and can manually feed one piece at a time from the stack **26** to the skate wheels.

MARKING STATION

When a piece of lumber arrives at the bottom of the skid rails and its tilted on edge at approximately a 60° angle to the horizontal by the flippers as shown in FIG. **3**, its righthand end as viewed in FIGS. **1** and **4** is supported by a wear plate **58** and the driven roll **60** of a pair of nip rolls at the infeed end of the marking station. The infeed nip rolls also include an idler roll **61** movable toward and away from the driven roll by an air cylinder **62**. Nip roll **60** is driven by a reversible orbit motor **64**. Idler roll **61** is carried on an arm **65** pivoted at **66** to a support **67**. Wear plate **58** is downturned at its opposite ends as shown at infeed end **68** to prevent boards from hanging up on the plate. The wear plate forms part of an angle member **69** and also includes a fence portion **70** providing support for a back portion of a piece of lumber traveling along the wear plate.

The wear plate defines a linear path of travel for a piece of lumber P driven endwise through the marking station by the infeed nip rolls. The speed and direction of endwise travel of a piece through the marking station is controlled from the operator's station by controlling the speed and direction of rotation of motor **64**.

A marking means shown most clearly in FIG. **3** is provided at the marking station along the path of travel of a piece. The marking means includes a spray nozzle **72** directed toward the face of any board passing through the marking station. The nozzle is supplied with a fast-drying retroreflective liquid from a reservoir (not shown) which is sprayed under control of the operator onto defects, such as knots, detected in a board as it travels on edge through the marking station. Defects marked in this manner are detected later by photosensors which actuate saws that remove such defects. A defect can readily be aligned with the marking nozzle **72**, which is preferably directly in front of the operator as shown in FIG. **1**, by reason of the reversible and variable speed drive provided for the board.

The marking station also includes an outfeed means comprising a pair of outfeed nip rolls **74, 75** similar in arrangement and operation to the infeed nip rolls **60, 61**.

The opening and closing of both the infeed and the outfeed nip rolls are controlled automatically by photoelectric sensors shown schematically in FIG. **1** including an infeed sensor PC–1 and an outfeed sensor PC–2. The infeed sensor detects the presence of a board in position at the infeed end of the marking station and in response to such sensing closes the normally open infeed nip rolls, driving the lumber into the marking station. When the leading end of the lumber passes outfeed sensor PC–2, the outfeed nip rolls close enabling the lumber to be driven out of the marking station and onto the aligned end of the transfer section **16**.

When a board moving through the marking station clears the infeed rolls **60, 61**, sensor PC–1 causes such nip rolls to reopen to await delivery of the next board. Similarly, when the trailing end of the same board clears the outfeed nip roll sensor PC–2, the outfeed nip rolls reopen to await the next piece.

TRANSFER SECTION

Transfer section **16** includes a series of screw rolls **80**

mounted on a frame table **82.** The rolls are rotated by a chain drive **84** in a direction so that lumber fed to the ends of the rolls in alignment with the marking station will be conveyed both downstream and sideways to the opposite ends of the rolls and up against a fence **86.** The fence serves to align each board endwise with the infeed end of the defect-cutting station. An angled bumper plate **88** limits the downstream movement of a board on the transfer table. Such plate also guides the leading end of each board toward a gate **94** and a pair of normally open nip rolls **90** at the infeed end of the defect-cutting station, as shown most clearly in FIG. **5.** Nip rolls **90** are similar to the nip rolls previously described and include an air cylinder-actuated upper idler nip roll and an orbital motor driven lower nip roll, the air cylinder being shown at **91** and the orbit motor at **92.**

Gate **94** is bounded on one side by a short fence section **96** and on the opposite side by a gate idler wheel **98** on bumper **88.** The lower portion of the gate is defined partially by another idler wheel **99.** Gate idler **98** is pivoted at **100** to a slide plate **102** and spring-biased toward the gate opening to prevent boards from moving through the opening until they are positively driven by nip rolls **90.** Slide plate **102** is slidably adjustable along the upper surface of bumper **88** to adjust the size of the gate opening to accommodate various board widths.

Referring to FIG. **5,** each screw roll **80** has two annular ribs **80***a* at its infeed end. These ribs prevent sidewise movement of the leading end of a board as it is fed onto the screw rolls by the outfeed nip rolls at the marking station until the entire board clears the outfeed nip rolls. When this happens, the edge-tilted board falls flat on the screw rolls enabling the helical ribs to begin their sideways conveying movement of the board toward fence **86.**

A photoelectric sensor **PC–3** at the infeed end of the transfer table senses the presence of a board on the table. This sensor illuminates a red warning light on a control panel at the operator's station if the sensor remains activated too long, indicating a full table.

Another sensor **PC–6** near gate **94** senses the presence of a board at the gate and between nip rolls **90** to close such rolls, enabling the infeed of a board into the defect station.

DEFECT-CUTTING STATION

The details of the defect-cutting station are shown most clearly in FIGS. **5, 5–A** and **6.** The relative levels of the defect-cutting station, screw roll transfer section **16** and cut-to-length station **22** with respect to floor level and each other are shown in FIG. **6.** The defect-cutting station is supported on a structural framework indicated generally at **104** which includes longitudinal channel members **106, 108** supporting the defect-cutting means and its actuating mechanism and pairs of longitudinal and vertically stacked rectangular tube members **109, 110** supporting the other components of the defect-cutting station. All of these longitudinal frame members extend between and are supported by cross frame members **112, 114.**

A pair of parallel, longitudinally extending fence assemblies, one fixed and one laterally movable, define a linear, horizontal path of travel for lumber fed endwise into and through the defect-cutting station. The fixed fence assembly includes a short fixed fence **116** and a longer fixed fence **118,** both defining continuations of the fence **86** of the transfer section and the short fence **96** of the gate leading into the defect station. The movable fence assembly includes a short movable fence **120** in opposition to the short fixed fence and a long movable fence **122** opposite the long fixed fence **118.**

The short movable and fixed fence sections are suspended beneath fence supports **124, 125.** The long fixed and movable fence sections are supported from similar fence supports **126, 127** and **128.** All of these fence supports are longitudinally slotted as shown at **129** on support **127** to receive suitable fasteners and to serve as slideways for the movable fence sections. The fence supports in turn are fixed to the tubular longitudinal frame members **109, 110.** Air cylinders **132** fixed to the underside of fence supports **124, 125, 126** and **128** are connected also to the movable fence sections for moving such sections in unison toward and away from the fixed fence sections.

As shown best in FIG. **6** with respect to short fixed fence **116** and short movable fence **120,** all fence sections carry bottom plates **134, 136** which have lip portions extending inwardly beyond the fence members themselves to form a drop gate which either supports a board within the defect station or drops a board from it, depending on the position of the movable fences. The plate **136** on the fixed gate sections is downturned at its outer end so as to guide a board downwardly along an inclined slideway when the movable fence is retracted by cylinder **132** to release the board.

The defect-cutting means includes a pair of defect-cutting circular saws **138, 139** positioned as shown in FIG. **5** in a gap between the short and long fence sections. Saw **139** is mounted on a fixed base **140.** However, saw **138** is mounted on an adjustable base **141** which enables the spacing between the pair of saws to be adjusted within the range of a few inches, with such range, for example, normally being approximately 4 to 6 inches. Except for the adjustable nature of the base of the movable saw, the mounting and actuation of the two saws is identical and so will be described only for the movable saw.

Saw **138** is fixed to a driven shaft **142** rotatably mounted on a yoke arm **144.** The yoke arm is pivoted to base **141** at **145.** The yoke arm carries a pulley wheel **146.** A drive belt **148** interconnects the yoke arm pulley and a drive pulley **150** connected to the drive shaft of an electric motor **152** for driving the saw. The motor is mounted on a base plate **153** which is pivoted at **154** to the main base **141.**

The saw-actuating means includes a toggle mechanism **156** pivoted at one end to an overhead frame member **157,** at the other end to the yoke arm **144** and in the center to an air cylinder **158** which in turn is connected to an upright frame member **159.** Thus in the normal inactive, retracted position of the saw, air cylinder **158** is retracted to position the lower cutting edge of the saw above the level of a board P supported between the fixed and movable fences. However, upon extension of the air cylinder, the toggle mechanism forces the yoke arm **144** downwardly and then upwardly, thereby moving saw **138** through its cutting stroke to sever a board extending through the saw's cutting plane. Normally both the defect-cutting saws are actuated simultaneously to cut a short defective section from a board. The severed section then drops

through the gap between fences to a "junk" collection point. However, for a reason to be developed later, each saw is also capable of operating independently of the other.

The means for driving pieces through the defect station comprises a pair of relatively fixed driver rolls **162** and an opposing pair of relatively movable idler rolls **164** mounted on opposite sides of the pair of defect saws just inwardly toward the saws from adjacent ends of the fixed and movable fence sections. Idler rolls **164** are carried by the movable fence sections so as to move with them. Driver rolls **162** are carried by the fixed fence sections. They are spring-loaded to extend a short distance beyond the lumber-engaging edge of these fence sections. The idler rolls are spring-loaded to extend a slightly greater distance beyond the lumber-confronting edge of the movable fence sections. Thus when the opposing spring-loaded drive and idler rolls press against the opposite edges of a piece of lumber within the defect-cutting station, they apply unequal forces against opposing edges of the lumber in a manner resulting in the lumber being held against the fixed fences with a positive force. This ensures that the drivers will firmly engage the lumber to drive it through the defect station while at the same time the lumber will follow a true straight course as defined by the fixed fence. The driver rolls are driven by orbital motors **166** depending beneath the rolls, one such motor being shown in FIG. **6.**

The defect saws are covered by a removable overhead guard **168.** The overhead guard also mounts a bracket **170** to which four photoelectric sensors I–**5,** I–**10,** O–**5,** O–**10** are mounted. These photoelectric sensors and others are illustrated elsewhere schematically by triangular symbols for simplicity and clarity. Actually these sensors and others may be mounted anywhere on the apparatus where convenient. A fifth photosensor PC–**4** is mounted behind and between the pair of defect saws on an upright support member **176** to detect defects between the saws. The functions of these and other sensors are described subsequently.

Referring to FIG. **5**–A, fixed fence **118** ends a shorter distance downstream of the defect saws than corresponding movable fence **122.** A stop bar **178** continues downstream from the downstream end of the fixed fence. Three air-actuated pop-out mechanical stops **180, 181, 182** are pinned to the stop bar at predetermined but adjustable positions along it to determine the downstream ends of three specified long clear lengths which can be cut from a piece using one of the two defect saws. In conjunction with these mechanical stops, three end-of-piece photo sensors A–**1,** A–**2,** A–**3** are positioned along the stop bar upstream of the stops and operate in conjunction with a defect sensor PC–**5** upstream of the defect saws. A second set of three photoelectric and end-of-piece sensors SA–**1,** SA–**2,** SA–**3** are positioned on the stop bar, one just in front of each pop-out stop to slow the drive rolls before a board reaches such stops. Finally a maximum length mechanical stop-sensor **188** is adjustably positioned on the stop bar down-stream of the pop-out stops to stop and control the processing of any piece that is not acted upon by the pop-out stops and has no defect detected prior to reaching such stop.

FIG. **10** shows one of the pop-out stops in detail. This typical pop-out stop includes a stop body **190** adjustably connected to stop bar **178** by a pair of removable pins **191** extending through a pair of openings **192** in the stop body and through an aligned pair of stop bar openings **193.** An upwardly extending portion **194** of the stop body pivotally mounts an air cylinder **195** via pivot pin **196.** The air cylinder has a piston rod portion **197** pivotally connected at **198** to a pop-out stop lever **199.** The stop lever is pivoted to the stop body at **200.** Thus when the air cylinder extends, the piston rod **197** pivots stop lever **199** downwardly and outwardly to a horizontal position **199***a* in the path of lumber passing downstream through the defect station.

Referring to FIG. **6,** the defect-cutting station includes an associated sorting and transfer means. Such means includes inclined slideways **202, 204** which merge at their upper ends at a primary diverter or flip-flop gate **206.** This gate determines onto which slideway a piece will drop when released from the defect-cutting station through retraction of the movable fence sections.

The transfer slideway **202** leads to cut-to-length station **22.** The sorting slideway **204** leads to a series of sorting stations to which pieces from the defect station are directed according to length or condition without passing them through the cut-to-length station. Sorting slideway **204** includes a pair of sorting gates **208, 209** leading respectively when open to conveyor belts **210, 211.** Pieces sliding down the slideway **204** with both diverter gates **208** and **209** closed will proceed onto a third, transfer belt **212.** Thus, for example, defective sections cut from a piece can be diverted to a junk sort by belt **210** by positioning flip-flop arm **206** in its right-hand position and gate **208** in its open position. Similarly, clear pieces too short to be dropped to the cut-to-length station can be diverted to a "core block" sort on belt **211** by keeping gate **208** closed but opening gate **209.** As a further example, long clear pieces cut to length at the defect station can be diverted directly to a sorting station without passing to the cut-to-length station by positioning flip-flop gate **206** in its right-hand position and by closing gates **208** and **209** so that the long clear pieces drop onto transfer belts **212.**

OPERATION AT DEFECT STATION

Summarizing the processing of lumber at the defect station, screw transfer rolls **80** crowd a piece of lumber with marked defects against fixed fence **86.** When the defect infeed nip rolls **90** are clear of the proceding piece and piece-present sensor PC–**6** detects the presence of a piece at the fence **86** and between nip rolls **90,** the nip rolls close, feeding lumber endwise through gate **94** and toward defect saws **138, 139.** At the same time movable fence sections **120** and **122** move inwardly to support the piece as it travels downstream in the defect station and to press the piece against the fixed fence sections and drive rolls **162.** When photoelectric sensor PC–**4** detects a marked defect on the piece between the saws, a signal from the sensor stops drive rolls **162** and the driven nip roll **90** and extends air cylinders **158** to stroke defect saws **138, 139** simultaneously to cut the defective section from the piece. This defective section drops from between the saws along slideway **204** through open gate **208** onto belt **210** where it is conveyed to the junk sort.

The remaining clear piece downstream of the defect saws is measured by a pair of outfeed photo sensors spaced apart a short distance downstream of the saw **139** including a junk sensor O–**5** and a core block sen-

sor O–10. If such downstream piece is longer than, say, 10 inches, it is diverted to the cut-to-length saw station. If such piece is within the range of, say, from 5 to 10 inches in length or as otherwise determined by spacing between the two sensors, it is diverted to the core block sorting station by opening gate **209.** If shorter than 5 inches or any other predetermined minimum length as determined by sensor O–5, such piece is diverted to junk via open gate **208.**

An identical pair of infeed sensors, including a junk sensor I–5 and a core block sensor I–10, measure and divert the remaining piece upstream of the saws in the same manner as the outfeed sensors except that upstream pieces longer than 10 inches or some other predetermined length resume their travel downstream toward the defect saws for processing as previously described through reactivation of nip rolls **90** and drive rolls **162.**

A piece having an exceptionally long clear length as measured from its leading end can be cut to one of three specified long lengths at the defect-cutting station, thereby eliminating the need to transfer such pieces to the cut-to-length station, and enabling direct sorting of these pieces from the defect station.

Whether or not a given piece contains a clear length at least as great as one of the three specified long clear lengths is determined by defect sensor PC–5 upstream of the defect saws and by the three end-of-piece sensors A–1, A–2, A–3 downstream of the saws. For example, if a piece moving past the defect saws has its leading end sensed by sensor A–1 but not sensors A–2 and A–3 as defect sensor PC–5 detects a defect, the associated electrical control circuit causes the air cylinder of pop-out stop **180** to extend and set such stop to block downstream travel of the piece when it reaches such stop. As the piece approaches stop **180,** sensor SA–1 slows drive rolls **162** and nip roll **90.** When the leading end of the piece reaches set stop **180,** the drive rolls stop and only the second defect saw **139** strokes to cut the piece to the shortest one of the three specified long lengths. The movable fences retract and the gates are set to drop the long clear piece onto belt **212** to convey it to a long length sorting station, bypassing the cut-to-length station.

In a similar manner the activation of sensor PC–5 and both A–1 and A–2 would set stop **181,** and the activation of sensor PC–5 with all three stops A–1, A–2, A–3 would set stop **182.** The end-of-piece sensors and their corresponding stops can be adjusted to various positions along the stop bar to provide various specified long lengths. Also a fewer or greater number of pop-out stops and corresponding sensors could be provided as desired to meet the needs of the user.

CUT-TO-LENGTH STATION

As shown in FIG. **6,** cut-to-length station **22** is positioned below and to one side of the defect-cutting station. As previously mentioned, pieces cut to random clear lengths at the defect station are dropped along slideway **202** to the cut-to-length station.

A piece arriving at the cut-to-length station is supported at about a 45° inclination to the horizontal and on edge by lumber support means including a pivotable bottom drop gate member **224** and a movable side-supporting fence **226.** As shown in FIG. **7,** gate **224** is composed of three gate sections **224***a*, **224***b*, **224***c* mounted for downwardly pivoting movement on a common shaft **230** (FIG. **9**). The fence and drop gate position a piece delivered to the cut-to-length station in parallel relationship to the position it occupied at the defect-cutting station. As shown best in FIGS. **8** and **9,** the sections of drop gate **224** are fixed to long lengths of tubing **229** pinned to common shaft **230.** The shaft is pivotally mounted in three sleeve bearings **228** having supports **227** attached to a frame portion **231** of the machine. The drop gate sections are pivoted downwardly simultaneously from a lumber-supporting position as shown in FIG. **8** to a position dropping lumber to the sorting area by an air cylinder **232** pivotally connected to a drop gate actuating arm **233.**

A cut-to-length saw **234** is positioned along drop gate **224** and has a cutting plane **234***a* extending normal to the length of the drop gate in the gap between the drop gate sections **224***a* and **224***b*. With reference to FIG. **5,** it will be seen that length saw **234** is in substantial alignment with the downstream saw **139.** However, the cut-to-length saw is offset just slightly downstream from such defect saw so that random lengths dropping laterally to the cut-to-length station from the defect station will have one end extending slightly into the cutting plane of length saw **234.**

Cut-to-length saw blade **234** is fixed to a shaft **235** carried on the outer end of a yoke arm **236.** The yoke arm is pivoted at its inner end at **237** to a support base **238.** The pulley **239** fixed on shaft **235** is driven by drive belt **240** from a second pulley **241** on the drive shaft of an electric motor **242.** Yoke arm **236** pivots upwardly to move the cut-to-length saw through its cutting stroke by an air cylinder **244** acting on a toggle linkage **246.** The cutting stroke of the saw is indicated by dashed lines in FIG. **6.**

Two pairs of nip-drive rolls, including two inwardly movable idler rolls **248** on fence **226,** an opposing fixed idler roll **249,** and a single fixed driven roll **250** are positioned along drop gate **224** for moving a piece at the cut-to-length station endwise toward and away from the cut-to-length saw. The driven roll **250** is driven by an orbital motor **251** mounted on a support above the drive roll as shown in FIGS. **6** and **8.**

A piece P dropped from the defect station to the cut-to-length station and supported on drop gate **224** is pressed against the fixed drive rolls **249, 250** by idler rolls **248** which move inwardly to engage one side of the piece with movable fence **226** under the influence of air cylinders (not shown). Drive motor **251** is reversible so that a piece can be driven in either direction along the drop gate, either toward or away from the cut-to-length saw.

A stop-sensor bar **254,** shown in FIGS. **7** and **9,** is positioned downstream of the cut-to-length saw opposite fence **226** and along drop gate sections **224***b* and **224***c*. The stop bar **254** is mounted on frame member **231.** A portion of the stop bar overhangs the drop gate and is provided with a series of spaced-apart pin openings which provide for adjustable connection of a series of stop-sensors SS at various distances from the saw **234** so as to determine specified lengths to which random-length pieces will be cut by such saw. The stop bar also adjustably mounts a piece-present sensor PP which detects the presence of a piece of lumber at the cut-to-length station to trigger the actuation of the nip-drive rolls. One or more random-length sensors RS may also be mounted on the stop bar to drop certain long ran-

dom-length pieces from the cut-to-length station without cutting them to length.

The stop-sensors SS are adjustably secured to stop bar **254** by a pair of removable pins **257** extending through aligned pin openings in the stop bar and stop-sensor. Referring to FIG. **11**, the stop-sensor includes a stop body **260** having an upper groove **261** receiving a depressible stop lever **262**. The stop lever is pivoted at **263** to the stop body and is biased outwardly by a spring **264** against the force of which the stop lever is depressible inwardly by a board forced against the stop bar. The lower portion of the stop body includes a pair of pin openings **265** which receive pins **257** for attaching the stop-sensor to the stop bar. For this purpose the lower portion of the stop body includes a groove **266** into which the stop bar projects.

Stop body **260** also includes an air tube connector **269** for connecting an air tube from a pneumatic-fluidic control panel (not shown). The connector leads into a drilled opening **267** in the body which connects to an air outlet **268** leading into the upper groove **261** of the body. Air entering the stop body is normally blocked by the stop lever **262** when in its normal released position. Thus normally the connected air tube will have a high back pressure. However, when the lever is depressed by a piece of lumber, air can escape through outlet **268**, producing a low pressure in the connected air tube. However, when the stop lever is again released, this will again block the escape of air from the stop body, sending a pulse of high-pressure air to the pneumatic-fluidic control circuit for a purpose to be described in conjunction with FIG. **13**.

The piece-present sensor PP and random-length sensor RS may be similar in construction to the stop-sensor, except that in the former the stop lever and associated outer groove are eliminated and the air tube connector communicates with an air outlet passage extending completely through the sensor body to its lumber-engaging surface.

Below the cut-to-length station there is another sorting area (FIG. **6**) where boards cut to length by the length saw are sorted according to length. The sorting area includes two inclined slideways **270, 272**. Slideway **270** includes a series of four diverter gates **274** selectively pivotable upwardly on shafts **275** by air cylinders (not shown) to divert boards into one of four chutes or bins **276**. Each chute leads to one of two driven side transfer belts **278, 279**, which, when the machine is in operation, continuously convey sorted material from the apparatus. The sorting chutes are constructed in pairs, with each pair being formed by two outer walls **280, 281** and a vertical divider wall **282**. An additional series of end transfer belts **284** convey pieces not diverted into one of the four chutes from the apparatus. The four gates **274** include a random sorting gate **274***a*, a No. **1** sorting gate **274***b*, a No. **2** sorting gate **274***c*, and a No. **3** sorting gate **274***d*.

Slideway **272** includes a "junk" gate **286** and a "core block" gate **288**. Each of these gates is upstream of the cut-to-length saw, whereas the sorting gates **274** are downstream of such saw.

OPERATION AT CUT-TO-LENGTH STATION

In operation a random-length clear piece of lumber from the defect-cutting station longer than the minimum length of, say, 10 inches drops along slideway **202** onto closed drop gate **224** with one end in alignment with the cut-to-length saw. Piece-present sensor PP detects the piece and closes the drive-nip rolls, causing the rolls and fence **226** to press one face of the piece against driven roll **250** and stop-sensors on bar **254**, depressing some or all of the stop-sensors, depending on the length of the piece. When this occurs, drive roll **250** rotates in a counter-clockwise direction, driving the piece endwise toward the cut-to-length saw. The piece continues toward such saw until the first one of the depressed stop sensors SS is released. Upon such release, drive roll **250** reverses to drive the downstream end of the piece against the released stop. Then air cylinder **244** extends to stroke the length saw **234**, cutting the piece to a specified length as determined by the released stop. Air cylinder **232** then retracts, opening drop gate **224** and dropping the piece of specified length into one of sorting chutes **276**. The chute into which the piece is diverted is determined by the released stop SS which, as soon as released, signals one of gates **274** to open through the pneumatic-fluidic control circuit of FIG. **13**.

A pair of sensors upstream of the cut-to-length saw, including junk sensor **S–5** and a core block sensor **S–10**, determine the length of the short piece on that side of the saw. Pieces less than a minimum length of, say, 5 inches are diverted to junk through gate **286**, whereas pieces between the minimum length and, say, 10 inches are diverted to the core block sort through diverter gate **288**.

If a piece arriving at the cut-to-length station is less than the shortest specified length as determined by the position of the closest stop sensor **SS–15** to the length saw, then piece-present sensor PP acts through the fluidic circuit to divert such short random-length piece directly to the random sort through gate **274***a* without stroking the saw. Additional adjustable random-length sensors such as sensor RS can be mounted on the stop-sensor bar to cause lumber covering such stops but not stop-sensors beyond such stops to be diverted to the random sort without saw operation.

The sensors on the stop-sensor bar are adjustable in short increments of, say, ¼ inch. Each stop-sensor SS can be connected to field-changeable connections in the pneumatic-fluidic control circuit in such a way as to cause any selected one of the sorting gates **274** to open when a given stop-sensor is released.

CONTROL SYSTEMS

The control system of the illustrated embodiment is broken down into two parts. First, an electrical control system shown in FIG. **12** controls the operation of the marking and defect-sawing sections of the apparatus. Second, a pneumatic-fluidic control system shown in FIG. **13** controls the operation of the cut-to-length section and sorting therefrom.

ELECTRICAL CONTROL SYSTEM

Referring to the electrical control circuitry of FIG. **12**, the portion of the circuit within bracket **300** represents marking station operations controlled manually from operator's station **14**. This portion of the circuit includes a series of manually controlled switches including a "flip" switch **290**, a "center" switch **291**, a "down" switch **292**, and a "feed" switch **293**. These four switches are opened and closed selectively by the operator using a four-way "wobble" stick control **302** shown schematically in FIG. **14**. With this stick the op-

erator controls actuation of flipper arms **44** at the infeed side of the marking station and operation of the driven infeed nip roll **61.** More specifically, with the wobble stick in its "down" position, arms **44** assume their retracted near-horizontal position as shown in full lines in FIG. **2.** With the wobble stick moved to its centered position, flipper arms **44** pivot to their midway position **44***a* of FIG. **2** to tilt a board on-edge at approximately a 60° angle to the horizontal. When the wobble stick moves to its "flip" position, flipper arms **44** pivot to their near-vertical position **44***b* in FIG. **2** to turn a board over on skid rails **40.** When the desired face of a board is tilted toward the operator, movement of the wobble stick to its "feed" position activates the driven infeed nip roll **60** at the marking station to feed a board toward marking nozzle **72.** In the illustrated circuit, the fifth position of the wobble stick is not used but could be used if desired to activate the infeed drive **60** in a reverse direction to help center a defect at the marking nozzle **72.**

Time delay relay TDB in line **294** controls the time interval between commanding the flipper arms to their down position and their return to their centered position **44***a* by closing contact TDB in line **295.** When "flip" is commanded by the wobble stick, flip switch **290** moves downwardly to close lines **296, 297,** thereby extending both air cylinders **47** and **48** in FIG. **2.** With the wobble stick centered, "center" switch **291** closes in line **295,** and as soon as relay TDB times out, its contact TDB in line **295** also closes, thereby extending only air cylinder **47** to move flipper arms **44** to their midway positions **44***a*. With the wobble stick in the "down" position, lines **304** and **304***a* are closed by upper throw of switch **292** to retract cylinders **47** and **48** and return flipper arms **44** to their lowered positions.

A relay X in line **306***a* is a control relay which allows the infeed nip rolls **60, 61** to remain closed if a piece of lumber is present between such rolls and "feed" is commanded by the wobble stick. Sensor PC–**1** is a retroreflective photocell which senses lumber in the marking station infeed nip rolls and in response closes a normally open contact PC–**1** in line **306** to retract air cylinder **62** and thereby close the nip rolls. A spring return on cylinder **62** opens the infeed nip rolls when contact PC–**1** is reopened by the absence of a piece between such rolls.

Retroreflective photocell PC–**2** at the outfeed nip rolls **74, 75** of the marking station closes a corresponding contact PC–**2** in line **308** when a piece is present between such rolls, thereby actuating an air cylinder to close the outfeed nip rolls. The outfeed nip rolls reopen via a spring return when a piece is no longer present between such rolls.

A retroreflective photocell PC–**3** on the screw roll transfer table senses the presence of lumber on such table and closes a corresponding contact PC–**3** in line **310** to energize a time delay relay TD–**1.** This relay times out if photocell PC–**3** is blocked longer than its setting to close relay contact TD–**1** in line **310***a* and thereby illuminate a warning light R on the operator control panel to warn the operator that the transfer table is full.

Photocell PC–**4** is a retroreflective "line scan" photocell which senses a marked defect between the defect saws. When a defect is sensed, corresponding contacts PC–**4** in lines **312, 315** close to energize single coil latching relays L–**1** and L–**2.** These relays close corresponding contacts L–**1** and L–**2** in lines **313, 316** to extend the air cylinders **158** for the defect saws to stroke such saws simultaneously. Normally closed latching relay contacts L–**1** and L–**2** in lines **314, 317** retract the defect saw actuating cylinders to return the saws to their initial positions.

The portion of the circuit within bracket **318** represents an anticipator circuit which provides the control for cutting pieces to specified long clear lengths at the defect-cutting station. This circuit includes a permanent magnet latch relay PML in line **319.** A pulse through line **319***a* causes unlatching of the relay, whereas a pulse through line **319***b* causes latching of the relay. The relay latches if the anticipator system is to be used. In this regard a pulse from photocell PC–**4** closes a corresponding contact PC–**4** in line **319***a* to cause unlatching of the relay. On the other hand, a pulse from the retroreflective line scan photocell PC–**5** upstream from the defect saws closes a contact PC–**5** in line **319***b* to cause latching of the relay when it senses a marked defect. This photocell is also used to control the screw roll transfer table off-feed nip rolls **90,** although a separate photosensor PC–**6** also serves this function.

A limit switch SW–**1** senses lumber at the defect saw outfeed drive roll. It has a contact SW–**1** in line **319***c* in parallel with a normally open contact PC–**4** in line **319***a* which functions to control the resetting of relay PML. An additional switch contact SW–**1** in line **323***b* controls a relay KA in line **323** which stops the motor for drive rolls **162** by closing contact KA in line **327.** A third contact SW–**1** in line **338***a* energizes time delay relay TD–**4** in line **338.** This relay controls the time allowed for the defect saws to stroke by delaying the retraction of the movable fence to drop a clear piece until after it times out to close relay contact TD–**4** in line **340.**

Sensors A–**1,** A–**2** and A–**3** are retroreflective photocells positioned on the outfeed side of the defect saws and at adjustable distances therefrom for sensing the downstream end of a piece traveling downstream through the defect station. These three sensors determine the maximum length available for the long clear cut-to-length function of the defect station. Latching of the PML relay in line **319** by photocell PC–**5** closes a contact PML in line **326,** energizing a time delay relay TDA forming part of a "one-shot" system for the anticipator circuit. The closing of the PML contact also energizes a control relay C in line **326***a*, in parallel with the relay TDA. Relay C is an output control for the one-shot anticipator system and remains energized until relay TDA times out to open contact TDA in line **326***a*. Energization of relay C closes a corresponding contact C in line **320.** At this moment if the photocell A–**1** senses the end of a board on the outfeed side of the defect saw but photocells A–**2** and A–**3** do not, the corresponding contact A–**1** in line **320** also closes, causing the air cylinder on the first pop-out stop **180** to extend to set such stop and determine the specified long length to be cut.

On the other hand, if, at the time the PML relay is latched, both photocells A–**1** and A–**2** sense the downstream end of the piece, corresponding contacts A–**1** and A–**2** in line **321** close while the corresponding contact A–**2** in line **320** opens, thereby extending the air cylinder on the second pop-out stop **181** to set that

stop and determine a slightly longer specified length to be cut.

A third line **322** with normally open sensor contacts A–**1**, A–**2** and A–**3**, all close when all three of the corresponding sensors detect the downstream end of a piece at the same time sensor PC–**5** detects a marked defect. This event also opens the contacts A–**3** in lines **320** and **321** so that only the third of the three pop-out stops **182** is set to determine the longest of the three specified clear lengths to be cut by the defect saw.

Sensors SA–**1**, SA–**2** and SA–**3** are retroreflective photocells which detect the end of a board as it approaches one of the stops and function to slow the drive rolls **162** to slow down the lumber before it reaches the set mechanical stop. These sensors have corresponding normally open contacts in line **324.** When any one of such sensors senses a piece, it closes its corresponding contact in line **324** to energize time delay relay TD–**2** which times out the deceleration period prior to stopping the lumber at the set mechanical stop. When relay TD–**2** times out, it closes a contact TD–**2** in line **323** thereby energizing a control relay KA. This relay has a contact KA in line **327** which closes when the relay is energized to stop drive rolls **162.** Contacts PC–**4** and SW–**1** in parallel with contact TD–**2** in line **323** also serve this function.

A single coil latching relay K–**1** in line **325** is energized either when a relay contact KA is closed or a relay contact TD–**6** is closed in the same line. Relay TD–**6** is a time delay relay in line **344** controlling the time allowed for the defect saws to clear the piece before restarting drive rolls **162.** Relay K–**1** thus is controlled by the drive "start-stop" signals and includes a corresponding contact K–**1** in line L to enable operation of the sorting gate circuitry.

Time delay relay TD–**4** in line **338** can be energized either by closing limit switch contact SW–**1** in line **338***a* or by closing relay contact K–**1** through its corresponding latching relay K–**1** in line **325.** When time delay relay TD–**4** times out, it closes contact TD–**4** in line **328** to retract the air cylinder on the set one of the three pop-out stops.

A time delay relay TD–**3** in line **329** controls the spacing between pieces of lumber fed into the defect station by the nip rolls **90.** It controls the spacing by controlling the delay in reopening of infeed nip rolls **90.** Relay TD–**3** is energized when a contact PC–**5** in line **329** closes. This contact is closed by the corresponding photocell PC–**5.** When relay TD–**3** times out, it closes contact TD–**3** in line **330** to open nip rolls **90.**

The piece-present sensor PC–**6** is also a retroreflective photocell which functions to reclose nip rolls **90** when a piece is present at the fence on the screw roll table by closing sensor contact PC–**6** in line **331.**

The remaining portion of the circuit controls the sorting from the defect station. As previously mentioned, it is necessary for the functioning of the sorting circuit for the normally open gate set-up control contact K–**1** in line L to be closed by relay K–**1** in line **325,** which can only occur when drive rolls **61** are stopped.

The two outfeed sensors O–**5** and O–**10** are retroreflective photocells which measure a piece at 5 inches and 10 inches, respectively, downstream from the downstream defect saw **139.** Sensor O–**5** has normally open contacts O–**5** in lines **332** and **333** and a normally closed contact O–**5** in line **334.** Outfeed sensor L–**10** has a normally open contact in line **332** and normally closed contacts in lines **333** and **334.** Thus if both sensors O–**5** and O–**10** sense the piece, indicating a piece longer than 10 inches on the outfeed side of the defect saws, contacts O–**5** and O–**10** in line **332** close to actuate the flip-flop gate **206** in FIG. **6** to a position for diverting the piece to the cut-to-length station. On the other hand, if only sensor O–**5** senses the piece, line **332** remains open and line **334** is open, but line **333** closes, energizing control relay K–**2.** This relay closes relay contact K–**2** in line **355***a* to close line **335** and position the flip-flop gate to divert the piece to the core block or junk sort. At the same time another relay contact K–**2** in line **336** closes to open core block gate **209.**

Similarly, if a piece on the outfeed side of the defect saws is less than 5 inches, neither lines **332** or **333** close, but line **334** remains closed, energizing relay K–**3** which closes relay contacts K–**3** in lines **335** and **337** to divert the short piece to junk, the line **337** controlling the junk sort gate.

The similar retroreflective photocell sensors I–**5** and I–**10** at the infeed side of the defect saws measure pieces at 5 inches and 10 inches, respectively, from upstream defect saw **138.** If the piece upstream of the defect saws is shorter than 5 inches so that neither photocell is activated, the normally closed contacts in line **339** and **339***a* remain closed to open infeed junk gate **208.** However, if the sensor I–**5** is energized, the contact I–**5** in line **339***a* opens and the contact I–**5** in line **339** closes, opening infeed core block gate **209.**

Now, however, assuming that the piece remaining upstream of the defect saws is so long that it energizes both sensors I–**5** and I–**10** indicating that its length is greater than 10 inches, neither the infeed core block gate nor the infeed junk gate opens, and contact I–**5** and I–**10** in lines **346** and **346***a* open to prevent retraction of the short movable fence and release of the piece to the sorting area. In the meantime, time delay relay TD–**6** times out and drive rollers **162** restart to feed the piece into the defect saws.

Time delay relay TD–**4** in line **338** controls the time allowed for the defect saws to stroke before the movable fence retracts to drop the piece. Time delay relay TD–**5** in line **341** controls the time allowed for the movable fences to operate. When relay TD–**4** times out, it closes contact TD–**4** in line **340** to retract the long movable fence **122** and drop the cut piece to the cut-to-length station. At the same time it closes contact TD–**4** in line **341** to energize time delay relay TD–**5.** When relay TD–**5** times out, it closes contacts TD–**5** in lines **342** and **343** to extend the short and long movable fences **120, 122.** The timing out of this relay also closes contact TD–**5** in line **344** to energize relay TD–**6.** When relay TD–**6** times out, it closes contact TD–**6** in lines **345, 345***a* to restart drive rolls **162.**

The retroreflective photocells are complete units including light source, pick-up, amplifier and output relay. The line scan photocells are complete with power supply, amplifier and relay. Both types of photocells are well known and readily commercially available.

PNEUMATIC-FLUIDIC CONTROL SYSTEM

Referring to the control logic diagram of FIG. **13,** a pneumatic-fluidic control system is used for controlling the operation at the cut-to-length station and the sorting which takes place from the cut-to-length station.

The circuit includes an air supply line **360** supplying air to each of the **15** stop-sensors SS–**1** through SS–**15** positioned along stop-sensor bar **254** and also to piece-present sensor PP and random-length sensor RS on the bar. All these sensors are on one side of the cutting plane **234***a* of the cut-to-length saw. The air supply line also supplies air to two measuring sensors SS–**5** and SS–**10** on the opposite side of the cut-to-length saw.

From the construction of a typical stop-sensor SS as shown in FIG. **11**, it will be seen that when the depressible stop lever of each stop-sensor is in its released position, there will be a relatively high back pressure in the various input lines **361** leading to the various pairs of input one-shot gates M–**1** through M–**4**. This is the normal condition of the circuit when there is no board present at the cut-to-length station.

However, with no board present, random-length sensor RS, piece-present sensor PP and core block and junk-measuring sensors S–**5** and S–**10**, all of which are normally open to atmosphere when unblocked, induce a relatively low back pressure in their input lines **362, 363, 364, 369**, respectively, leading to their respective input gates M–**6**, M–**8**, M–**9**.

When a board arrives at the cut-to-length station normally blocking at least piece-present sensor PP and the random-length sensor RS, a relatively high back pressure is induced in their respective input lines **362, 363**. Of course, when sensors S–**5** and S–**10** are blocked, there is a high back pressure output from these sensors also to their respective input gates.

However, when a board is pressed against the stop-sensors SS to depress their stop levers, a low pressure pulse is induced in their input lines **361**. When one of the stop-sensors SS is released again, its input line **361** transmits a high pressure pulse.

The illustrated control circuit includes ten series of NOR gates M–**1** through M–**10** interconnected in such a manner with each other and connected to the various stop-sensors, random sensors and other sensors to operate the various elements at the cut-to-length station in the manner previously described under the heading "Operation at Cut-to-Length Station."

In addition to the NOR gates, the circuit includes three sorting gate manifolds **365, 370, 374**. Manifold **365** controls the air supply through line **366** to a No. **1** sorting gate flip-flop circuit **367** which controls the opening and closing of the No. **1** sorting gate **274***a* through controlling the shifting of a No. **1** gate cylinder operating valve **368**.

Manifold **370** controls the air supply to a second flip-flop circuit **367***a* through line **371** to control the shifting movement of the No. **2** sorting gate cylinder operating valve **372**.

The third gate manifold **374** controls the supply of air through a line **375** to a third sorting gate flip-flop circuit **367***b* which controls the operation of the No. **3** sorting gate cylinder operating valve **376**.

Lines **377** from each of the three sorting gate manifolds lead to a CTL flip-flop circuit **378** which controls signals to a drive reverse timing control one-shot circuit **380**, including a variable timer D–**4** and a pair of gates M–**7**. The CTL flip-flop circuit also controls the signal to a saw stroke time delay D–**3**, to saw stroke one-shot gates M–**7** at **382**, and to the CTL drive motor control valve **384**. Signals from the saw stroke one-shot gates **382** are transmitted to a saw "single stroke" steerable flip-flop circuit **386** controlling the operation of the saw stroke control valve **388**.

Because there are only three sorting gates which sort material to length but a total of **15** stop-sensors, the sensors are arranged in the circuit so that sensors SS–**1**, SS–**5**, SS–**9** and SS–**13**, that is every fourth sensor, lead to manifold **365** so as to sort into the No. **1** sorting gate. Then sensors SS–**2**, SS–**6**, and so forth sort into the No. **2** sorting gate, and sensors SS–**3**, SS–**7** and so forth sort into the No. **3** sorting gate. Sensors SS–**4**, SS–**8** and SS–**12** then can be arranged to either sort into the random sorting gate, not shown in the circuit, or connected so as not to actuate any of the gates whereby they are carried off on the transfer belts **284**. In any event, the input gates for the sensors SS–**4**, SS–**8**, SS–**12** are connected so as to transmit a signal into the CTL flip-flop circuit **378** in a manner, for example, shown with respect to the stop-sensor SS–**8**, which is typical of the way in which the input gates from sensors SS–**4** and SS–**12** would also be connected.

When random-length sensor RS is covered but downstream sensors SS–**12**, SS–**13**, etc., are not depressed, a high pressure air pulse is transmitted from random-length sensor RS through input line **362** to a series of three gates M–**6**. These gates transmit a signal to a random-length flip-flop circuit **390** including a pair of gates M–**8** which, in conjunction with downstream pairs of gates M–**8** and M–**7**, maintain the CTL drive motor valve **384** in its neutral position so that the CTL drive does not operate. At the same time a signal shifts control valve **392** to operate the CTL drop gate and drop the random piece to its sorting area.

The piece-present sensor PP, when blocked, transmits a high pressure signal through line **363** to piece-present flip-flop circuit **394** including a pair of gates M–**8**, which controls the operation of a CTL fence control valve **396** and a fence-extend time delay D–**1**. At the same time a line **397** leading from sensor SS–**15**, under high pressure when sensor SS–**15** is not depressed, leads to a series of three short length random control gates **398**. These gates produce a signal which shifts the CTL drop gate valve **392** in a direction for opening the drop gate when only the piece-present sensor is blocked and none of the stop-sensors are depressed. These control gates also control the operation of a piece drop time delay D–**2**.

Further down the diagram of FIG. **13**, measuring sensors S–**5** and S–**10**, when blocked, transmit a high pressure pulse through a series of input gates M–**9** to a junk gate flip-flop circuit **400** in the case of sensor S–**5** and to a core block flip-flop circuit **402** in the case of sensor S–**10**. Flip-flop circuit **400** controls the operation of a CTL junk gate cylinder operating valve **404**. Flip-flop circuit **402** controls the operation of a valve **406** for controlling the operation of the core block gate cylinder.

In typical operation of the logic circuit to cut a board to length, assume that a long, clear, random-length board drops to the cut-to-length station and is long enough to cover all of the **15** stop-sensors from SS–**1** through SS–**15**. First the board blocks piece-present sensor PP, sending a high pressure signal to the flip-flop gates **394** and resulting in a high pressure signal to the "extend" side of the CTL fence-operating valve to shift the valve, whereby fence **224** and the drive-nip rolls press the board against the CTL stop bar **254**, depressing all of the stop-sensors SS–**1** through SS–**15**. At this

time the stop-sensor input gates place the manifolds **365, 370, 374** under low pressure, closing the three sorting gates. The low pressure also causes CTL flip-flop circuit **378** to transmit a low pressure signal to the input side of the gate M–7 leading to the CTL drive motor control valve **384** whereby such gate transmits a high pressure output to the "forward" side of valve **384,** causing the CTL drive roll to operate in a direction to feed the board endwise toward the saw cutting plane **234***a*. This endwise movement continues until stop SS–1 is released.

When stop-sensor SS–1 releases, its input gates M–1 send a high pressure signal into manifold **365** causing the No. 1 sorting gate valve **368** to shift to open the No. 1 sorting gate. At the same time, a high pressure signal from manifold **365** causes a high pressure input into the CTL flip-flop circuit **378,** resulting in a high pressure input signal at the drive reverse timing one-shot **380** to shift the CTL drive motor valve **384** to its reverse position, reversing the direction of the CTL drive roll, and at the same time actuating the drive reverse timer D–4 and the saw stroke time delay D–3. Thus the board is driven back against the released stop lever of stop-sensor SS–1 and the CTL drive motor stops when timer D–4 times out. Thereafter time delay D–3 also times out, whereby the saw stroke one-shot **382** transmits a signal to saw stroke steerable flip-flop **386** which actuates the saw stroke operating valve **388** to stroke the saw. Thus the board is cut to specified length as determined by the distance of stop-sensor SS–1 from the cutting plane **234***a*.

After the CTL saw strokes, piece drop time delay D–2 times out, permitting the CTL drop gate valve **392** to shift to open the drop gate, dropping the cut-to-length piece through the open No. 1 sorting gate. When the piece drops from the cut-to-length station, all of the stops are cleared and the piece-present sensor is opened causing the CTL fence to retract and the CTL drop gate to reclose to await arrival of the next piece.

With the foregoing description of the operation of the circuit, those skilled in the art should be able to trace the operation of the circuit for other lengths of boards, including short boards which cover only the piece-present sensor and longer boards extending only to random sensor RS. Under both mentioned conditions, the CTL drop gate opens without the drive motor operating and without the saw stroking.

Having illustrated and described a prototype of my invention and what is now a preferred embodiment thereof, it should be apparent to those skilled in the art that the same permits of modification in arrangement and detail. It will be apparent, for example, that various types of control circuits may be employed other than the typical electrical and fluidic circuits illustrated. It will also be obvious that various other sorting and transfer arrangements could be used. It may also be desirable in certain instances to increase the speed of production by providing two cut-to-length stations to which pieces are fed alternately from the defect-cutting station. In any event, I claim as my invention all such modifications coming within the true spirit and scope of the following claims.

I claim:

1. The method of clear-cutting preformed lumber of specified width and thickness dimensions to specified or random lengths comprising the steps:

cutting defects from a piece of lumber at a first defect-cutting station by sensing the defect, severing said piece on opposite sides of each said defect in response to the defect sensing to remove defect-containing sections from said piece and to thereby form a clear piece of lumber of random length extending downstream of said station,

transferring the resulting clear random-length piece from said defect-cutting station to a cut-to-length station,

sensing the longest one of several predetermined specified lengths in said random-length clear piece at said cut-to-length station,

and cutting said piece to the longest specified length sensed in response to the longest-length sensing at said cut-to-length station to thereby form a finished clear piece of lumber of specified length.

2. The method of claim **1** inluding diverting clear pieces shorter than a predetermined minimum clear length from said defect-cutting station to a collection point bypassing said cut-to-length station.

3. The method of claim **1** wherein each said defect is removed from said piece by severing said piece on opposite sides of said defect simultaneously using a pair of defect-cutting saws spaced closely apart along the length of said piece.

4. The method of claim **1** wherein defects are removed from a piece at said defect-cutting station by moving said piece endwise in one direction past a pair of defect-cutting saws until a defect is sensed between said saws and then stopping said piece and then moving said saws simultaneously against said piece in response to said defect sensing to cut the defective section therefrom, and then repeating the aforesaid sequence for each successive defect along the length of said piece until all defects are removed therefrom to produce a series of random-length clear pieces.

5. The method of claim **4** including measuring the clear lengths in each piece at the defect-cutting station and sorting according to length directly from said defect-cutting station those clear lengths cut which are less than a predetermined minimum length and transferring only clear lengths exceeding said predetermined minimum length to said cut-to-length station.

6. The method of claim **4** including measuring the clear length in a piece at said defect-cutting station and when a piece contains a clear length exceeding a specified long clear length, positioning said piece with respect to one of said defect-cutting saws to enable cutting said specified long clear length and then actuating only said one defect-cutting saw in response to said positioning to sever said specified long clear length from the piece, and then diverting said specified long clear length to a collection point bypassing said cut-to-length station.

7. The method of claim **4** including detecting the defects in a piece at an inspection station upstream from said defect-cutting station, marking said defects with a sensitive material and then sensing said material at said defect-cutting station and using said sensing to position said defect between said defect-cutting saws and to actuate said saws.

8. The method according to claim **8** including sorting according to specified-length pieces cut to specified clear lengths at said cut-to-length station by using the specified length sensings at said cut-to-length station to

determine the sorting station to which each piece is directed.

9. The method of claim **4** including sliding a clear cut random-length piece from said defect-cutting station sideways and downwardly by gravity to said cut-to-length station to a position wherein one end of each random-length piece is in approximate alignment with the cutting plane of a cut-to-length saw at said cut-to-length station.

10. The method of claim **4** including transferring a random-length clear piece from said defect-cutting station to a position at said cut-to-length station wherein one end of the piece is in approximate alignment with the cutting plane of a cut-to-length means at said station, then pressing said random-length piece sideways against a series of aligned depressible stop-sensors referenced to said cutting plane in a manner determining specified lengths of lumber, then driving said random-length piece endwise over said depressed stops toward said cutting plane until one of said stops is released, then driving said piece endwise in the reverse direction against said released stop, then moving said cut-to-length means across said piece in said cutting plane to cut said piece to a specified length as determined by said released stop.

11. The method of claim **1** including tilting each piece on edge, and moving it endwise through a marking station upstream of said defect-cutting station in a manner so that a width dimension of said piece is visible to a defect detector alongside the marking station, detecting and marking defects along each piece with a retroreflective material at the marking station, then moving the marked piece endwise from said marking station to said defect-cutting station, sensing each retroreflective marking at said defect-cutting station and using such sensing to position each defect between a pair of defect-cutting saws and to actuate said saws to remove each defective section from said piece.

12. The method of cutting lumber to random or specified clear lengths comprising the steps:

detecting and marking defects in a piece of lumber with a sensitive material at a first station,

sensing said marked defects at a second station as said defects are positioned between a pair of defect-cutting means and using said defect sensings to activate said cutting means to sever defective sections from said piece,

then transferring resulting clear random-length pieces greater than a predetermined minimum clear length to a third station,

at said third station sensing the longest one of several specified clear lengths in a random-length clear piece and cutting said random-length clear piece to the longest specified clear length sensed in response to the length sensing.

13. The method of claim **13** including sorting pieces from said third station according to length as determined by length sensings at said third station.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,856,061

DATED : December 24, 1974

INVENTOR(S) : Thomas R. Miles

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 47, "proceding" should be --preceding--;
Column 16, line 37, "contact" should be --contacts--;
Column 20, claim 2, line 18, "inluding" should be --including--;
Column 20, claim 8, line 64, "claim 8" should be --claim 1--;
Column 22, line 27, claim 13, "claim 13" should be --claim 12--.

Signed and sealed this 27th day of May 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

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Commissioner of Patents
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