United States Patent [19]

Wentz

[11] **3,792,758**

[45] **Feb. 19, 1974**

[54] STACKER CRANE CONSTRUCTION

[75] Inventor: **Edward A. Wentz**, Gaithersburg, Md.

[73] Assignee: **American Chain & Cable Company Inc.**, Bridgeport, Conn.

[22] Filed: **Nov. 15, 1971**

[21] Appl. No.: **198,917**

Related U.S. Application Data

[63] Continuation of Ser. No. 840,667, July 10, 1969, abandoned.

[52] **U.S. Cl.** ..... **187/9**, 214/730, 92/61, 214/16.4 A

[51] **Int. Cl.** **B65g 1/06**

[58] **Field of Search** ..... 214/16.4 A; 187/9, 95, 17; 212/14, 6

[56] **References Cited**

UNITED STATES PATENTS

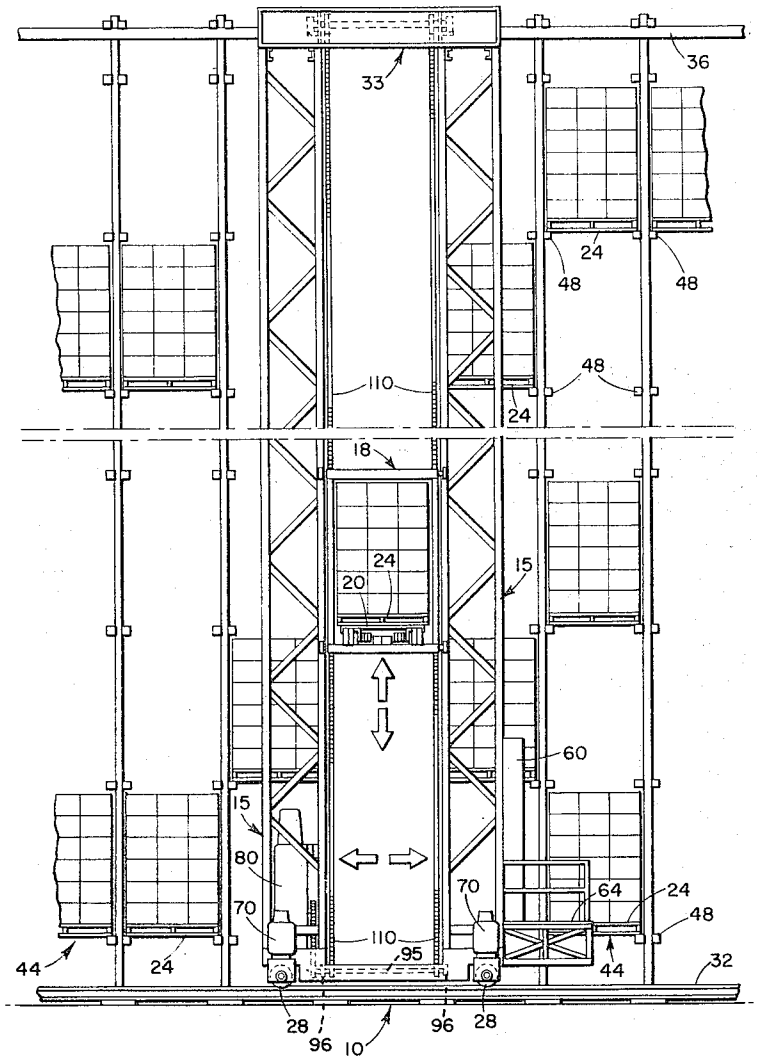
1,066,052	7/1913	Ritter	214/16.1 EC
1,697,478	1/1929	Sandberg	187/9
2,966,996	1/1961	Friend	187/17 X
1,699,544	1/1929	Rohlfing	187/9
1,927,677	9/1933	Bennington	187/9
2,876,913	3/1959	Roth et al.	214/16.1 EB

Primary Examiner—Robert G. Sheridan
Assistant Examiner—R. B. Johnson
Attorney, Agent, or Firm—Zalkind, Horne & Shuster

[57] **ABSTRACT**

A stacker crane storage arrangement wherein a tray is supported for reversible extension transversely of a tower which is movable on a track, so as to deposit cargo laden pallets in cells or cubicles of open sides storage grids on both sides of the track. The tray of the tower is movable by a compact mechanism, utilizing telescopically and reversibly extending drive members carried by pairs of cantilever beams and driven by sprocket chains and hydraulic cylinders in a dual system which effects reversible motion of a tray to either side of the tower. The telescopic tray mechanism provides for moving a cargo laden tray to either a part distance or a full distance transversely of the tower, so that pallets can be stored in or retrieved from double depth storage grids. The specific racks or cells can hold two pallets in tandem, there being a first pallet position and a second pallet position in each cell. The arrangement and construction has features whereby very tall towers are usable.

6 Claims, 23 Drawing Figures



PATENTED FEB 19 1974

3,792,758

SHEET 01 OF 16

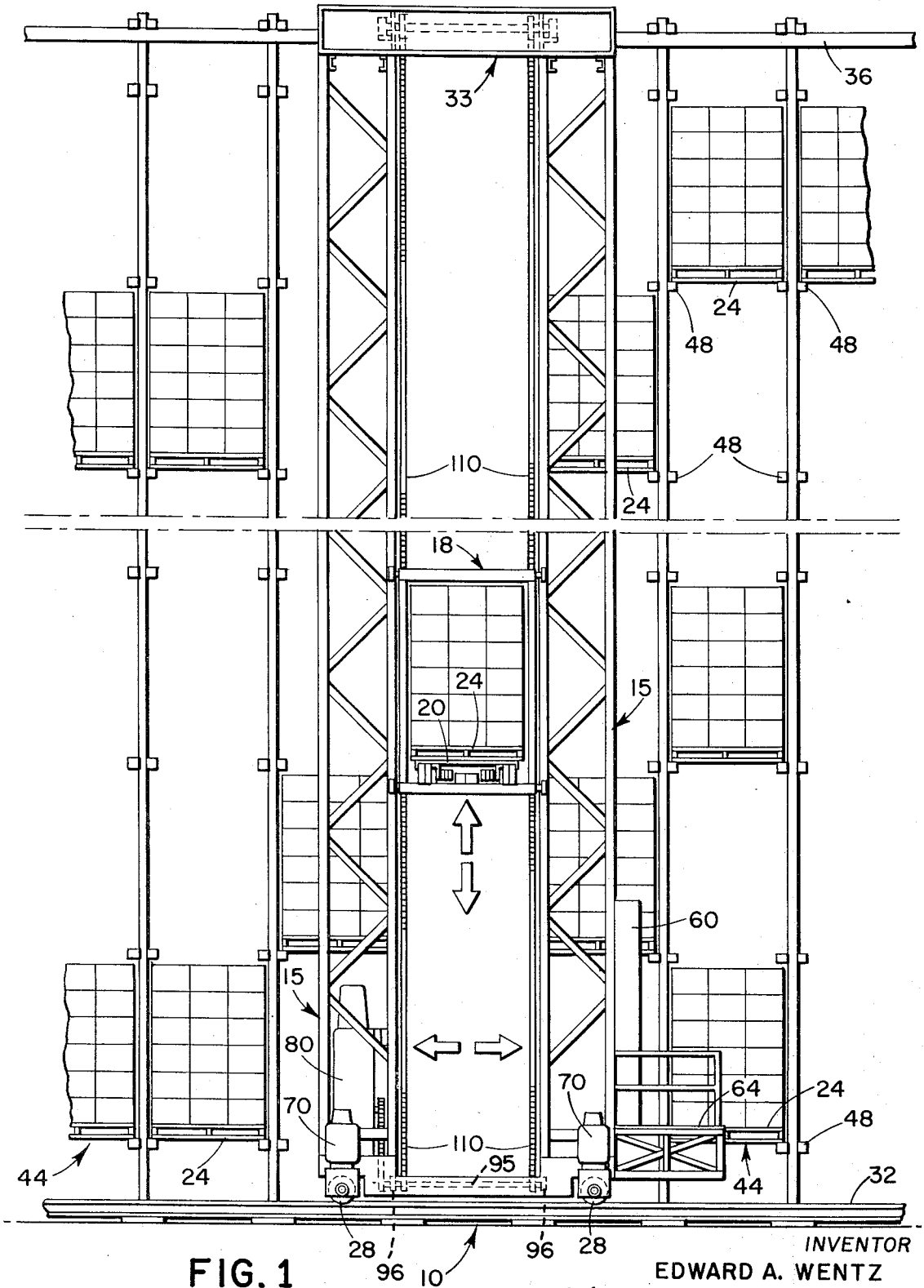


FIG. 1

INVENTOR
EDWARD A. WENTZ
BY Albert M. Zalkind
ATTORNEYS

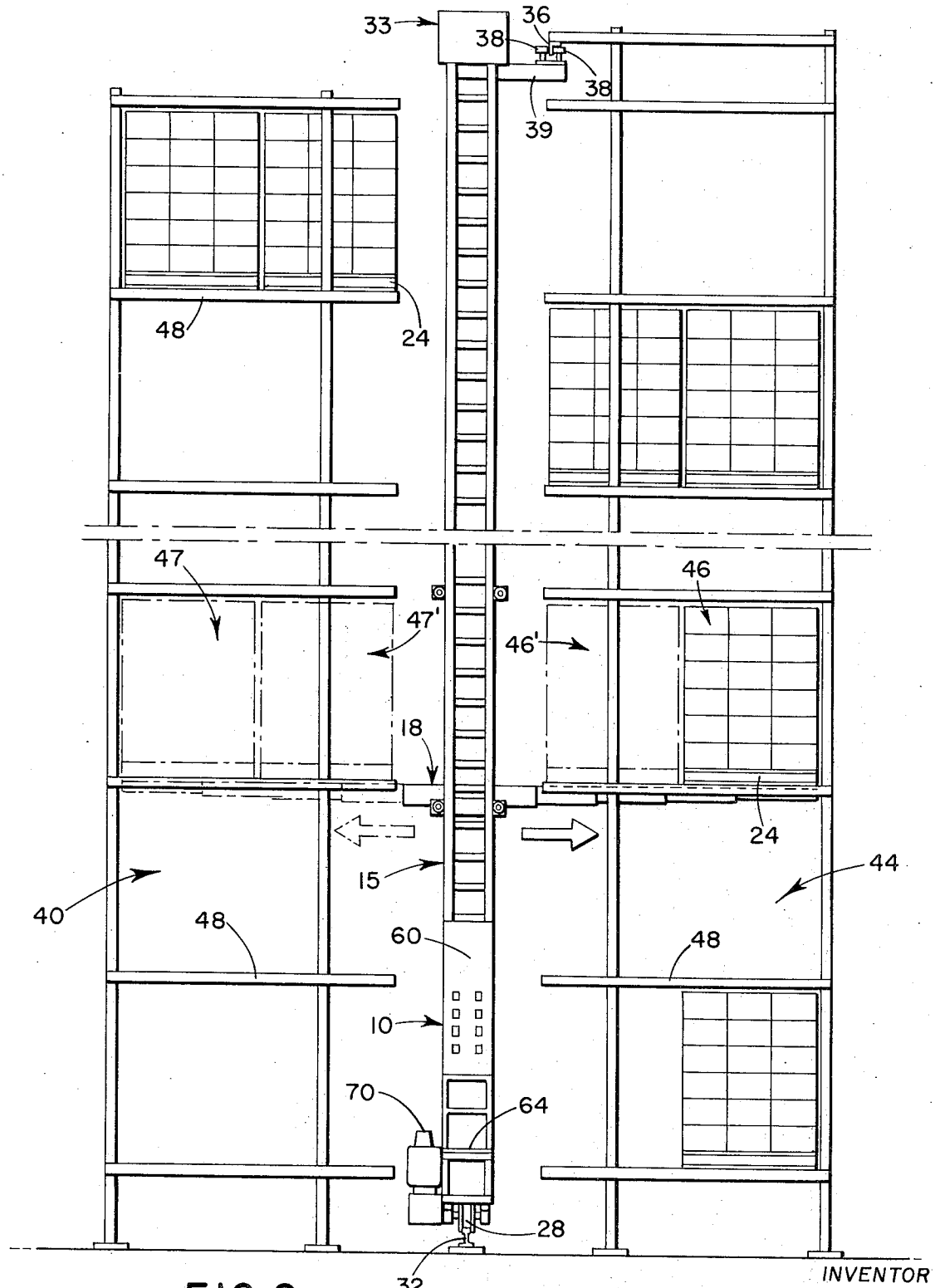


FIG. 2

INVENTOR
EDWARD A. WENTZ

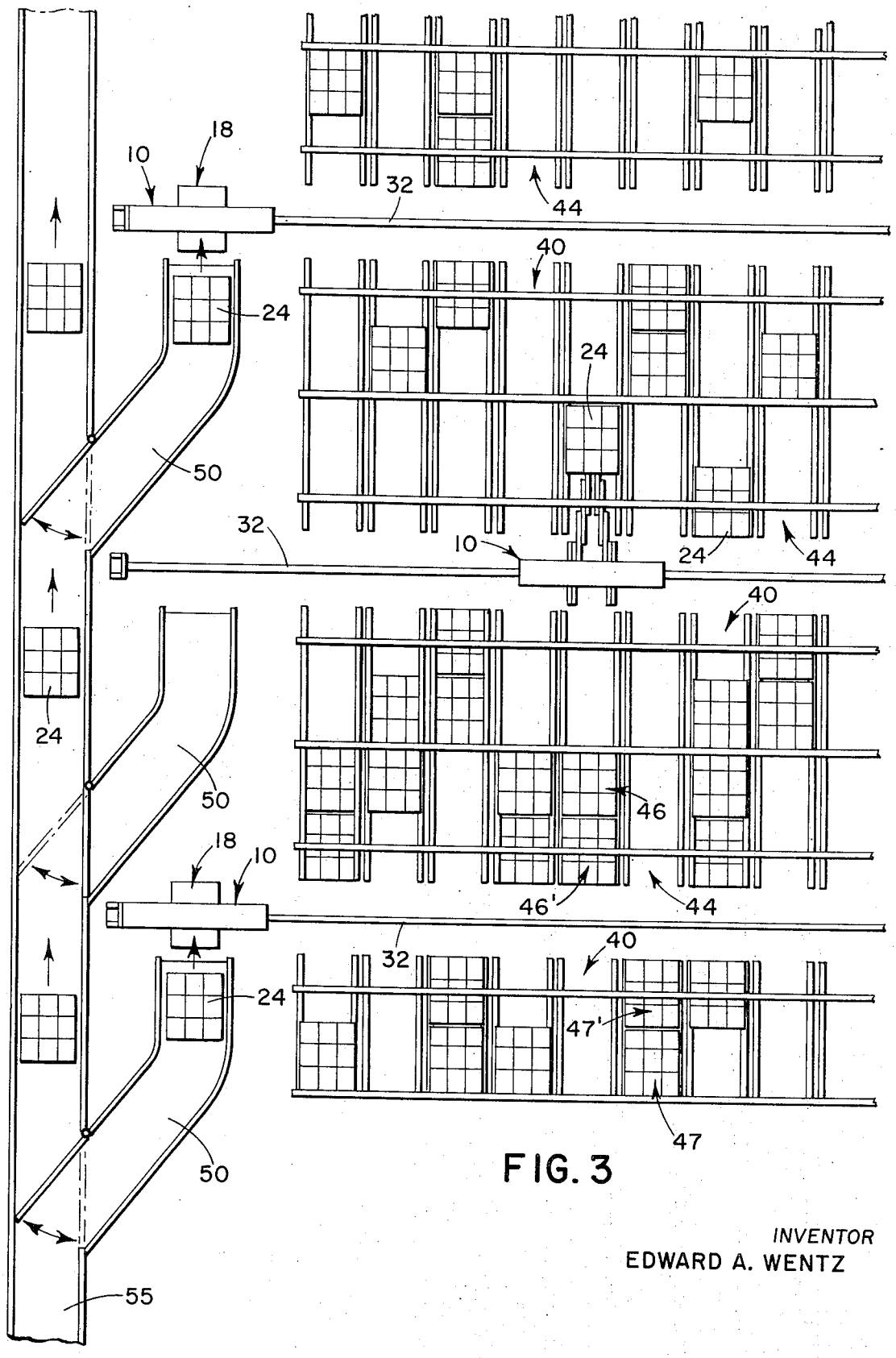


FIG. 3

INVENTOR
EDWARD A. WENTZ

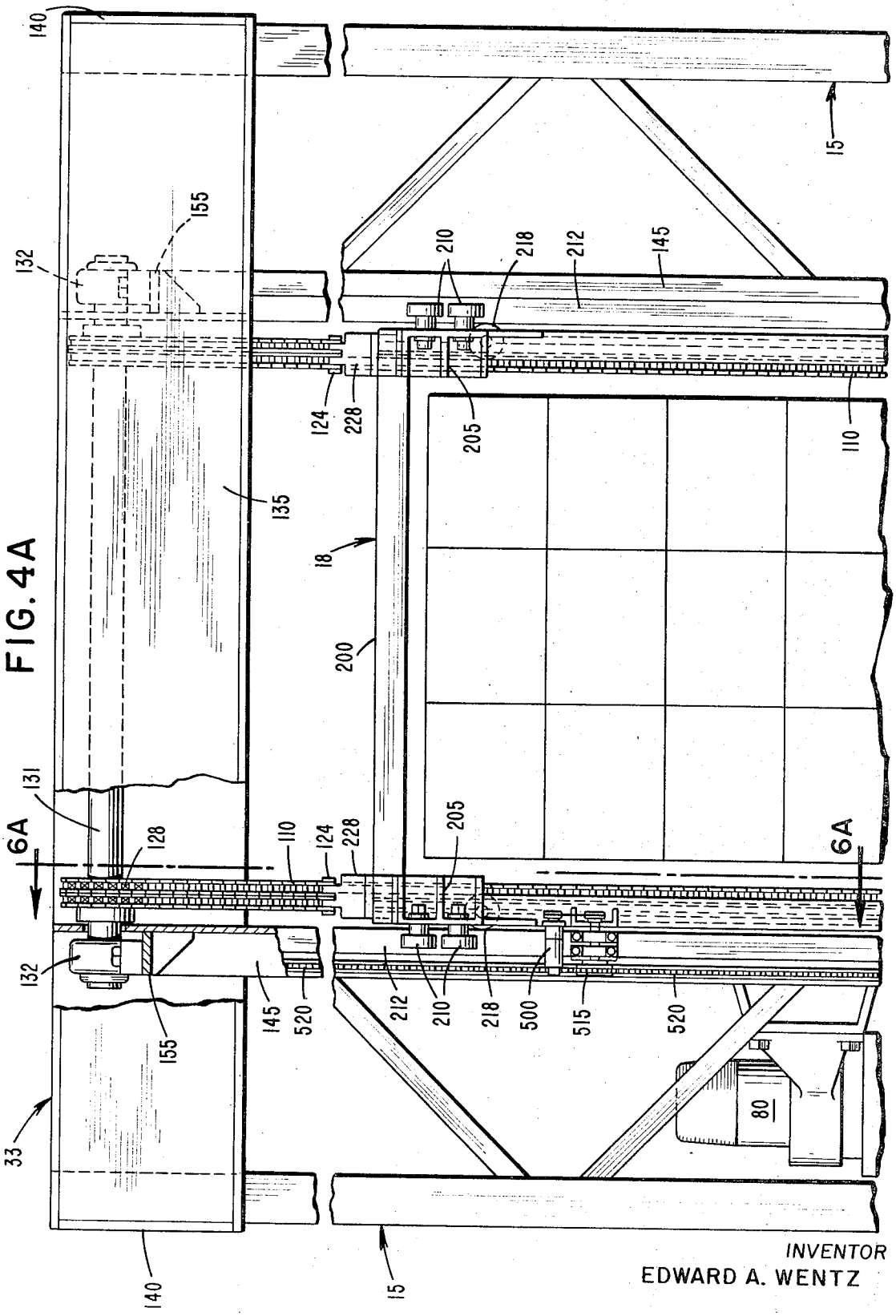


FIG. 4A

INVENTOR
EDWARD A. WENTZ

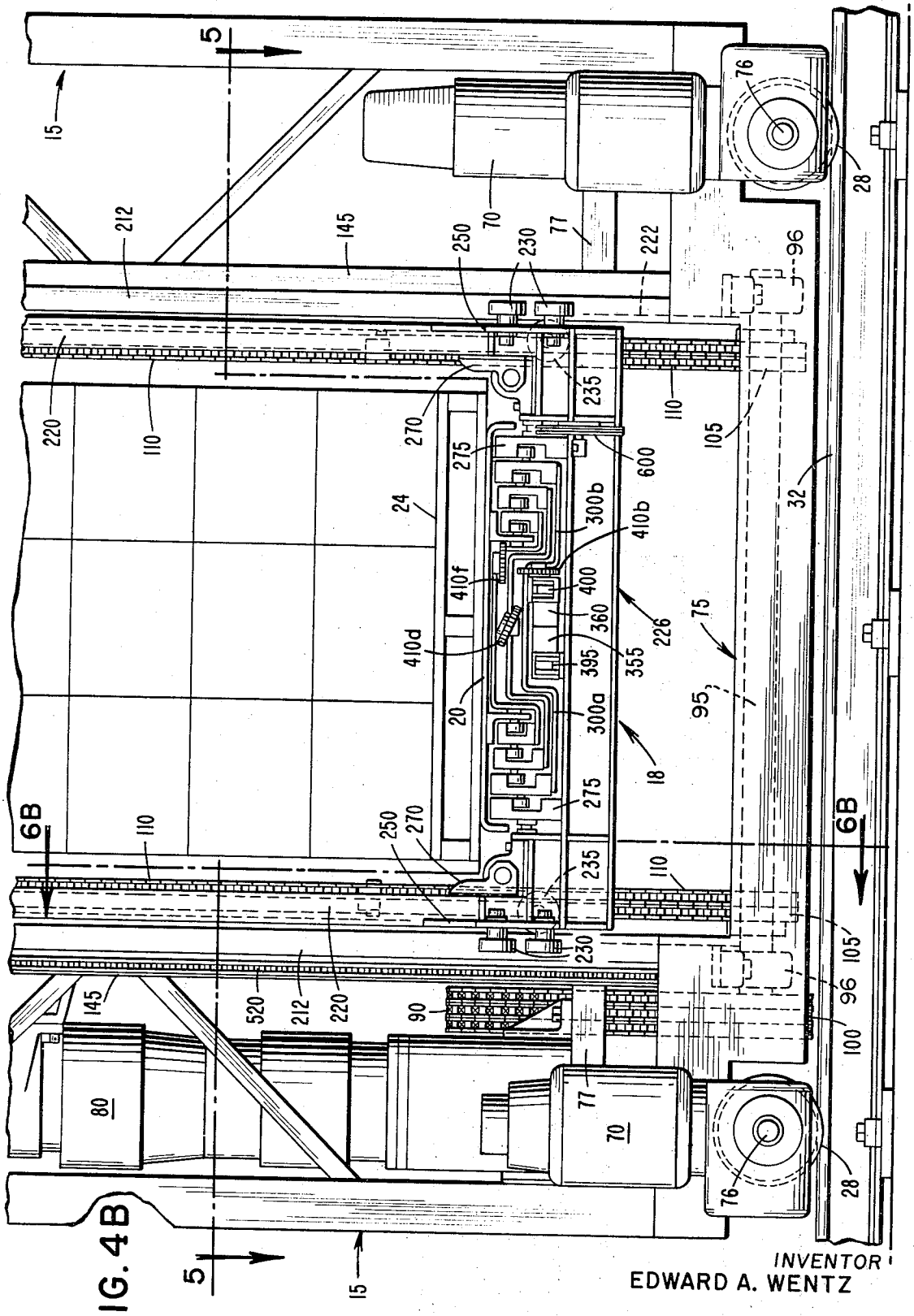


FIG. 4B

INVENTOR
EDWARD A. WENTZ

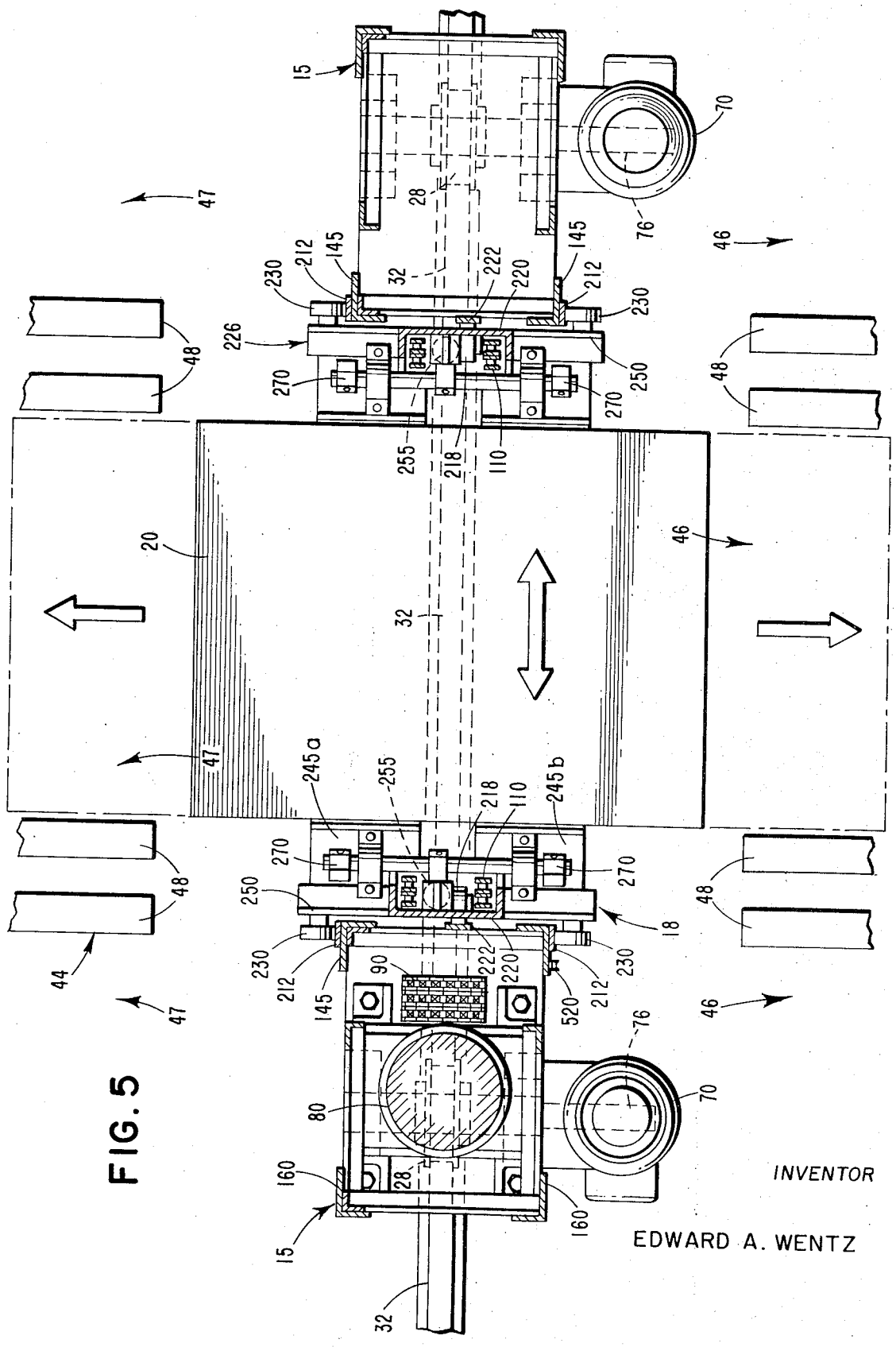


FIG. 5

INVENTOR

EDWARD A. WENTZ

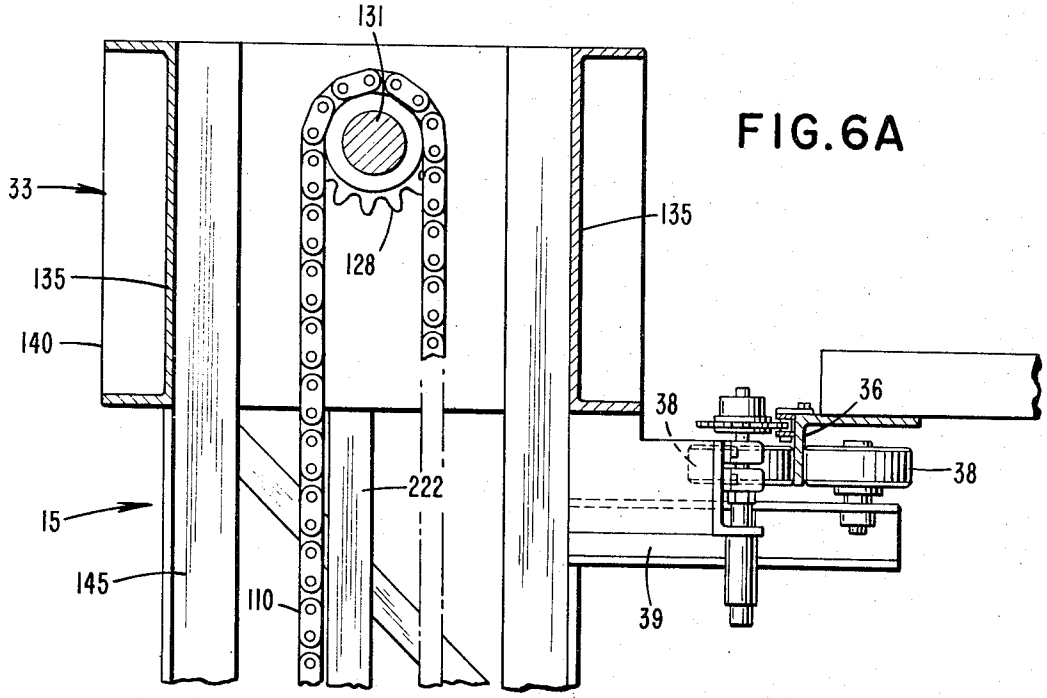


FIG.6A

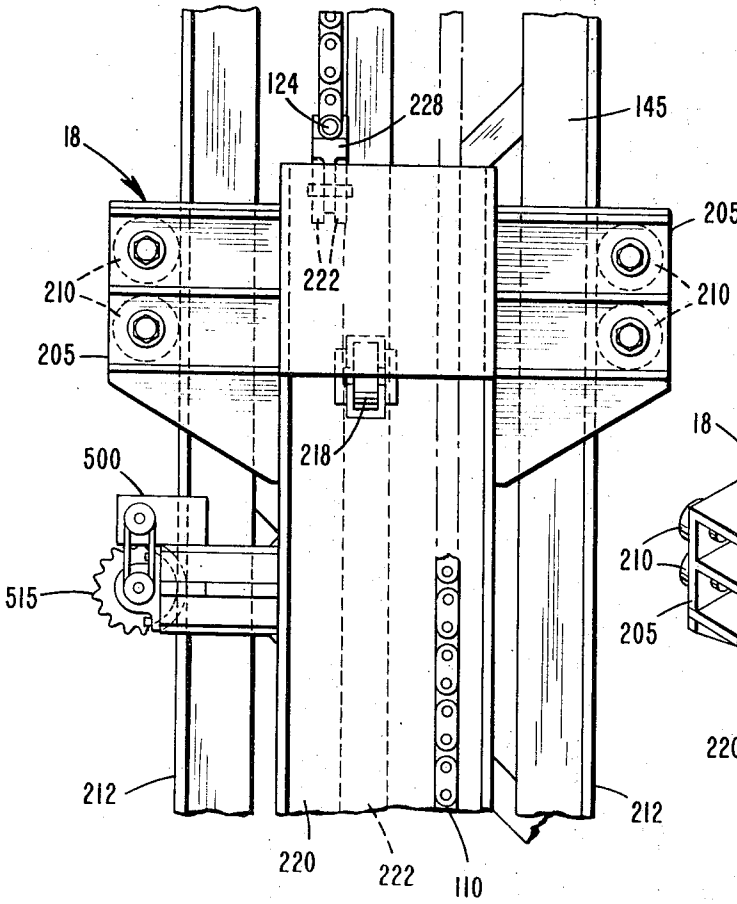
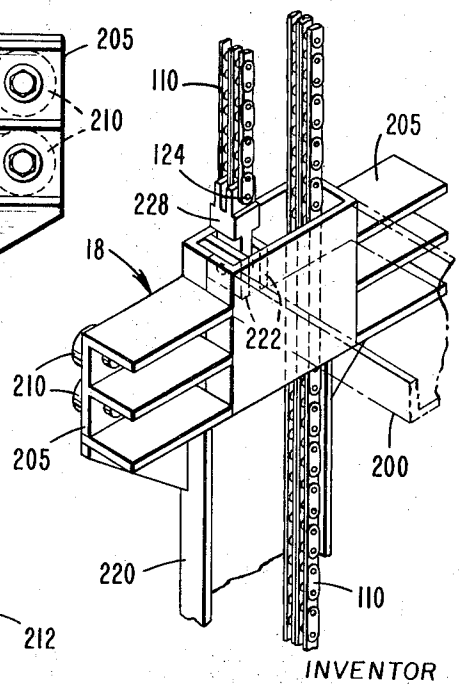


FIG.6C



INVENTOR
EDWARD A. WENTZ

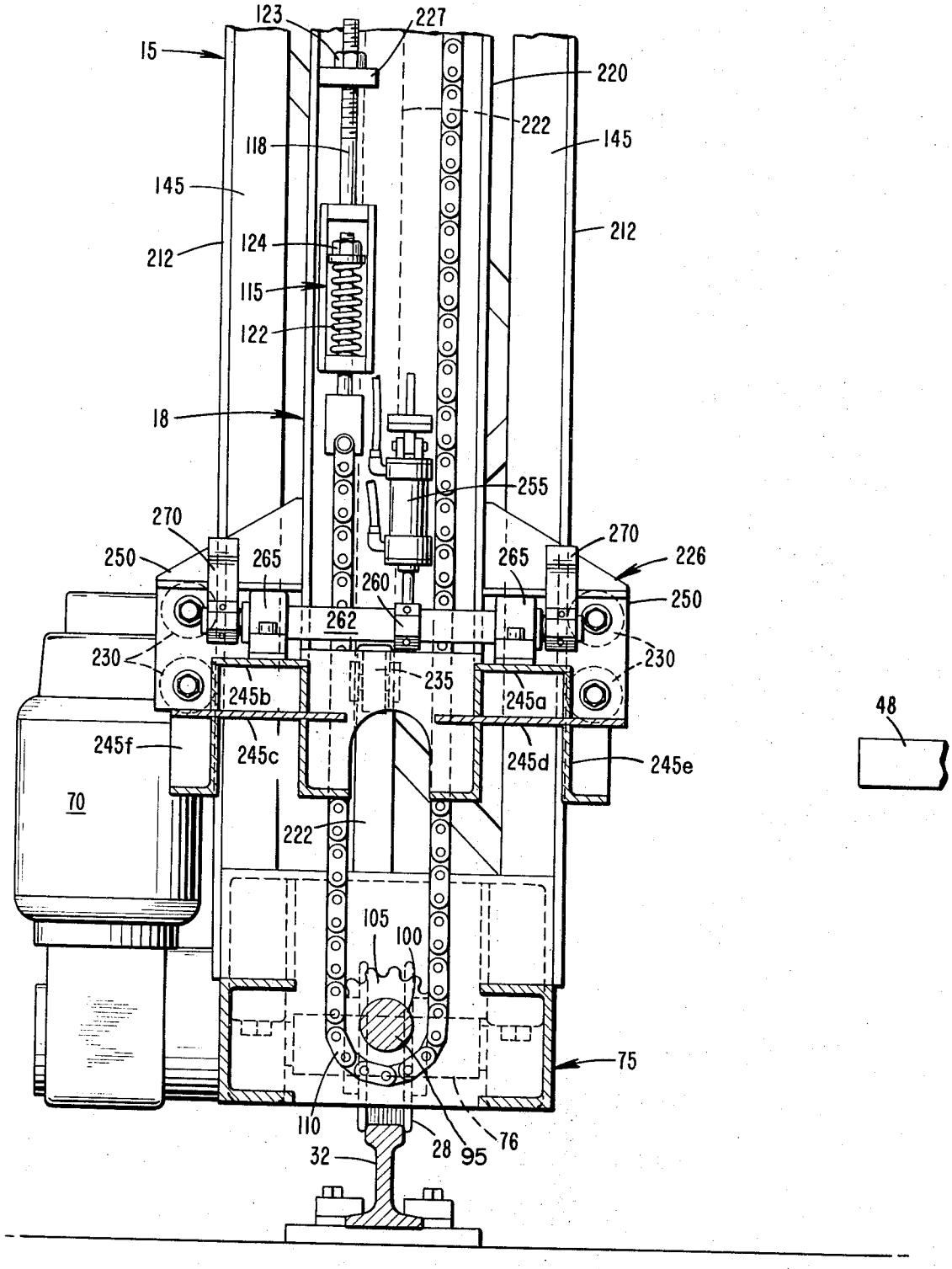


FIG. 6B

INVENTOR
EDWARD A. WENTZ

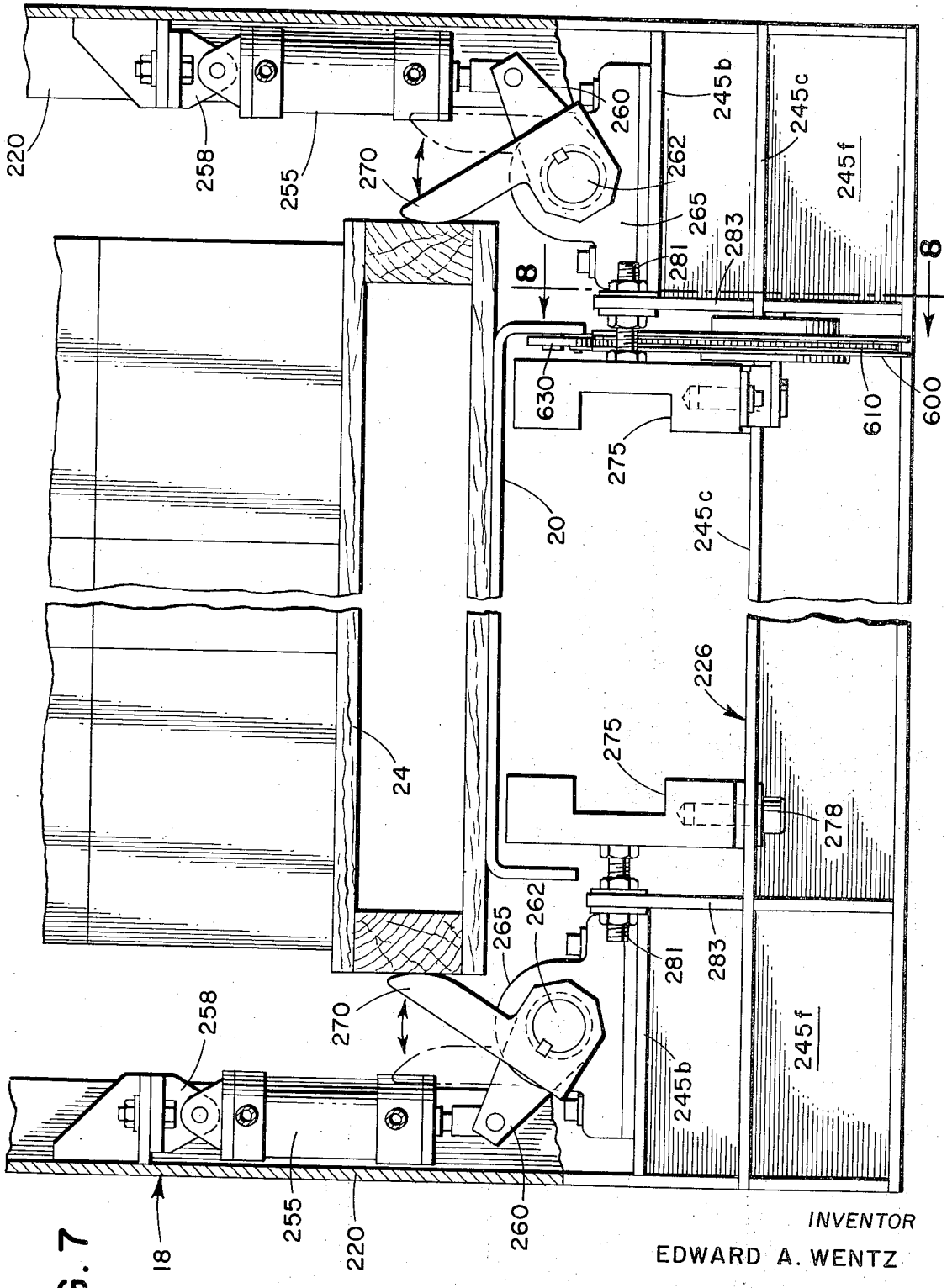


FIG. 7

INVENTOR

EDWARD A. WENTZ

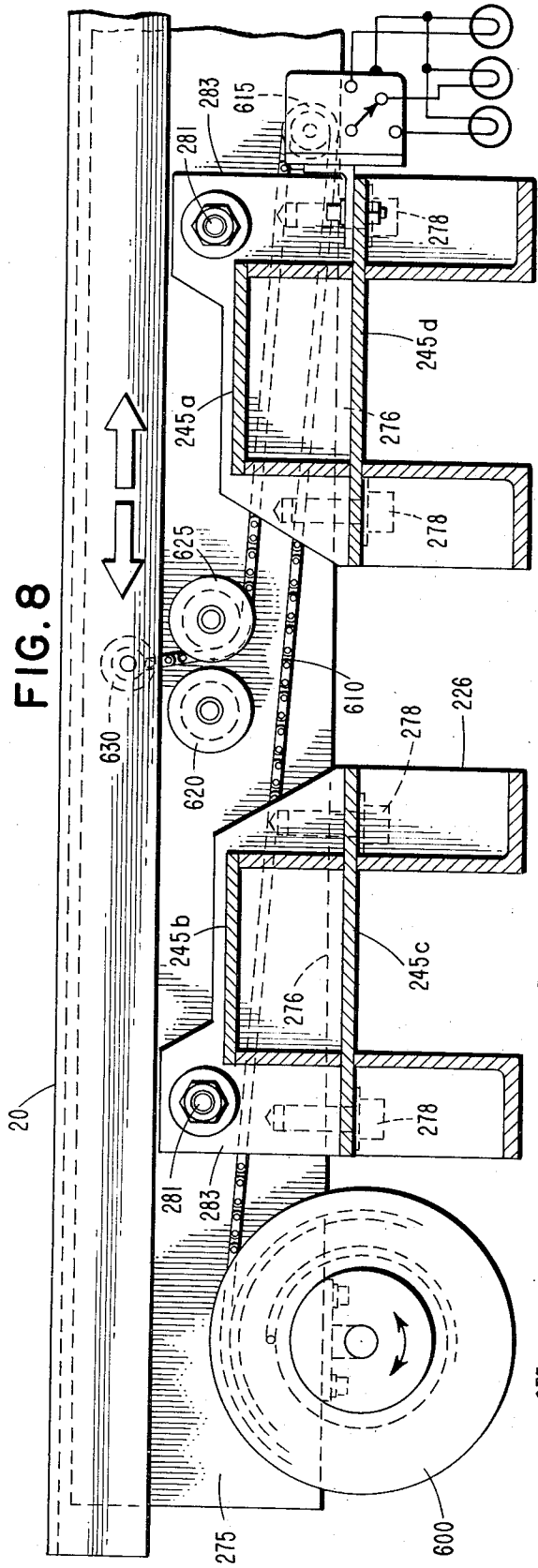

20
275
600
630
620
625
610
226
245a
245b
245c
245d
276
278
281
283
615

FIG. 8

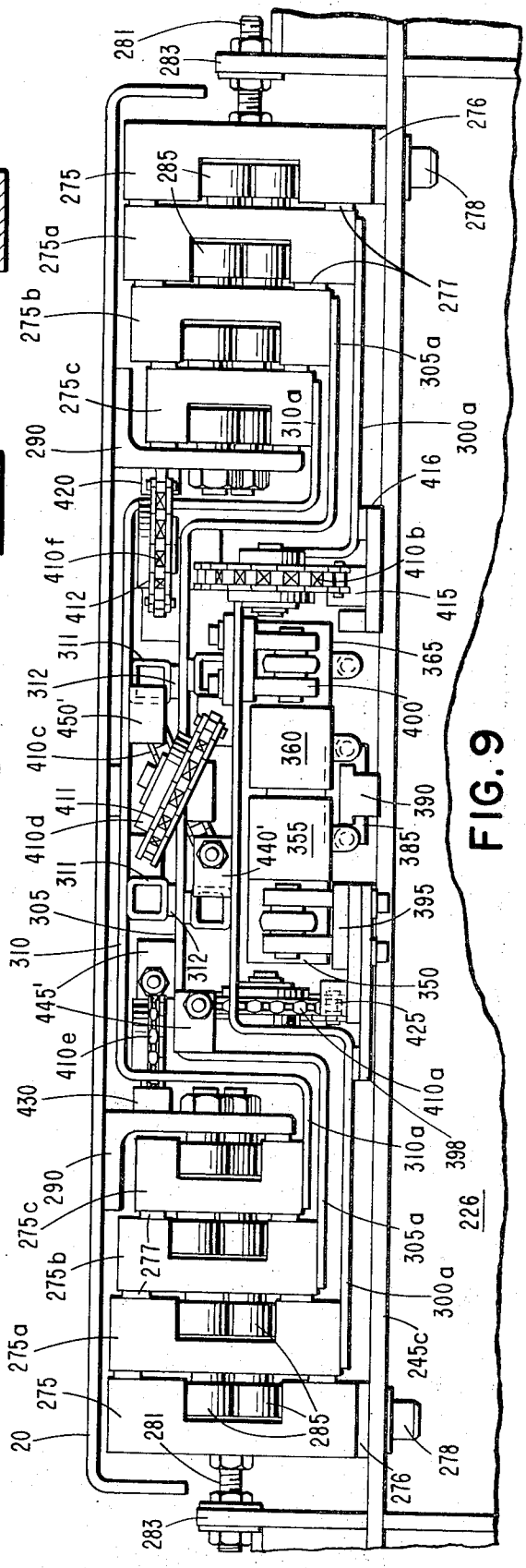
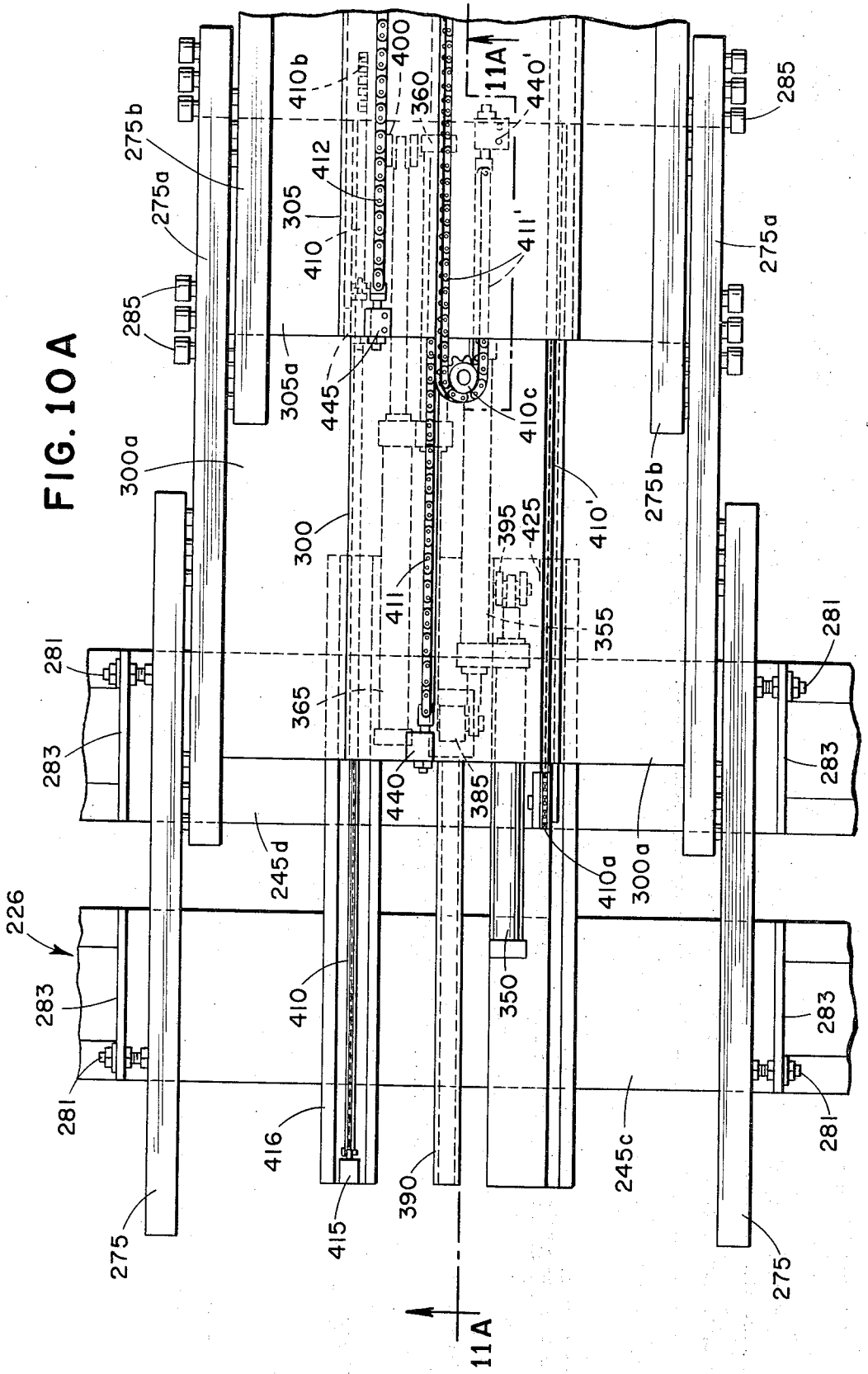

20
275
275a
275b
275c
276
277
278
281
283
285
290
300a
305a
310a
310
311
312
355
360
365
385
390
395
398
400
410a
410b
410c
410d
410e
410f
411
412
415
416
420
425
430
440'
445'
450'
226

FIG. 9

FIG. 10A


11A
11A
226
275
275a
275b
281
283
285
300
300a
305
305a
360
365
385
390
395
400
410
410a
410b
410c
411
411'
412
415
416
425
440
440'
445
245c
245d
350
355

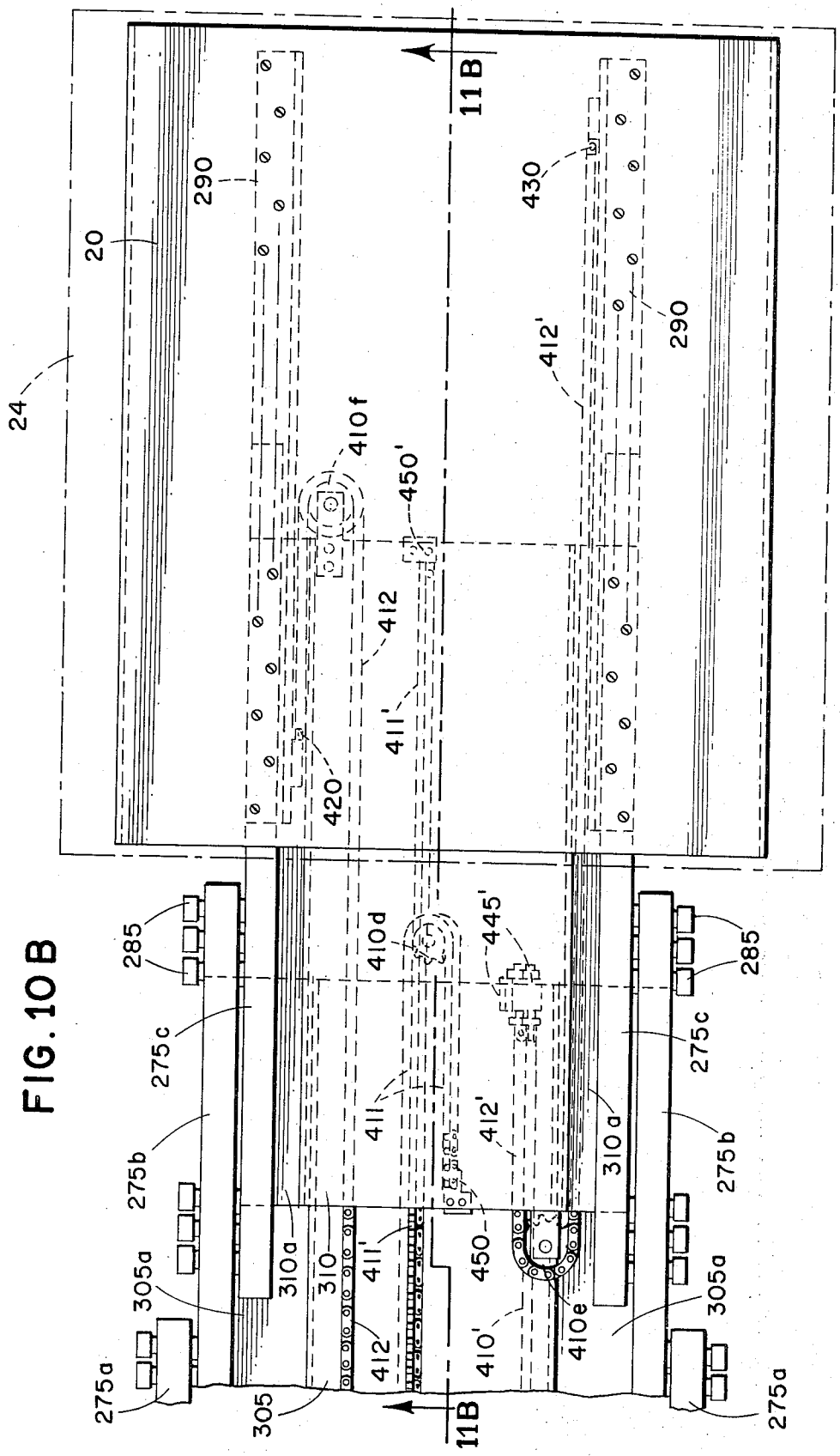

11B
290
20
430
24
410f
450'
412'
290
412
411'
420
285
410d
445'
285
275c
275c
411
412'
310a
275b
275b
310a
310
411'
450
305a
305a
412
410'
410e
275a
275a
305
11B

FIG. 10B

FIG. 11A

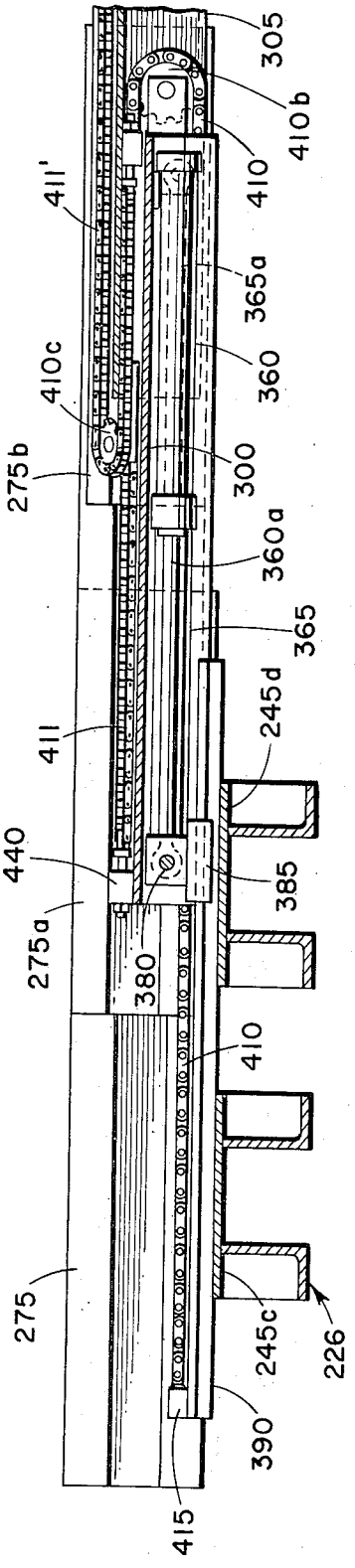


FIG. 13

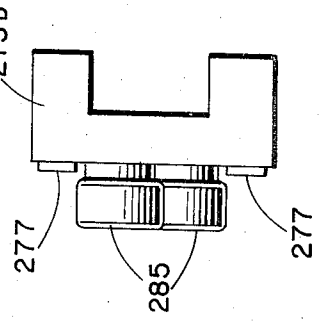
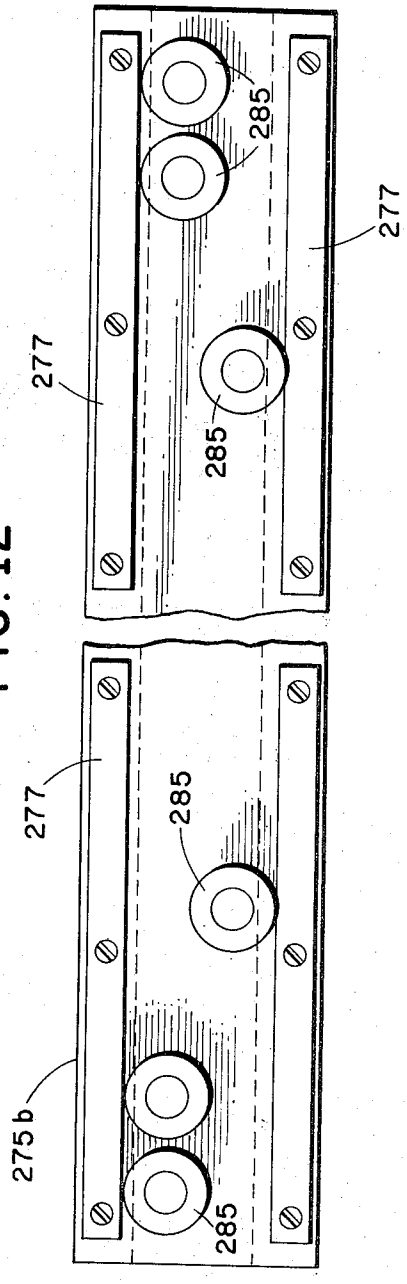


FIG. 12



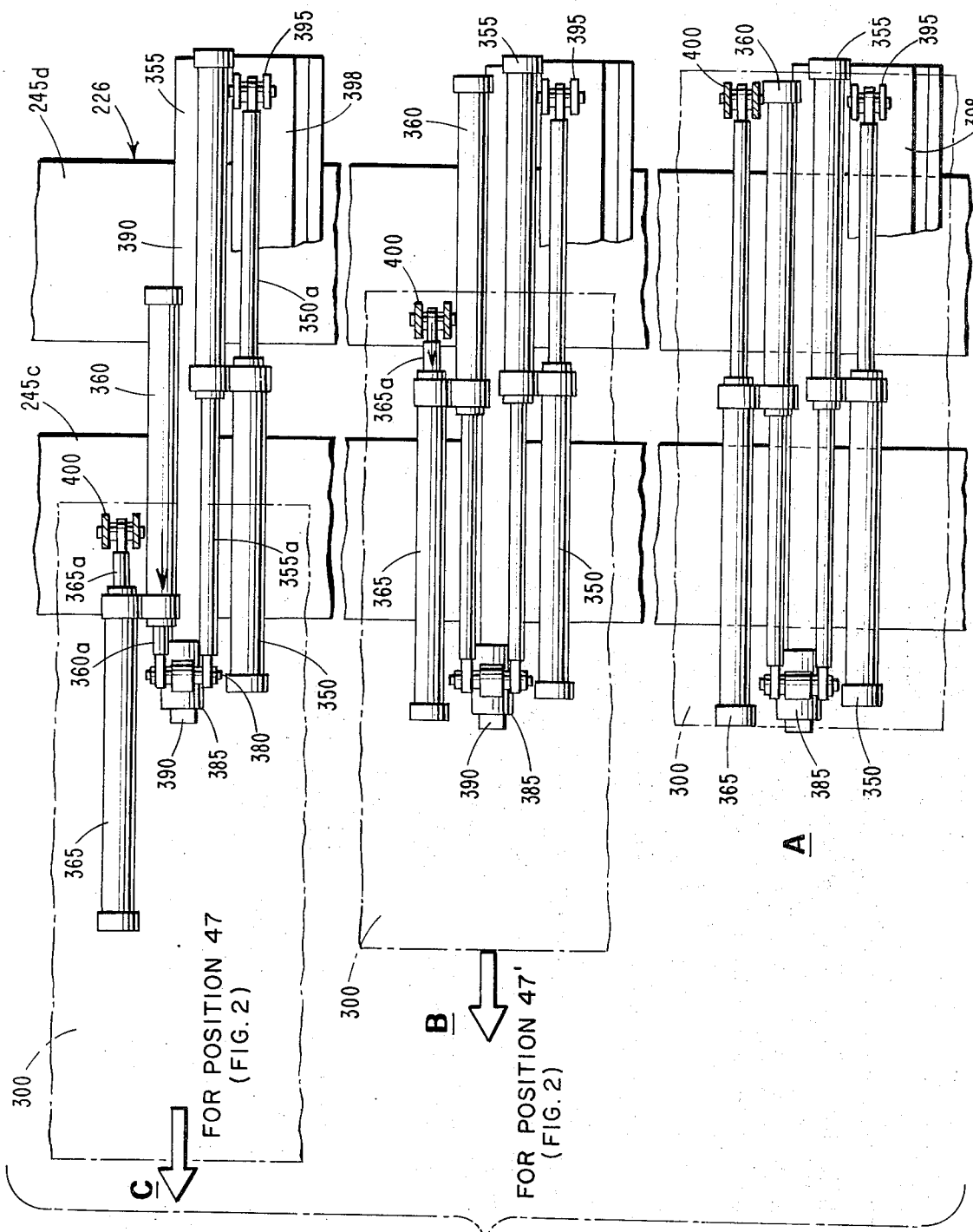


FIG. 14

INVENTOR
EDWARD A. WENTZ

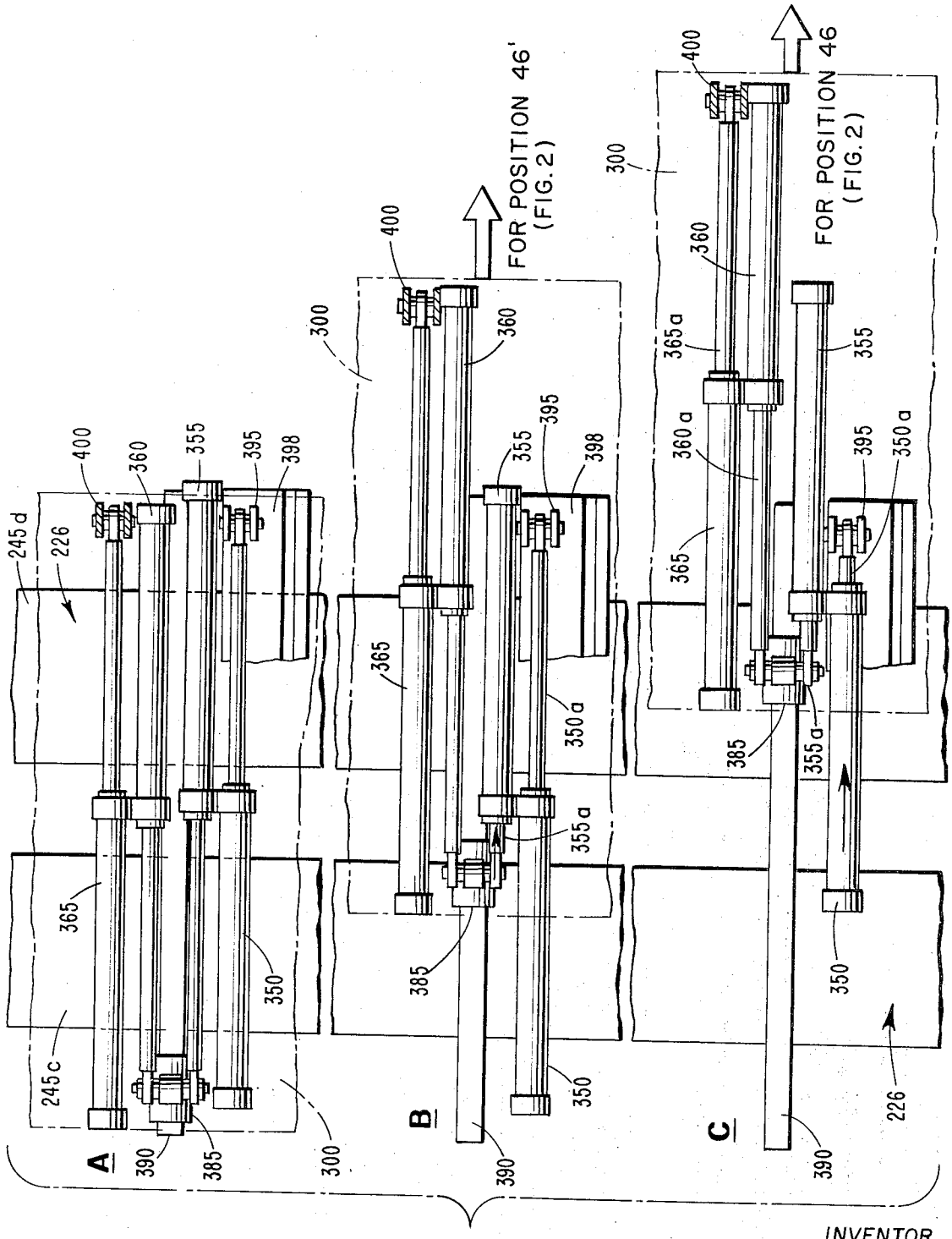
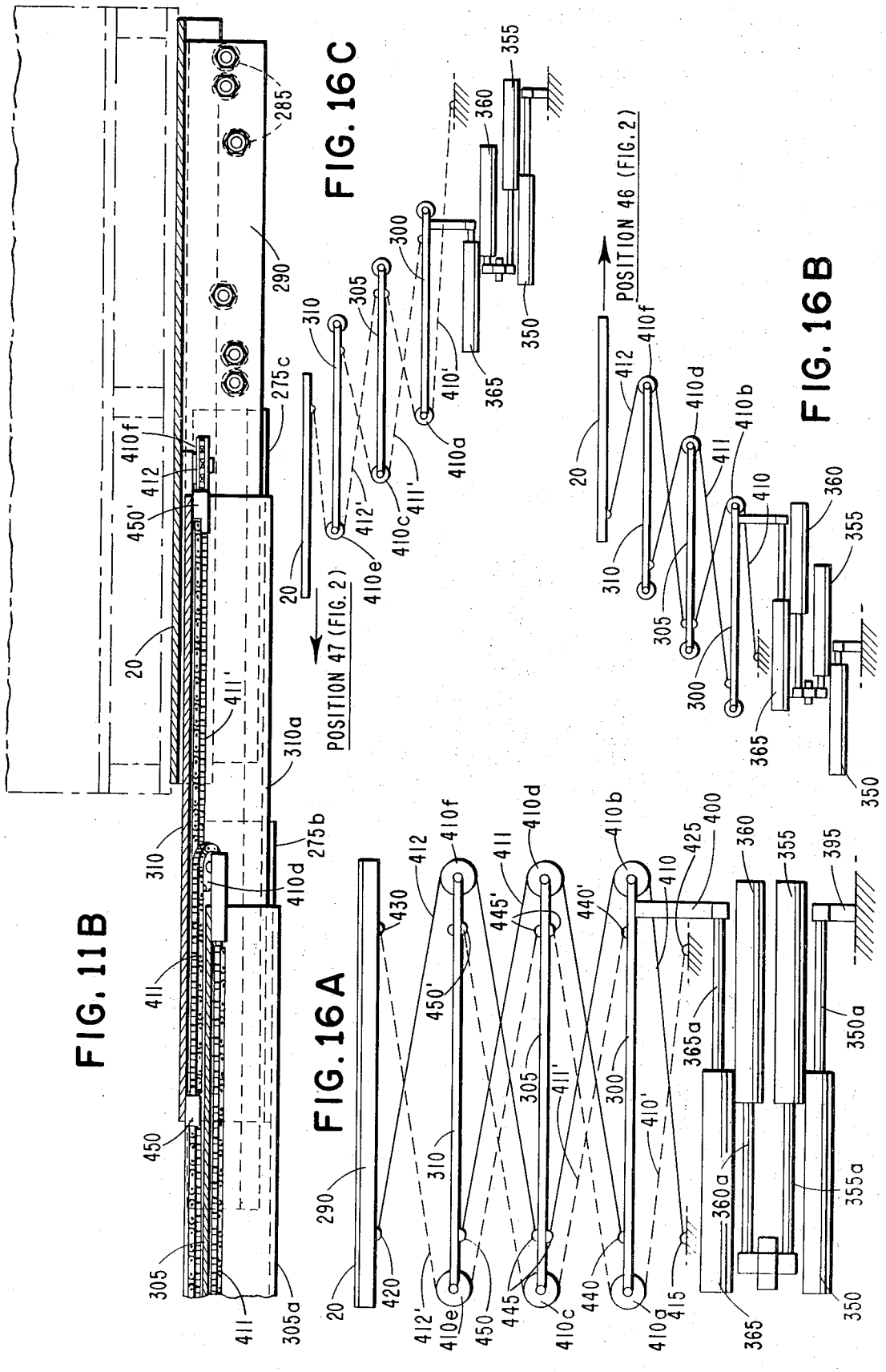


FIG. 15

INVENTOR
EDWARD A. WENTZ


FIG. 11B
FIG. 16A
FIG. 16C
FIG. 16B
POSITION 47 (FIG. 2)
POSITION 46 (FIG. 2)

STACKER CRANE CONSTRUCTION

This is a continuation of application Ser. No. 840,667 filed July 10, 1969 now abandoned.

Briefly, the invention contemplates a roller mounted tower comprising a pair of spaced columns, intermediate spacing having an elevator in which a tray is disposed and supported for reciprocal vertical movement driven by a sprocket chain arrangement for raising or lowering cargo laden pallets. The tray is mounted on a telescopic transport mechanism for sliding movement to either side of the tower from a retracted or neutral position so as to insert or remove cargo laden pallets relative to storage grids at selected positions, i.e., cells in the grids. The invention can be used with manual, semi-automatic, or fully automatic control. The transport mechanism can extend the tray to either of two distances or pallet positions to either side of the tower so that the storage grids of double depth cell construction at the same level on each side of the tower can be served.

The device is capable of handling very heavy loads albeit with a telescopic tray transport which is relatively flat and compact, comprising a conbination of telescopic cantilever beams and four hydraulic cylinders coupled to each other in a novel manner and to a drive member. Such drive member is coupled to a series of telescopically arranged drive members, coupled by flexible members, e.g., sprocket chain arrays in such a manner that hydraulic actuation of the first drive member causes an additively increased actuation of the series for telescopically extending the drive members. The combination of actuations effects a telescopic movement of the drive members and of the beams to transport of the pallet laden tray. Such telescopic coaction is simultaneous and reversible so as to move the tray to either side of the tower, and control of the hydraulic cylinder action can effect a half or full distance of tray movement to utilize double depth storage cells for handling two pallets to a cell.

The drive members all nest within each other to form a compact structure, but are not subject to cargo load nor weight stress. Such weight stress is borne by the beams distributed at both sides of the nested drive members and substantially in the same plane to effect compactness. A first pair of beams is secured to the tower frame while a final pair is secured to the tray. Intermediate pairs articulate the first and final pairs thus described, for reversible telescopic load supporting effect on either side of the tower. The load carrying beams slide with respect to each other on intermediate roller bearing arrays.

The tower is driven on a track intermediate the storage grids, there being two rollers supporting the tower each independently driven by an electric motor. Accordingly, very tall towers can be utilized, albeit the higher the tower, the higher the center of gravity. Thus, a lessening of traction of either roller due to forward or rearward pivotal forces on the tower about a roller caused by deceleration or acceleration will not affect drive of the tower since one roller or the other will inherently have traction increased when traction of the other is decreased.

A detailed description of the invention now follows in conjunction with the appended drawing, in which:

FIG. 1 is a front elevation showning the horizontally movable tower and the vertically movable elevator for carrying a tray in relation to the cells of a structural storage grid at one side of the track on which the tower rolls, the tray being extensible towards and away from the plane of the paper;

FIG. 2 is an end elevation of a tower between a pair of storage grids showing the reversible direction of motion of the tray elevator, the tower being movable toward and away from the plane of the paper;

FIG. 3 is a plan view of a storage system having a plurality of towers in movable and parallel array with an infeed conveyor;

FIG. 4A is a front elevation of the upper construction of the tower;

FIG. 4B is a continuation of FIG. 4A showing the construction of the lower portion of the tower;

FIG. 5 is a section generally through 5—5 of FIG. 4B;

FIG. 6A is a vertical section through 6A—6A of FIG. 4A;

FIG. 6B is a vertical section through 6B—6B of FIG. 4B;

FIG. 6C is a fragmentary perspective of an upper corner of the tower;

FIG. 7 is a front elevation showing details of the fingers of a mechanism for horizontally aligning pallets on the tray so as to be centralized thereon;

FIG. 8 is a side elevation of the tray on line 8—8 of FIG. 7 showing the tray position indicator assembly;

FIG. 9 is a front elevation of the tray showing the relationship of the telescopic drive members, support channels, support rollers and chain and hydraulic drive mechanism;

FIG. 10A is a fragmentary plan view showing the telescopic mechanism for the tray in transported, i.e., extended condition;

FIG. 10B is a fragmentary plan view which is a continuation of FIG. 10A showing the remainder of the telescopic transport mechanism with the tray supported at the end thereof fully extended outwardly for depositing a pallet in a storage cell, or lifting a pallet out of a cell;

FIG. 11A is a section through 11A—11A of FIG. 10A;

FIG. 11B is a section through 11B—11B of FIG. 10B;

FIG. 12 is a side elevation of the support roller layout on a slide beam of the tray transport mechanism;

FIG. 13 is an end view of one of the support beams of the telescopic transport mechanism;

FIG. 14 is a plan view of the hydraulic system comprising respective pairs of articulated cylinders for actuating the tray in respective directions transversely of the tower wherein the sub FIGS. A, B, and C show progressive extension of a drive member as certain cylinders are pressurized for transport of the tray toward the left;

FIG. 15 is a view similar to FIG. 14, but wherein the sub figures illustrate the progressive drive member positions A, B and C away from the tower wherein the cylinders are pressurized for extension to the right;

FIG. 16 is a diagram of the chain drive of the tray wherein sub FIGS. A, B, and C show central position and full left and right extensions, respectively.

GENERAL DESCRIPTION

Referring to FIG. 1, the invention comprises a tower 10 having a pair of spaced structural columns 15 built up of corner angle irons and diagonal cross braces as generally illustrated and supporting for vertical move-

ment a pallet carrier or tray elevator **18** comprising a tray **20** and capable of vertically lifting pallets **24** carrying, e.g., boxed merchandise as illustrated, the vertical arrows indicating the reverse directions of motion of the elevator. The tower is movable reversibly as indicated by the horizontal arrows, being supported on a roller **28** under each column, which rollers travel on a track **32.** The lower end of the tower is thus supported and guided on track **32** while the upper end frame **33** of the tower (FIG. **6A**) is guided by an angle iron member **36** between guide rollers **38** (FIG. **2**) carried by the tower on arm **39.**

Referring to FIGS. **2** and **3,** the tower rolls between storage grids **40** and **44** made up of structural members in cellular construction in a known manner.

A grid **40** and a grid **44** can be assembled back to back to effect a plurality of bays as illustrated in FIG. **3.** Each cell can be double depth horizontally to hold two pallets **24** as illustrated in FIG. **3.**

As seen in FIG. **2,** tray **20** is extended toward the right for the purpose of moving a pallet **24** containing a load of cartons to be deposited in a cell at **46.** Extension of the tray is indicated in solid lines, the cargo being stored at the full horizontal depth of the cell, i.e., towards the rear. Another pallet as indicated in phantom at **46'** is stored at the front. Obviously, the same extension of the tray can be used for lifting to retrieve a pallet and its cargo. Likewise in FIG. **2,** the position of cargoes at **47** and **47'**(in phantom) to the left illustrates the reversible movement of the tray **20** as indicated by the dotted arrow.

Thus the tower can move horizontally into alignment in any desired location between a pair of storage grids and the tray elevator can then move vertically. Subsequently the can move transversely horizontally toward or away from the storage grids for depositing or retrieving loads. Obviously, vertical control of the tray elevator is such as to place the tray initially slightly above the spaced cell beams **48** in inserting a pallet and slightly below for withdrawal, final vertical movement of a couple of inches then being had to rest the pallet or lift it. The tray is slightly narrower than the distance between beams **48** as noted in FIG. **5.**

The members **48** are support rails on which pallets are stored, and are spaced apart a sufficient distance for tray clearance in moving up or down between them.

FIG. **3** shows a schematic layout whereby the invention can be used for a plurality of storage grids back to back, with a track **32** intermediate such grids **40** and **44** formed in bays and each track being served by a diverter chute **50.** Thus, a series of diverter chutes such as **50** are spaced along an infeed conveyor **55** and the diverter device **58** can divert cargo carrying pallets **24** to any chute **50** in accordance with manual or automatic control.

Referring again to FIGS. **1** and **2,** the tower carries a control panel **60** and a platform **64** on which an operator may stand for manual control of the tower and tray. The tower and tray may likewise be controlled by automatic electronic means from a remote console by conventional equipment, or by computer programming.

Power for motivating the tower is derived from a pair of motors **70** (see FIG. **4B**) each driving a flanged roller **28** on track **32** via conventional reduction gearing, the motors, rollers and gearing all being supported by the roller shafts **76** with bracing **77** to the columns; FIGS. **4B, 5,** and **6B.**

The base frame **75** may be made up of welded plates and structural members as illustrated, in any conventional manner.

Referring to FIG. **1,** it will be appreciated that the tower can be of any desired height. However, the taller it is the higher the center of gravity. This is especially true if the tray elevator **18** is at some elevated level, and cargo loaded, when the tower is moving in either direction on track **32.** Accordingly, assuming that the tower is starting to move from a standstill position, going to the left, the acceleration force will cause a reduction of traction on the left hand roller. However, load remains on the right hand roller for traction effect. Similarly, when the tower slows down, the deceleration causes lessening load on one or the other roller, depending on direction, and braking effect is then applied to the more heavily loaded roller. Therefore, by providing a separate motor **70** for each roller, the traction differential is minimized. Where a tower is set in motion or slowed down with a simultaneously rising load in the tray elevator, the advantage of the independent motor or arrangement is apparent.

The tray elevator motor **80** (FIGS. **4B** and **5**) is carried by the base frame **75** of the tower and as in the case of the tower drive motors **70** is disposed on a vertical axis, driving the multiple sprocket chains **90** for rotating a shaft **95** on beaming blocks **96** in frame **75** and having a gear **100** at the left end of the shaft as shown in FIG. **4B** which will be understood to mesh with the lower loop of the chains **90.**

The shaft **95** (FIGS. **4B** and **6B**) has a pair of gears **105** at respective ends keyed thereto around each of which is a tray lifting chain **110.** The chains **110** each terminate at their lower ends through a spring tensioned connection **115** (FIG. **6B**), being thus fastened to the frame of tray elevator structure **18** through the take up bolt **118** and a spring **122.** The frame of the tray elevator will be later described. By taking up on a respective bolt via the nut **123** (FIG. **6B**) chain wear elongation is compensated. Elongation due to load variation is compensated by respective springs **122,** adjusted by nut **124.** The other ends of the chains **110** (FIGS. **4A, 6A**) are ultimately secured at respective points **124** to the tray structure **18** as later described. Chains **110** pass upwardly to the top frame **33** of the tower and around idler gears **128** carried on a shaft **131** having suitable bearing blocks **132** in a box like structure comprised of heavy longitudinal beams **135** which form the rigidifying top frame **33** (FIG. **4A**) in conjunction with equally heavy transverse channels **140,** for the columns of the tower. The bearing blocks **132** rest on the inner vertical structural iron angle members **145** of the columns **15** (FIGS. **4A, 6A, 6B**) specifically on cross brackets **155.**

From the foregoing description it will be understood that energization of motor **80** will raise or lower the tray elevator **18** via chains **110** dependent upon direction of motor rotation (FIGS. **1, 2, 4B, 6A, 6B**) drive being had via chains **90** and shaft **95** and associated gears so that both sides of the tray elevator **18** have lifting force applied thereto at the respective connections **124,** FIG. **6A.**

THE TRAY ELEVATOR

Referring to FIGS. **4A, 4B, 5, 6A, 6B, 7** and **8,** the

tray elevator **18** comprises a frame having a top beam **200** (FIGS. 4A, 6A) extending between tower columns **15** and secured at its ends on the back of a short channel **202.** A pair of transverse beams (FIG. 4A) or channels **205** carry transverse guide rollers **210** that ride (FIG. 4A) on vertical members **145,** on tracks **212** welded thereto. The construction is symmetrical at both ends of beam **200.** A longitudinal guide roller **218** is carried at each side of the tray elevator in a respective vertical frame channel **220** which form the sides of the elevator frame structure and which are secured at their upper ends to respective pairs of beams **205.** Rollers **218** ride on fixed vertical guide bars **222** (FIGS. **5,** 6A) intermediate members **145.**

The side frame members **220** are secured at their lower ends to the elevator base frame **226** (FIGS. 4B, **5,** 6B) and the upper flange edges are welded to the flange edges of short channels **202** to form openings for chain passage and the plates **222** welded therein which form the chain end fastenings at **124** (FIG. 6A).

As seen in FIG. 6B the lower ends of chains **110** (one shown) are secured via bolts **118** as heretofore mentioned, passing through ears **227** welded inside channels **220.**

The construction is symmetrical as far as the guide roller arrangement at top and bottom (FIGS. 4B, 6B) of the tray elevator is concerned in that guide rollers **230** at the sides of column members **145** are similar to rollers **210.** Also, guide rollers **235** are similar to rollers **218,** provided to roll on bars **222.**

The elevator base frame **226** (FIGS. 4B, **5,** 6B, **7, 8**) comprises a box beam construction shown in transverse section in FIGS. 6B and **8** and in full line front elevation in FIG. **7,** being built up of plates such as **245***a*, **245***b*, **245***c*, **245***d*, and channel members **245***e*, **245***f* in a rigid welded construction suitable for load support. Other types of frame construction can, of course, be used.

The plates **245***c* and **245***d* extend longitudinally across the frame **226** construction (FIGS. **7, 9,** 10A, 11A, **14, 15**) at a central area as a main support for the tray transport mechanism later described.

The side channel members **220** are secured at respective sides of the base frame **226.** The webs of such channel members **220** form the lateral side walls of frame **226** to some extent by being coplanar with angle iron members **250** (FIG. **5**) which carry rollers **230.**

The construction permits lift chains **110** to be nested within the flanges of the side channel members **220** as seen in FIG. **5.** Also nested within such flanges are hydraulic cylinders **255** (FIGS. **5,** 6B, **7**) pivotally secured to the webs at **258** and having rods articulated via levers **260** to respective shafts **262** having bearing support as by pillow block **265** secured to respective cross plates **245***a* and **245***b* of the elevator base from **226.** The shafts are on respective sides of tray **20** and each has a pair of spaced fingers **270** (FIGS. 6B, **7**) which are thus rockably actuated upon the pressurizing of cylinders **255** to engage the sides of pallets such as **24** in order to center the pallets on the tray **20.** The fingers move in unison to the same predetermined inner limits, e.g., as may be provided by identical positioning of identical cylinders **255** and full movement of the piston rods, in the instant case such movement being one of retraction.

THE TELESCOPIC TRAY TRANSPORT

Referring to FIGS. **7, 8** and **9,** the plates **245***c* and **245***b* support heavy cantilever channel beams **275** on spacers **276** and secured by bolts **278,** provided in plurality (FIG. **8**), and these beams will be understood to be thus fixed to elevator frame **226.** Lateral adjustment bolts **281** provided on side plates **283** secured to the frame **226** effect alignment and parallelism of beams **275.**

Referring to FIGS. **9,** 10A and 10B, three additional pairs of channel beams **275***a*, **275***b*, **275***c* similar to beams **275** are provided, all coplanar and of progressively smaller size, but all cantilever load carrying beams telescopically connected with each other and ultimately with beams **275,** including a final pair of channel beams **275***c* of smallest size.

Slide bearings **277** (FIGS. **9, 12**) are secured to the beams for ease of sliding engagement and precise spacing.

All such beams except **275** carry groups of rollers **285** (FIG. **12**), three rollers to a group, four groups to a beam, which rollers ride the upper and lower surfaces of the channel of the adjoining beam (FIG. **9**).

The innermost pair of channel beams **275***c* carry angle iron beams **290** to which tray **20** is secured (FIGS. **9** and 10B). Such support of beams **290** are likewise by groups of rollers **285.** It will be apparent from consideration of FIGS. 10A and 10B that the tray **20** is supported for horizontal reversible movement away from and back to or through the tower (as represented by plates **245***c* and **245***d*) wherein the tray can extend to either side of the tower to the maximum distance provided within predetermined limits, due care being had to provide proper support by two roller groups **285** for all beams within adjoining channels at maximum extension in either direction.

The driving mechanism for tray **20** for reversible motion away from and back to or through the tower comprises three nested drive members or plates **300, 305, 310** (FIGS. 4B, **9,** 10A, 10B, 11A, 11B). As seen in FIG. **9,** the drive members are nested channel shaped plates having progressively wider horizontal flanges and spaced vertical flanges as well as vertically spaced horizontal webs. The horizontal flanges of each drive plate are secured to the lower surfaces of a pair of channel beams. Thus, flange pairs **300***a*, **305***a*, **310***a* are secured to beam pairs **275***a*, **275***b*, **275***c*, respectively, (FIG. **9**).

The drive plates may be secured to the beams by bolts (not shown) or in any other suitable manner, and are thus carried by the beams. Bracing tubes **311** which have slide bearings **312** are welded to plates **305** and **310.**

The drive plates are telescopically movable with respect to each other, the innermost plate **300** being driven hydraulically. Plates **305** and **310** are chain driven from plate **300** as is tray **20** via angle iron beams **290,** in a manner to be described.

Referring to FIGS. 10A, 11A, and **15,** the hydraulic drive for plate **300** comprises four double ended cylinders **350, 355, 360, 365** (FIG. **14**). Cylinders **350** and **355** are welded at their rod ends to each other, at **370,** as are cylinders **360** and **365** welded at **275.** The piston rods **355***a* and **360***a* of cylinders **355** and **360** are pivotally connected to each other by a pin **380** having bearing support on a T-slide guide block **385.** A T-slide guide bar **390** (also see FIG. 10A) is secured to fixed cross plates **245***c* and **45***d* being thus rigidly secured horizontally to the elevator base frame **266.** Rod **350***a*

of cylinder **350** is pivotally secured at **395** to cross plate **245***c* via plate **398** secured to plate **245***c* (FIG. **14**). and is thus fixed to provide reaction support (FIG. **9**). Rod **365***a* of cylinder **365** is pivotally secured at **400** (FIG. **9**) to drive plate **300.**

The four cylinders are carried in a common plane and thus float as an integral assembly having pivotal securement to the frame **226** of the tray elevator (via the cross plates **245***c* and **245***d*) and the innermost drive plate member **300,** as described.

In FIG. **14,** a neutral position A with all rods extended is shown wherein the cylinders are under pressure at one side to hold such position locked and drive plate **300** (and tray **20**) is centered between the tower columns (FIG. **5**). For such purpose hydraulic blocking is possible but positive pressure is preferred. However, in FIG. **14** the result of pressurizing by valving (not shown) the right end of cylinder **365** is noted in position B; rod **365***a* has been shifted to the left (see arrow) carrying late **300** with it to the left toward an intermediate position away from the tower. This would be the position for moving tray **20** into the first half of the full horizontal depth of a cell, e.g., to first pallet position **47'** of FIG. **2.** This is possible because of the reaction support at **395** and by maintaining all pistons (not shown) of the cylinders hydraulically blocked or pressurized against movement except for the cylinder being pressurized. If full tray movement, e.g., to second pallet position **47** (FIG. **2**) is to be had, then simultaneously with the pressurizing of cylinder **365,** the left end of cylinder **360** is pressurized, rod **360***a* remains stationary (cylinders **350** and **355** blocked) but the cylinder **360** shifts to the left (see arrow) carrying cylinder **365** with it to the left since they are welded together. This causes continued shifting of rod **365***a* additively to the left. The position of plate **300** is thus to its maximum shift leftwards as shown in position C, via rod **365***a* and connection **395.**

Referring now to FIG. **15,** position A of the hydraulic system again shows the neutral position, with centralized drive plate **300.** However, by pressurizing the left end of cylinder **355,** rod **355***a* moves to the right (see arrow) into cylinder **355,** pulling rod **360***a* via pin **380** and T-slide **385** therewith. Rod **360***a* is hydraulically blocked in cylinder **360** and therefore pushes that cylinder along with attached cylinder **365** and its hydraulically blocked rod **365***a* to the right. Plate **300** is thus moved to the right as illustrated in position B for a movement of tray **20** to position **46'** of FIG. **2.** However, a simultaneous movement added thereto can be effected by pressurizing the right end of cylinder **350** causing it to shift to the right with respect to rod **350***a* which is fixed at its outer end. Therefore, cylinders **350** and **355** shift to the right further shifting (via T-slide **385**) rod **360***a*, cylinder **360,** cylinder **365,** and rod **365***a* to maximum extended position C for drive plate **300** for a full depth position of tray **20** at **46,** FIG. **2.** The guiding function of T-bar **390** will be evident in comparing position A, B and C to maintain alignment of the multi-cylinder floating array with the drive plate.

Referring to FIG. **16,** the chain and sprocket extending arrangement for the drive plates **300, 305,** and **310** and angle beams **290** is diagrammatically illustrated in conjunction with the hydraulic system comprising the four cylinders **350, 355, 360** and **365.**

The neutral position of the cylinders wherein the tray **20** is centralized with respect to the tower is illustrated at position A. Thus all cylinders are under pressure in order to positively lock the tray in the central position. Pressure maintenance for locking the position is preferred as, in fact, it is preferred also for the extended position of sub FIGS. B and C even though hydraulic blocking by valving in a well known manner could be used. Referring to the diagrammatic components shown at position A, the drive plate **300** will be noted as being fastened at **400** to the piston rod **365A** whereas at the other end of the hydraulic system array, the piston rod **350A** is connected to the elevator frame at **395,** all as herein before described and illustrated in the several views preceding, e.g., FIGS. **14** and **15.**

Suitable fastened to the elevator frame (FIGS. **9, 10A, 10B**) as by a clamp or other member, at **415,** on a plate **416** wherein such plate is fastened to the cross plates **245***c* and **245***d*, is a sprocket chain **410** which passes around a sprocket wheel **410B** carried by and just forward of the right edge of plate **300.** Chain **410** is then fastened to the left end of and on the underside of drive plate **305** at **445.**

Reference character **445** represents two fastening locations for chains, one above and one below the drive plate **305** (FIG. **9**) as set forth below.

From the upper surface of plate to a sprocket **410D** carried at the edge of drive plate **305** is a chain **411** the other end of which chain is fastened to the lower surface of the plate **310.** Finally, a third chain **412** is fastened at **445,** upper surface of plate **305,** passing around the sprocket **410***f* for securement at **420** with one of the iron angle beams **290** which carried the tray **20.**

All flexible members are thus described as chains although, of course, it will be understood that equivalent components such as cables, pulleys, belts, etc. could be used. All sprocket wheels are carried on ears extending just beyond the edges of the drive plates to which they are secured, e.g., the sprocket wheel **410***f* (FIG. **10B**) carried at the edge of plate **310.**

All chains shown in solid lines (FIG. **16A**), and just described, effect positioning of the several plates and ultimately the tray **20** to the right to position **46,** FIG. **2,** for the chain position B, FIG. **16,** and reference may be had to FIG. **15.** for comparision therewith insofar as the hydraulic system is concerned. Either position **46** or **46'** can be thus reached and the tray **20** held locked by full actuation of the cylinder or cylinders required for the desired extent of tray motion and subseqeunt maintenance of pressure to hold the position.

In the same manner, position of the tray to the first or second pallet positions for handling of pallets to positions **47** or **47'** (FIG. **2**) is accomplished by simple reverse action effected by the chains **410', 411',** and **412'** and the hydraulic positioning shown for the cylinders at position C of FIG. **14,** such chains being shown dotted in the position A, FIG. **16.** For neutral tray position the opposite set of chains are used, in either case.

Chain **410'** is frame fastened at **425** to cross plate **245***c* and passes around the sprocket **410***a* at the left end of plate **300** (FIG. **10A**) to terminate at the fastening **455'** below plate **305.** A second chain **411'** is secured at the upper surface of **440'** of plate **300** and passes around sprocket **410C** to fastening at **450'** at the lower surface of plate **310.** Finally, a chain **412'** fastens at **445'** to the upper surface of plate **305** and passes around the sprocket **410E** to be fastened at **430** to the other iron angle beam **20.**

In general it will be noted that all of the drive plates carry sprockets at their ends and that the two series of chains are a reversed in layout geometrically.

In operation, when the plate **300** is hydraulically motivated in either direction it exerts a thrust via the sprocket wheel at one end or the other against the chain engaged therearound and for each increment of hydraulically driven travel of plate **300,** the plate **305** moves outwards in the same direction for twice the distance of plate **300,** in accordance with well known principles. Of course, the angularity as shown in FIG. **16A,** of the sides of the chain **410** or **410'** makes a slight reduction in exact doubling of the movement, but this is of no significance since it is not present in the device and only a very large angle would appreciably reduce the doubling of the distance. However, plate **305** being thus drivin in either direction does not double the travel of plate **310,** nor does the travel of plate **310** double the travel of beams **290** and tray **20,** but merely give single increment additive travel at each step. The reason for this is that the plate **300** must move in the same direction in order to actuate either chain series and this subtracts from relative increment increase between the remaining plates and the tray because their drive chains do not have fixed ends as do chains **410** and **410'**. However, the actual travel of tray **20** is four time the travel of the plate **300.**

The compactness and versatility of the tray transport power drive mechanism comprising hydraulic cylinders, and chains or other suitable belt-like members, will be apparent from the above description and the drawings. Thus, the tray and the coplanar nested beam pair supports are reversible and pass through their own rest positions in either direction. The hydraulic cylinders are all coplanar in a flat array integral unit floating between drive plates and beams and having limited rocking movement as the beams move. All chains and sprocket wheels are also disposed in this beam plane and are located in the spacing between the innermost beam pair **290.** All sprockets are carried on short outrigger arms at the edges of the drive plates, and most of the chains pass between the webs of such plates. In particular, space is saved by skewing the sprockets **410***c* and **410***d* at the edges of drive plate **305,** the chains **411** and **411'** passing respectively therearound on both sides of that plate.

Thus, what may be termed "left" and "right" telescopic chain systems have chains and sprockets in reverse but symmetrical series, the chains of each system being individually secured in sequence from the elevator frame **226** to the final beams **290** via the drive plates **300, 305, 310** whereby sequential pull is exerted on the next succeeding plate (or ultimately beams **290**) by virtue of thrust exerted by a preceeding plate. Except for chains **410** and **410'**, which have fixed reaction connections, the reaction connection for each chain is on the drive plate preceding the drive plate that carries the thrust sprocket for that chain. Accordingly, the initial thrust of plate **300** is transformed into a series of alternate chain tensions and plate thrusts via the sprockets to simultaneously telescope the beams by a succession of pulling forces which are virtually simultaneous in either left or right direction as viewed on FIG. **2,** depending on which of the dual chain systems is being actuated, a matter of the direction of hydraulic drive of plate **300.**

THE POSITION INDICATING SYSTEMS

While in commercial practice the stacker crane described herein would be fully automatically controlled by a system which does not form part of the present application. It can be manually controlled, if desired, by mere personal skill in positioning the tower and the tray. However, as a practical matter for precise positioning mechanical position indicating means should be utilized, particularly since the tower may have a horizontal traverse of several hundred feet and a height of as much as 60 feet. Obviously it would be quite impractical for an operator to be present at the tower location in order to precisely control it and to control the tray for the precise positioning needed.

Accordingly, referring to FIG. **4A,** an indicating sensor and signal transmitter arrangement for vertical movement is illustrated which comprises a shaft angle encoder **500** secured to the elevator on an outrigger arm **505** and coupled to a sprocket wheel **515.** A fixed sprocket chain **520** is carried on the corner angle iron **145.** As the elevator moves vertically the sprocket wheel is caused to rotate by the fixed chain which rotates the encoder. The encoder is a conventional rotary type, for example, Norden type ADC-13-BNRY-E, style 46, which by conventional electrical connections is capable of sending a binary signal of distinct character for each quarter inch of vertical movmenet of the elevator. Such binary signals can be utilized in conventional readout apparatus to apprise an operator of the vertical position of the tray elevator and the tray **20.** The operator can thus control motor **80** to reach a selected storage cell level. Of course, the tray would be initially positioned a couple of inches below the cell support rails **48** for picking up a pallet or initially positioned a couple of inches above for depositiong a pallet, prior to being horizontally extended either to first or second pallet positions for either purpose. The final slight movement of the tray up or down would be under slow motor control, either by gearing, or circuitry or motor construction, all long known, and with the aid of the indicating system readout in an obvious manner.

Referring now to FIG. **6A,** the same arrangement is used for indicating the precise horizontal positon of the tower wherein the shaft angle encoder **550,** the same type as encoder **500,** and sprocket wheel **560** are carried on the arm **39** to engage the chain **565** fixed lengthwise to the guide rail iron angle **36** fixed to the storage rack construction. Thus by the vertical and horizontal indicating systems an operator would know the position of the tower with respect to the length of the storage grid and could thus precisely position the tower in front of a selected storage cell as well as positioning the tray vertically, it being understood that suitable slow speed control motors **70** and **80** are utilized or other means for effecting "creep" are present.

It is, of course, necessary for an operator too far removed from a tray to observe it visually, to have an indicating system so that he will know the exact position of the tray **30** with respect to the tower. Referring to FIG. **8,** such a system is illustrated comprising a chain reel **600** carried by a fixed beam **275** and having a sprocket chain **610** maintained in tension by a spiral spring (not shown) within the reel which chain extends around a sprocket wheel **615** carried at the outer end of plate **245***d* and thence passes between a pair of rollers **620** and **625** carried by the fixed beam and having

an end **630** fixed to the tray **20** (FIG. 7). Accordingly, regardless of the direction of motion of tray **20** as indicated by the reversed arrows (FIG. **8**), the sprocket chain will be pulled in the same direction from the reel. This causes rotation of sprocket wheel **615** to actuate the arm of a swtich **640** between contact positon such that a first positon of the switch arm gives a signal to apprise the operator that the tray is in central positon, whereas when the tray starts to move the switch arm moves to a successive contact positon indicating that the tray is in first pallet position, or the switch moves to a further contact position to signal that the tray is in second pallet position, corresponding to positions **46, 47** or **46', 47'**.

Details of the switch mechanism are not necessary, but obviously a suitable gearing between sprocket wheel **615** and the switch **640** would be utilized so that full traverse of the tray in either direction would move the switch arm through the several contacts and return. The signals used could be three lights of different colors wired to the switch in an obvious manner.

CONTROLS

From all the preceding, it will be apparent that any conventional control system can be utilized, for example, the motors **70** and **80** can be energized simultaneously and either the motors **70** or the motor **80** controlled to "creep" when the operator is apprised by readout that the tray is close to the proper respective horizontal or vertical positon, the respective motors being stopped by braking when the readout indicates precise positions, i.e., within one fourth inch with the particular encoders used. Similarly, the hydraulic cylinders **255** (FIG. 7) for centralizing the pallet would be operated by solenoid valves and this could be done at the time the pallet is picked up on the tray **20** from a conveyor, or at any time prior to actual insertion in a cell.

The hydraulic cylinders **350**, etc., (FIGS. **14, 15, 16**) for the tray transport telescopic mechanism are likewise solenoid valve operated and, in fact, such hydraulic system requires only repsective solenoid operated multiway valves all of conventional construction and hook-up, although, of course, any suitable hydraulic circuitry control system could be utilized. In an operative embodiment conventional solenoid spool valve as made by Vickers Div. of Sperry-Rand Corp. were used, Model DG 454-012A-50 connected to a pressure source and sump and to the cylinders, all in the usual manner and carried by the tower and elevator, whereby one end of each cylinder was always under pressure (position A, FIG. **14**) to maintain the tray **20** in central positon until it is desired to actuate it. Such valves are spring biased to an initial position for that effect, by spring biased return from an actuated position.

It will of course be appreciated that various obviously required components are omitted for the sake of clarity, such as flexible hoses to hook up to the hydraulic cylinders and electric cables for the motors. Such connecting componenet are well known in the field, and as a matter of design, various types are usable. Likewise, as a matter of design, the solenoid vales for the various sets of hydraulic cylinders can either be at a fixed control point or carried by the tower. Further, power control circuitry and switching circuitry likewise could be at a fixed control point, but preferably is carried by the tower at the control panel **60** (FIGS. **1, 2**).

The compactness and practicality of the invention should be apparent from the description and the drawing, and in particular, the exceedingly simple power drive means for telescopically transporting the tray reversibly via flexible loop members such as sprocket chains which roll around sprocket wheels, all within the vertical and horizontal planes defined by the innermost pair of beams **290.** Thus by providing dual systems of what might be called zig-zag orders of sequentially connected chains, a very economical yet highly effective arrangement is provided.

Having thus described the invention, I am aware that various modifications can be made within the spirit of the concept and therefore do not seek to be limited to the exact illustration herein.

I claim:

1. A stacker crane comprising a tower having a pair of horizontally spaced columns and a traction wheel under each, said columns and wheels being spaced longitudinally in the direction of travel of said stacker crane, a respective traction drive motor for each traction wheel adjacent the respective traction wheel, a tray elevator in the space between said columns and an elevator drive motor for actuating said tray elevator in a vertical path of traverse, said traction drive motors being disposed outside the space between the columns, a pair of spaced lift chains extending vertically and supported by said columns and having upper and lower ends attached to said tray elevator and being spaced substantially the distance between said columns and extending downwardly intermediate said traction wheels below the upper peripheries thereof effecting space between said wheels and said chains to increase the path of vertical traverse of said tray elevator.

2. A stacker crane as set forth in claim **1,** including means at the lower ends of each chain for taking up slack due to chain wear elongation and means to adjust elongation due to load variation.

3. A stacker crane as set forth in claim **2,** both of said means comprising bolt and nut devices and the latter of said means being resilient.

4. A stacker crane as set forth in claim **1,** said towers comprising vertical corner members extending substantially the height of said tower and said tray elevator having guide roller means encompassing said corner members and movable threalong for guidance.

5. A stacker crane as set forth in claim **1,** said tower columns being each comprised of four corner angle irons having diagonal structural bracing therebetween, a top frame extending across said tower and securing said columns, said columns extending into said frame, bearing blocks carried by said columns in said top frame and a shaft extending between said bearing blocks and having sprocket wheels thereon and said lift chains being carried on respective sprocket wheels.

6. A stacker crane as set forth in claim **1,** and comprising a bottom frame for said columns, bearing blocks in said bottom frame disposed below said respective columns and a shaft extending between said bearing blocks and having sprocket wheels thereon and respective lift chains extending around said sprocket wheels, incldung a drive means between said tray elevator motor and said shaft.

* * * * *

CERTIFICATE OF CORRECTION

Patent No. 3,792,758 Dated February 19, 1974

Inventor(s) Edward A. Wentz

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

Col. 1, line 24, "conbination" should be --combination--;
line 38, "action" should be --actuation--.

Col. 2, line 1, "of" should be --on--.

Col. 3, line 36, after "the" insert --tray--.

Col. 4, line 29, "beaming" should be --bearing--.

Col. 6, line 57, after "11A" insert --14--;
line 61, "275" should be --375--.

Col. 7, line 20, "late" should be --plate--.

Col. 8, line 14, "Suitable" should be --Suitably--;
line 25, after "plate" insert numeral --300--;
line 48, "subseqeunt" should be --subsequent--;
line 61, "455'" should be --445'--;
line 67, after "beam" change numeral "20" to --290--.

Col. 9, line 17, "drivin" should be --driven--.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,792,758 Dated February 19, 1974

Inventor(s) Edward A. Wentz

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

Col. 10, line 28, "movmenet" should be --movement--;
line 36, "depositiong" should be --depositing--;
line 61, change numeral "30" to --20--;

Col. 11, line 6, "swtich" should be --switch--;
lines 6, 7, 8, 10, in each instance "positon" should be --position--;
line 42, "repsective" should be --respective--;
line 60, "componenet" should be --component--;
line 62, "vales" should be --valves--.

Signed and Sealed this

Thirty-first Day of *January 1978*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

LUTRELLE F. PARKER
Acting Commissioner of Patents and Trademarks