Dec. 7, 1971 J. E. POWERS ET AL 3,624,886

APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 1

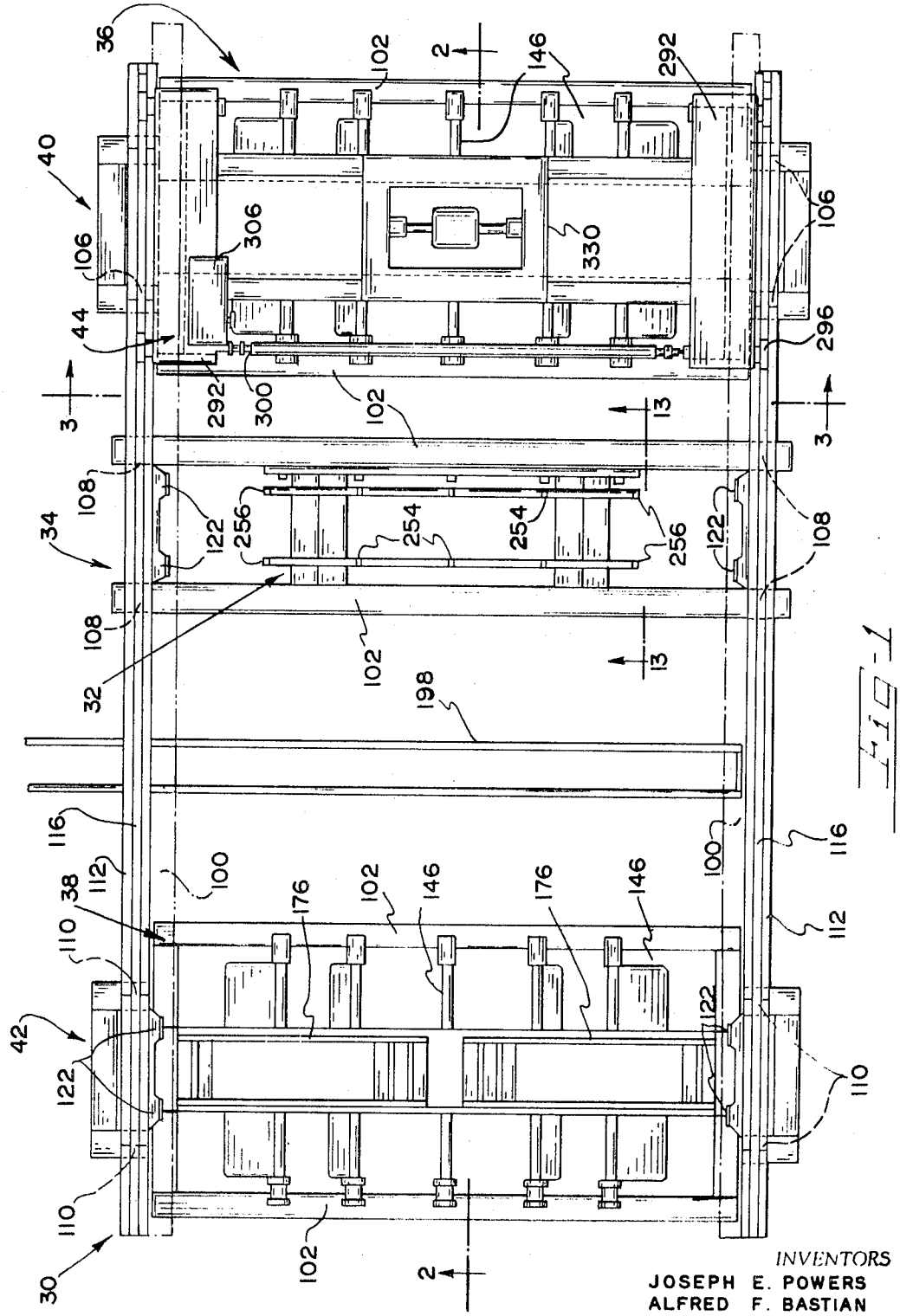


FIG-1

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 8

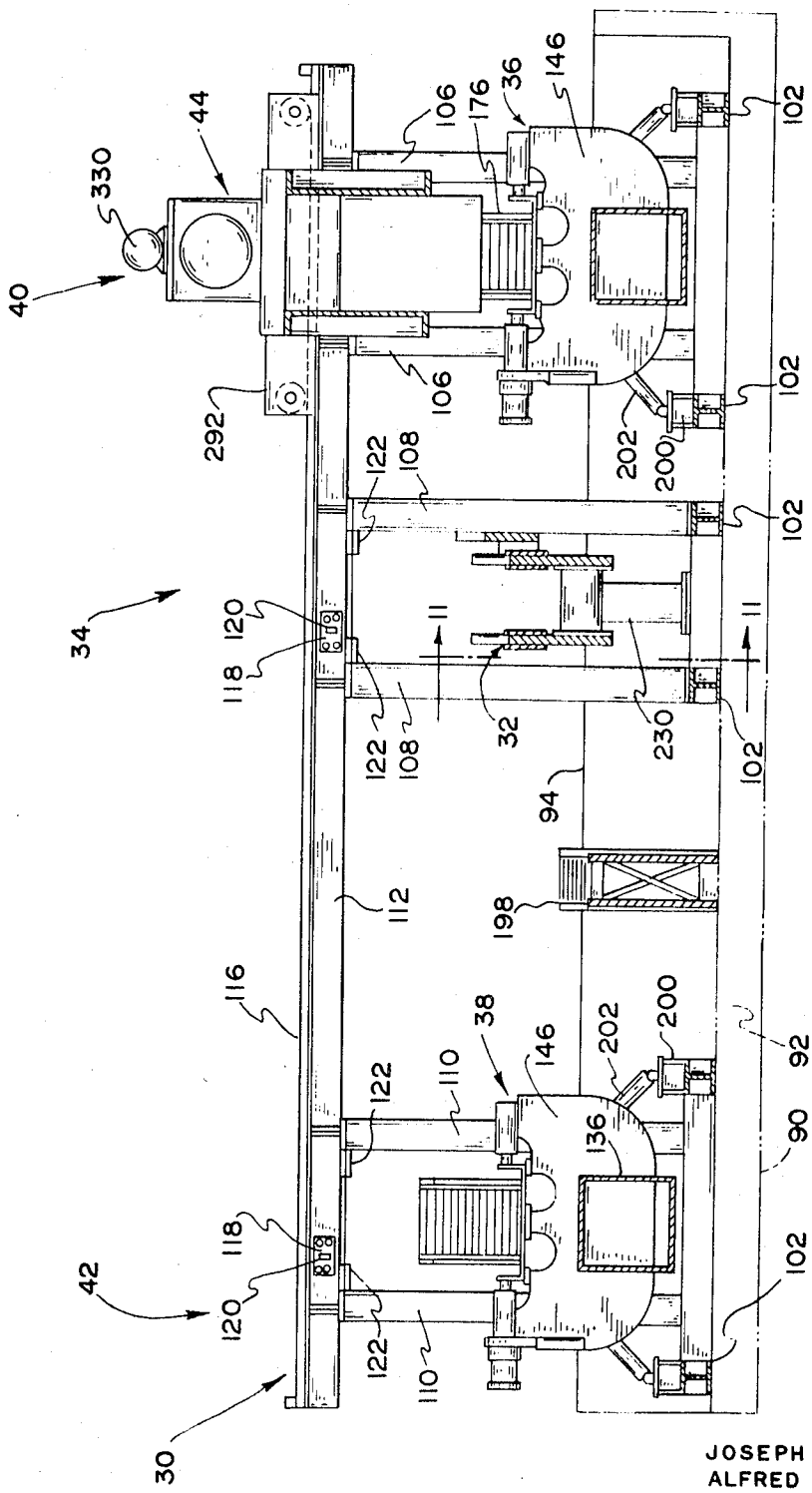


Fig. 2

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Dec. 7, 1971 J. E. POWERS ET AL 3,624,886

APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 3

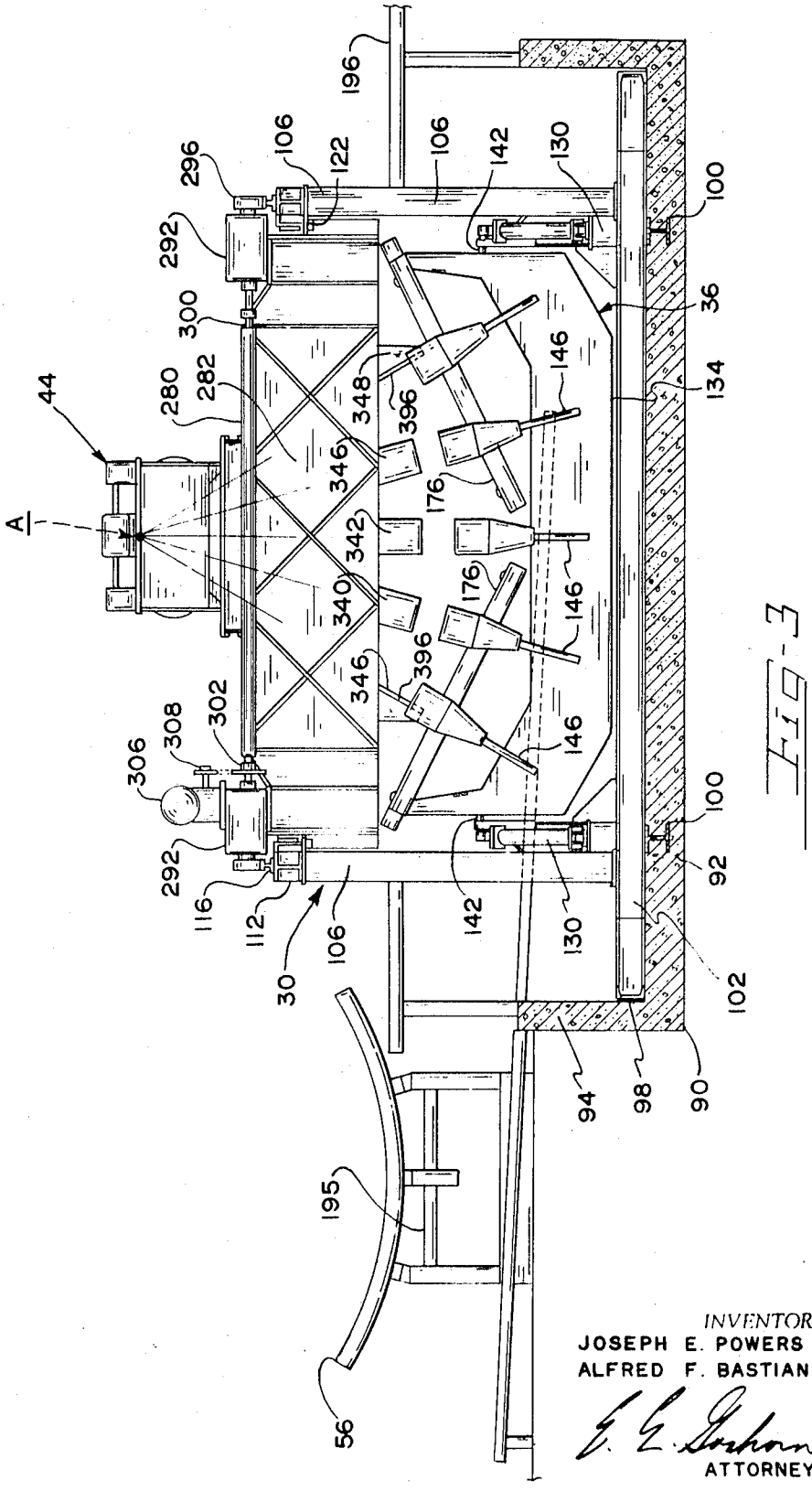


FIG. 3

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Dec. 7, 1971 J. E. POWERS ET AL 3,624,886

APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 4

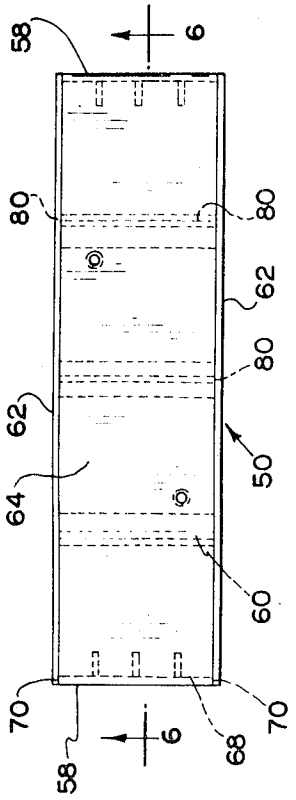


FIG. 5

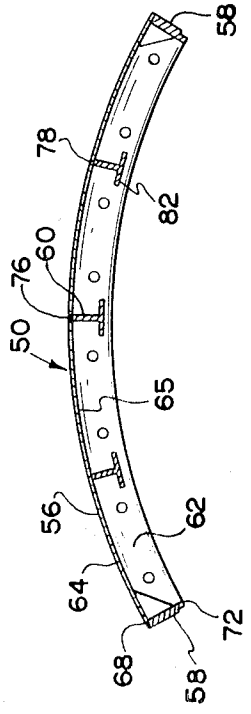


FIG. 6

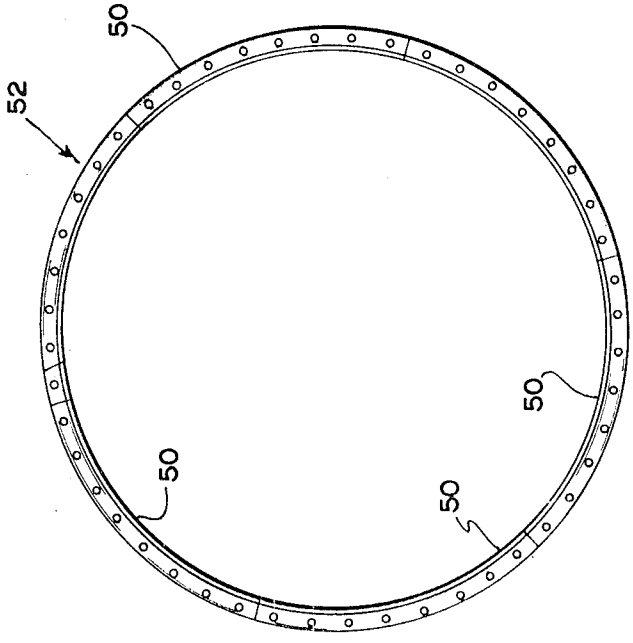


FIG. 4

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Dec. 7, 1971 J. E. POWERS ET AL 3,624,886

APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 5

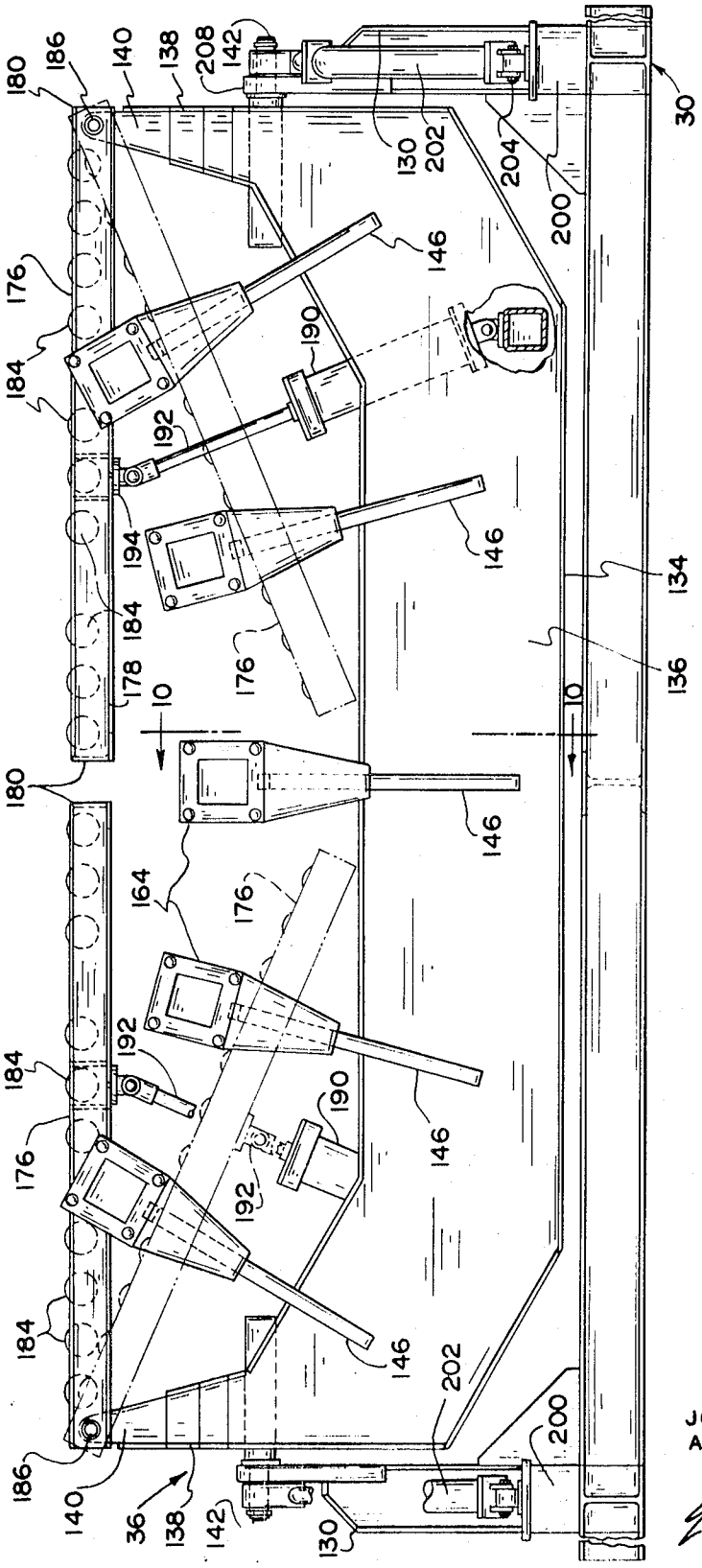


FIG. 7

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Dec. 7, 1971 J. E. POWERS ET AL 3,624,886

APPARATUS FOR ASSEMBLING A WORKPIECE

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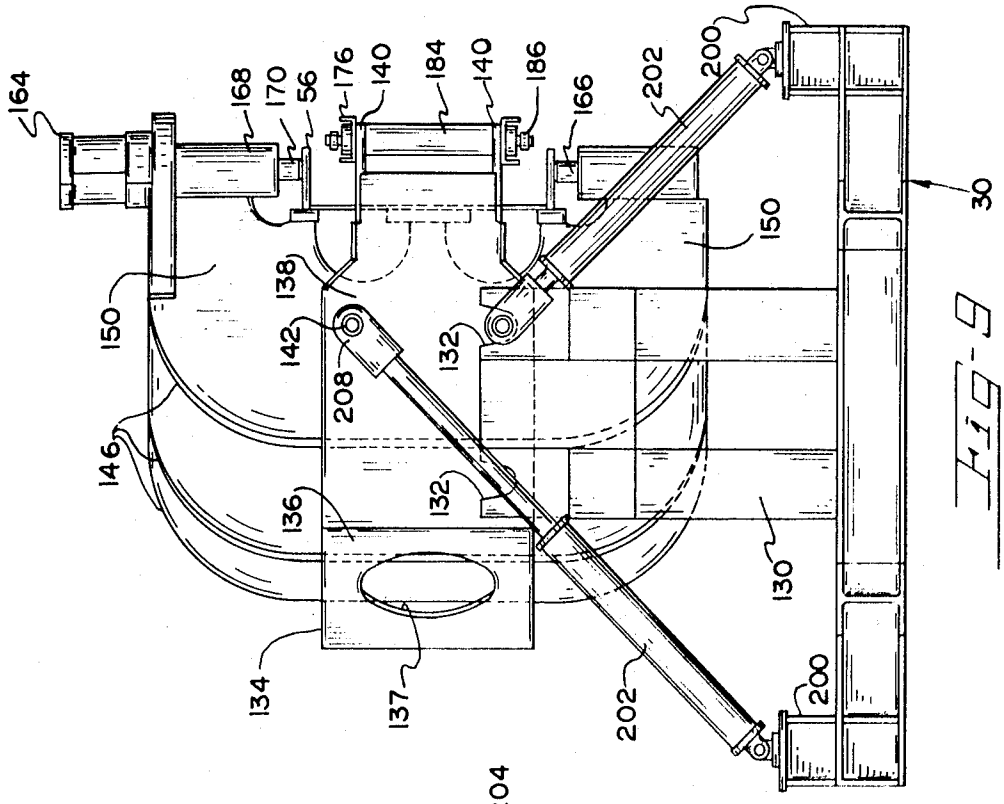


FIG-9

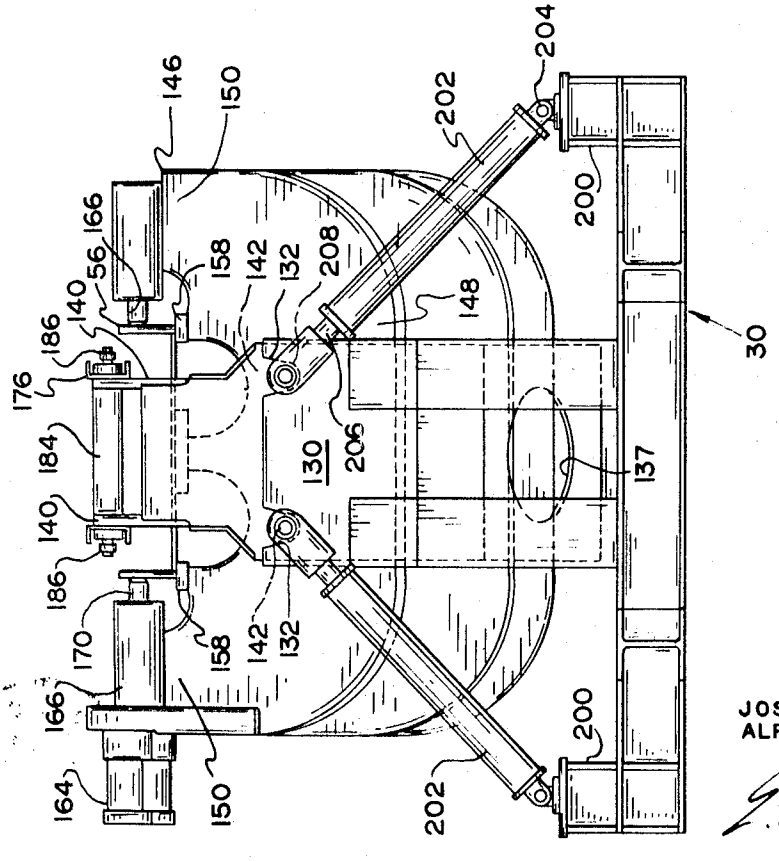


FIG-8

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 7

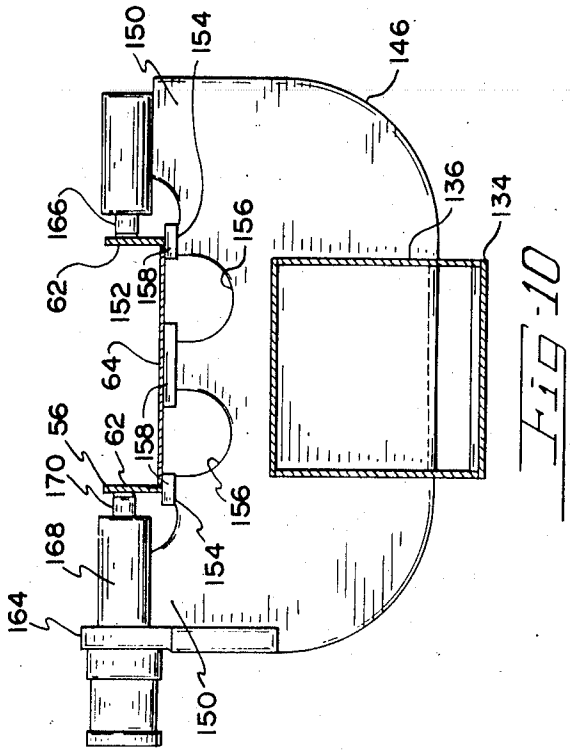


FIG-10

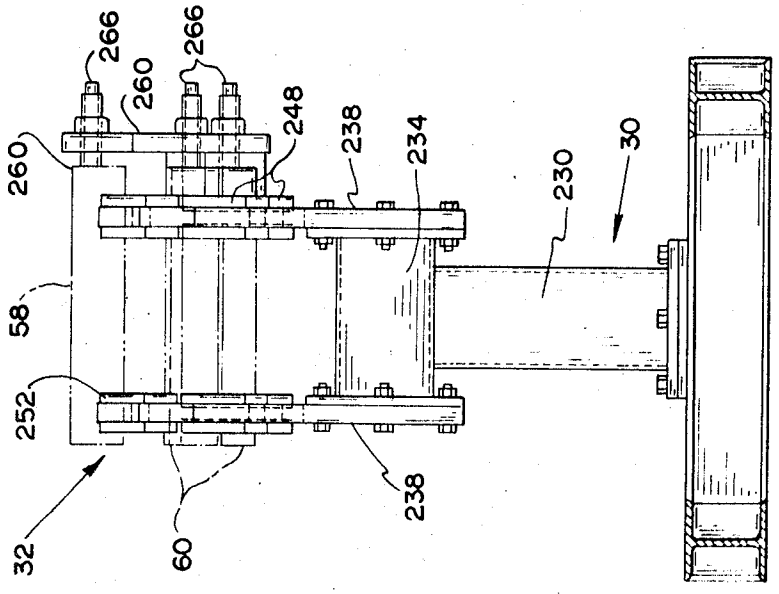


FIG-13

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 8

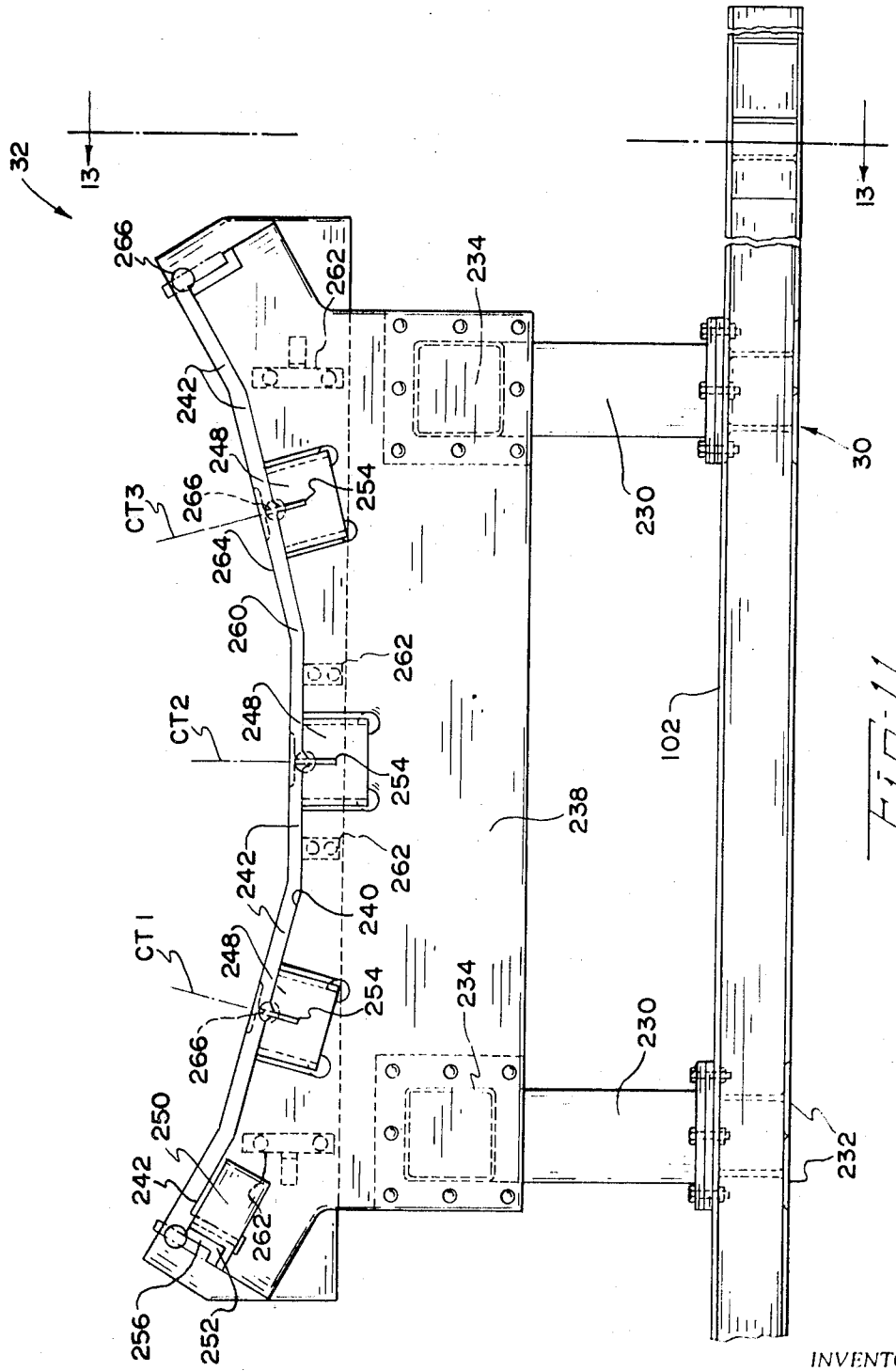


FIG-11

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 9

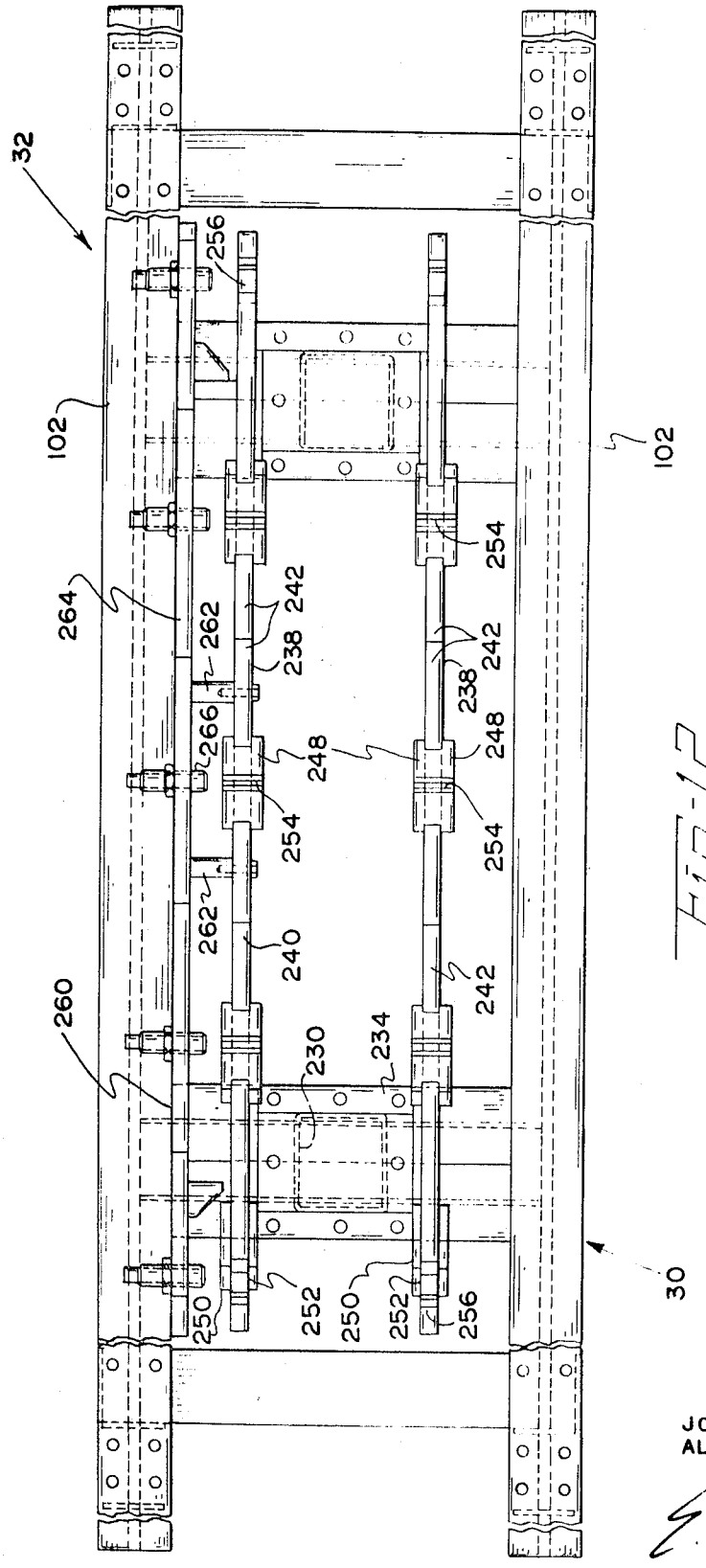


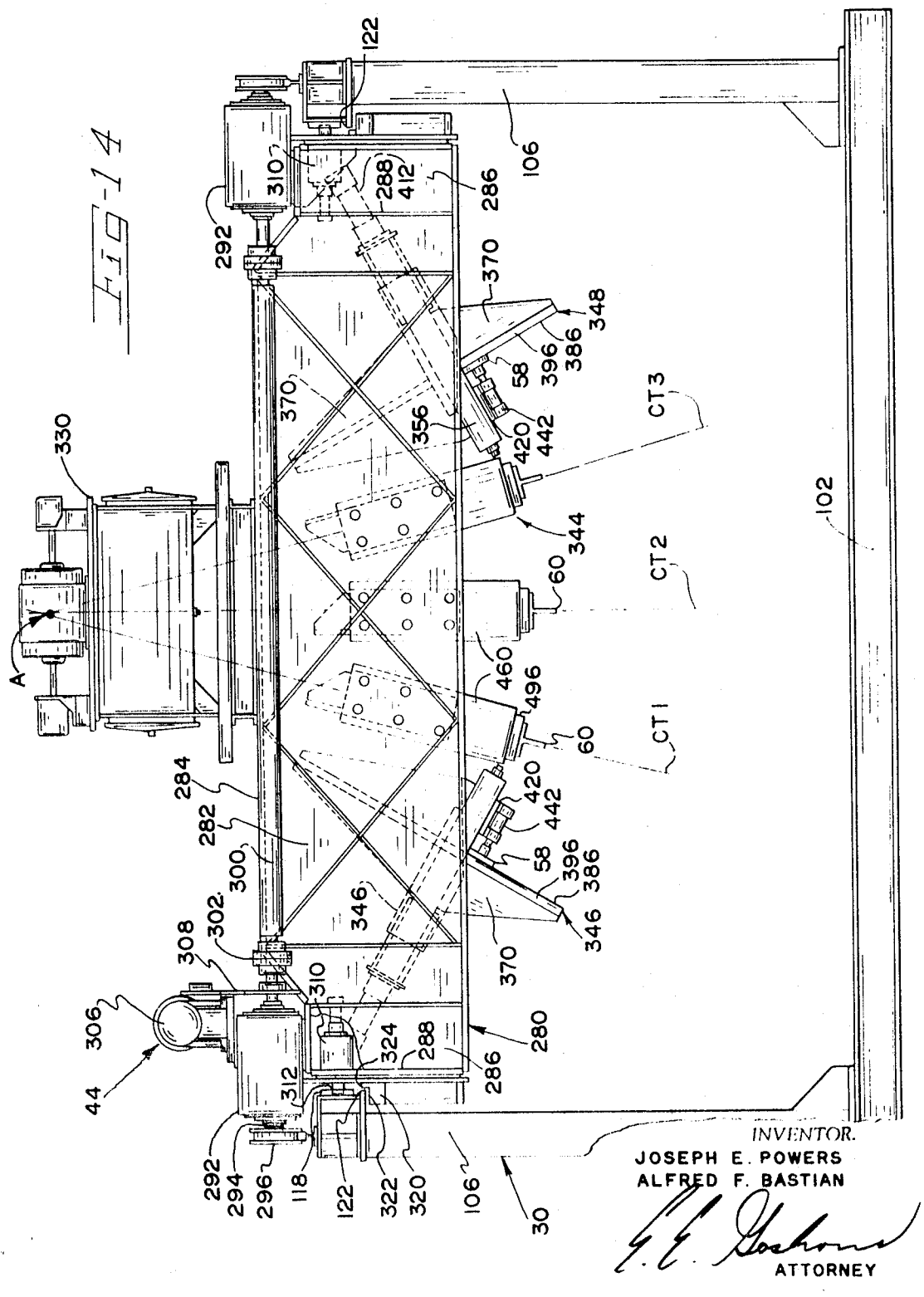
Fig-12

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 10

Fig-14



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Dec. 7, 1971 J. E. POWERS ET AL 3,624,886

APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 11

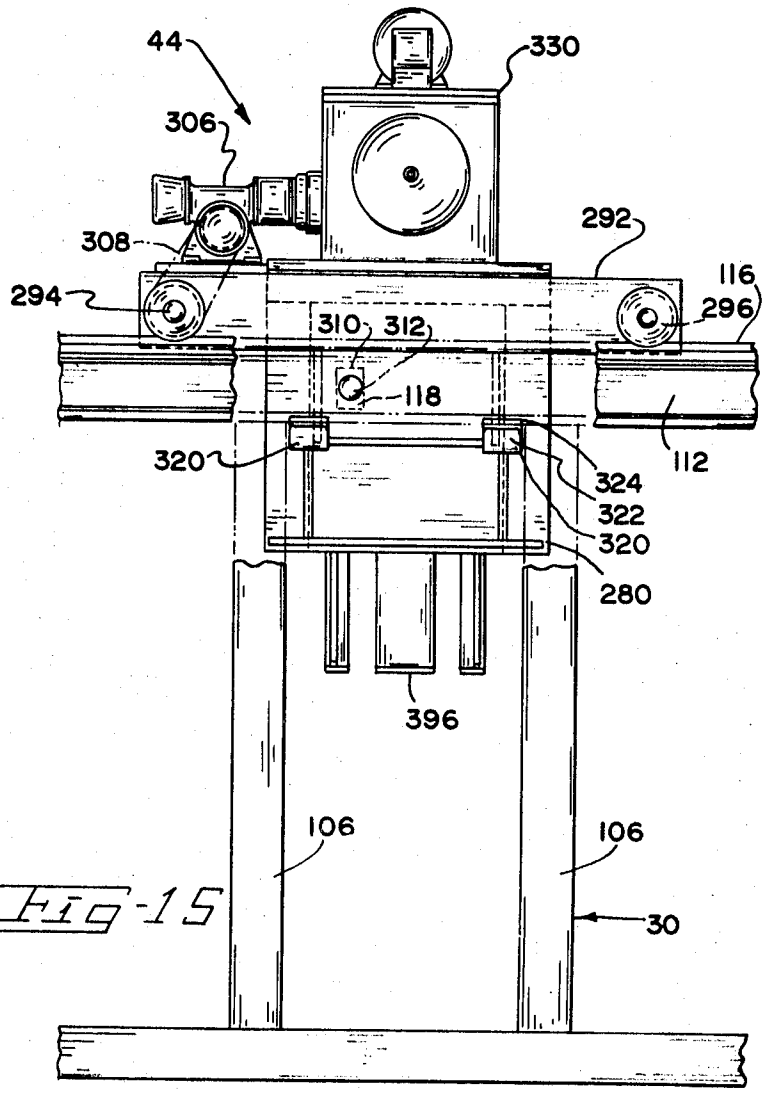


Fig-15

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 12

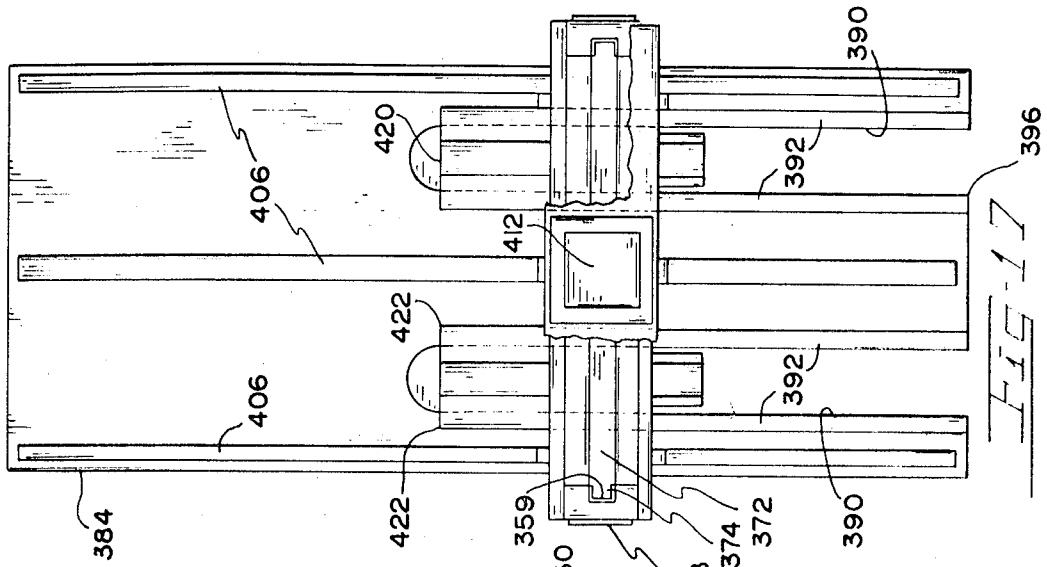


FIG-17

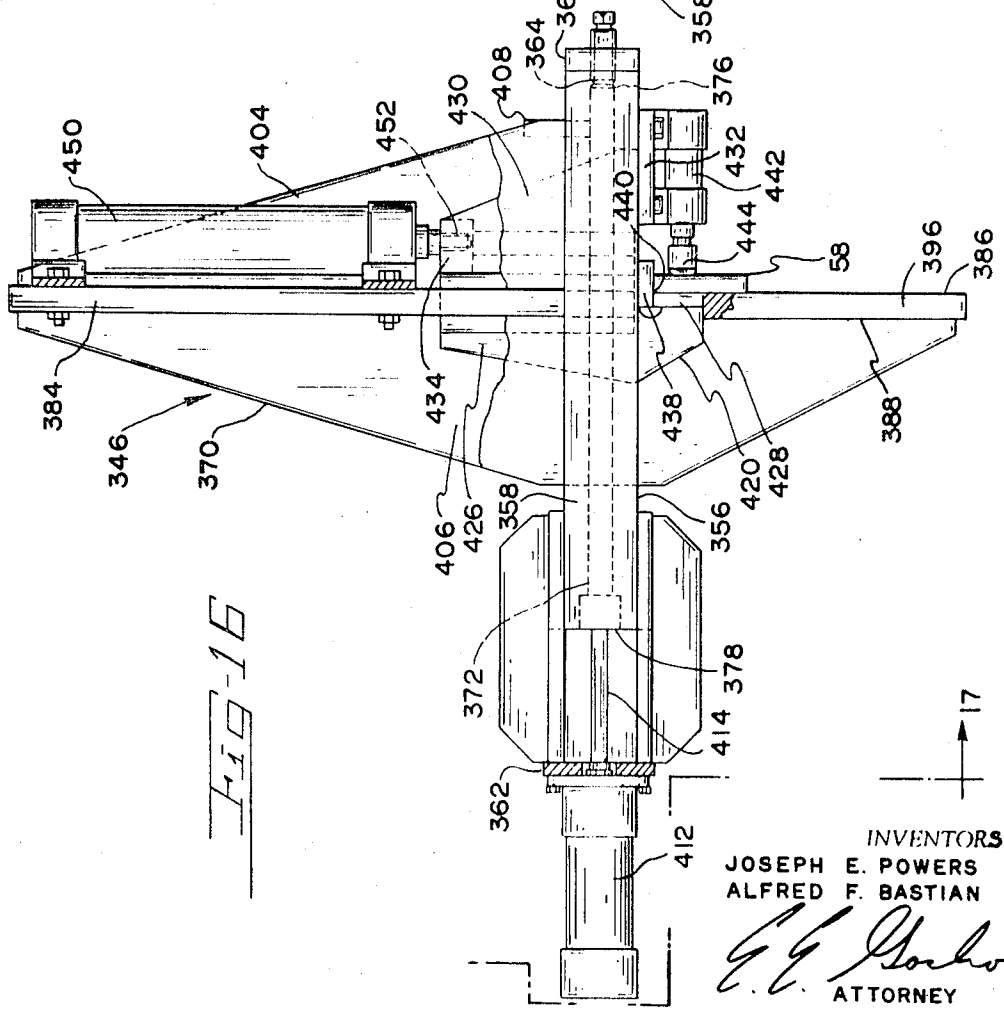


FIG-16

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 15

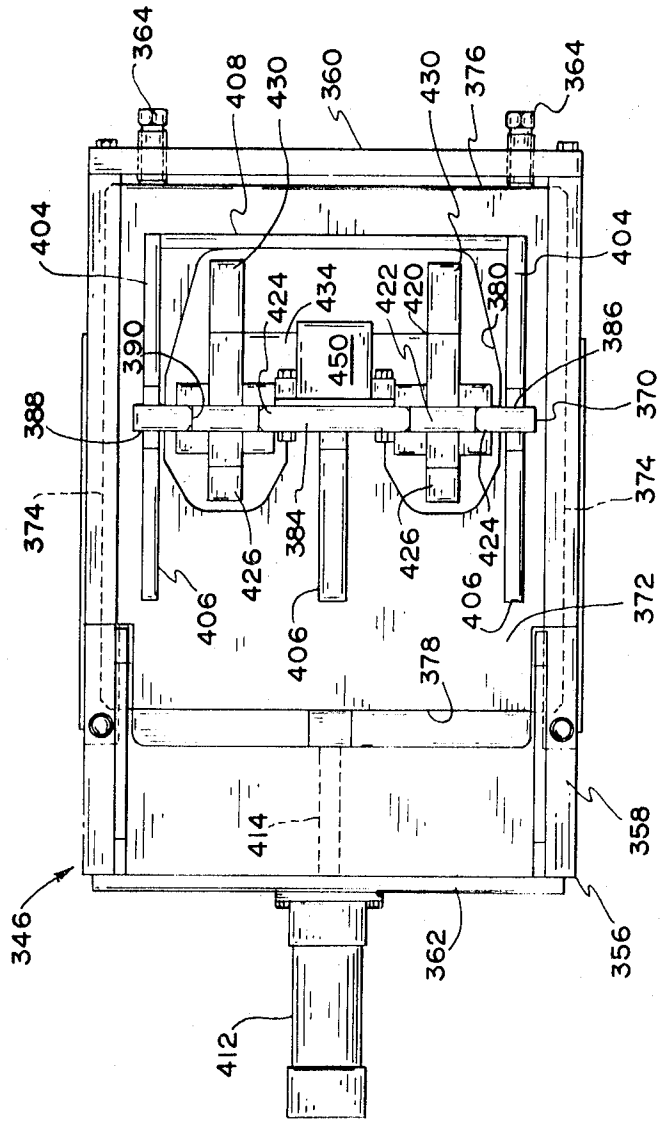


FIG-18

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 14

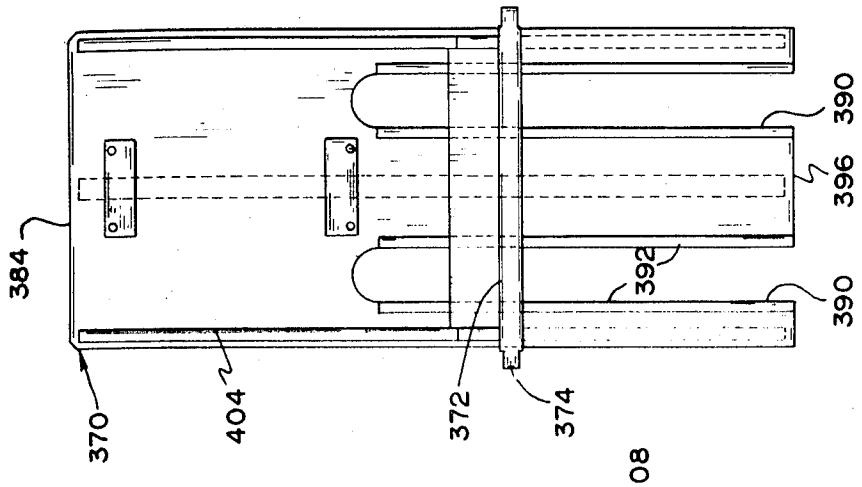


FIG-21

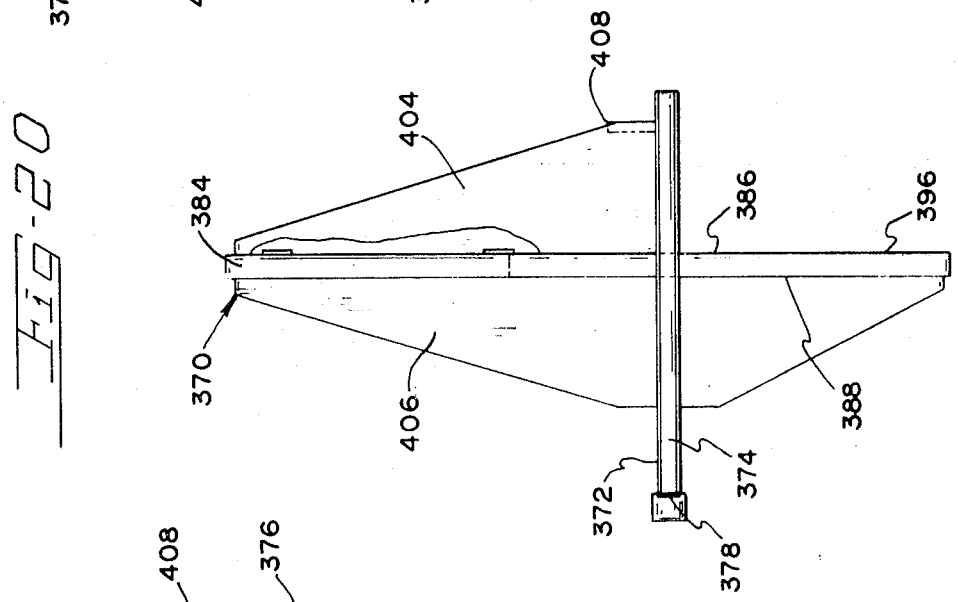


FIG-20

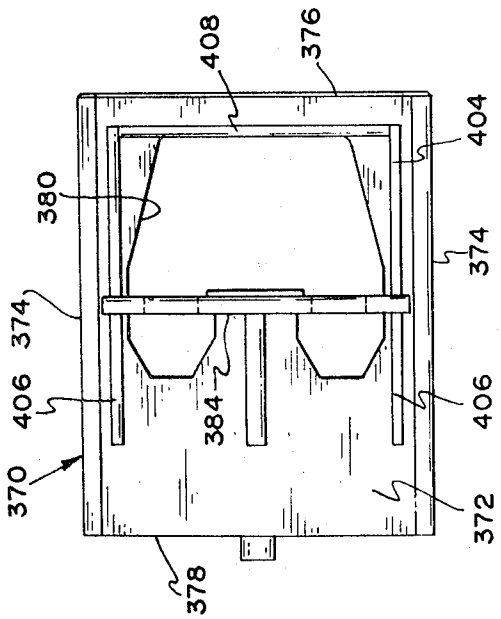


FIG-19

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 15

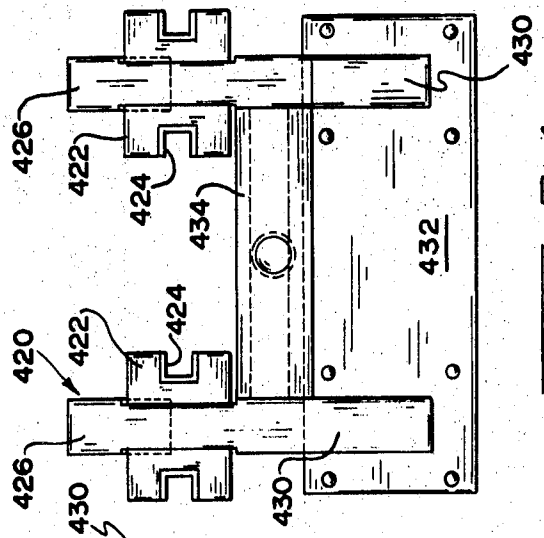


Fig-24

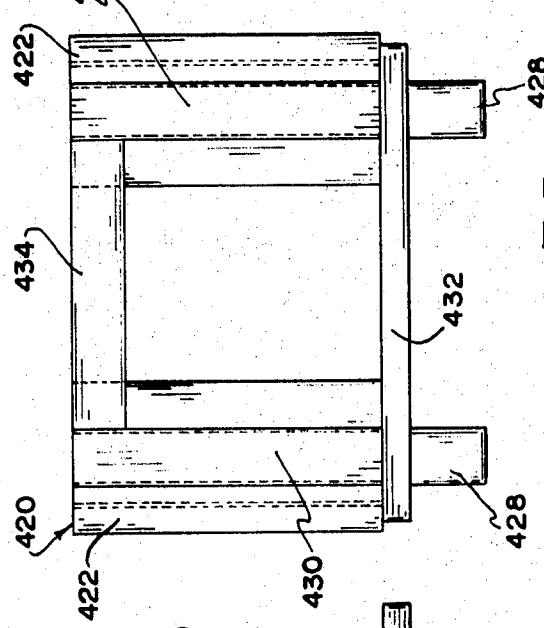


Fig-23

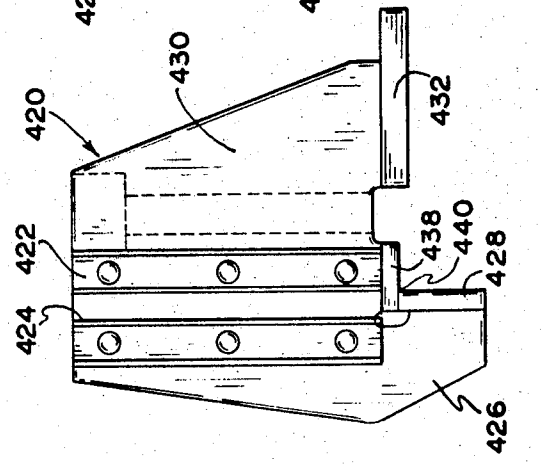


Fig-22

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APPARATUS FOR ASSEMBLING A WORKPIECE

Original Filed March 27, 1967 16 Sheets-Sheet 16

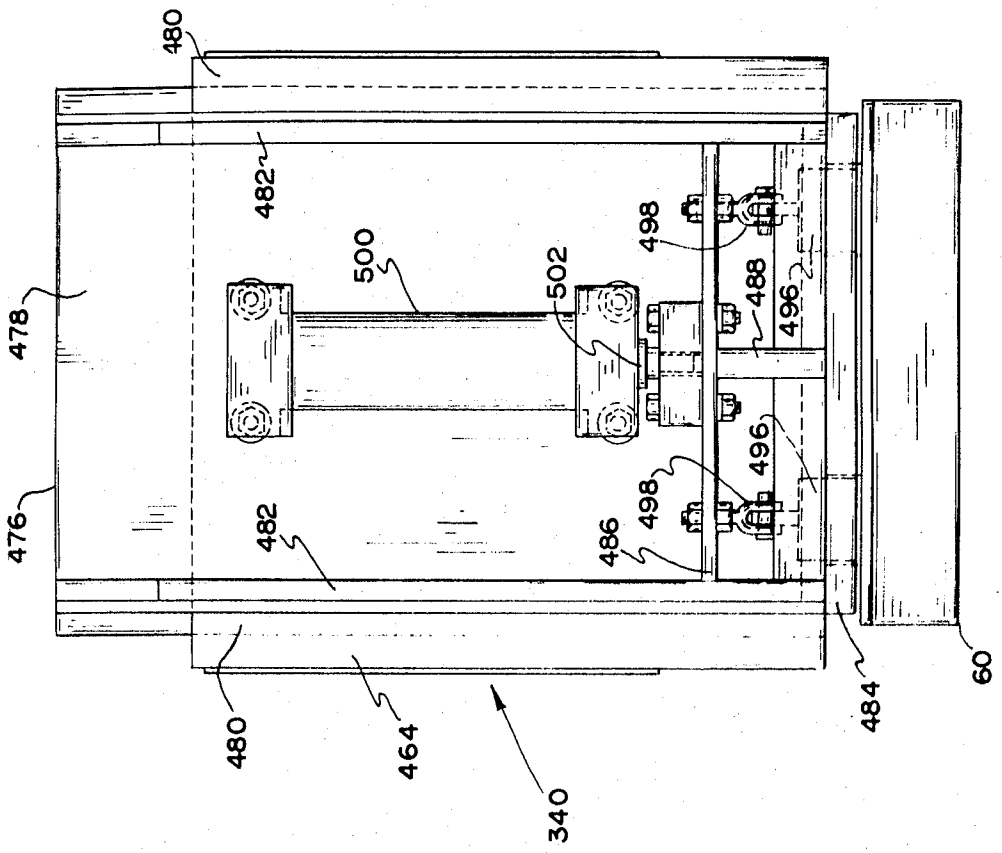


Fig-26

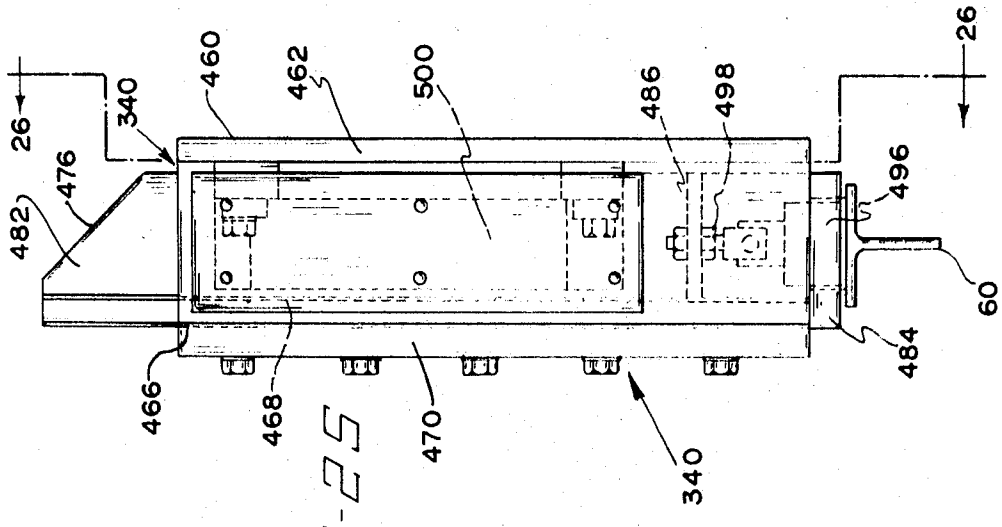


Fig-25

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United States Patent Office

3,624,886

Patented Dec. 7, 1971

3,624,886

APPARATUS FOR ASSEMBLING A WORKPIECE

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Original application Mar. 27, 1967, Ser. No. 626,111, now Patent No. 3,507,024, dated Apr. 21, 1970. Divided and this application Nov. 24, 1969, Ser. No. 877,593

Int. Cl. B23p *19/00, 17/00*

U.S. Cl. 29—200 J 28 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for assembling a workpiece, especially a modular workpiece, wherein a group of elements of the workpiece is oriented in predetermined angular and spaced relationship in one location; wherein these elements, with their angular and spaced relationship under control, are transferred as a group to another location where they are assembled in said predetermined relationship with another element of the workpiece; and wherein the assembled elements are interconnected.

This application is a division of application Ser. No. 626,111 filed Mar. 27, 1967, now U.S. Patent 3,507,024 granted Apr. 21, 1970.

BACKGROUND OF THE INVENTION

The present invention pertains to an apparatus for assembling a workpiece and more particularly to an apparatus for producing modular workpieces by positioning certain parts of each workpiece in predetermined positions against another part of the workpiece and for holding all the parts together while they are being interconnected in assembled relation.

Although the invention has broader utility, it is conveniently described in connection with the assembly of certain parts of a segment for a liner of a tunnel ring. As used for underground railroads, for example, many such tunnel rings are attached end-to-end to form a long, continuous tunnel, which, as is well known, prevents collapse of the surrounding earth. Each tunnel ring is usually made of steel and includes a plurality of arcuate reinforced segments. In turn, each segment is composed of an arcuate channel, end plates inserted in and attached to opposite ends of the channel, and T bars inserted in and attached to the channel between the end plates.

In order to constitute a strong modular segment, that is, one which is interchangeable with other segments and which will fit with several other segments to make up a complete ring, the end plates and T bars must be placed in intimate engagement with, and in precise positions within, the channels. Moreover, especially in view of the demand for such tunnels, the assembly of such segments must be performed with a minimum of time, labor and expense.

The prior known apparatus for assembling tunnel ring segments are not suited to mass production of the segment because they depend too much on manual operations and are therefore relatively slow and subject to human error. For example, as disclosed in the Fine et al. U.S. Pat. No. 2,366,961, it has been known manually to place the individual parts (skin plate, side flanges, end plates and T bar) of a tunnel ring segment in a jig, to

clamp the parts in the jig, and thereafter to rotate the jig (which is mounted on trunnions for such purpose) into various positions of access for a welder. It is apparent that such a manual operation is not conducive to producing tunnel ring segments or modules at a fast rate because the rate and manner of placing the parts in the jig is dependent on the human operator.

SUMMARY OF THE INVENTION

The present invention avoids the shortcomings of the prior art by providing an apparatus for assembling several parts of a structural member or other workpiece (which is composed of certain auxiliary parts that must be fitted and attached in a predetermined manner to a main part) by precisely arranging the auxiliary parts separately from the main part in the manner in which they will eventually fit the main part, and then by moving the auxiliary parts as a group and with their relative positions and angles under control into fitted relationship with the main part. By following the concepts of the present invention, not only can the production rate be vastly increased but also the use of cumbersome and expensive jigs can be avoided. Moreover, since each workpiece, i.e., tunnel ring segment herein, is a mirror-image of every other workpiece the parts can be fitted togther more intimately and with greater precision.

Accordingly, it is an object of the present invention to provide an apparatus for assembling several parts of a workpiece by arranging certain auxiliary parts of the workpiece in a predetermined manner in one location and then moving the auxiliary parts as a group, while maintaining control over their arrangement, into fitted relationship with another part of the workpiece.

Another object is to provide an apparatus for assembling the parts of a workpiece, such as a tunnel ring segment, on a mass production basis.

Another object is to produce segments or modules of uniform construction and dimensions so that a number of the segments can be interfitted.

Another object is to pick up a plurality of elements which are in a certain relationship to each other, and to move them out of such relationship but under such control that they can readily be returned to said certain relationship.

Another object is to provide an apparatus which locates one part of a supported workpiece in predetermined position with respect to a plurality of other parts being held by the apparatus.

Another object is to provide an apparatus for holding the separate parts of a tunnel ring segment in assembled relation and for moving the assembly into various positions of convenient access for welders.

Another object is to minimize the time and expense involved in precisely and intimately interfitting the parts of a tunnel ring segment, or other workpiece.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan of an apparatus embodying the principles of the present invention.

FIG. 2 is a longitudinal vertical section taken on line 2—2 in FIG. 1.

FIG. 3 is a transverse vertical section taken at a position indicated by line 3—3 in FIG. 1 with entry and exit conveyors for the apparatus included.

FIG. 4 is an end view of a tunnel ring the segments of which can be made by the apparatus of the present invention.

FIG. 5 is an enlarged plan of one of the segments in the tunnel ring of FIG. 4.

FIG. 6 is a longitudinal section taken on line **6—6** in FIG. 5.

FIG. 7 is an enlargement of a portion of FIG. 3 showing an assembly fixture of the subject apparatus in greater detail with conveyor sections of the fixture shown in level positions in full lines and in declined positions in dash lines.

FIG. 8 is an end elevation of the fixture shown in FIG. 7 in its horizontal loading and unloading position and with the channel of a tunnel ring segment being held therein.

FIG. 9 is also an end elevation of the assembly fixture of FIG. 8 but with the fixture in one of its tilted positions.

FIG. 10 is a transverse section taken on line **10—10** in FIG. 7 but with a tunnel ring segment being held in the fixture.

FIG. 11 is a transverse vertical section taken at a position indicated by line **11—11** in FIG. 2 showing a loading jig of the subject apparatus but with T bars and end plates shown in dash lines in the jig.

FIG. 12 is a top plan of the apparatus shown in FIG. 11 but with parts broken away and with the T bars and end plates omitted.

FIG. 13 is a vertical section taken on line **13—13** in FIG. 11.

FIG. 14 is an enlargement of a portion of FIG. 3 showing a carrier of the subject apparatus partially broken away and with certain hidden parts being indicated in dashed lines.

FIG. 15 is an end elevation, partially broken away and showing certain hidden parts in dashed lines, as seen from a position at the right of the carrier illustrated in FIG. 14.

FIG. 16 is an enlarged side elevation of an end plate pick-up unit which is part of the carrier shown in FIG. 14 and showing an end plate held in the unit.

FIG. 17 is an end view of the pick-up unit shown in FIG. 16 as viewed from a position indicated by line **17—17** in FIG. 16 but with the end plate omitted.

FIG. 18 is a top plan of the pick-up unit shown in FIG. 16.

FIG. 19 is a top plan of a paddle frame constituting part of the end plate pick-up unit of FIG. 16, although reduced somewhat in scale.

FIG. 20 is a side elevation of the paddle frame shown in FIG. 19.

FIG. 21 is an end view of the frame shown in FIGS. 19 and 20.

FIG. 22 is a side elevation of a clamp frame constituting a part of the end plate pick-up unit shown in FIG. 16, although reduced somewhat in scale.

FIG. 23 is an end view of the clamp frame shown in FIG. 22.

FIG. 24 is a top plan of the clamp frame shown in FIG. 22.

FIG. 25 is an enlarged side elevation of a T bar pick-up unit constituting a part of the carrier shown in FIG. 14 and with a T bar being shown held by the unit.

FIG. 26 is a view taken on line **26—26** in FIG. 25.

DETAILED DESCRIPTION

With particular reference to FIGS. 1, 2 and 3, an apparatus embodying the present invention includes a main frame **30**, a loading jig **32** mounted in the main frame at a loading station **34**, first and second assembly fixtures **36** and **38** mounted in the frame at first and second assembly stations **40** and **42**, in spaced relation to each other on opposite sides of the loading jig, and a carrier **44** mounted on the frame for movement between a loading position, not shown, over the loading jig and releasing positions located alternately over the first and second assembly fixtures, one of the latter positions being illustrated in FIGS. 1, 2 and 3. As mentioned above, the method and apparatus of the present invention are particularly suited for assembling parts of a workpiece such as a tunnel ring segment **50** as illustrated in FIGS. 5 and 6, and before describing the details of the jig, fixture and carrier, reference is made to this segment.

A plurality of these arcuate segments or modules **50** are interconnected in a tunnel ring **52**, as shown in FIG. 4. The tunnel ring is circular so that the radii of curvature of the segments intersect in the center of the ring. Each tunnel ring segment (or main part or piece as hereinafter sometimes referred to) includes an elongated arcuate channel **56**, a pair of rectangular end plates **58**, and a plurality of T bars **60** (the end plates and the T bars being some times referred to as reinforcing or auxiliary parts or pieces). The channel has a pair of spaced parallel side flanges **62** welded to opposite side edges of a skin plate **64** whose concave inner surface **65** has a predetermined radius of curvature. The reference to various parts as being either "inner" or "outer" is with respect to the center of the tunnel ring, this center being regarded as the innermost part of the ring. Each end plate has an outer edge **68** intimately engaging the inner surface of the skin plate, a pair of side edges intimately engaging the inside surfaces of the side flanges, and an inner edge **72** generally in same plane as the inner edges of the side flanges. Each T bar has a stem plate **76**, which has an outer edge **78** intimately engaging the inner surface of the skin plate and side edges **80** in intimate engagement with the inside surfaces of the side flanges, and a flange plate **82** perpendicular to its respective stem plate and likewise engaging the inside surfaces of the side flanges, it being noted that the flange plate of the T bar is spaced somewhat outward, along the radius of the tunnel ring, from the inner edges of the side flanges.

As disclosed herein, the main task of the subject method and apparatus is to assemble the channel **56**, the end plates **58** and T bars **60** into a tunnel ring segment **50**, since all of these parts are initially separate from each other. Briefly stated, this task is accomplished as follows: the channel **56** is positioned on one of the assembly fixtures, as **36** and the end plates **58** and T bars **60** are initially placed in the loading jig **32**. The carrier **44** picks up the end plates and T bars from the loading jig, in the same orientation as they were in the jig, transfers them from the jig to the assembly station **40** or **42** where the channel is located, orients the channel relative to the plates and bars, inserts the latter in the channel in said orientation, and once they are held in the channel by the assembly fixture, releases them and returns to the loading station **34** to repeat the cycle of operation with the alternate assembly fixture **38**. The assembled channel, end plates and T bars are held together in the assembly fixture until they are at least temporarily secured together, as by welding, and thereafter the interconnected channel, plates and T bars (which may be thought of as a package) are discharged from the apparatus as a tunnel ring segment (although additional welding and machining are required).

Main frame

In more detail, the main frame **30** is positioned on a foundation **90** (FIG. 3) providing a horizontal slab **92** and a vertical peripheral wall **94**. The main frame includes a base **98**, lower longitudinal I-beams **100** embedded in the slab and extending lengthwise of the apparatus, pairs of transversely extending I-beams **102**, opposed pairs of columns **106**, **108**, **110**, and upper longitudinal I-beams **112** connected to the columns on each side of the main frame. Further, tracks **116** (FIG. 3) are supported on and secured to the upper I-beams **112**. Latch plates **118** are mounted on the upper I-beams, on the inside surfaces thereof, between each pair of columns and each latch plate has an inwardly opening socket **120**. In addition, a

pair of stop plates **122** project inward from each upper I-beam respectively adajcent to the columns and slightly below the latch plates. All of the latch plates are in a common horizontal plane and all of the stop plates are likewise in a common horizontal plane which is slightly below the plane of the latch plates.

Assembly fixtures

The assembly fixtures **36** and **38** at the assembly stations **40** and **42** are identical and thus only one (i.e. **36**) will be described in detail with the same reference numerals being applied to the same parts on each fixture. The assembly fixture is provided to support the channels **56** while the end plates **58** and T bars **60** are being inserted therein and to hold the channel, the plates and T bars in assembled relation while they are being at least temporarily interconnected, as by tack welding. The assembly fixture (FIGS. 7, 8, 9, 10) includes a pair of standards **130** secured to the main frame **30** with each standard having a pair of upwardly opening notches **132** therein, it being noted that each notch in each standard is in horizontal alignment with a notch in the other standard. The assembly fixture also has U-shaped box frame **134** which includes a central beam **136** and a pair of legs **138** projecting from the central beam and terminating in spaced support arms **140**. Stub shafts **142** project endwardly from each leg and individually pivotally rest in the notches of the standards.

The assembly fixture **36** also includes a plurality of C frames **146** having central portions **148** rigidly connected to the U frame **134** and individually located in radial planes which intersect in a common axis A above the assembly fixture, as is viewed in FIG. 3. It will be noted that the C frames are substantially equally spaced lengthwise of the central beam **136**, and in the disclosed embodiment, there is a central C frame, an inside pair of C frames on opposite sides of the central C frame and in slight angular relation thereto and an outside pair of C frames spaced outward from the first pair and at a still greater angle with respect to the central C frame. Each C frame also has a pair of legs **150** (FIGS. 8, 10) a central ledge **152**, a pair of side ledges **154**, and notches **156** between the ledges. Blocks **158** are secured to the ledges and are in a common plane with respect to their individual C frame. Insofar as the blocks on all of the C frames are concerned, they are generally tangent to a curved surface having as its center the axis A referred to above.

A clamp **164** (FIG. 10) is associated with each C frame **146**. Each clamp includes a pad **166** mounted on one of the legs **150** of each C frame above the adjacent block **158** and adjustable toward and away from the center of the C frame and a cylinder **168** mounted on the opposite leg of such C frame and including a piston rod **170** axially aligned with its associated pad and movable toward and away from the same upon actuation of its respective cylinder. The C frames are intended to support the channels **56** with skin plate **64** resting on the blocks **158** on all of the frames and with the piston rods **170** engaging one of the side flanges and pressing the other side flanges against the pads **166**, as illustrated in FIGS. 8, 9 and 10.

The assembly fixture **36** also includes cradling conveyer sections **176** each including a rectangular frame **178** having opposite ends **180** and opposite sides **182** and a plurality of rollers **184** journalled in and extending between the sides of the frame. The conveyer sections are pivotally supported in opposite ends of the U frame **134** by pivot pins **186** (FIGS. 7 and 8) which project from the legs **138** into opposite sides **182** of the frame. The conveyer sections are thus pivoted for movement between substantially coplanar positions (also horizontal when the U frame **134** is positioned with its legs **138** projecting upward as in FIG. 7), as shown in full lines in FIG. 7, and obtusely angulated positions (also declined when the legs **138** project up), as shown in dashed lines in FIG. 7. In the angulated positions of the conveyer sections, the sides **182** of the frames **178** are received in the notches **156** of those C frames **146** that are on opposite sides of the central C frame; for this purpose, it is to be noted that two relatively large gaps are provided between certain rollers **184** to permit each conveyer section to fit within the notches and to avoid interference between the rollers and the central blocks **158**. When the U frame has its legs **138** pointing upward and when the conveyer sections are in their coplanar positions, the conveyer sections can support a channel **156** with its arcuate skin plate **64** resting on the rollers; when the U frame legs point upward and the conveyer sections are pivoted into their angulated positions, they constitute a cradle along which the channel can move by gravity (or be moved by an outside force) for the purpose of bringing the axis of curvature of the channel into coincidence with axis A. In their lowermost angulated positions, the sections lower the channel so that its skin plate rests on the blocks **158** and its side flanges **62** are between the pads **166** and the piston rods **170** of the clamps **164**. As an additional feature, the blocks **158** can include adjustable wedge pieces, not shown, to wedge the blocks tightly against the skin plate.

For pivoting the conveyer sections **176** between their coplanar and angulated positions, cradling cylinders **190** are pivoted within the central beam **136** of the U frame **134** and project upwardly through openings in the beam and have piston rods **192** pivoted to mounting pieces **194** on the frames **178** of the conveyer sections. When the cylinders are extended, they support the conveyer sections in coplanar positions and when they are retracted they move the conveyer sections in their angulated positions.

It should be noted at this point that the channels **56** are fed into the assembly fixtures **36** and **38** on respective entry conveyers **195**, and they are removed from the assembly fixtures on exit conveyers **196**, the exit and entry conveyers as well as associated assembly fixture in its upright position defining a conveying path along which the channel and segment **50** are moved. Also in FIG. 1, a conveyer **198** is shown for conveniently moving the end plates and T bars into a position adjacent to the loading jig **32**.

The assembly fixture **36** is intended to be pivoted about the stub shafts **142** and for this purpose posts **200** are provided on the main frame **30** inwardly (FIG. 3) of the columns **106**, it being noted that each pair of posts is spaced apart (FIG. 8) by about the width of the assembly fixture as measured by the width of one of the C frames **146**. Tilting cylinders **202** have lower ends connected to the posts by pivot pins **204** and have piston rods **206** individually connected to the stub shafts **142** by collars **208**. When both of the stub shafts **142** are in their respective notches **156** and the legs **138** and **150** of the U and C frames **134** and **146** are pointing generally upward, the assembly fixture is in a conveying position. By expanding one set of tilting cylinders, on one side (as distinguished from the ends) of the assembly fixture, the fixture is tilted into a work position (FIG. 9) wherein the legs **138** and **150** are directed outward in a generally horizontal direction; the assembly fixture can be returned to its conveying position by retracting this set of cylinders. By expanding the other set of cylinders, the assembly fixture can be tilted into another work position with the legs pointing outward on the opposite side from that shown in FIG. 9. The advantages of this arrangement are the stability of the assembly fixture when it is in a conveying position because the four stub shafts rest in four notches at the ends of the fixture and the accessibility to workmen, such as welders, of the assembled segment **50** when the assembly fixture is tilted into one of its two work positions.

Loading jig

In order to locate the end plates **58** and T bars **60** in positions they will eventually assume within a channel **56**, the loading jig **32** (FIGS. 11, 12 and 13) includes a pair of upstanding posts **230** mounted on I-beams **232** which extend between the pair of transverse I-beams **102** at the

loading station **34**. Cross-pieces **234** are secured to the tops of the posts, and a pair of spaced parallel vertical mounting walls **238** are secured on opposite sides of the cross-pieces and project upward therefrom. The mounting walls have upper edges **240**, each having a series of flat portions **242**, and intermediate and end openings in the flat portions. With reference to FIG. 11, intermediate, right end, and left end inserts **248**, **250** and **252** are positioned in the openings of the upper edges **240** and are secured to the mounting wall. As used herein, the terms "left" and "right" are merely convenient designations for describing the apparatus as shown in the drawings and as such have no limiting effect on the invention. The intermediate inserts have U-shaped slots **254** therein and the end inserts have L-shaped open slots **256** therein, it being noted, with reference to both walls **238**, that there are opposed pairs of horizontally aligned slots. The left end and intermediate inserts are adjustable for making different sizes of segments **50**, but the right end insert is stationary. It is also to be noted that the slots are located in radial planes whiuh intersect in axis A (above and off the sheet in FIG. 11). Both the angular relationship and spacing of the slots in the loading jig **32** are the same as the angular relationship and spacing of the C-shaped frames **146** of the asembly fixture **36** (and **38** as is believed understood). This angular relationship and spacing correspond to the desired manner in which the end plates **58** and T bars **60** are to fit within a channel **56**, and thus the slots **254** and **256** respectively releasably receive a plurality of T bars and end plates; in the disclosed embodiment, the loading jig is constructed to receive three T bars and two end plates with the stem plates **76** of the T bars and the entire end plates disposed in the respective radial planes if the slots. As illustrated in FIG. 1, the slots **254** and **256** of the loading jig **32** are preferably individually aligned longitudinally of the main frame **30** with corresponding C frames **146** of the assembly fixtures **36** and **38**.

The loading jig **32** also includes an auxiliary wall **260** (FIGS. 12 and 13) supported on one of the mounting walls **238** in spaced parallel relation thereto by brackets **262** and having an upper edge **264** which is higher than the upper edges **240** of the mounting walls. Adjustable stops **266** are mounted in the auxiliary wall in individual alignment with the pairs of aligned slots **254**, **256**. The ends of the end plates **58** and T bars **60** engage the adjacent stops **266** when the end plates and T bars are disposed in the slots thereby correctly to locate the end plates and T bars transversely of the loading jig. These stops **266** can be adjusted so as to be spaced closer to or farther from the mounting walls.

Carrier

The carrier **44** (FIGS. 1, 3 and 14 through 26) includes several significant features of the present invention. The carrier is provided with a frame **280** having a pair of vertical side walls **282** each of which has an intermediate portion **284** and a pair of end portions **286**, the latter being interconnected by vertical end walls **288**. Box-shaped trucks **292** are secured to and extend between adjacent end portions **286** of the side walls and project endwardly beyond the end walls **288**. With particular reference to FIGS. 1 and 14, axles **294** are journalled in the trucks, and wheels **296** on the axles ride on the tracks **116** and thereby support the carrier for movement lengthwise of the main frame **30** into positions over the loading jig **32** and the assembly fixtures **36** and **38** at the loading and assembling stations **34**, **40** and **42**.

For driving the carrier **44** along the tracks **116**, a connecting rod **300** is journalled in the frame **280**, extends between the trucks **292**, and is connected by couplings **302** to an axle **294** in each truck. A motor **306** is mounted on one of the trucks and is connected by a drive linkage, generally indicated by the number **308**, to one of the axles thereby to rotate the connecting rod and the axle in the other truck. Thus, by energizing the motor, the carrier is propelled in either direction along the tracks.

In order precisely to locate the carrier **44** in the loading and assembling stations **34**, **40** or **42**, latching cylinders **310** are mounted on the end walls **288** of the frame **280** and provide latching rods **312** movable endwardly of the frame into and out of the adjacent sockets **120** of the latch plates **118** when the carrier is properly positioned in any one of the stations, as illustrated in FIG. 14. When the latching rods are within the sockets, the carrier is locked against movement lengthwise of the main frame **30**. In addition, an L-shaped limit block **320** is secured to each end wall **288** and includes a horizontal flange **322** which is positionable under the adjacent stop plates **122** when the carrier is latched in any of the stations. This limit block also includes a vertical flange **324** which confronts the vertical edges of the stop plates when the carrier is latched as described. The relationship between the limit blocks and their associated stop plates is such as to limit upward movement of the carrier as well as movement of the carrier transversely of the main frame. Fluid power for the latching cylinders is obtained from a power unit **330** mounted on top of the carrier frame **280**.

With particular attention being directed to FIGS. 3 and 14, it will be noted that the carrier **44** includes a plurality of T bars, pick-up units **340**, **342** and **344** and a pair of end plate pick-up units **346** and **348**, those units being mounted in the carrier frame **280** and individually disposed along generally radial planes. When the carrier is located in either assembly station **40** or **42**, the radial planes CT1, CT2, and CT3 of the T bar units are the same as the radial planes in which the central and inside C frames **146** are located, and when the carrier is located in the loading station **34**, the T bar radial planes are the same as the planes in which the slots **254** are located. The end plate units are transversely adjustable into and out of similar coplanar relationship with the outside C frames and outside or end plate slots **256**.

Each end plate pick-up unit as **346** (FIGS. 14, 16, 17, and 18) includes a rectangular mounting frame **356** having a pair of spaced parallel sides **358** provided with inwardly opening grooves **359**, a forward end **360** and a rearward end **362**. Adjustable stops **364** are provided in the forward end for movement inward and outward of the frame. Each end plate pick-up unit as **346** also includes a paddle frame **370** (FIGS. 16 through 21) including a slide plate **372** coplanar with the mounting frame **356** and having side edges **374** slidably received in the grooves **359**, a front edge **376** in spaced parallel relation to the forward end **360** of the mounting frame, and a rear edge **378** in spaced parallel relation to the rear end **362** of the mounting frame. The slide plate has a generally U-shaped opening **380** therein with a substantial portion of the opening existing in the forward portion of the plate and portions projecting into the rear half of the plate.

With continued reference to the paddle frame **370**, a support plate **384** is secured to the slide plate **372** centrally thereof and projects both upward and downward in right angular relation to the slide plate, it being noted that the support plate is disposed transversely of the slide plate. The support plate has a front face **386**, a rear face **388**, a pair of slots **390** open at the lower edge of the support plate and extending upward therein above the slide plates (FIGS. 17 and 21), and slideways **392** on opposite sides of each slot. The three portions of the support plate which project below the slide plate are hereinafter collectively referred to as a paddle **396**. To impart rigidity to the support plate, forward and rear gussets **404** and **406** extend between the support plate **384** and the slide plate **372**, and a front rib **408** extends transversely between the front gussets. From what has been described so far, it will be understood that the paddle frame **370** is movable lengthwise of the mounting frame **356** between a workpiece engaging position, with the front edge **376** of the slide plate relatively close to, and perhaps engaging,

the stops **364**, and a retracted position with this front edge spaced farther from the stops than when the paddle frame is in the workpiece engaging position. A primary actuating cylinder **412** is mounted on the rearward end **362** of mounting frame **356** and has a piston rod **414** connected to the rear edge **378** of the slide plate for moving the paddle frame **370** between its workpiece engaging and retracted position. At this point it is to be noted that the only difference between the left and right end-plate pick-up units **346** and **348** (as illustrated in FIG. 14) is that the cylinder **412** of the unit on the left is larger than the cylinder of the unit on the right, it bring understood that left and right are merely arbitrarily designated and that the positions of the larger and smaller cyliners could be reversed from that above described.

Each end plate pick-up unit as **346** also includes a clamping frame **420** (FIGS. 16–18 and 22–24). This clamping frame has a pair of slides **422** individually located in the slots **390** of the paddle frame **370** with channels **424** individually fitted on the slideways **392** for guiding movement of the clamping frame lengthwise of the slots between an upper holding position, as illustrated in FIG. 16, and a lower projected position adjacent to the lower end of the slot for picking up and releasing end plates **58**. Rear ribs **426** project from the slides, and back blocks **428** in slots **390** are connected to ribs **426** and protrude slightly forward from face **386** out of the slots. Front ribs **430** project forward from the slides and have lower ends which are joined by a mounting panel **432** that is located underneath the mounting frame **356**. A connecting plate **434** is attached to the front ribs and extends transversely therebetween. A top block **438** is secured to the lower end of each slide and is in right-angular relation with the back block adjacent thereto to define an L-shaped recess **440**. Clamping cylinders **442** are individually attached under and to the mounting panel with their piston rods **444** individually aligned with, and movable toward and away from, the back blocks upon actuation of the clamping cylinders. It will be noted from FIG. 16 that when an end plate is positioned flush against the front face **386** of the paddle **396** and in the recess **440**, the end plate can be held in this position by actuating the clamping cylinders in order to press their rods against the plate and thereby press the end plate against the paddle and retain it tightly in the recess. Still further, each end plate pick-up unit, as **346**, includes a pick-up cylinder **450** mounted on the front face **386** of the support plate **384**, above the mounting frame **356**, and having a piston rod **452** attached to the connecting plate **434** of the clamping frame **420** for moving the clamping frame between its upper retracted position and its lower pick-up and release position.

Each T bar pick-up unit **340**, **342** and **344** includes a housing **460** (FIGS. 14, 25 and 26). The housing has a back wall **462**, side walls **464** projecting from the back wall and terminating in front edges **466** which have guideways **468** extending lengthwise on the inside corners of the edges. The housing also includes a cover **470** which is bolted against the front edges of the side walls in covering relation to the guideways. A slide frame **476** is disposed within the housing and includes a front plate **478** in slidable engagement with the cover and having side edges **480** slidably fitted in the guideways **468**. Side flanges **482** project rearward from the front plate adjacent to the side walls **464** of the housing, and a lower transverse plate **484** interconnects the side flanges. A mounting plate **486** also interconnects the side flanges in spaced parallel relation above the lower plate, and a reinforcing rib **488** joins the lower and mounting plates.

Each T bar pick-up unit, as **340**, includes a pair of electro-magnets **496** which are positioned in the lower plate **484** of the slide frame **476** so that their lower faces are slightly below the lower face of the lower plate, as best seen in FIGS. 25 and 26. Adjustable links **498** are connected to each magnet and attached to the mounting plate **486** thereby enabling precise adjustment of the lower faces of the magnets. In order to move the slide frame **276** and thus the magnets **496** relative to the housing **460**, a pick-up cylinder **500** is mounted within the housing on the back wall **462** and has a piston rod **502** connected to the mounting plate **486** of the slide frame. Thus, when the pick-up cylinder is extended, it moves the slide frame downward relative to the housing into a pick-up and release position and when the pick-up cylinder is retracted, the slide frame moves upward within the housing into a retracted position, the latter being illustrated in FIGS. 14, 25 and 26.

The T bar and end plate-pick-up units **340**, **342**, **344**, **346**, **348** are mounted on the carrier frame **280** in the manner illustrated in FIG. 14. That is, the pick-up units are oriented so that the up and down paths CT1, CT2 and CT3 of travel of the respective magnets **496** and the up and down paths of travel, as defined by faces **386** of recesses **440** (when the paddle frames **370** are in their workpiece engaging positions against the stops **364**) are in radial planes which intersect in the axis A. To effect mounting in these radial planes, the side walls **464** of the T bar-pick-up units and the slides **358** of the end plate-pick-up units are bolted to the inside surfaces of the side walls **282** of the carrier frame **280**. The power unit **330** supplies fluid for the cylinders **412**, **450** and **500** through suitable valves and conduits, not shown.

Operation

The operation of the apparatus of the present invention is described at this point. Initially both of the assembly fixtures **36** and **38** have their U frames **134** in their conveying positions and their conveyor sections **176** in coplanar positions. While the carrier **44** is displaced from the loading jig **32**, T bars **60** (three herein) and end plates **58** (two herein) are placed in the slots **254** and **256** against the stops **266**.

By operating the motor **306**, the carrier **44** is moved along the tracks **116** until it is over the loading jig **32**. The latching cylinders **310** are actuated to project the rods **312** into the sockets **120** whereby the carrier is located in the proper position at the loading station **34**. Next, the primary actuating cylinders **412** are activated to move their paddle frames **370** inwardly relative to the loading jig **32** until the paddles **396** strike the adjacent end plates **58** in the end slots **256** of the jig; activation of these cylinders is continued until the left (FIG. 14) paddle frame strikes its associated stops **364** thereby drawing the entire carrier frame **280** toward the left (since the paddle frame **370** is prevented from moving any further to the right by its engagement with the adjacent end plate **58** and since limited movement of the carrier frame transversely of the main frame **30** is permitted between the stop plates **122**) and locating the center lines CT1, CT2, and CT3 of the T bar pick-up units **340**, **342**, and **344** in predetermined spaced relation to the front face **386** of the left panel. Even though the right paddle is held against the right end plate by the right primary actuating cylinder **412**, the left primary actuating cylinder is still capable of moving the carrier frame toward the left, as above described, because this left actuating cylinder is larger and more powerful than the right cylinder and can exert greater force on the carrier frame. The importance of such action is that the spacings between the front face **386** of the left paddle and the center lines CT1, CT2 and CT3 are identical to the desired spacings between one end plate **58** and the T bars **60** of a tunnel ring segment **50**.

After both paddles **396** are in engagement with their end plates **58** in the loading jig **32** and after the left (FIG. 14) paddle frame **370** is in engagement with the left stops **364**, the pick-up cylinders **450** and **500** are energized to move the clamp and slide frames **420** and **476** into their lower pick-up and release positions wherein the magnets **496** individually magnetically engage the

flange plates 82 of the respective T bars 60 and the back and top blocks 428 and 438 engage the adjacent end plates 58. The clamping cylinders 44 are then actuated to clamp the end plates against the back blocks. The pick-up cylinders 450 and 500 are retracted thereby lifting the end plates and T bars out of the loading jig 32 and supporting them entirely on the carrier 44. It is significant that the T bars are retained in the same radial planes in which they were located in the jig and, although the left end plate can be moved out of its original radial plane by retracting the left paddle frame, it can always be moved back into such plane by moving the paddle frame into contact with the stops 364. The precise radial plane of the right end plate is not significant although its minimum spaced relation to the left end plate is limited by the right paddle frame's engagement with the right stops 364.

While the end plates 58 and the T bars 60 are being loaded into the jig 32 and while the carrier 44 is picking them out of the jig, an empty channel 56 is being conveyed into one or both of the assembly fixtures 36 or 38. Thus, before describing the action of the carrier 44 in depositing its load of end plates and T bars into a channel, reference is made to how the channel is positioned in the assembly fixture. With the assembly fixture in its conveying position (FIG. 8), conveyor sections 176 are held in their level positions by extension of the cradling cylinders 190. A channel is moved from the entry conveyor 195 onto the horizontally aligned conveyor sections with the convex surface of the channel resting against the rollers 184 and with the center of the channel lying near the central C frame 146. The conveyer sections are then lowered, by retracting the cradling cylinders, into their declined positions whereby the channel is lowered onto the blocks 158 of the C frames and between the pads 166 and rods 170 of the clamps 164. The channel is thus free to move generally along an arcuate path defined by its skin plate 64, and it does so move either by gravity or with a slight manual assist so that the opposite ends of the channel are located inward of the paddles 396 of the carrier 44 when the paddles are in their maximum spaced relation to each other. Next, the clamping cylinders 168 are actuated to clamp the channel lightly between the pads 164 and rods 170 while still permitting said arcuate sliding movement of the channel upon exertion of adequate force to either end thereof.

After releasing the latch rods 312, the motor 306 is energized to move the carrier 44 with its load of end plates 58 and T bars 60 along the tracks 116 until it is over the assembly fixture, as 36, where the channel 56 is located. Once again, the latch rods 312 are projected so as to fit in the sockets 120 at this assembly station 40; this locates the radial planes in which the T bars are being held by the carrier 44 in the exact positions desired transversely of the assembly fixture 36 and makes it possible to move the end plates into the correct planes. In order to locate the channel 56 in the assembly fixture 36 so that the radial planes of the T bars intersect the channel 56 in the places where the T bars are to be inserted, the paddles 396 are moved inwardly toward each other by the primary actuating cylinders 412 until the left paddle frame 370 contacts the stops 364. Assuming that the channel has been cut to the exact length desired and if the channel is already in the correct position in the assembly fixture 36, the paddles 396 merely come to rest against the ends of the channel at the same time as the left paddle frame 370 strikes the stops 364. However, if the channel is left of its desired position, the left paddle will engage the left end of the channel and slide it rightward until the left paddle frame strikes its stops 364. Conversely, if the channel is too far to the right, the right paddle will engage the right end of the channel and slide the channel leftward until the left end of the channel engages the left paddle (which is at its innermost position as determined by engagement of the left paddle frame with its associated stops). In any event the channel will eventually be located in the exact position desired relative to the pick-up units 340, 342, 344, 346 and 348; this exact position is determined by the position of the front face 386 (FIG. 14) of the left paddle 396, as explained above in the discussion of the loading jig. The advantage of maintaining the channel under light pressure by clamps 164 is that the channel remains in whatever position it is slid by the endward force exerted by the paddle.

It is to be noted that if the channel 56 is too short, both paddle frames 370 will strike their stops 364 and yet both paddles 396 may not contact their respectively adjacent ends of the channel; nevertheless, when the end plates 58 are placed into the channel by the pick-up units 346 and 348, they will be located the correct distance apart for proper assembly of the segment 50 in a tunnel ring 52.

With the channel 56 properly located between the paddles 396, the pick-up cylinders 450 and 500 are expanded to lower the end plates 58 and the T bars 60 thereby to insert and to press them into the channel in the exact locations desired. The pressure placed on the T bars and end plates is such as to urge the outer edges 68 and 78 of the end plates and stem plates 76 into firm contact with the concave surface 65 of the skin plate 64. As the rods 452 and 502 of the pick-up cylinders press downward and thus press the T bars and end plates against the skin plates and therefore the entire channel against the assembly fixture 36, the carrier frame 280 tries to move upward but is resisted by engagement of the horizontal flanges 322 with the stop plates 122 on the main frame 30. This upward force is, in turn, transferred to the columns 106 of the main frame. It is to be noted (FIG. 3) that the shape of the C frame 146 and the U frame 134; and the interconnection of the base 98, columns 106, I-beams 112 and carrier 44 are especially capable of withstanding the forces involved when the end plates and T bars are pressed into the channel.

While the plates 58 and bars 60 are held in their precise positions and under compression against the skin plate 64 by the carrier 44, the pressure of the clamps 164 is increased thereby tightly squeezing the plates and bars between the side flanges 62 of the channel 56. The clamping cylinders 442 are first retracted and then the pick-up cylinders 450 and 500 are retracted to lift the clamp frames 420 and the slide frame 476 free of its load of end plates and T bars, and the carrier 44 is returned to the loading station 34 in order to pick up another load of end plates and T bars.

When the carrier 44 is displaced from its position over the assembly fixture 36, the tilting cylinders 202 on one side of the assembly are expanded (FIG. 9) in order to pivot the assembly fixture on the stub shafts 142 on the other side of the assembly fixture and thus to move the assembly fixture into one of its outwardly directed work positions. While in this position, workmen tack-weld the end plates 58 and T bars 60 in the channel 56. Thereafter, the extended tilting cylinders are retracted and the other set of tilting cylinders is expanded in order to tilt the assembly fixture into the opposite work position where additional tack welding is performed. Finally, the assembly fixture is returned to its conveying position (FIG. 8) with both stub shafts resting in their respective notches 132.

With the channel 56, end plates 58 and T bars 60 at least temporarily interconnected in assembled relation as a tunnel ring segment 50, the clamps 164 are released and the cradling cylinders 190 are expanded in order to raise the conveyor sections 176 into their coplanar position and thus raise the segment upward into alignment with the exit conveyor 196 onto which the segment is moved.

While a load of end plates 58 and T bars 60 is being

placed in a channel **56** at one of the assembly stations **40**, another load of end plates and T bars is being positioned in the loading jig **32**, and other channel is being prepositioned in the assembly fixture **38** at the second assembly station **42**. Furthermore, while the assembled parts of one segment are being tack-welded at the assembly station **40**, a load of T bars and end plates is being picked up from the loading jig by the carrier **44** for transport into a position over and insertion into a channel at the second assembly station **42**. It will be understood that the carrier operates continuously between a position at the loading station **34** to pick up a load of end plates and T bars and alternate positions over the assembly stations to insert each load into a channel at an assembly station.

From the foregoing it will be evident that an apparatus has been provided for collectively positioning certain parts of a workpiece (such as T bars and end plates of a tunnel ring segment) in predetermined assembled relation with another part (such as a channel) and for holding all of the parts together while they are being interconnected in assembled relation. It is significant that the assembly of these parts can be performed in a minimum of time and with a minimum of labor and expense so that the apparatus is excellently suited for production line operation. Notwithstanding the speed of assembly, the apparatus is designed to assemble the parts with dependability and precision so that the final workpiece is structurally sound and, in the case of the tunnel ring segments, each segment is interchangeable with others in constructing a complete tunnel ring.

Although an embodiment of the present invention has been illustrated and described, it will be understood that changes can be made in the details thereof without departing from the spirit and scope of the following claims, wherein what is claimed is:

1. In the apparatus for assembling several elements of a workpiece, the combination of means for supporting a first element of the workpiece, jig means spaced from said supporting means for releasably mounting a group of other elements of the workpiece in predetermined relation to each other, and carrier means mounted for movement between a receiving position adjacent to said jig means, wherein in the carrier means takes said group of elements from said jig means, to a discharge position adjacent to said supporting means, and wherein the carrier means places said group of elements against said first element in said predetermined relation and thereafter releases said group.

2. The apparatus of claim **1** wherein said supporting means includes means for holding said one element and said group of elements together after placement and before release by said carrier means.

3. The apparatus of claim **2** wherein said first element is a channel having side flanges, wherein said group of elements are reinforcing elements adapted to be positioned between said side flanges by the carrier means, and wherein said holding means includes a pad engageable with one of said side flanges and an actuatable member engageable with the other side flange to press said side flanges together and thereby clamp said group of elements in said channel.

4. The apparatus of claim **1** including a frame in which said supporting and jig means are mounted, and interengaging means on said carrier means and said frame for releasably locking said carrier means in said discharge position.

5. The apparatus of claim **1** wherein said carrier means includes means for pressing each element of said group into close engagement with said first element during placement of said group against said first element.

6. The apparatus of claim **1** wherein said first element is an arcuate channel and wherein said supporting means includes a frame, a pair of conveyor sections pivoted in the frame for movement between first positions wherein the sections are level and in alignment for receiving and discharging said channel and second positions wherein the sections are in downwardly convergent relation to each other, said sections in said second positions constituting means on which said channel can be moved lengthwise thereof into predetermined relation with said carrier means.

7. The apparatus of claim **1** wherein said carrier means includes a frame, there being a reference plane passing through the frame; positioning members; and means mounting the members in said frame on opposite sides of said plane for movement toward and away from each other between inner positions, wherein at least one of the members is in precisely spaced relation to said plane for engagement with said first element and wherein the other member is engageable with said first element to clamp the element between said members, and outer positions spaced farther apart than the dimension of the first element as measured between said members.

8. The apparatus of claim **1** including second means for supporting a first element of another workpiece, said jig means being located between said first mentioned and said second supporting means, and said carrier means being movable alternately between said supporting means.

9. The apparatus of claim **1** wherein said group of elements includes a pair of end plates and a T bar, wherein said jig means has a plurality of slots for said group of elements including end plate slots spaced on opposite sides of a T bar slot, wherein means are provided for releasably latching said carrier means relative to said jig means, and wherein said carrier means includes T bar and end plate pickup means respectively engageable with T bar and end plates in said slots when said carrier means is in said latched position.

10. The apparatus of claim **9** wherein each of said pickup means includes element contacting means and fluid actuated means for moving its contacting means into engagement with its respective element in the jig means, for removing the element from said jig means, and for placing such element against said first element.

11. In an apparatus for assembling a pair of end plates, a T bar and a channel so that the T bar is located intermediate the ends of the channel and the end plates are at opposite ends of the channel, a frame, fixture means mounted on the frame for supporting the channel for movement lengthwise thereof while constraining it against lateral movement, jig means mounted in the frame in spaced relation to said supporting means and having a plurality of slot means for releasably receiving a T bar and end plates in the same orientation as they are to be located in said channel, track means on the frame extending from said supporting means to said jig means, carrier means mounted on the track means for movement between first and second positions respectively adjacent to said jig means and to said supporting means, and means for releasably locking said carrier means in each of said positions, said carrier means including fluid actuated means for picking up said T bar and end plates in the first position of the carrier means and for inserting said T bar and end plates firmly into the channel in said second position, said carrier means including means engageable with opposite ends of the channel in said second position for clamping said channel in a predetermined position relative to the T bar and end plates picked up, and subsequently to be inserted, by said fluid actuated means, and said supporting means including clamping means for constraining transverse movement of said channel and clamping the T bar and end plates in the channel.

12. In an apparatus for cradling an arcuate workpiece adapted to be delivered to and discharged from the apparatus along a predetermined path, a support, and a pair of conveyor sections pivoted in the support on spaced parallel axes individually adjacent to delivery and discharge areas of the apparatus for movement between first positions wherein the sections are in alignment with each other and with said path to second positions and

wherein the sections decline from their respective axes and form a cradle on which the convex surface of an arcuate workpiece can rest and move lengthwise thereof.

13. The apparatus of claim 12 including means for pivoting the sections between said positions.

14. In an apparatus for supporting an elongated workpiece having opposite sides and opposite ends, the combination of an elongated frame having opposite ends and opposite sides, means borne by the opposite ends of the frame for suporting such a workpiece with the workpiece disposed lengthwise of the frame, means on the frame for clamping the workpiece therein, and means mounting opposite ends of the frame for pivoting movement about an axis extending lengthwise of the frame between first and second positions angularly displaced from each other.

15. The apparatus of claim 14 wherein said mounting means mounts said frame for pivoting movement about a pair of axes which are in spaced parallel relation to each other in a horizontal plane whereby said workpiece can be positioned to face upward and to face outward from either axis.

16. The apparatus of claim 14 wherein said frame is U-shaped with the legs of the U being directed upward in said first position and generally horizontally outward in said second position.

17. The apparatus of claim 16 wherein said mounting means includes a base and a pair of standards upstanding from the base, each of said standards having a pair of upwardly opening notches, all of the notches being generally in a horizontal plane and each notch in each standard being axially aligned with a notch in the other standard, pairs of axially aligned stub shafts projecting endwardly from the opposite ends of the frame and individually resting in said notches thereby to provide four point support for the frame, and means interconnecting the base and one axially aligned pair of shafts for lifting said one pair out of their notches thereby to pivot said frame about the other pair of axially aligned shafts which remain in their notches.

18. In an apparatus for supporting an elongated workpiece having opposite sides, a U-frame having an elongated central portion and a pair of legs projecting from the central portion; a plurality of C-frames connected to said central portion of the U-frame in longitudinally spaced relation thereon, extending transversely of said central portion, and having legs projecting in generally the same direction as the legs of the U-frame, said C-frames having means for supporting a workpiece between opposed pairs of legs of said C-frames, and means mounted on the legs of said C-frames for clamping such a workpiece between the legs of the C-frames.

19. The apparatus of claim 18 including means mounting the U-frame so that all of the legs project upward, means mounted on the legs of the U-frame for lowering such workpiece into a position where it is supported on the C-frames and for raising such workpiece to a position off said C-frames.

20. The apparatus of claim 18 including means engaging said U-frame legs for supporting said U-frame with all of said legs projecting upward and for movement of the U-frame alternatively about a pair of axes extending lengthwise of said central portion of the U-frame on opposite sides of a vertical plane passing lengthwise between and equally distant from said opposed pair of C-frame legs.

21. In an apparatus for positioning a group of generally flat auxiliary plates having predetermined inner edges against the surface of a main plate so that the auxiliary plates are located in separate planes, the main plate being adapted to be supported with said surface facing up; carrier means adapted to be positioned in predetermined confronting relationship to said surface of such a main plate, said carrier means including a frame, and a plurality of holding units located generally in planes individually coplanar with the planes in which said auxiliary plates are to be located when said carrier means is in said confronting relationship, each such unit having means for releasably grasping an auxiliary plate and means for moving the plate held thereby, along its respective plane.

22. The apparatus of claim 21 wherein at least one of said auxiliary plates is made of magnetically attractive material, and wherein at least one of said grasping means has a magnet for grasping said one of said auxiliary plates.

23. The apparatus of claim 21 wherein said moving means is fluid actuated.

24. The apparatus of claim 21 wherein at least one of said grasping means includes a socket means having an open position for receiving an auxiliary plate and a closed position for clamping an auxiliary plate therein.

25. The apparatus of claim 21 wherein said surface of the main plate is arcuate, wherein said planes are radial and intersect in the axis of curvature of said surface as it is supported, wherein the apparatus is adapted to position a pair of flat rectangular auxiliary plates and a plurality of T-bars against said surface, each of said T-bars having a flat rectangular flange plate and a stem plate projecting from the flange plate, said holding units being spaced lengthwise of the carrier means and including a pair of endwardly disposed socket means and a plurality of magnet means positioned between the socket means, said socket means and magnet means constituting said grasping means, and said moving means being fluid actuated for moving said socket means and magnet means toward and away from the axis of the main plate along their respective radial planes.

26. The apparatus of claim 21 including jig means having a frame and a plurality of slots in the frame, each slot being adapted to receive an auxiliary plate, said slots being individually disposed in predetermined planes, means positioning said carrier means in confronting relation to said jig means with said slots being individually coplanar with the planes of said holding means, and said grasping means being engageable with their respectively adjacent auxiliary plates in said confronting relation upon movement of said grasping means toward said slots to remove said auxiliary plates from the slots.

27. An apparatus for holding a workpiece which is initially supported in a predetermined position comprising a mounting frame positionable adjacent to said supported workpiece, an auxiliary frame including a backing member, means supporting the auxiliary frame in the mounting frame for movement between a work position with the backing member in engagement with the workpiece to a retracted position with the backing member spaced from the workpiece, clamp means having a socket, and means mounting the clamp means on the auxiliary frame for movement along the backing member between a receiving position wherein the socket is adapted to receive the workpiece when the auxiliary frame is in said work position to a position retracted from said clamping position, said clamp means being capable of holding the workpiece in said socket when said clamp means is in said receiving position.

28. An apparatus for fabricating a tunnel ring segment made up of a skin plate and side flanges projecting from the skin plate to thereby form a channel having opposite ends along with opposed end plates connected to the channel at said opposite ends and a T-bar connected to the channel between said side flanges and between said end plates, said apparatus comprising support means for holding a channel so as to enable assembly of opposed end plates to opposite ends of the channel and of the T-bar interposed between the end plates and disposed intermediate the channel, jig means spaced from said support means for initially receiving and orienting said end plates and the T-bar in predetermined assembly positions relative to the channel on said support means and carrier means movable between said support means and said jig means for removing said T-bar and end plates from said jig means when said carrier means is disposed in alignment with said jig means and for assembling said T-bar

and end plates to the channel in said support means when said carrier means is disposed in alignment with said support means after said carrier means removes the T-bar and end plates from said jig means.

References Cited

UNITED STATES PATENTS

2,176,664	10/1939	Burke	29—200
2,342,179	2/1944	Ciesa et al.	29—200
2,366,961	1/1945	Fine et al.	29—155
3,319,323	5/1967	Groat	29—200
3,367,010	2/1968	Lytle et al.	29—200

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29—155, 200 P, 429