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[54] APPARATUS FOR MANUFACTURING
PRESTRESSED CONCRETE MEMBERS
16 Claims, 40 Drawing Figs.

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25/41, 264/228
[51] Int. Cl. B28b 15/00,
B28b 23/06
[50] Field of Search 25/2, 118
(T), 41.1; 254/29.5; 264/228

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ABSTRACT: A system for casting prestressed concrete members on a highly automated, mass production basis. The system employs a plurality of portable molds, each of which defines a hollow mold cavity. The portable molds are preferably substantially identical in construction, include open top portions through which charges of concrete mixture can be directed into the mold cavities, and further include means for releasably securing lengths of reinforcing strand in a selected arrangement within each mold cavity. Conveying means carry a plurality of molds simultaneously along a predetermined path of travel through operating stations adapted to subject each mold to a series of successive operations. A mold cleaning and oiling station cleans the interior surfaces of each mold cavity and coats the interior surfaces with a releasing agent. An placement station inserts hardware into the mold cavities, to be cast within the concrete members. A strand placement station emplaces predetermined lengths of reinforcing strand within the mode cavities, and a tensioning station applies a selected pretensioning force to the reinforcing strand. Filling and compacting stations successively feed a measured charge of concrete mixture into each of the molds and compact the concrete charge in the molds. Means are provided to cure the concrete charge within each of the molds after the filling and compacting operations are completed. Conveyor means receive and convey a plurality of the molds simultaneously along a predetermined path of travel after the curing operation is completed. A tension releasing station operates to release the pretensioning load on the reinforcing strand emplaced within each of the molds. Means are provided downstream from the tension releasing station for preparing the molds for the removal of the cast concrete members. A demolding station operates to remove the cast concrete member from each mold. Means are also provided to finish the demolded concrete members and to prepare the empty molds for recirculation through the manufacturing system. In the preferred embodiment each operating station is provided with a portable mold, and the operating stations perform their respective operations substantially simultaneously, within a selected time interval.

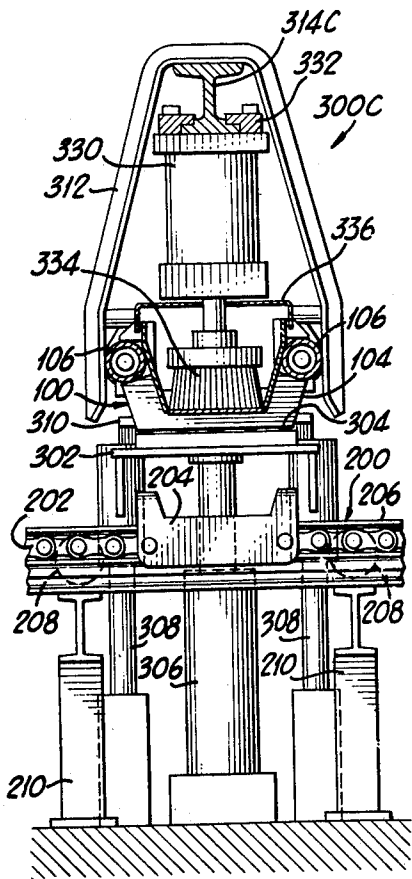


FIG. 4

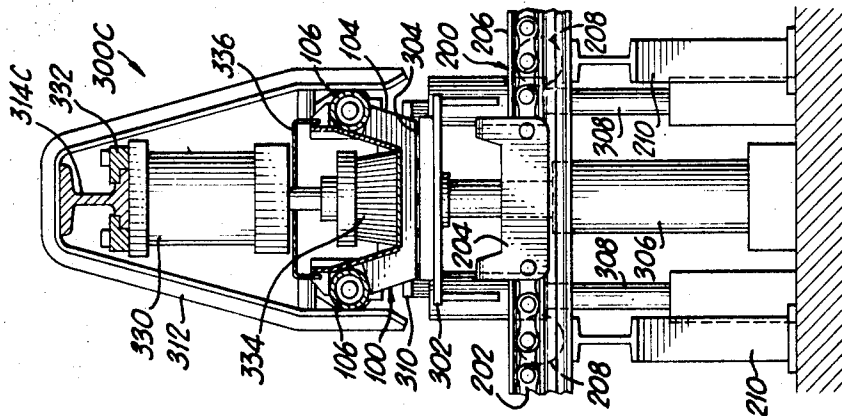


FIG. 3

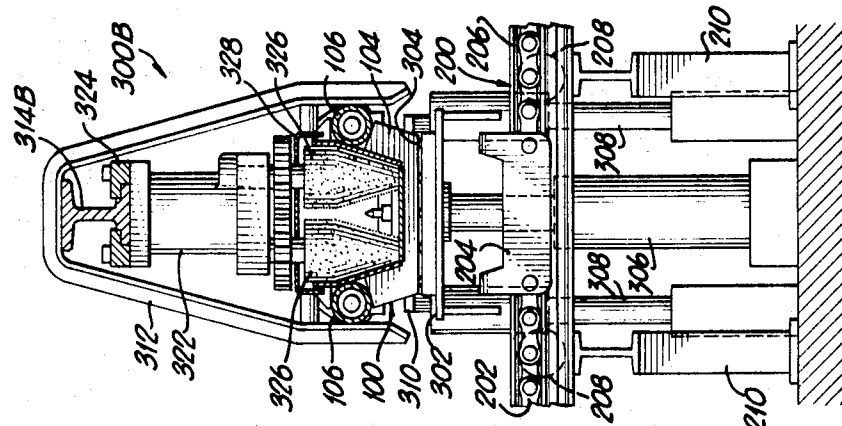


FIG. 2

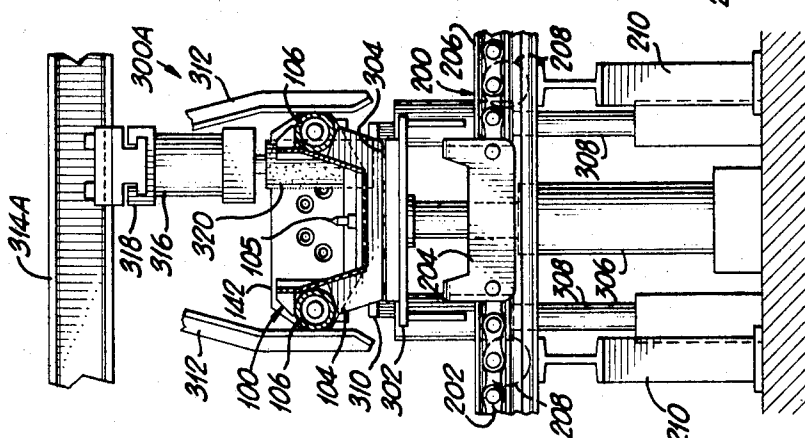
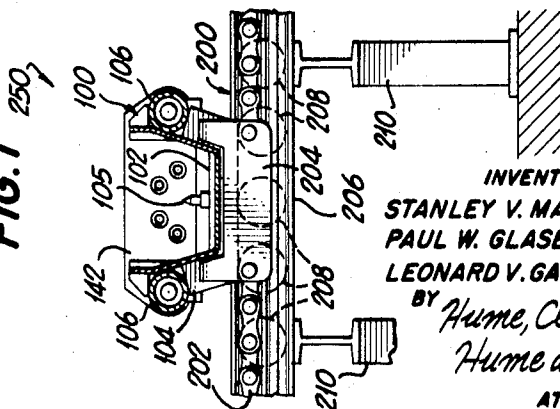


FIG. 1



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FIG. 7

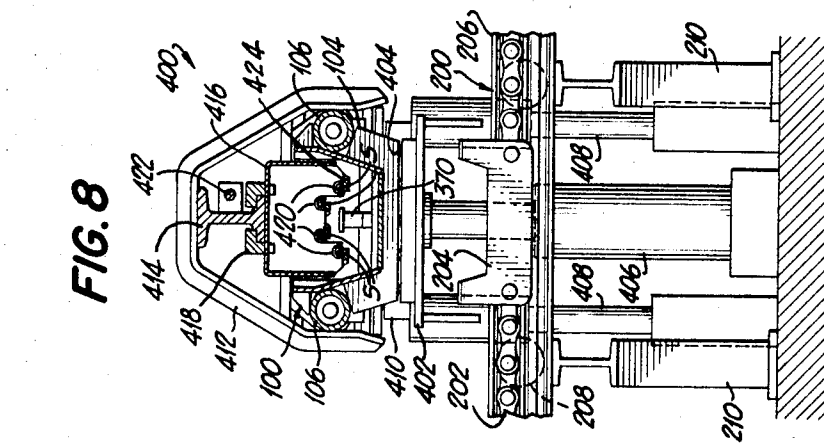


FIG. 6

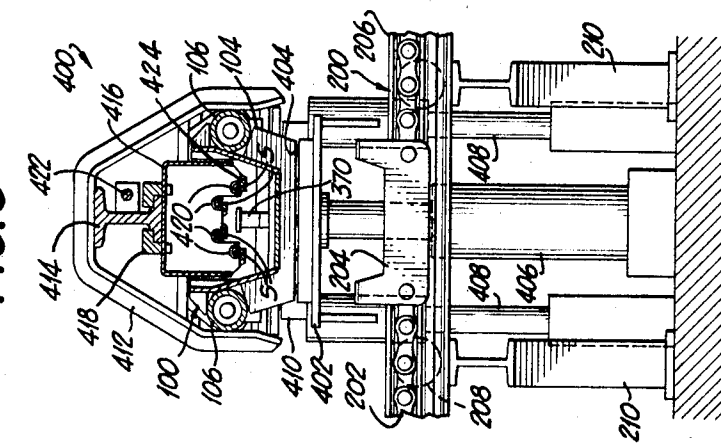
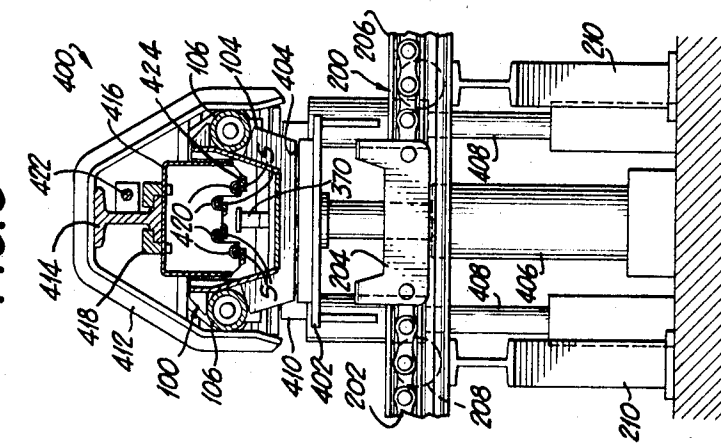
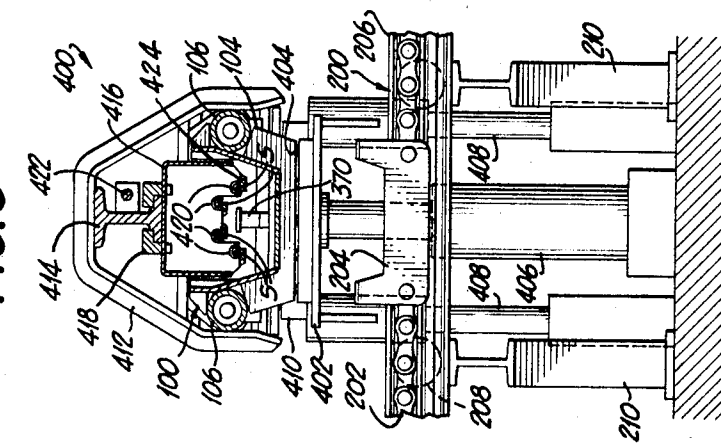
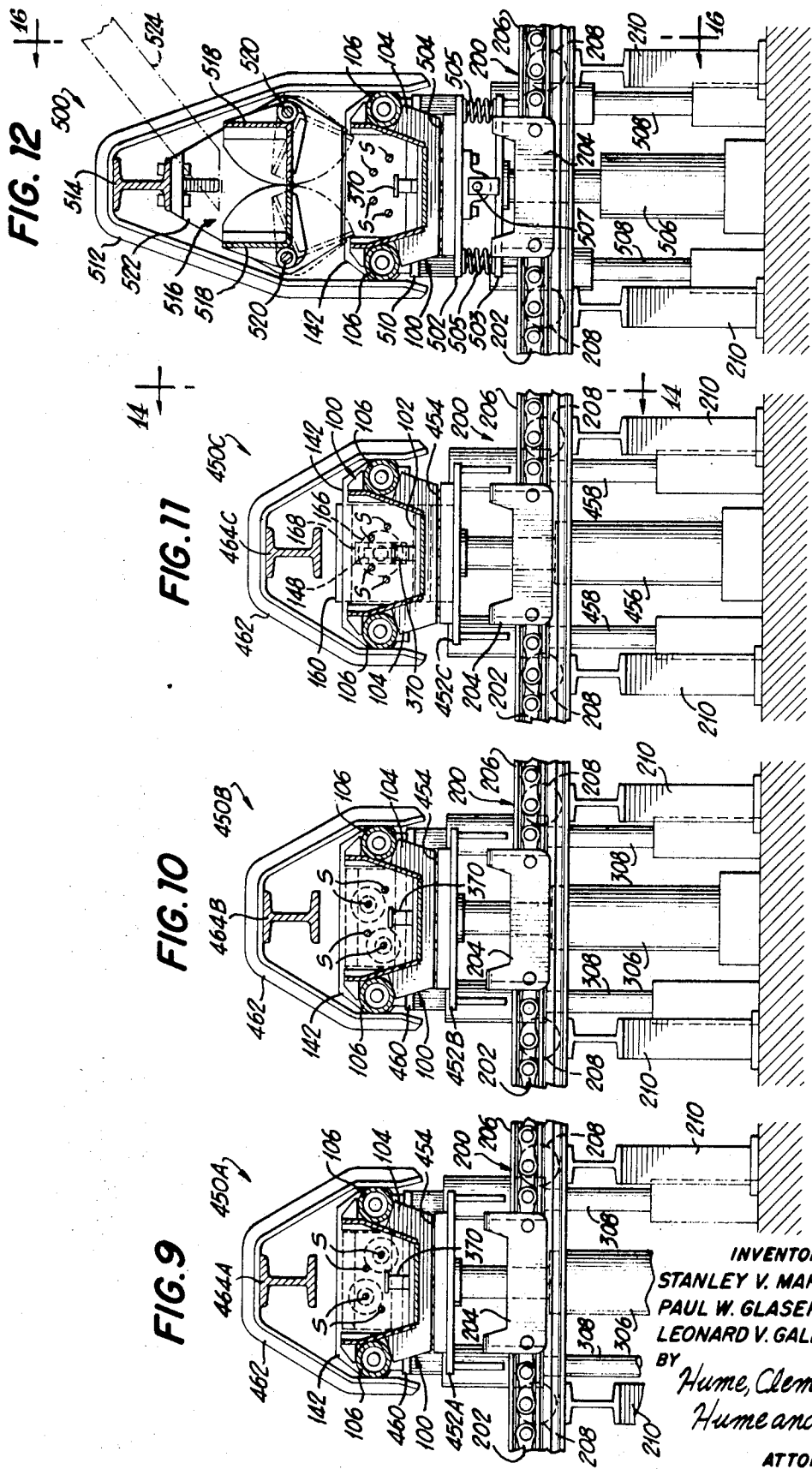


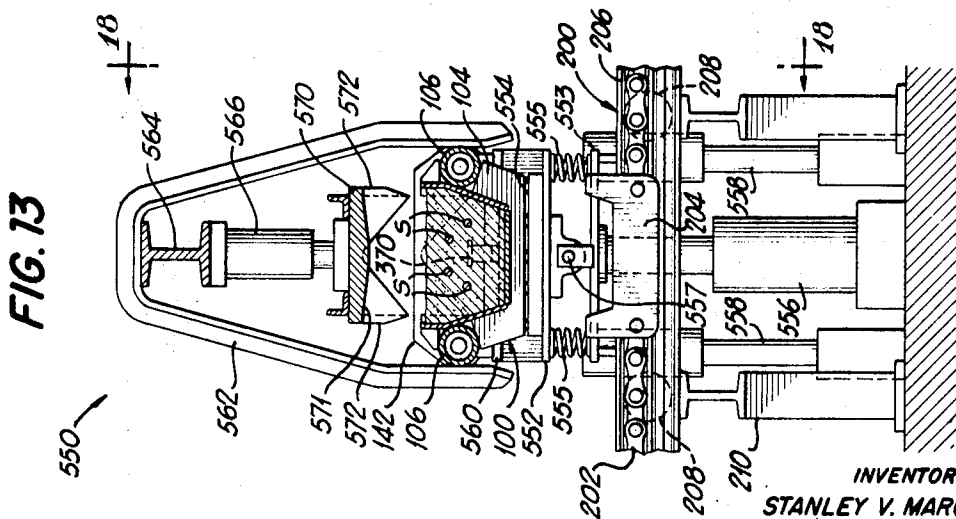
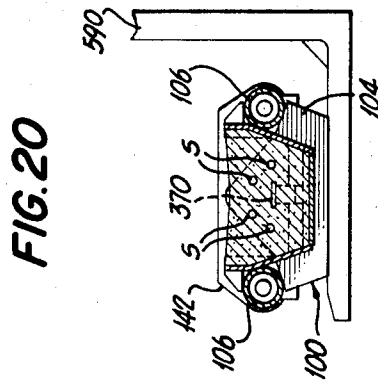
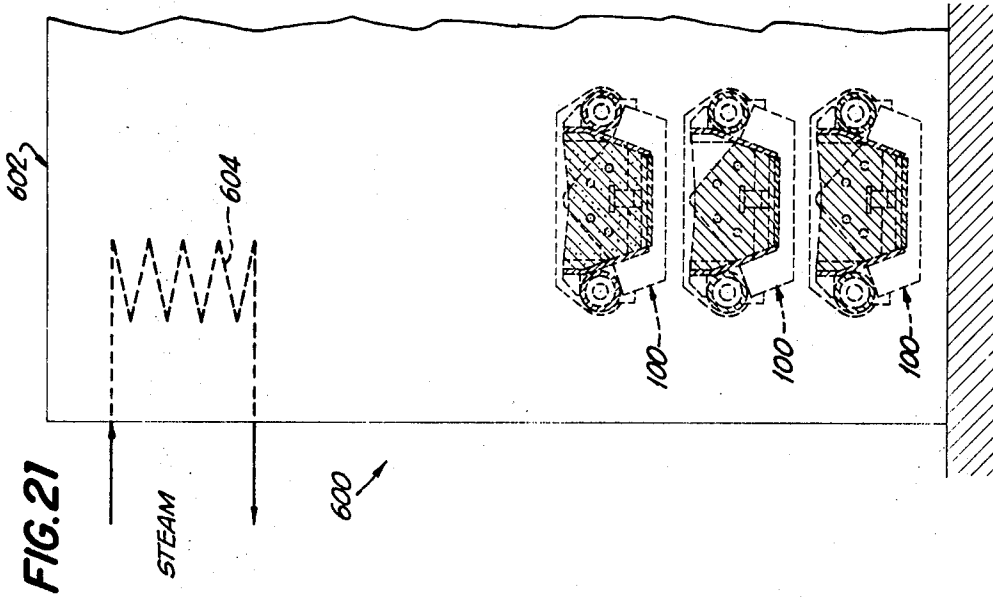
FIG. 5



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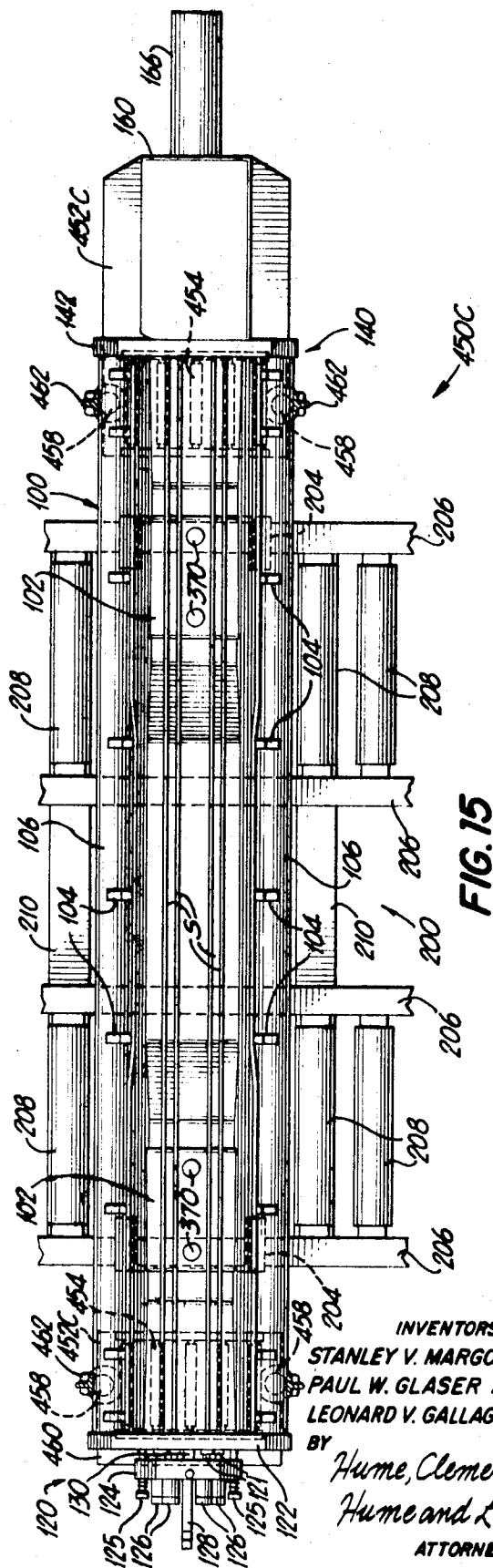
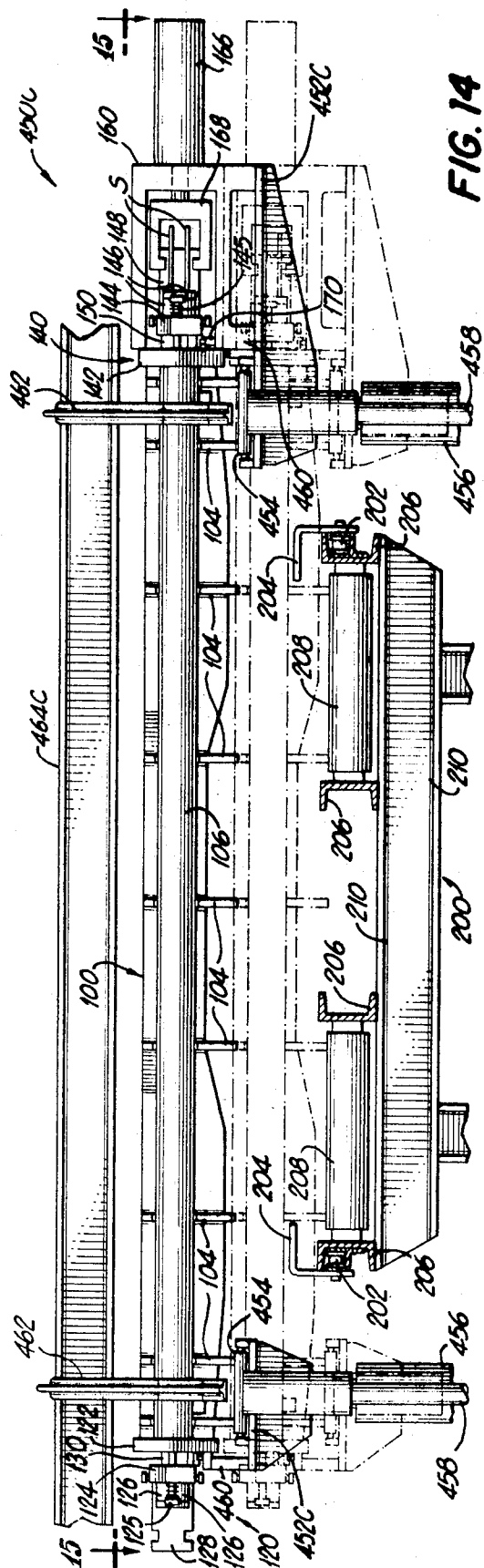
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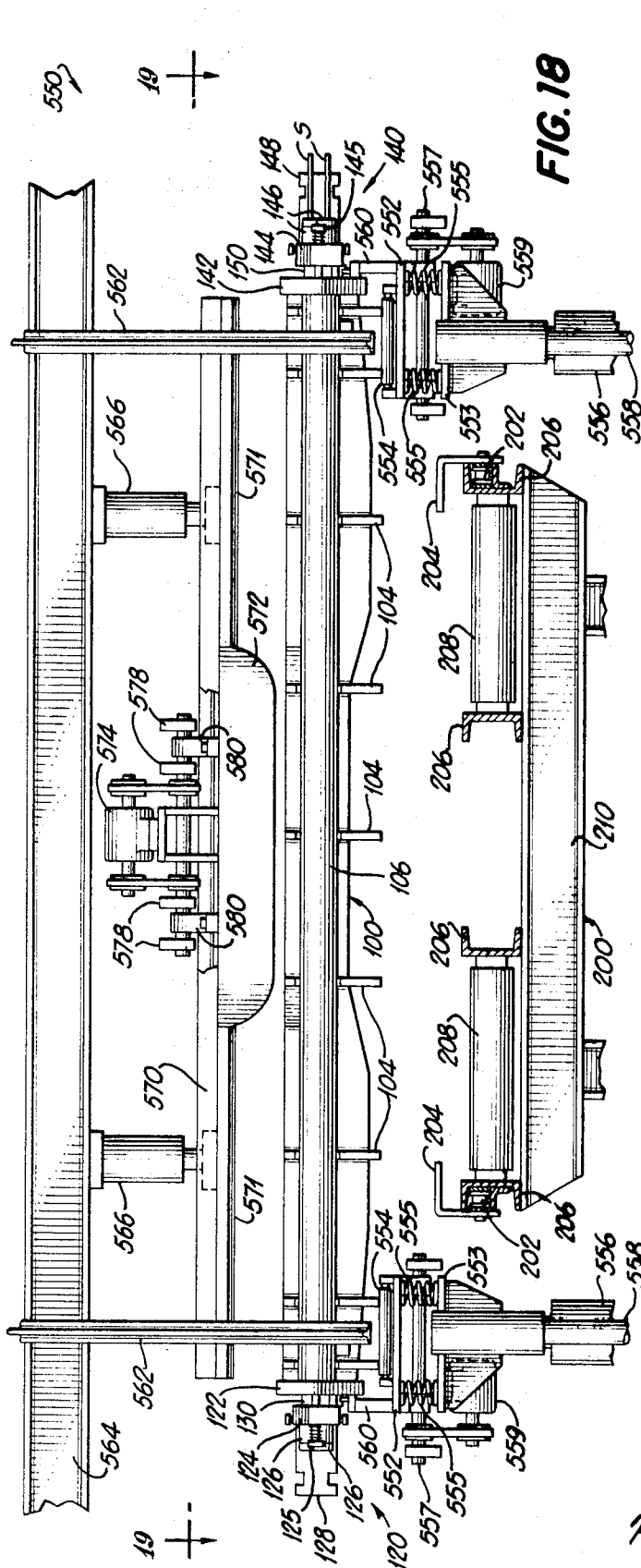


FIG. 18

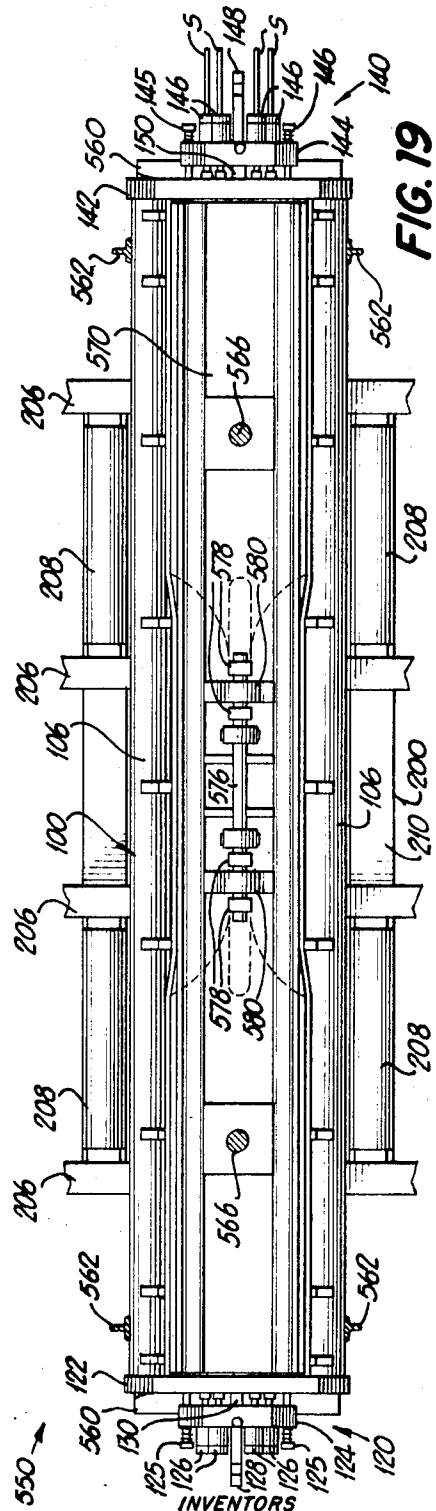
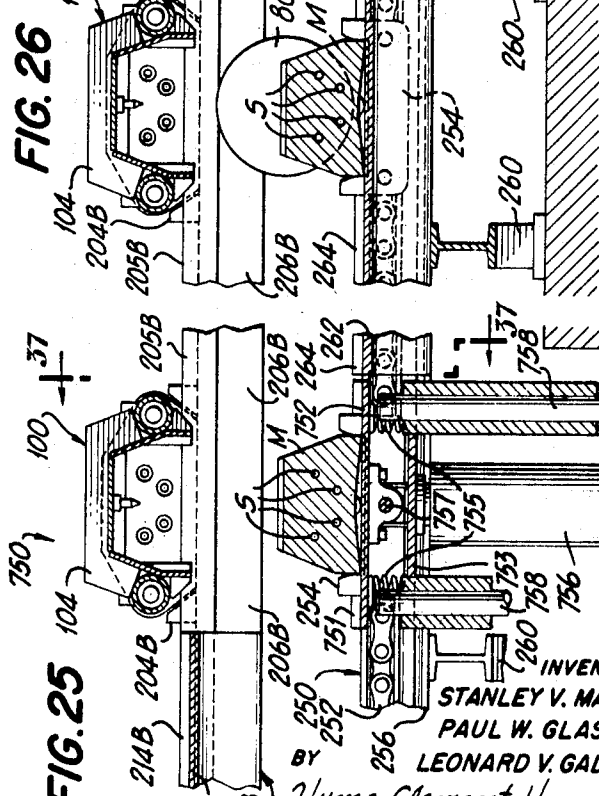
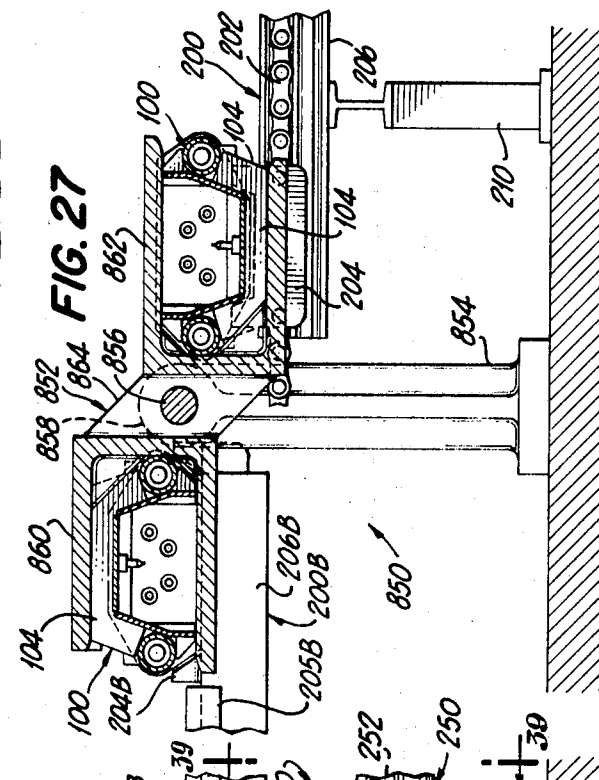
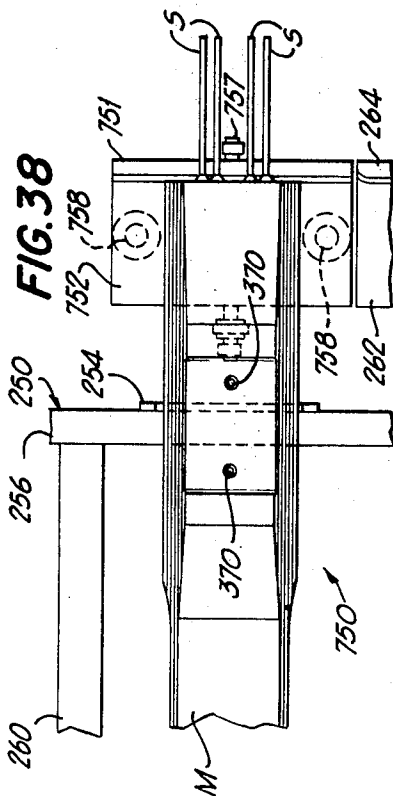
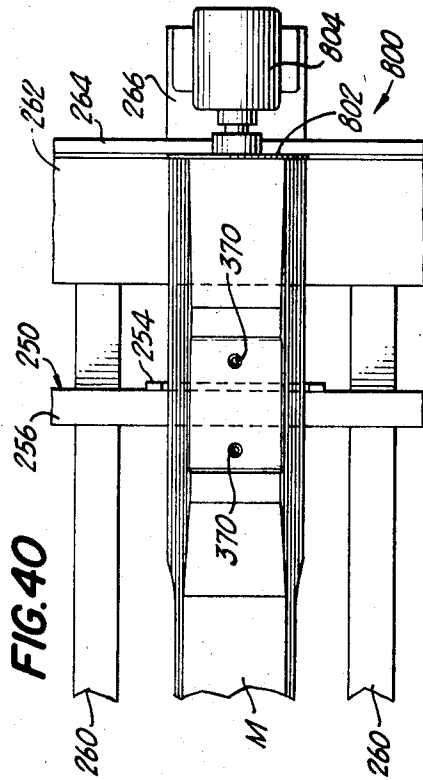


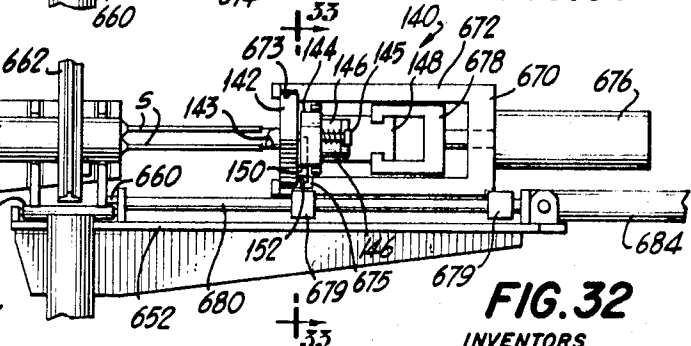
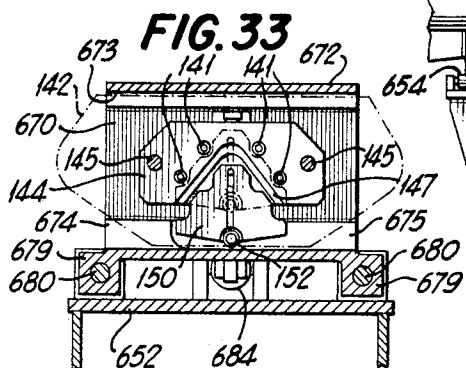
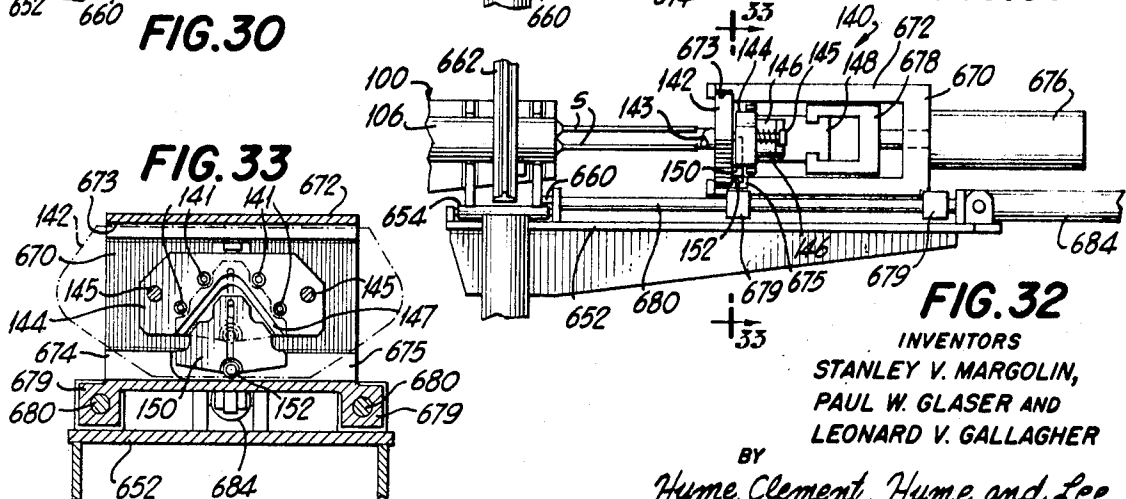
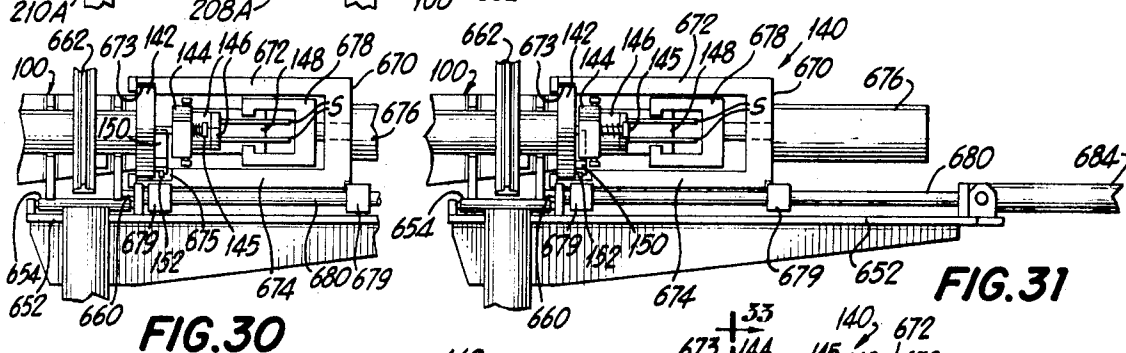
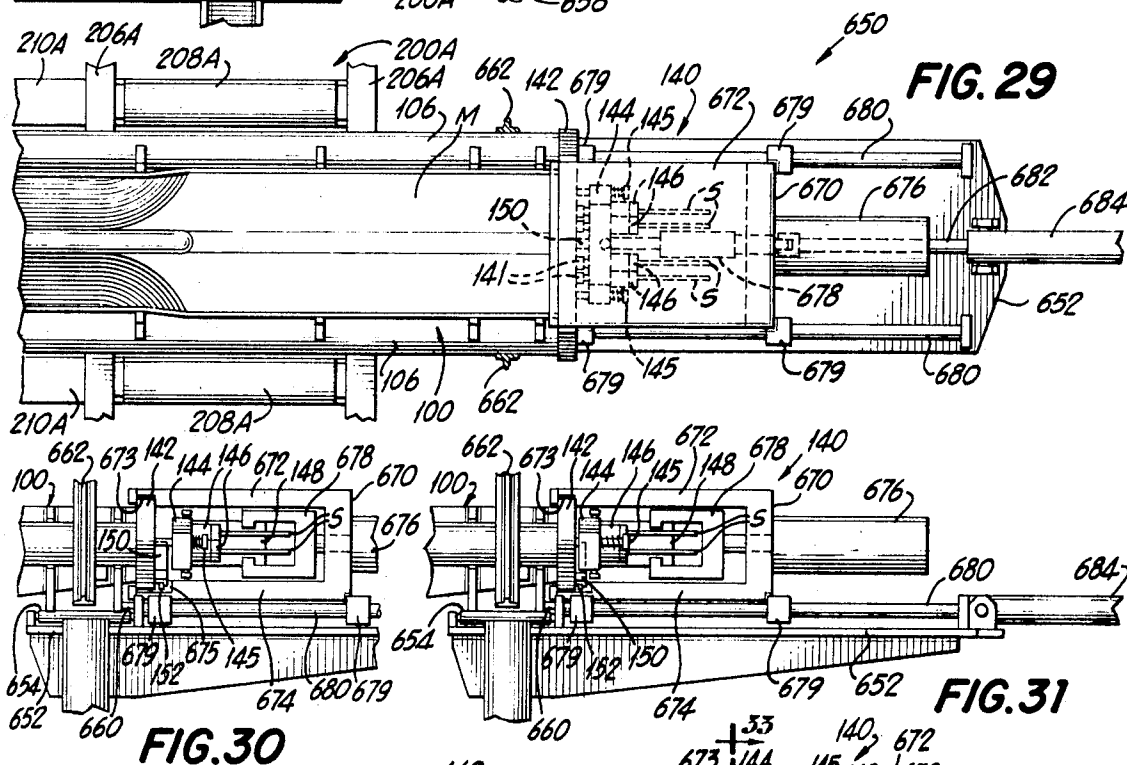
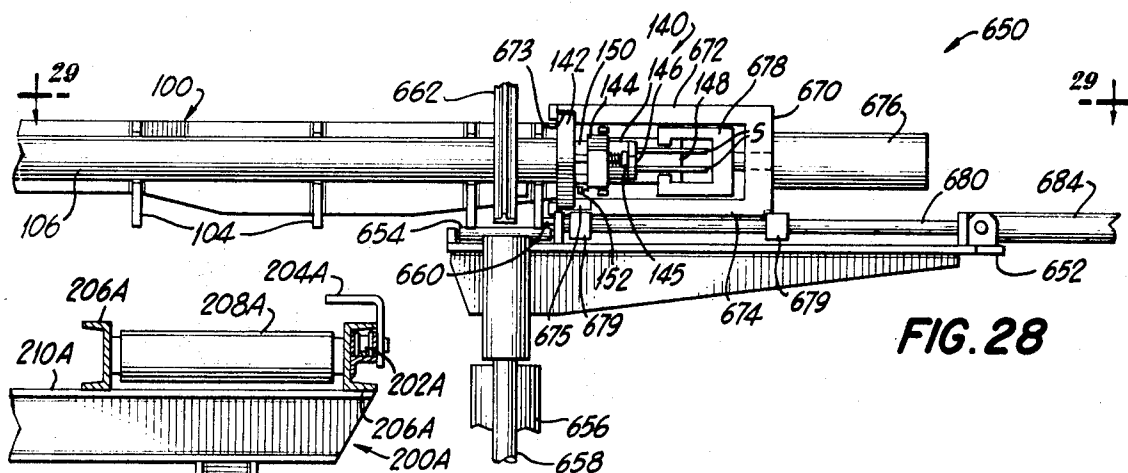
FIG. 19

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FIG. 35

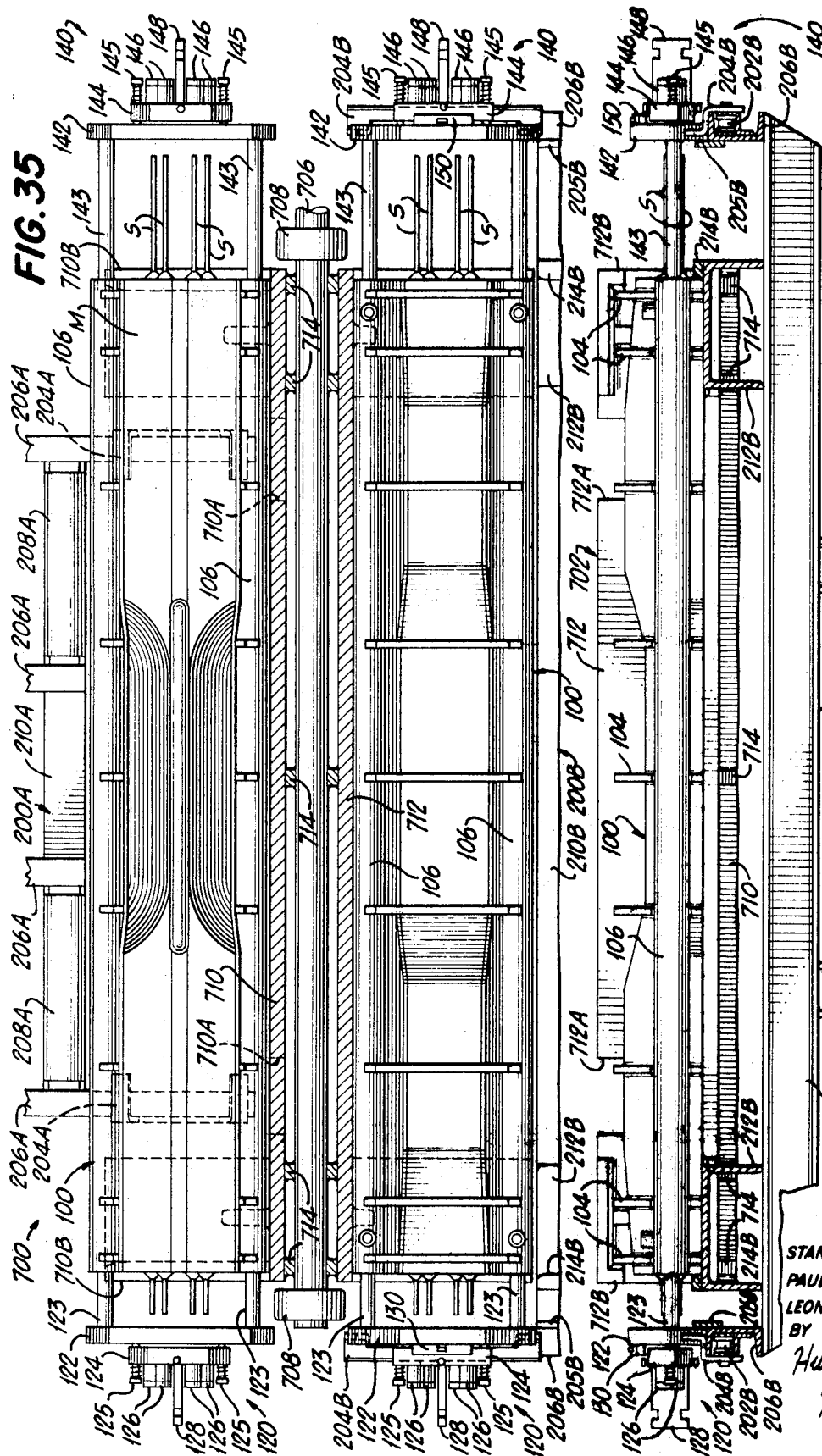
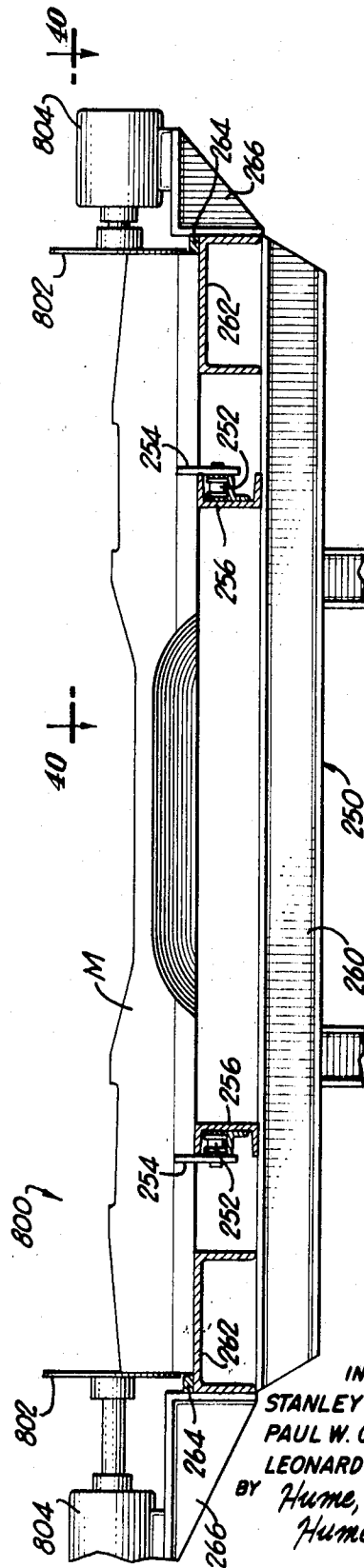
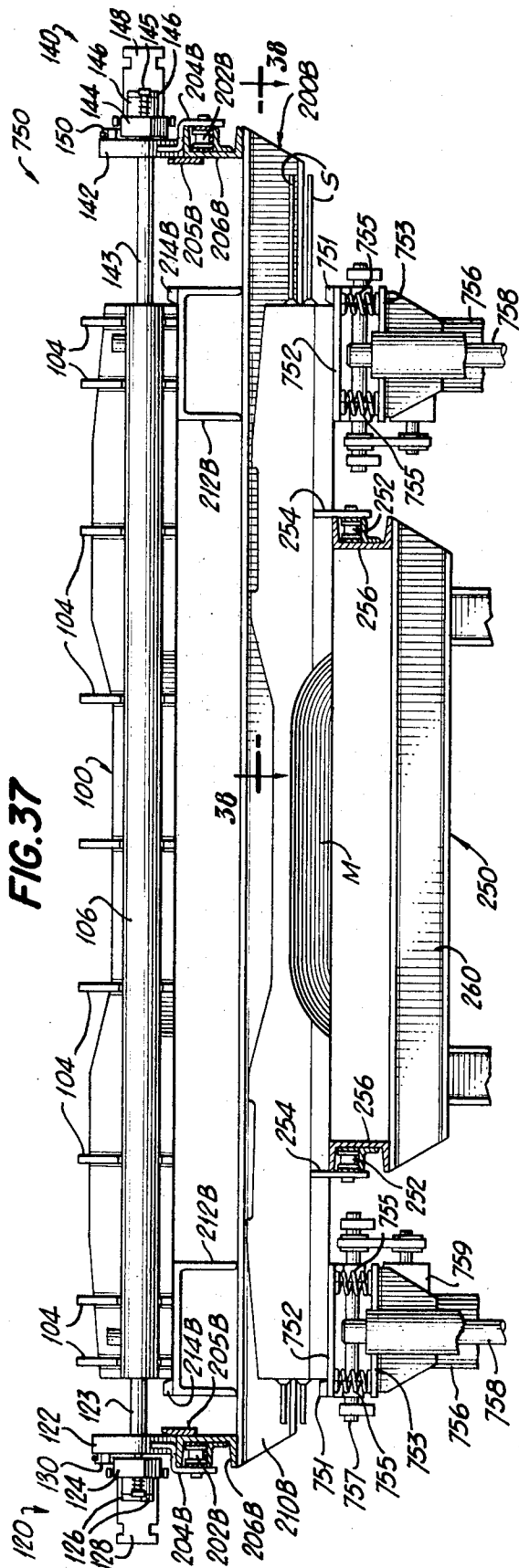


FIG. 36

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APPARATUS FOR MANUFACTURING PRESTRESSED CONCRETE MEMBERS

RELATED APPLICATIONS

The invention disclosed and claimed herein relates generally to the inventions disclosed and claimed in the applications of William P. Hidden and Robert Yetman, entitled "Method and Apparatus for Manufacturing Prestressed Concrete Members" Ser. No. 721,793; the application of William P. Hidden and Robert E. Hunt entitled "Cleaning and Oiling System for Molding Apparatus," Ser. No. 721,808; and the application of William P. Hidden, entitled "Portable Molding Apparatus," Ser. No. 721,767, each of which was filed concurrently and commonly assigned with the present application.

BACKGROUND AND SUMMARY OF THE INVENTION

This invention generally relates to a system for manufacturing prestressed concrete members, such as concrete railway ties, concrete beams and the like, on an automated mass production basis.

Prestressed concrete members are being employed in many industrial applications at the present time, such as in the railroad, building construction and road building industries, because of the inherent structural qualities of such members. However, many systems now used to make concrete members are small scale, labor-intensive operations. Such systems, involving a high degree of direct labor, substantially increase unit cost of the concrete members, often to the point where the members cannot compete effectively with other forms of structural components. Moreover, such systems often include expensive or poorly designed equipment which materially reduces the efficiency of the system and which prevents the continuous manufacture of a concrete member which is reproducible within closely held specifications. It is thus apparent that the use of prestressed concrete members would be more prevalent, and concrete members could compete more effectively with other types of structural members such as steel or wooden members, if more efficient and economical systems could be employed to manufacture the concrete members.

In an attempt to solve the above problems, the present invention provides a manufacturing system which permits prestressed concrete members to be made economically, with a minimum need for direct labor. The system of the present invention also allows the concrete members to be manufactured rapidly, on a mass production basis, while permitting the product to be reproduced within closely held specifications.

To accomplish the above objectives, the system in accordance with this invention provides integrated apparatus which cast a prestressed concrete member in each of a plurality of substantially identical portable molds with a minimum of direct labor. Each portable mold defines an open mold cavity of a desired configuration for receiving a charge of concrete mixture and includes means for suspending lengths of pretensioned reinforcing strand through the mold cavity in a desired pattern. In the preferred embodiment each mold is provided with movable end assemblies, defining the end portions of the mold cavity, which include means for securing the reinforcing strand within the mold cavity and for applying a desired pretensioning force to the strands. The movable end assemblies of the preferred form of mold can be spaced away from the adjacent end portions of the mold, to thereby facilitate the cleaning of the molds, the placement and pretensioning of the reinforcing strand, and the demolding of the completed concrete members.

The system of the present invention further includes means to convey a plurality of the portable molds simultaneously along a predetermined path of travel. The mold conveying means is arranged to carry each mold through a successive series of operating stations which cooperate to form a concrete member of the desired configuration within each mold. Briefly, the operating stations positioned along the path of

travel of the conveying means operate to successively clean and oil each mold; emplace reinforcing strand and other hardware within each mold cavity; apply a selected pretensioning force to the reinforcing strands; fill each mold cavity with a measured charge of concrete mixture; and compact the concrete charge within the mold cavity. The molds are thereby prepared for treatment at a curing station, where the concrete in each mold is hardened around the reinforcing strands to form the desired prestressed concrete member.

The system of the present invention also provides means for demolding and finishing the cured concrete members. In this regard, the system includes a second conveyor means adapted to carry each mold through an additional series of operating stations following the concrete curing operation. The additional stations successively release the pretensioning force on the reinforcing strands; demold the completed concrete members; and finish the concrete members by removing excess strand. Means are also provided to orient the empty portable molds for recycling through the system. Finally, in the preferred embodiment the system is arranged to conduct the operations of the stations substantially simultaneously, within a selected time. By such an arrangement, the system when in continuous operation will function to prepare concrete members for curing, and will demold completed members, within a selected short interval of time.

EXEMPLARY EMBODIMENT

The exemplary embodiment of the manufacturing system in accordance with this invention is particularly adapted for casting a concrete railway tie of current design. In this regard, the current specifications of the American Association of Railroads require the exemplary concrete tie to be prestressed by four lengths of reinforcing strand in a manner which applies a 100,000 pound pretensioning load to the tie. The pretensioning load is further required to be equally distributed among the four strands, at 25,000 pounds per strand. In addition, inserts for receiving rail fastening hardware are to be cast within the rail pad area of the concrete ties.

Of course, although the exemplary embodiment is particularly adapted to manufacture concrete railway ties on a highly automated mass production basis, it will be recognized by those skilled in the art that the present invention is readily adaptable for use in making other types of prestressed concrete units, with substantially the same degree of accuracy and speed.

Additional features and advantages of the invention will be more fully understood by considering the following description of an exemplary embodiment thereof, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a cross-sectional view of a mold inspection station incorporated in the concrete casting system embodying the features of the present invention;

FIG. 2 is a cross-sectional view of one stage of a mold cleaning and oiling station incorporated in the system, which operates to abrade and clean the end portions of the cavity defined by a portable mold;

FIG. 3 is a cross-sectional view of an additional stage of the mold cleaning and oiling station, which operates to abrade and clean the interior sidewalls of a mold;

FIG. 4 is a cross-sectional view of a further stage of the mold cleaning and oiling station, which operates to abrade and clean the bottom wall of a mold;

FIG. 5 is a cross-sectional view of a further stage of the mold cleaning and oiling station, which operates to remove loosened dust and debris from the cavity of a mold;

FIG. 6 is a cross-sectional view of the oiling stage of the mold cleaning and oiling station, which operates to apply a suitable releasing agent to the interior surfaces of a cleaned mold cavity;

FIG. 7 is a cross-sectional view of an insert placement station incorporated in the system in accordance with this invention which operates to place rail fastening inserts within the mold body;

FIG. 8 is a cross-sectional view of a strand placement station incorporated in the system, for positioning lengths of reinforcing strand in a desired pattern within the mold;

FIG. 9 is a cross-sectional view of the initial stage of a strand tensioning station incorporated in the system, which operates to apply a selected pretensioning force to two diametrically opposed reinforcing strands emplaced within the mold;

FIG. 10 is a cross-sectional view of a second stage of the strand placement station incorporated in the system, which operates to apply a selected pretensioning force to the two remaining diametrically opposed reinforcing strands within the mold;

FIG. 11 is a cross-sectional view of the final stage of the strand tensioning station incorporated in the system, which operates to apply a final tensioning force to the reinforcing strands;

FIG. 12 is a cross-sectional view of a filling station incorporated in the system, illustrating a mold in position to receive a measured charge of concrete mixture within the cavity of the mold body;

FIG. 13 is a cross-sectional view of a compacting station incorporated in the system, illustrating a filled mold positioned for compaction of the concrete charge;

FIG. 14 is an elevational view of a mold positioned at the final stage of the strand tensioning station, as viewed along the line 14-14 in FIG. 11;

FIG. 15 is a plan view of a mold positioned at the final stage of the strand tensioning station, as viewed along the line 15-15 in FIG. 14;

FIG. 16 is an elevational view of the filling station incorporated in the system of the present invention, as viewed along the line 16-16 in FIG. 12;

FIG. 17 is a plan view of the mold filling station, as viewed along the line 17-17 in FIG. 16;

FIG. 18 is an elevational view of the compacting station included in the system of the present invention, as viewed along the line 18-18 in FIG. 13;

FIG. 19 is a plan view of the compacting station, as viewed along the line 19-19 in FIG. 18;

FIG. 20 is a schematic cross-sectional view illustrating a filled mold in transit from the compacting station illustrated in FIGS. 13 and 18 to a suitable concrete curing station such as shown in FIG. 21;

FIG. 21 is a schematic illustration of a concrete curing station, showing a plurality of filled molds stacked in preparation for curing of the concrete charged into the molds;

FIG. 22 is a schematic illustration of the concrete curing station, showing a mold prepared to be discharged from the station after the curing cycle has been completed;

FIG. 23 is a cross-sectional view of a strand tension releasing station incorporated in the system, which operates to release the pretensioning force on the reinforcing strands after the concrete in the mold body has been cured;

FIG. 24 is a cross-sectional view of a mold turnover station incorporated in the system, which operates to orient the mold to permit the demolding of the cured concrete member;

FIG. 25 is a cross-sectional of a demolding station included in the system in accordance with the present invention which operates to remove the cured concrete member from the mold;

FIG. 26 is a cross-sectional view of a finishing station included in the system, which operates to finish the cured concrete members by removing the excess lengths of reinforcing strands from the ends of the concrete members;

FIG. 27 is a cross-sectional view of a mold turnover station included in the system, which operates to return the empty mold body to an upright position in preparation for recycling the mold through the manufacturing system;

FIG. 28 is a partial elevational view of the tension releasing station as viewed along the line 28-28 in FIG. 23, illustrating the condition of the station at the beginning of the tension releasing operation;

FIG. 29 is a partial plan view of the tension releasing station, as viewed along the line 29-29 in FIG. 28;

FIG. 30 is a partial elevational view of the tension releasing station illustrated in FIGS. 23, 28 and 29, showing the condition of the station after the initial strand tension releasing step has been completed;

FIG. 31 is a partial elevational view of the releasing station shown in FIG. 30, illustrating the condition of the station after the pretensioning force on the strands has been released;

FIG. 32 is a partial elevational view of the releasing station illustrated in FIGS. 30 and 31, showing the releasing station condition after the station has been operated to extend the adjacent movable mold end plate assembly away from the mold body;

FIG. 33 is a cross-sectional view of the releasing station and movable mold end plate assembly, taken along the line 33-33 in FIG. 32;

FIG. 34 is an elevational view of the mold turnover station, as viewed along the line 34-34 in FIG. 24;

FIG. 35 is a plan view of the mold turnover station, as viewed along the line 35-35 in FIG. 24;

FIG. 36 is an elevational view of the mold turnover station, as viewed along the line 36-36 in FIG. 24;

FIG. 37 is an elevational view of the demolding station included in the system in accordance with the present invention, as viewed along the line 37-37 in FIG. 25;

FIG. 38 is a partial plan view of a demolded concrete member positioned at the demolding station, as viewed along the line 38-38 in FIG. 37;

FIG. 39 is an elevational view of the finishing station, as viewed along the line 39-39 in FIG. 26; and

FIG. 40 is a partial plan view of the demolded concrete member positioned at the finishing station, as viewed along the line 40-40 in FIG. 39.

Referring generally to the drawings, the portable molds employed in the system in accordance with this invention are indicated by the reference numeral 100. Each mold 100 defines a mold cavity having an open top portion which permits the mold to receive a charge of concrete mixture, insert hardware, and reinforcing strand. As shown in FIG. 17, in the preferred embodiment each mold 100 includes movable left and right mold end assemblies, generally indicated by the reference numerals 120 and 140, respectively. The end assemblies 120 and 140 are adapted to be movable from a closed position against the adjacent end of the mold 100 as illustrated in FIG. 14, where the assemblies define the end portions of the mold cavity, to an extended or opened position, such as illustrated in FIGS. 35 and 36. Each mold 100 is reinforced transversely by a series of reinforcing struts 104, and is reinforced longitudinally by a pair of elongate compression tubes 106.

The construction and operation of the preferred form for the movable mold end assemblies 120 and 140 are fully described in the copending application of Hidden and Yetman, Ser. No. 721,793. Briefly, the left end assembly 120, as shown in FIGS. 15 and 35, includes an end plate 122 adapted to engage with and close the adjacent end of the mold 100. Guide rods 123 extend into the adjacent ends of the compression tubes 106 to join the end plate 122 to the body of the mold 100. A chuck plate 124, spaced outwardly from the end plate 122, includes a plurality of strand receiving chucks 126 which are adapted to receive and releasably grip the adjacent free ends of reinforcing strands S placed within the mold. A pair of mounting pins 125 operated to slidably connect the chuck plate 124 to the end plate 122. A tension post 128 is connected to the chuck plate 124 and is capable of receiving an outwardly directed pulling force. The application of a sufficient pulling force to the post 128 will separate the chuck plate 124 from the end plate 122 and thereby apply a tensioning force to reinforcing strands S.

As shown in FIG. 14, the right mold end assembly 140 similarly includes an end plate 142 which engages with and closes the adjacent end of the mold 100. Guide rods 143 extend into the compression tubes 106 to movably join the plate 142 to the body of the mold 100. A chuck plate 144 is positioned adjacent the end plate 142 and includes a plurality of

strand chucks 146. The chucks 146 are adapted to receive and releasably grip the adjacent free ends of the reinforcing strand S. Mounting pins 145 join the chuck plate 144 to the end plate 142 and permit the plates to slide with respect to each other. A tensioning post 148 attached to the chuck plate 144, is provided to perform the same function for the end assembly 140 as the post 128 performs for the other end assembly 120.

As explained further in the copending Hidden and Yetman application, Ser. No. 721,793, the end assemblies 120 and 140 also include slidable locking plates 130 and 150, respectively, for controlling the function of the assemblies during the concrete casting operation. More specifically, the locking plate 150 is engaged between the end plate 142 and chuck plate 144 within a two-stepped recess 147 (FIG. 33). By this arrangement, the vertical position of the locking plate 150 can be varied to engage the adjacent end plate 142 and chuck plate 144 at three different positions. The plate 150 can thereby function to maintain the plates 142 and 144 spaced apart at three selected distances. The locking plate 130 is similarly arranged between the plates 122 and 124 of the left end assembly 120. In addition, the locking plate 130 can be arranged to space the plates 122 and 124 at either two or three selected distances.

As explained in application Ser. No. 721,793, the end assemblies 120 and 140 are arranged so that the strand chucks 126 and 146 are deactivated or "unlocked" by suitable means, such as bushings 121 and 141 (FIGS. 15 and 29), when the locking plates 130 and 150 are in their lowest operating position (FIG. 33). Under such conditions the end and chuck plates of the end assemblies are closely spaced. When the plates 130 and 150 are raised to their second positions, the adjacent end and chuck plates are separated and the bushings 121 and 141 are disengaged from the chucks 126 and 146. The chucks 126 and 146 are thereby arranged in a "ready" condition, prepared for gripping the strands S. Movement of the plates 130 or 150 to their uppermost "locked" position further separates the adjacent end and chuck plates and causes the strands S to be elongated a measured amount to compensate for the strand pretensioning force which is lost when the chucks 126 and 146 seat on the strands S.

Referring to FIGS. 1-15, the system in accordance with the present invention includes a horizontal conveyor 200 which defines a path of travel for the portable molds 100. Conveyor 200 is adapted to support a plurality of portable molds 100 spaced longitudinally along its length. Suitable power means (not shown), preferably an intermittent drive, is arranged to drive the conveyor 200 through the various operating stations of the system which precede the concrete curing operation. In the preferred embodiment the conveyor 200 places a portable mold 100 at each operating station so that the functions of all of the stations can be performed simultaneously, within a selected time interval.

As illustrated in FIGS. 1-15, the mold conveyor 200 comprises a pair of continuous parallel drive chains 202 which are provided with a plurality of mold-receiving saddles 204. In the exemplary embodiment, the opposed saddles 204 on the chains 202 are adapted to receive and support the bottom portion of a mold 100 which is configured to cast the current form of concrete railway tie. Further, the saddles 204 are uniformly spaced along the longitudinal length of the drive chains 202 at predetermined intervals. A pair of channel-shaped chain tracks 206, supported by a frame structure 210, guide the parallel drive chains 202 throughout the length of the conveyor 200. As seen from FIGS. 14 and 15, the conveyor 200 also includes a pair of parallel roller beds 208 formed from a plurality of longitudinally spaced and transversely extended rollers. The roller beds 208 are positioned to engage with and support the bottom surface of the molds 100 as the molds are carried along the path of the conveyor 200.

As illustrated in FIG. 1, the exemplary embodiment of the system includes an inspection station 250. This station 250 is positioned at an open space at the front end of the conveyor 200 and precedes the operating stations included in the

system. The longitudinal position for the station 250 is selected so that the conveyor 200 places each mold 100 at the station 250 for a time interval sufficient to permit visual inspection of each mold. By such an arrangement, each of the molds 100 can be examined by an operator at station 250, to check for damage or improper assembly, before the molds are carried through the subsequent operating stations of the system.

A mold cleaning and oiling station 300 is the first operation station included in the system of the present invention. As seen in FIGS. 2-6, the station 300 is positioned adjacent the conveyor 200 longitudinally downstream from the above-described inspection station 250. Generally, the operating station 300 includes a series of substations 300A-E which successively engage with each portable mold 100 to clean and oil the internal wall portions of each mold. Thus, the station 300 operates to prepare the cavity of each mold for receiving a fresh charge of concrete mixture at subsequent operating station of the system.

The preferred form for the mold cleaning and oiling station 300, as illustrated in FIGS. 2 through 6 of the drawings, is more fully described in the above-mentioned copending application of Messrs. Hidden and Hunt, Ser. No. 721,808. Briefly described, each of the operating substations 300A through 300E includes an elevator mechanism designed to intercept the molds 100 as the molds are conveyed along the path of the conveyor 200. The elevator mechanisms at substations 300A-E are longitudinally spaced along the conveyor 200 in a manner which allows the conveyor 200 to position a mold 100 at each of the substations simultaneously. Thus, the elevator mechanisms can be operated to raise the associated mold 100 from the conveyor 200 so that the operations of the substations can be performed simultaneously.

Referring to FIGS. 2 through 6 in more detail, the elevator mechanism included in each of the substations 300A-E comprises a pair of elevator platforms 302 which are transversely aligned at a selected location along the path of the conveyor 200. In the preferred arrangement each platform 302 is positioned along the outside of the conveyor 200, closely adjacent the associated conveyor drive chain track 206. Each platform 302 includes a roller bed 304 adapted to receive and support a mold 100 as the mold is carried into the operating substation. Moreover, each platform 302 is connected to a hydraulic lift cylinder 306 which controls the vertical positioning of the platform 302 during the operation of the associated substation. Guide rods 308 are included in each elevator mechanism to guide the vertical movement of the elevator platforms 302. The substations 300A-E also include means to control the longitudinal and transverse positioning of the molds 100. In this regard, each elevator platform 302 is provided with a longitudinally arranged cam track 310, and each substation 300A-E includes a pair of downwardly-directed spacing brackets 312. As illustrated in FIGS. 2 through 6, the cams 310 are designed to engage with the mold 100 as the mold approaches each of the substations, to thereby align the mold in the desired transverse position. Similarly, the brackets 312 engage with the mold 100 as the mold is elevated by the operation of the cylinders 306, to align the molds into the desired longitudinal position at each substation.

In operation, the hydraulic cylinders 306 initially maintain the elevator platforms 302 in a lowered position at each substation 300A-E, with the roller beds 304 horizontally aligned with the conveyor rollers 208. The saddles 204 of the conveyor 200 can thereby carry a mold 100 onto the pair of roller beds 304 at each substation. The lift cylinders 306 then can be actuated by suitable hydraulic control means (not shown) to raise the associated mold 100 from the mold saddles 204. The cylinders 306 thereby raise a mold 100 into operating position at each of the substations 300 through 300E, as shown in FIGS. 2-6, so that the cleaning and oiling functions of the substations can be initiated. In the preferred arrangement the hydraulic control for the cylinders 306 is arranged to raise all of the elevator platforms 302 in unison, so that the substations

300A—E will function simultaneously, with a different mold 100 at each substation. Further, it is preferred that the stroke of all of the cylinders 306 be substantially the same to facilitate the completion of the operation of each substation 300A—E within the same selected time interval. After the operation of each substation is completed, the operation of the hydraulic cylinders 306 is reversed, and the mold 100 is lowered into the adjacent saddle 204 of the conveyor 200. The conveyor can then operate to carry the mold to the following substation or to subsequent operating stations of the system.

As more fully described in the copending Hidden and Hunt application, Ser. No. 721,808, the substation 300A is adapted to abrade and clean the interior surfaces of the end walls of each mold 100. As seen in FIG. 2, the substation 300A accordingly includes a pair of cleaning heads 316, only one of which is shown. A pair of longitudinally arranged beams 314A (only one of which is shown) support the heads 316 adjacent the conveyor 200 in a position directly above the elevator platforms 302 of substation 300A. A universal joint 318 connects each head 316 to the beam 314 in a manner which permits the head to oscillate longitudinally and transversely with respect to the conveyor 200 during the operation of substation 300A.

Each cleaning head 316 includes a rotatable brush 320 for engaging with the interior end portions of the mold 100, to thereby remove dust and debris from the mold end portions. Each head 316 also can be provided with a collecting means such as a vacuum mechanism (not shown), for collecting the dust and debris removed from the mold 100 by the rotating brushes 320. Suitable means (not shown) are also provided to oscillate the brushes 320 longitudinally and transversely during the operation of substation 300A, to assure that the end portions of the mold 100 are thoroughly cleaned. As explained in the Hidden and Hunt application Ser. No. 721,808, the operation of substation 300A is further facilitated by arranging the mold end assemblies 120 and 140 in their open positions (see FIG. 34) at substation 300A so that the brushes 320 can readily clean the adjacent end portions of the mold body 100.

Referring to FIG. 3, the cleaning substation 300B is adapted to abrade and clean the interior sidewalls of the molds 100. As explained more fully in the copending application of Hidden and Hunt, this sidewall cleaning operation is accomplished by providing the substation 300B with a translating cleaning head 322. As shown in FIG. 3, the head 322 is suspended above the conveyor 200 at substation 300B by a transverse frame member 314B. Suitable brackets 324 slidably join the cleaning head 322 to the member 314B in a manner which permits the head 322 to translate transversely across the conveyor 200. The head 322 includes a pair of rotatable conically-shaped brushes 326 which are designed to engage with and abrade the interior sidewalls of each mold 100. Additionally, the substation 300B includes a collecting means, such as a vacuum hood 328 which extends over the cavity of the mold 100 when the mold is raised by the cylinders 306. Suitable means (not shown) are also provided to translate the head 322 across the conveyor 200.

As illustrated in FIG. 3, when the substation 300B is in operation the brushes 326 of the head 322 will engage with and abrade the interior wall surfaces of the mold 100. Moreover, the translation of the head 322 across the conveyor 200 brings the brushes 326 into engagement with the mold sidewalls throughout the entire length of the mold 100. The vacuum hood 328 operates simultaneously with the head 322 and collects the major portion of the dust and debris loosened from the mold sidewalls by brushes 326.

The substation 300C is operative to abrade and clean the interior bottom wall of each mold 100, as set forth in the above-identified Hidden and Hunt application Ser. No. 721,808. As shown in FIG. 4, the substation 300C includes a cleaning head 330 which is movably mounted to a transverse supporting beam 314C by means of a sliding bracket 332. The head 330 forcibly rotates a brush 334 which is designed to engage with

the bottom wall of each mold 100. Means (not shown) operate to translate the head 330 transversely across the conveyor 200 to bring the brush 334 into engagement with the mold bottom wall along the full length of the mold 100. Substation 300C also includes a collection mechanism such as a vacuum hood 336 to remove the major portion of the loosened dust and debris from the cavity of the mold 100.

In operation, the hydraulic cylinders 306 at the substation 300C raise the mold 100 from the conveyor 200 and bring the brush 334 into engagement with the mold bottom wall. The head 330 then rotates the brush 334 and simultaneously translates the brush transversely across the conveyor 200. Accordingly, dust and debris stuck to the bottom wall of the mold cavity is forcibly removed by the brush 334 along the full length of the mold 100. At the same time, the vacuum hood 336 is activated to remove the major portion of the dust and debris loosened from the mold by the brush 334.

Referring to FIG. 5, the operating substation 330D is adapted to collect and remove any dust and debris from the interior surfaces of the mold cavity which may remain after the above-described mold cleaning operations are completed. To accomplish this result, the substation 300D includes a vacuum head 338 which is slidably supported on a transverse frame structure 314D by means of sliding brackets 342. The vacuum head 338 is connected to a suitable high-powered vacuum source (not shown) by means of a conduit 340. As seen in FIG. 5, the vacuum head 338 is designed to fit within the cavity of the mold 100, in close relationship to the interior wall portions of the mold, when the mold is elevated at the substation 300D. During the operation of the substation 300D, the vacuum head 338 is translated transversely across the conveyor 200 by suitable means (not shown) so that the head forcibly collects the dust and debris accumulated within the cavity of the mold 100. The construction and operation of substation 300D is also described in detail in the copending Hidden and Hunt application.

The final substation 300E of the cleaning and oiling station 300 is designed to uniformly coat the interior surfaces of the mold cavity of each mold 100 with a suitable releasing agent. As shown in FIG. 6, the substation 300E accordingly includes a spraying head 334 which is movably supported on a transverse frame member 314E by means of sliding brackets 348. The head 344 is designed to be freely received within the cavity of the mold 100, and includes a plurality of nozzles 346 arranged to direct a spray of releasing agent onto all of the interior wall surfaces of the mold. During operation of the substation 300E the head 344 is translated across the conveyor 200 by suitable means (not shown) so that the head traverses the full length of the mold 100. The interior surfaces of the mold 100 are thereby uniformly coated with a suitable releasing agent which will facilitate the following operations of system. The construction and operation of substation 300E is again more fully described in the Hidden and Hunt Application Ser. No. 721,808.

As set forth above, the exemplary embodiment of the present invention comprises a system for manufacturing a current form of concrete railway tie. At the present time, the specifications of the American Association of Railroads require that each of the concrete ties be provided with threaded inserts at the rail pad area for receiving the fastening means which holds the rails in correct position on the tie. Accordingly, as illustrated in FIG. 7, the exemplary embodiment of the system is provided with an insert placement station 350. Station 350 is positioned adjacent the conveyor 200 immediately downstream from the cleaning and oiling station 300, and is adapted to automatically place the desired number of rail-fastener inserts within the cavity of each mold 100.

Referring to FIGS. 7 and 15 in detail, the inserts to be placed within the interior of each mold 100 in the illustrated embodiment are schematically illustrated by the cylindrical bodies 370. The inserts 370 have internally-threaded openings for receiving threaded bolts which are typically used to fasten rails to concrete ties. As shown in FIG. 15, two inserts 370 are

to be placed within the mold 100 at each of two raised bosses 102 which are provided to define the rail pad area of the cast railway tie. As seen in FIG. 7, each mold 100 includes a pair of vertical studs 105 positioned on each boss 102, for receiving the inverted inserts 370. It has been found that the loose friction fit between the inserts 370 and the studs 105, which results from the projection of the studs into the threaded openings of the inserts, will maintain the inserts 370 in position within the mold 100 during the subsequent operations of the present manufacturing system.

In accordance with the present invention, the insert placement station 350 includes means to automatically place the inserts 370 upon the studs 105 in each of the molds 100. In this regard, the station 350 is provided with a placement head 366 which is mounted upon a transverse supporting member 364. As seen in FIG. 7, the head 366 comprises a storage compartment 367 within which a supply of inserts 370 can be stored. The head 366 further includes four funnel nozzles 368, only one of which is illustrated in FIG. 7. The nozzles 368 are in communication with the storage compartment 367 and are spaced transversely across the conveyor 200 in a pattern which corresponds to the spacing of the insert studs 105 on the portable molds 100. Accordingly, a supply of inserts 370 can flow downwardly from the compartment 367 into the nozzles 368, and the nozzles 368 will in turn direct the inserts downwardly toward the studs 105 in the mold 100. Suitable means (not shown), such as a vibrating mechanism or the like, is joined to the head 366 to orient the inserts 370 within the compartment 367, and to feed each insert 370 into the nozzles 368 in the desired direction, such as illustrated in FIG. 7. In addition, gating means (not shown) are provided within the head 366 to control the discharge of the inserts 370 from the nozzles 368. Of course, other types of vibrating feed hoppers such as the head 366 are available or can be devised by those skilled in the art without departing from the present invention.

The insert placement station 350 also includes an elevator mechanism to raise each of the molds 100 into engagement with the insert placement head 366. Station 350 is thus provided with a pair of elevator platforms 352 which are transversely aligned adjacent the conveyor 200. Each platform 352 includes a roller bed 354 for supporting the mold 100, and each platform is supported by a hydraulic actuating cylinder 356. Guide rods 358 control the positioning of the platforms 352 when the cylinders 356 are actuated. Further, the elevator platforms 352 have a cam track 360 for engaging with each of the molds 100 as the mold is conveyed to the station 350, to orient the mold into the desired transverse position. The station 350 also includes brackets 362 which engage with the mold 100 as the elevator platforms 352 raise the mold 100 upwardly from the conveyor 200. The brackets 362 thereby control the longitudinal positioning of the molds 100 at the station 350.

The operation of the insert placement station should be apparent from the above description of the exemplary embodiment of the station. At the start of the insert placement operation the elevator platforms 352 are vertically arranged, by means of cylinders 356, so that the roller beds 354 are in horizontal alignment with the roller beds 208 of the conveyor 200. The insert placement station 350 will thereby receive the mold 100 being carried by the conveyor 200. As a mold 100 approaches the station 350 the mold engages with the cam tracks 360 on the elevator platforms 352 and is thereby arranged into the desired transverse position with respect to the insert head 366. With the mold 100 positioned on the roller beds 354, the cylinders 356 are actuated by a hydraulic control system (not shown) to raise the mold 100 into a position adjacent the insert placement head 366, such as seen in FIG. 7. The brackets 362 engage with the rising mold 100 and orient the mold into the desired longitudinal position with respect to the head 366.

With the mold 100 in the raised position as shown in FIG. 7, the head 366 can be actuated, as described above, to place an insert 370 onto each of the studs 105 in the mold. The actua-

tion of the hydraulic cylinders 356 can then be reversed to return the mold 100 to the mold saddle 204 on the conveyor 200. The mold 100 is thereby prepared for movement by the conveyor 200 into the subsequent operating stations of the system. As seen in FIG. 7, the stroke of the cylinders 356 at the station 350 is preferably substantially the same as the stroke for the cylinders 306 of the preceding station 300. Such an arrangement facilitates the completion of the operation of the station 350 within the same selected time interval as needed for the operation of the mold cleaning and oiling substations A—E. Of course, it will be appreciated by those skilled in the art that the station 350 can be adapted to place other types of hardware within the cavity of the mold 100 in substantially the same manner that the station operates with respect to the railway tie inserts 370.

As illustrated in FIG. 8, the system of the present invention also includes a strand placement station 400, positioned adjacent the conveyor 200 downstream from the insert placement station 350. The station 400 is adapted to automatically feed the desired lengths of reinforcing strands S transversely across the path of the conveyor 20 and to place the strands S in a predetermined arrangement within the cavity of the mold 100. In the exemplary embodiment, the station 400 operates to place four lengths of reinforcing strand S within each of the portable molds 100 in a manner which satisfies the specifications of the American Association of Railroads for the current form of reinforced concrete railway tie.

The preferred form of strand placement station is fully described in the above-mentioned copending application of Messrs. Hidden and Yetman, Ser. No. 721,793. Briefly, the placement station 400 includes a channel-shaped placement head 416 which is slidably supported on a transverse beam 414 by brackets 418. A hydraulic piston 422, schematically illustrated in FIG. 8, is provided to control the transverse positioning of the head 416 with respect to the mold 100 during the strand placement operation. The head 416 also includes an array of channels 420 for receiving lengths of reinforcing strands S. The channels 420 are arranged in a predetermined pattern and preferably extend the full length of the placement head 416. A releasable support member 424 is adapted to close against the lower portion of each of the channels 420 to temporarily maintain a strand S within each channel.

As fully described in the copending application of Messrs. Hidden and Yetman (Ser. No. 721,793), the placement station 400 includes a suitable feeding apparatus (not shown) which feeds the reinforcing strands S transversely across the conveyor 200 into the channels 420. During such strand feeding, the members 424 are closed against the channels 420, as shown in FIG. 8, so that the strands S are temporarily supported within the channels. The strand feeding continues until a desired length of strand S is within each channel 420, and a free end of the strands projects beyond each end of the channel. Suitable limit switches or the like (not shown) can be included on the head 416 to stop the strand feeding operation after the desired strand lengths are fed into the channels 420. If the strand is being fed into the head 416 from a continuous source, a suitable cutting device (not shown) also can be provided at the station 400, to cut each of the strands S to the desired length.

The placement station 400 further includes a pair of aligned elevator platforms 402 (only one of which is shown) for raising the portable molds 100 from the conveyor 200 into engagement with the placement head 416. Each platform 402 has a roller bed 404 for receiving the molds 100 as the molds are carried along the path of the conveyor 200. A hydraulic actuating cylinder 406 and guide rods 408 control the vertical positioning of the elevator platforms 402 and roller beds 404 during the operation of the station 400. Each platform 402 also has a cam track 410, as shown in FIG. 8, positioned for engagement with the molds 100. The tracks 410 control the transverse positioning of each mold 100 with respect to the placement head 416. The station 400 also includes brackets 412 which engage with the molds 100 and control the longitudinal positioning of the molds with respect to the head 416.

In the preferred embodiment, the molds 100 are positioned on the conveyor 200 so that the movable mold end assemblies 120 and 140 are maintained in an open position (FIG. 35) as the molds are carried to the station 400. During the operation of the placement station 400, the elevator platforms 402 are vertically arranged by the hydraulic cylinders 406 so that the roller beds 404 are in horizontal alignment with the roller beds 208 on the conveyor 200. As a mold 100 is carried toward the stations 400 by the conveyor 200, the mold engages with the cam tracks 410 and is thereby aligned transversely with respect to the placement head 416. The mold 100 further becomes positioned on the roller beds 404 of the elevator platforms 402. Simultaneously with the movement of the mold 100 into the station 400, the strands S are fed into the channels 420 of the placement head 416 in the above-described manner. Also, the hydraulic piston 422 is activated by suitable control means (not shown) to move the head 416 transversely into a predetermined position above the conveyor 200 so that the strands S are suspended between the open mold ends 120 and 140 of the mold 100.

After a mold 100 and the head 416 are arranged at the placement station 400 in the above-described manner, the hydraulic cylinders 406 are activated to elevate the mold 100 into engagement with the head 416. As illustrated in FIG. 8, the lengths of reinforcing strands S are thereby emplaced in the desired pattern within the cavity of the mold 100, between the open ends 120 and 140 of the mold. As explained in copending application Ser. No. 721,793, the mold ends 120 and 140 can then be closed against the body of the mold 100 to engage with the strands S within the strand chucks 126 and 146 provided on the end assemblies. As shown in FIGS. 14 and 15, the chucks 126 and 146 will thereby grip the adjacent free ends of the strands S and maintain the strands in the proper position within the mold 100 during the subsequent operating steps of the system.

Upon completion of the strand placement, the members 424 are retracted from the channels 420 by a suitable actuating mechanism (not shown). The cylinders 406 can then be actuated to lower the mold 100 from the head 416, to return the mold to the saddle 204 on the conveyor 200. The mold 100 is thereby positioned on the conveyor 200 for movement through the subsequent operating stations included in the system.

The system in accordance with this invention also includes a strand tensioning station 450, as illustrated in FIGS. 9 through 11 of the drawings. The tensioning station 450 includes substations 450A—C which operate to apply a selected pretensioning force to each of the reinforcing strands S which are emplaced within the portable molds 100. The preferred form for the strand tensioning means included in station 450 is fully illustrated and described in the copending application of Messrs. Hidden and Yetman, Ser. No. 721,793.

The station 450 in the exemplary embodiment includes a first tensioning substation 450A, as shown in FIG. 9. Substation 450A is adapted to apply an axial load to two diametrically opposed strands S, to thereby pretension the two strands. To accomplish the strand pretensioning, a tensioning head (not shown), such as described in the Hidden and Yetman application, is connected to the free ends of the strands S, and actuated to apply a measured axial load to the strands. The strand chucks 126 and 146 on the mold end assemblies 120 and 140 grip the strands, and maintain the strands in their pretensioned condition, after the force of the tensioning head is released. The substation 450B, as illustrated in FIG. 10, is adapted to apply the same measured pretensioning force to the other two diametrically opposed reinforcing strands S, in the same manner. Again, as fully explained in the Hidden and Yetman application Ser. No. 721,793, the strand chucks 126 and 146 will operate to maintain the strands in their pretensioned condition after the tensioning operation of substation 450B is completed.

Referring to FIG. 11, the exemplary embodiment of the tensioning station 450 also includes a substation 450C adapted to apply a final tensioning force to the reinforcing strands S. As

explained fully in the copending Hidden and Yetman application Ser. No. 721,793, the final tensioning of the strands is carried out to compensate for the pretensioning force lost as a result of the seating of the chucks 126 and 146 on the ends of the strands S. Preferably, substation 450C applies a load to the four strands S simultaneously, to elongate the strands an additional measured amount. The final pretensioning force in the strands S is thereby applied with a high degree of accuracy.

As seen from FIGS. 9—11, 14 and 15, each substation 450A—C of the strand tensioning station 450 includes a pair of elevator platforms 452A—C, respectively. As in the operating stations described above, the platforms 452A—C are adapted to raise the molds 100 from the conveyor 200 so that operation of the substations can be performed. Accordingly, the elevator platforms 452A—C have roller beds 454 for receiving the molds 100, and are joined to hydraulic lift cylinders 456. Guide rods 458 control the positioning of the elevator platforms 452A—C and brackets 462, supported on transverse beams 464A—C, are provided to control the longitudinal position of the molds 100 at each of the substations 450A—C. Finally, each substation 450A—C includes a cam track 460, mounted on the respective elevator platforms, for controlling the transverse positioning of the molds 100 at the substations.

A suitable mechanism by which the final tensioning may be applied to the strands S at substation 450C is illustrated in FIGS. 14 and 15 of the drawings. As shown therein, the substation 450C can be provided with a bifurcated tensioning head 160 which is mounted upon the elevator platform 452C and adapted for engaging the adjacent end plate 142 of the mold 100. The tensioning head 160 has a hydraulic power cylinder 166 connected to a pulling fork 168. The fork 168 is positioned for engagement with a pulling post 148, connected to the adjacent chuck plate 144 of the mold end assembly 140. Since the strands S are engaged within the strand chucks 126 and 146, which in turn are joined to the chuck plates 124 and 144, it is apparent that an outward pull by the power cylinder 166 (rightward in FIGS. 14 and 15) will apply a tensioning force to the strands S. The engagement between the head 160 and the adjacent end plate 142 assures that the mold 100 will not shift during the operation of the power cylinder 166.

When the manufacturing system in accordance with the present invention is in continuous operation, a mold 100 will be positioned at each of the substations 450A—C of the station 450, and the operations of the substations will be performed simultaneously. However, for simplicity, the operation of the strand tensioning station 450 will be described with reference to the movement of a single mold 100 through the substations.

To begin with, a mold 100 having the strands S emplaced therein is carried by the conveyor 200 to the substation 450A (FIG. 9). The action of the conveyor 200 places the mold 100 on the roller beds 454 of the elevator platforms 452A. The motion of the conveyor 200 also brings the mold 100 into engagement with the cam tracks 460, thereby aligning the mold in the desired transverse position at the substation 450A. The cylinders 456 can then be actuated to raise the mold into the operating position illustrated in FIG. 9. The brackets 462 align the mold longitudinally as the mold rises. As explained in the Hidden and Yetman application Ser. No. 721,793, a tensioning head (not shown) can then be secured to two of the strands S, and operated to apply a measured pretensioning load to such strands. The strand chucks 126 and 146 (FIGS. 14 and 15) seat against the two strands and maintain the strands in a pretensioned condition.

After the tensioning operation is completed at substation 450A the actuation of the cylinders 456 is reversed to lower the mold 100 onto the conveyor 200, within the saddles 204. The mold 100 is next carried to the substation 450B. The substation 450B operates in the same manner as substation 450A to raise the mold 100 into the elevated position shown in FIG. 10. A tensioning head (not shown) is then activated to apply the same pretensioning load to the other opposed strands S.

Again, the chucks 126 and 146 (FIGS. 14 and 15) seat with the strands S and maintain the strands in a pretensioned condition.

Upon completion of the tensioning operation at substation 450B, the mold 10 is again lowered into the conveyor saddles 204 and carried by the conveyor 200 toward substation 450C. As shown by the phantom lines in FIG. 14, the elevator platforms 452C at substation 450C are initially positioned in alignment with the conveyor roller beds 208. The action of the conveyor 200 will thereby place the mold 100 onto the elevator roller beds 454, and the adjacent mold end assembly 140 will project into the bifurcated tensioning head 160. The cam tracks 460 position the mold 100 transversely so that the head 160 engages with the adjacent mold end plate 142 and the post 148 engages with the pulling fork 168, such as shown in solid lines in FIG. 14. As explained in the Hidden and Yetman application, the cam tracks 460 (FIG. 14) also maintain the locking plates 130 and 150 of the mold end assemblies 120 and 140 in a selected position, so that the previously applied pretensioning force is maintained in the strands S.

Next, the cylinders 456 at substation 450C are actuated to elevate the mold 100 above the conveyor 200. As the mold rises, the brackets 462 engage with the mold and assure that the mold is in a selected longitudinal position. The power cylinder 166 on the tensioning head 160 is then activated to create a pulling force on the mold end chuck plate 144 through the pulling post 148 and fork 168. Since the strands S are secured in the chucks 146, this action of the cylinder 166 further separates the chuck plate 144 from the adjacent end plate 142 and applies an additional pretensioning load to the strands. As mentioned in the Hidden and Yetman application, the pull of the power cylinder 166 is applied to the strands S until the strands have been stretched or elongated a measured amount. Then the locking plate 150 is raised by a hydraulic ram 170 (FIG. 14) into engagement between the separated end plate 142 and chuck plate 144, thereby maintaining the strands in their elongated condition. The pull of power cylinder 166 can then be released, and the lift cylinders 456 can be actuated to return the mold 100 to the conveyor 200.

The mold 100 is thereby provided with pretensioned reinforcing strands, and is ready for conveyance to the subsequent operating stations of the system. Of course, it will be appreciated by those skilled in the art that the functions of substations 450A and 450B could be combined at one substation, or a single tensioning head could be employed to apply a force-measured pretensioning load to all of the strands S simultaneously, without departing from the present invention. Further, as explained in the Hidden and Yetman application Ser. No. 721,793, the substation 450A and 450B could be bypassed and only an elongation-measured pretensioning load could be applied to the strands by a mechanism similar to substation 450C.

The next operating station spaced along the path of the conveyor 200 is a mold filling station 500, as illustrated in FIGS. 12, 16 and 17. The mold filling station 500 is adapted to charge a measured amount of fresh concrete mixture into the cavity of each of the portable molds 100. Further, the mold filling station 500 includes means for vibrating the molds 100 as the charge of concrete mixture is being fed into the mold cavity. Such vibration will tend to compact the concrete, and will assure that the concrete will be uniformly distributed throughout the mold cavity around the inserts 370 and the reinforcing strands S.

Referring to FIGS. 12, 16 and 17 of the drawings in more detail, the station 500 is provided with a charging hopper 516, suspended above the conveyor 200 upon a transverse supporting beam 514. In the illustrated embodiment the charging hopper 516 comprises a pair of mating channel members 518 which together define a hopper cavity of a predetermined volume. In the preferred arrangement the volume of the hopper 516 is chosen to be equal to the volume of the cavities in the molds 100 so that the hopper can contain the exact volume of concrete mixture needed to fill one of the molds

100. As seen in FIG. 17, the channel members 518 in the preferred embodiment are also preformed so that the hopper 516 will temporarily store the concrete mixture in a distribution pattern which closely coincides with the pattern of concrete distribution within the cavity of the molds 100. Thus, since the concrete tie being cast by the exemplary embodiment of the system includes a restricted central portion (see FIG. 39) the members 518 include restricted central portions 518A (FIG. 17).

Moreover, each channel member 518 is rotatably supported on the beam 514 by means of a shaft 520 and bearing block 522. By this arrangement the members 518 can be selectively rotated about the shafts 520 by a suitable control mechanism (not shown), between a closed position, as shown in full lines in FIGS. 12, 16 and 17, and an opened position, as shown by the phantom lines in FIG. 12. In the closed position the members 518 engage to form the hopper 516 for storing the concrete charge. In the opened position the members 518 define a discharge chute through which the stored concrete charge will be fed into the cavity of the mold which is positioned at station 500. Any suitable feeding mechanism, such as a feeding chute 524 schematically shown in FIG. 12, can be employed to periodically fill the charging hopper 516 with a measured volume of concrete mixture during the operation of the station 500.

The station 500 also includes a pair of elevator platforms 502 for raising the portable molds 1100 from the conveyor 200 during the mold filling operation. As illustrated in FIGS. 12 and 16, the platforms 502 are positioned in transverse alignment adjacent the conveyor 200, and include roller beds 504 for engaging with and supporting the molds 100 at the station 500. Further, each platform 502 is mounted upon a plurality of springs 505 which project upwardly from a rigid plate 503. Thus, the platforms 502 are freely suspended at the station 500, and can be used for vibrating the molds 100 during the filling operation. To accomplish such vibrating movement, each platform 502 is coupled with a vibrator mechanism comprising an eccentric shaft 507 and a drive motor 509. The motor 509 is connected to the shaft 507 by suitable means such as a belt and pulley arrangement and will operate to rapidly rotate the shaft 507, thereby vibrating the platform 502 on the springs 505. Suitable means (not shown) can be provided to energize the drive motors 509 at the desired time during the operation of the station 500.

The station 500 also includes hydraulic cylinders 506, connected to the plates 503, for elevating the molds 100. Guide rolls 508 are also provided to control the positioning of the platforms 502 during the operation of the hydraulic cylinder 506. As in the elevator mechanisms positioned at the other operating stations described above, the platforms 502 also include cam tracks 510 for positioning the mold 100 transversely, and the station 500 includes brackets 512, as shown in FIGS. 12 and 16, for aligning the molds longitudinally.

To begin the operation of the mold filling station 500, a mold 100 is carried from the tensioning station 450 (FIGS. 9-11) to station 500 by means of conveyor 200. The cylinders 506 are controlled so that the elevator roller beds 504 initially are aligned horizontally with the conveyor roller beds 208. Thus, the conveyor 200 will drive the mold 100 onto the beds 504, and the cylinders 506 can be actuated to elevate the mold 100 toward the hopper 516 (FIGS. 12 and 16). During these operations, the mold 100 is aligned transversely by engagement with the cam tracks 510 and is aligned longitudinally by engagement with the brackets 512. Also, a measured volume of concrete mixture is fed through the chute 524 into the hopper 516 with the channel members 518 closed, as shown in FIG. 12.

After the mold 100 is elevated into a position such as illustrated in FIGS. 12 and 16, and the hopper 516 has been filled, the station 500 is in condition to charge a measured volume of concrete mixture into the cavity of the mold. The motor 509 can then be energized to rotate the eccentric shaft 507, to thereby vibrate the elevator platforms 502 and the mold 100.

Further, the members 518 then can be rotated about the shafts 520 into their opened positions, such as shown in phantom lines in FIG. 12. The volume of concrete mixture stored within the hopper 516 will thereby be charged into the cavity of the mold 100 while the mold is vibrating. The vibrating action of the eccentric shaft 507 and the motor 509 will cause the concrete charge to become distributed uniformly throughout the mold cavity. Upon completion of the mold filling operation, the members 518 will be rotated into their closed position, and the elevator platforms 502 will be lowered to return the filled mold 100 to the conveyor 200.

The present system also includes a concrete compacting station 550. The compacting station 550 is positioned adjacent the conveyor 200, immediately downstream from the filling station 500, and operates to compact and form the charge of concrete in the molds 100.

Referring to FIGS. 13, 18 and 19, the compacting station 550 is provided with a pair of elevator platforms 552, spaced adjacent the conveyor 200, which include roller beds 554 for supporting the portable molds 100. Further, each elevator platform 552 is mounted on a plurality of springs 555 which project upwardly from a rigid plate 553. To vibrate the molds 100 during the compacting operation, each platform 552 is also joined to an eccentric rotatable shaft 557 which is powered by a drive motor 559. Hydraulic actuating cylinders 556 and guide rods 558 are provided to control the vertical positioning of the platforms 552 at the station 550. As shown in FIGS. 18 and 19, cam tracks 560 are also mounted on the platforms 552 to engage with the adjacent ends of the molds 100 as the molds enter the station 550, to thereby control the transverse positioning of the molds. Similarly, brackets 562, supported by a transverse beam 564, and are adapted to engage with the portable molds 100 as the molds are raised by the cylinder 556. The brackets 562 will thereby position the molds 100 in the desired longitudinal position during the operation of the station 550.

The compacting station 550 additionally includes a stripper head 570 adapted to compact the charge of concrete within the cavity of the mold 100, and to further form the top surface of the concrete charge into the desired configuration. For example, the molds 100 are designed to cast a current form of concrete railway tie in an inverted position. Accordingly, since the bottom surface of such railway tie includes concave end portions and a recessed central portion, the end portions 571 of the head 570 are provided with a convex surface, and the central head portion is provided with projections 572. By this arrangement, the head 570 can be lowered against the concrete in the molds 100 to force the bottom surface of the concrete charge into the desired shape.

Referring to FIGS. 13 and 18, it will be seen that the stripper head 570 is supported above the conveyor 200 by means of a pair of hydraulic control cylinders 566 connected to the transverse beam 564. The cylinders 566 are connected to a suitable control system (not shown), and can be selectively operated to force the head 570 into engagement with the charge of concrete in the mold 100, thereby compacting and forming the concrete charge. To facilitate such compacting operation, the stripper head 570 is also provided with a drive motor 574 which is connected by a pulley and belt arrangement to an eccentric shaft 576. The shaft 576 includes offset weights 578 which cause the stripper head 570 to vibrate when the shaft 576 is rapidly rotated. Bearing blocks 580 rotatably join this shaft 576 to the top of the stripper head 570, to assure that the vibration caused by the rotation of the shaft 576 is communicated directly to the stripper head. Suitable control means (not shown) is provided at station 550 to selectively energize the drive motor 574 during the compacting operation.

In operation of the compacting station 550, the lifting cylinders 556 are actuated to align the elevator roller beds 554 with the conveyor roller beds 208. The motion of the conveyor 200 will thereby move the mold 100 onto the roller beds 554. At the same time, the cam tracks 560 engage with the mold 100

and move the mold into the desired transverse position with respect to the stripper head 570. The cylinders 556 are then actuated to raise the mold 100 from the conveyor 200, such as into the elevated position shown in FIGS. 13 and 18. The motors 559 are then energized to rotate the eccentric shafts 557 and thereby vibrate the elevator platforms 552 and the mold 100. Thereafter, the control cylinders 566 are activated to forcefully lower the stripper head 570 into engagement with the concrete in the cavity of the mold 100. Also, the motor 574 is energized to vibrate the head 570 as the head is lowered.

As a result of the above operations, the stripper head 570 forms the open surface of the concrete charge into the desired shape and compacts the concrete in the mold cavity. The simultaneous vibration of the head 570 and the mold 100 further compacts the concrete charge. After the compaction operation of the station 550 is completed, the motors 559 and 574 are deenergized to stop the vibration of the mold 100 and the head 570. Further, the control cylinders 566 are activated to raise the head 570 back into its initial position. Thereafter, the cylinders 556 are actuated to return the compacted mold 100 to the conveyor 200. The station 550 is thereby conditioned to receive an additional mold 100, and the compacted mold is prepared for a concrete curing operation.

When the operations of above-described stations 250, 300, 350, 400, 450, 500 and 550 have been completed, the molds 100 carried through such stations will be cleaned and oiled, provided with pretensioned reinforcing strands S and inserts 370, and will be filled with a compacted charge of concrete mixture. Upon completion of this first aspect of the system, each of the portable molds 100 is thereby prepared for movement to a curing station, where the concrete within the molds can be cured for the desired length of time.

A suitable curing station 600 is schematically illustrated in FIG. 21. Similarly, FIG. 20 schematically illustrates a lifting mechanism 590 which may be connected to a suitable overhead hoist or the like (not shown) for transferring the portable molds 100 from the conveyor 200 to the curing station 600. As shown in FIG. 21, the curing station 600 is provided with a concrete curing oven 602 which is adapted to receive stacks of filled molds 100. Stem coils 604 extend through the oven 602, in the conventional manner, to heat the interior of the oven and thereby cure the concrete in the molds 100. The curing oven 602 is a conventional concrete curing kiln, and can be constructed and operated in the conventional manner to subject the concrete in the stacked molds 100 to the desired presetting, steam curing, cooling and surging phases of a concrete curing cycle.

The manufacturing system in accordance with this invention includes a second aspect which subjects the molds 100 to a series of operations after the curing cycle of the curing station 600 has been completed. This second aspect of the system, illustrated in FIGS. 22-40, functions to release the pretensioning load on the reinforcing strands S; demold and finish the cured concrete members M; and to prepare the empty portable molds 100 for recycling through the manufacturing system.

Referring to the drawings in more detail, FIG. 22 is an additional illustration of the curing station 600, schematically showing the condition of a stack of molds 100 after the concrete curing cycle has been completed. At the end of the curing cycle each of the molds 100 is transferred from the curing station 600 by suitable means, such as the lifting mechanism 590 illustrated in FIG. 20, to a mold conveyor mechanism 200A. As shown in FIGS. 23 and 24, the conveyor 200A is substantially identical to the above-described conveyor 200, and is likewise adapted to carry a plurality of portable molds 100 simultaneously along a predetermined path of travel. Thus, the conveyor 200A includes a pair of continuous drive chains 202A which carry a plurality of mold saddles 204A. Two parallel chain tracks 206A support the chains 202A and guide the chains along a predetermined path. A pair of roller beds 208A are mounted adjacent the tracks 206A for engaging and supporting the molds 100. A suitable frame

structure 210A supports the conveyor tracks 206A and the roller beds 208A in the desired arrangement.

As illustrated in FIG. 23, a strand tension releasing station 650 is the initial operating station positioned along the path of the conveyor 200A. The station 650 is adapted to release the external pretensioning load on the reinforcing strands S in each mold 100, after the concrete in the mold has been cured to form the completed cast member M. In the preferred embodiment of the system the station 650 additionally extends the movable mold end assemblies 120 and 140 to their opened positions, such as shown in FIGS. 32, 35 and 36, to facilitate the removal of the cast member M from the mold 100.

Referring to FIGS. 23, 28 and 29 in detail, the station 650 includes a pair of elevator platforms 652 positioned adjacent the conveyor 200A. Each platform 652 includes a roller bed 654 for receiving and supporting the portable molds 100 at the station. A hydraulic actuating cylinder 656 is provided to raise and lower each platform 652 and guide rods 658 are provided to control the positioning of each platform. Further, the station 650 includes brackets 662, supported above the conveyor 200A on a transverse beam 664, for controlling the longitudinal positioning of the molds 100 as the molds are elevated at the station. Also, a cam track 660 is positioned on each platform 652 to orient the molds 100 in the desired transverse position at the station 650.

As illustrated in FIGS. 28—32, each elevator platform 652 at the station 650 is also provided with a releasing head 670 for releasing the external pretensioning load on the reinforcing strands S. Each head 670 (only one of which is shown in FIGS. 28—32) is bifurcated to form an open channel having upper and lower channel portions 672 and 674, respectively. These channel portions 672 and 674 project toward the adjacent end of mold 100 and are vertically spaced so that the adjacent mold end assembly (120 or 140) can extend into the head 670 between the channel portions. Longitudinal grooves 673 and 675 are provided in the channel portions 672 and 674, respectively, to receive the end plate of the adjacent mold end assembly, such as the end plate 142, as shown in FIGS. 28—32. By such an arrangement, each head 670 can be joined to the adjacent end plate in a manner which permits the head to extend the adjacent mold end assemblies into the opened position. Further, the lower groove 675 on each head 670 is dimensioned so the head will not interfere with the strand tension releasing operation, as explained hereinbelow.

Additionally, each head 670 is slidably supported on the elevator platform 652 by means of bearing blocks 679 and transversely extended guide rods 680 provided on the platform. A control cylinder 684, including a push rod 682 joined to the head 670, is also provided on each platform 652 to control the transverse positioning of the releasing head 670. Thus, the heads 670 can be transversely translated on the elevator platforms 652 to, first, engage with the adjacent end assembly of the mold 100, and secondly to extend the adjacent end assembly into an opened position after the external pretensioning load on the strands S has been released. In this latter regard, each head 670 additionally includes a power cylinder 676 joined to a pulling member 678. As seen in FIGS. 28—32, the pulling member 678 is positioned within the head 670 for engagement with the pulling post (148) on the adjacent movable mold end assembly. Thus, an outward pulling force created by the power cylinder 676 will be directly transmitted to the pulling post on the adjacent mold end assembly.

The operation of the tension releasing station 650 is apparent from FIGS. 23 and 28—33 of the drawings. The mold 100, including the cured concrete member M, is carried toward the station 650 by the conveyor 200A. The roller beds 654 initially are aligned horizontally with the conveyor roller beds 208A so that the mold 100 can engage with the beds 654 and the cam tracks 660. The mold is thereby positioned in the desired transverse arrangement on the beds 654. The horizontal movement of the mold 100 along the conveyor 200A also slides the mold end plate assemblies 120 and 140 into engagement with the adjacent releasing head 670, as shown in FIG.

28. The same movement of the mold 100 engages the end assembly pulling post (148 in FIG. 28) with the adjacent pulling member 678. Then the lift cylinders 656 can be actuated to raise the mold 100 and the member M into an elevated position at the station 650 (FIGS. 23 and 28). The station 650 is thereby prepared to begin the strand tension releasing operation.

As fully set forth in the Hidden and Yetman application Ser. No. 721,793, in the exemplary embodiment the external pretensioning load is applied to the strands S by the grip of the strand chucks 126 and 146 on the ends of the strands S. Further, the desired pretensioning load is maintained in the strands S by the engagement of the locking plates 130 and 150 between the end plates (122 or 142) and the adjacent chuck plates (124 or 144) of the mold end assemblies. Since the strand chucks 126 and 146 are mounted on the respective chuck plates 124 and 144, the locking plates 130 and 150 function to space the chuck plates outwardly away from the adjacent end plates 122 and 144, and thereby hold the strands S under the pretensioning load.

As seen in FIGS. 17, 29 and 33, the end plates 124 and 144 further include suitable means such as cylindrical bushings 121 and 141 for engaging with the strand chucks 126 and 146, respectively. When the adjacent end plates (122 or 142) and chuck plates (124 or 146) of the mold end assemblies are spaced apart by the associated locking plates (130 or 150) the bushings are disengaged from the adjacent strand chucks 126 or 146, and the chucks can forcefully grip the strands S. On the other hand, when the adjacent end and chuck plates are close together, the bushings 121 and 141 engage the associated chucks 126 or 146 and deactivate the chuck jaws. As explained in the Hidden and Yetman application Ser. No. 721,793, this latter arrangement releases the grip of the chucks 126 and 146 on the strands S so that the chucks can be moved outwardly over the strands. Thus, it is apparent that the releasing head 670 must operate to return the chuck plates 124 and 144 inwardly, to a position adjacent the end plates 122 and 142, to release the pretensioning load on the strands S by bringing the strand chucks 126 and 146 into engagement with the associated bushings 121 and 141. Since the operation of the releasing head 670 is the same for both end assemblies of the mold 100, the steps through which the head 670 progresses will be described with reference to the mold end assembly 140, as illustrated in FIGS. 28—33.

The tension releasing is initiated after the mold 100 and head 670 are arranged as shown in FIGS. 28 and 29. Initially, the power cylinder 676 is actuated by a suitable hydraulic control (not shown) to forcefully move the pulling member 678 and pulling post 148 outwardly away from the mold 100 (rightward in FIGS. 28—32). This action pulls the chuck plate 144 and strand chucks 146 outwardly, and elongates the strands S. The pull of the cylinder 676 is continued until the chuck plate 144 is spaced outwardly from the adjacent end plate 142, as shown in FIG. 30. In such an arrangement, the force which was previously retaining the locking plate 150 in engagement between the plates 142 and 144 is released. Upon release of such force, the locking plate 150 will drop by gravity from its upward position between the plates 142 and 144 to a lower position disengaged from the plates 142 and 144. The upper position for plate 150 is illustrated in full lines in FIG. 28 and in phantom lines in FIG. 33, and the lower plate position is illustrated in full lines in FIGS. 30—33. Further, as seen in FIG. 33, the groove 675 in the head 670 provides an unobstructed opening into which the locking plate 150 can be lowered.

As mentioned above, the movement of the chuck plate 144 by the operation of power cylinder 676 from an inward position, such as shown in FIGS. 28 and 29 to the outward position, such as shown in FIG. 30, allows the locking plate 150 to drop out of engagement with the end plate 142 and chuck plate 144 (FIGS. 30 and 33). The grip of the chucks 146 on the strands S is then released by reversing the operation of the power cylinder 676 to move the chuck plate 144 inwardly,

such as from the position shown in FIG. 30 to the position shown in FIG. 31. As a result of the reversed operation of cylinder 676 the bushings 141, or other suitable releasing means, engage with the chucks 146 and release the grip of the chucks. Accordingly, the external pretensioning load applied to the strands S at the above-described station 450 is released by the head 670. The end assemblies 120 and 140 can then be opened and the completed concrete member M can be removed from the mold 100.

In addition to releasing the pretensioning load on the strands S, the head 670 further functions to open the movable mold end assemblies 120 and 140. In this regard, after the operation of the power cylinder 676 is completed, the hydraulic cylinder 684 is actuated to slide the head 670 outwardly on the associated elevator platform 652. Due to the engagement of the mold end plate 142 (FIG. 28) with the grooves 673 and 675 on the head 670, movement of the head 670 also causes the mold end assembly 140 to slide outwardly. This translation of the end assembly 140 is controlled by the guide rods 143, which join the end assembly to the adjacent end of the mold 100. The operation of the cylinder 684 is continued until the end assembly 140 is moved outwardly a sufficient distance to clear the projecting ends of the reinforcing strand S, such as illustrated in FIG. 32. The other mold end assembly 120, not shown in FIGS. 28-33, is similarly translated outwardly beyond the adjacent free ends of the strands S by the associated releasing head 670. The heads 670 thereby operate to space the mold end assemblies 120 and 140 away from the body of the mold 100 so that the completed concrete member M, having the strands S projecting from its ends, can be readily demolded at a following operating station.

Referring to FIG. 24, and 34-36, a mold turnover station 700 is included in the system and is designed to invert each of the molds 100 in preparation for demolding the concrete members M. The turnover station 700 immediately follows the tension releasing station 650, and is supported adjacent the conveyor 200A by suitable frame structure 704. A turnover head 702 is rotatably supported on the frame structure 704 by means of a pivot pin 706 extended within bearing blocks 708. Suitable driving means (not shown) are provided to selectively revolve the head 702 about the pin 706 during the operation of the station 700. Further, the head 702 defines an opposed pair of channels 710 and 712 which permit the head to receive and invert the portable molds 100. The channels 710 and 712 are joined to the pivot pin 706 by a series of struts 714 in a manner which permits each channel to be revolved into alignment with the conveyor 200A, as shown in FIG. 24. As shown in FIG. 34, the channels 710 and 712 are dimensioned to freely receive the molds 100 from the conveyor 200A, and include recesses 710A and 712A, respectively, which permit the head 702 to revolve without interfering with the operation of the conveyor 200A. The channels also have side flanges 710B (FIG. 34) and 712B (FIG. 36), respectively, for controlling the transverse position of the mold 100 during the turnover operation.

In operation of the station 700, the channel 710 is initially aligned with the conveyor 200A so that the conveyor 200A drives a mold 100 into the channel. Then, the turnover head 702 is rotated about the pin 706 to thereby lift the mold 100 from the conveyor 200A and revolve the mold 180°. Such rotation of the head 702 also revolves the other channel 712 into alignment with the conveyor 200A, to thereby position the channel 712 for receiving a mold 100. The station 700 thus will operate to invert the molds 100, and the associated concrete member M, so that the member M can be readily demolded.

As shown in FIGS. 24 and 36, the turnover station 700 also includes a conveyor mechanism 200B for receiving the molds 100 and cast members which are inverted by the operation of the head 702. The conveyor 200B comprises a pair of parallel drive chains 202B having a plurality of mold-supporting saddles 204B. In contrast to the above-described mold saddles 204 and 204A, which engaged the body of the molds 100, the

saddles 204B are positioned for engagement with the opened mold assemblies 120 and 140. By such an arrangement the inverted molds 100 will be supported by the conveyor 200B in a manner which permits the concrete members M to be discharged downwardly from the molds, between the conveyor drive chains 202B. As seen in FIG. 36, a channel-shaped chain track 206B supports each chain 202B. Additionally, a guide plate 205B extends upwardly from the inside edge of each track 206B for engaging with the adjacent mold end plates 122 or 142, to assure that the end assemblies 120 and 140 of each mold are maintained in an opened position (FIG. 36).

Referring to FIGS. 24, 25 and 36, it will be seen that a frame structure 210B supports the conveyor 200B and further supports a pair of longitudinal guide rails 212B. The rails 212B are provided to support the concrete member M after the mold 100 is inverted by the turnover head 702. As seen in FIG. 36, the rails 212B also will continue to support the concrete member M as the conveyor 200B carries the mold 100 and the associated concrete member from the turnover station 700. Side flanges 214B are provided along the side edges of the rails 212B for engaging the adjacent end portion of the concrete member M, to thereby control the transverse positioning of the members M during the operation of the conveyor 200B.

In operation, the conveyor 200B carries the inverted molds 100 and concrete members M from the turnover station 700 to a demolding station 750 where the completed concrete members M are discharged downwardly from the cavity of the molds 100. As seen in FIGS. 25, 37 and 38, the conveyor 200B extends through the station 750 and will support the molds 100 throughout the demolding operation. However, the guide rails 212B terminate at station 750 so that the rails do not interfere with the downward discharge of the members M from the molds 100. In addition, the movement of the mold end assemblies 120 and 140 to their opened positions (FIGS. 35 and 36) permits the demolding of the members M to take place without interference from the strands S which project from the ends of each member M. As a result of such an arrangement, the station 750 can be provided with an elevator mechanism for lowering the members M from the portable molds 100.

In this regard, a pair of elevator platforms 752 are positioned at the station 750 adjacent the conveyor 200B immediately beyond the point at which the guide rails 212B terminate. As seen in FIGS. 25 and 37, the platforms 752 are connected to hydraulic cylinders 756 and are provided with vertical guide rods 758. The cylinders 756 can be actuated by suitable means (not shown) to elevate the platforms 752 into alignment horizontally with the rails 212B, so that the operation of the conveyor 200B will move a concrete member M onto the elevator platforms.

The elevator platforms 752 at the station 750 also include vibrating means, to facilitate the removal of the member M from the cavity of the mold 100. In this regard, each platform 752 is connected to a rigid plate 753 by means of a plurality of springs 755. As illustrated in FIG. 37, each platform 752 is further provided with an eccentric vibration mechanism 757 which is connected to a suitable drive motor 759. When the drive motor 759 is energized by suitable drive control means (not shown) the mechanism 757 is rotated rapidly and will rotate the shaft 757, thereby causing the platforms 752 to vibrate on the springs 755.

The demolding station 750 further includes a conveyor 250 for receiving the members M after the members are removed from the molds 100. As illustrated in FIGS. 25 and 37, the conveyor 250 comprises a pair of parallel drive chains 252 provided with a plurality of saddle members 254. The saddles 254 are adapted to receive the concrete members M as the members are lowered at the station 750 by the elevator platforms 752. The chains 252 of the conveyor 250 are supported within longitudinal tracks 256 which extend beneath the conveyor 200B. A frame structure 260 supports the chain tracks

256. Further, the frame 260 defines pair of parallel guide rails 262 which engage with the members M and support the ends of the members during the operation of the conveyor 250. As seen in FIG. 39, the rails 262 preferably have side flanges 264 for controlling the transverse positioning of the members M during the operation of the conveyor 250.

As seen in FIGS. 26 and 27, the conveyor 200B in the exemplary embodiment of the system is continued beyond the demolding station 750 to a second mold turnover station 850. As in the turnover station 700 (FIG. 24) the station 850 includes a head 852 which is rotatably supported on a frame structure 854 by means of a pivot pin 856 and bearing blocks 858. The head 852 defines a pair of opposed mold-receiving channels 860 and 862 which are joined by struts 864. The turnover station 850 operates in the same manner as the above-described station 750. Thus, one of the channels 860 or 862 (FIG. 27) receives the empty mold 100 from the conveyor 200B, and the head 852 is then rotated through 180°. The turnover station 850 thereby returns the empty molds 100 to their original upright positions, so that the molds are arranged for recycling through the manufacturing system. As shown in FIG. 27, the upright empty molds 100 preferably are returned to the conveyor 200 by the operation of the station 850, so that the empty molds can be immediately recycled through the system.

A finishing station 800, as illustrated in FIGS. 26, 39 and 40, is the final operating station included in the system in accordance with the present invention. This finishing station 800 is positioned adjacent the conveyor 250 and is adapted to finish the completed concrete members M by cutting off the excess strands projecting from the ends of the members (see FIG. 39). Accordingly, the station 800 includes a pair of rotary cutting assemblies comprising a rotary saw blade 802 and a drive motor 804. As seen in FIGS. 39 and 40, the cutting assemblies are mounted on the frame structure 260 by brackets 266, and are arranged so that the blades 802 sever the excess strand from the members M as the members are carried through the station 800 by the conveyor 250. The guide rails 262 and the flanges 264, provided at the demolding station 750, are extended through the station 800, to support the members M during the strand cutting operation. After the completion of the strand cutting the finished concrete members M are removed from the conveyor 250 by a suitable pickup mechanism, such as a flight conveyor (not shown), and are transferred to a storage and shipping area.

In accordance with this invention, the above-described operating stations of the manufacturing system are integrated and controlled so that the operation of each station (except for the curing station 600) is completed within a selected short time interval. Moreover, the operating stations and the mold conveying mechanisms are controlled so that the stations will carry out the above-described operations substantially simultaneously. The system of the present invention will thereby manufacture prestressed concrete members of a desired configuration at a very rapid rate. In fact, with the preferred embodiment of the system in continuous operation, charged molds could be prepared for the concrete curing operation and completed concrete members could be discharged from the final finishing station 800 at a rate of several members per minute. Of course, the rate of completion of the members would be a direct function of the time interval selected for completing the operating cycles of the various operating stations of the system.

Although an embodiment of a system in accordance with the present invention has been described above with particularity, and with reference to the manufacture of prestressed concrete railway ties, the disclosure is of course only exemplary. Consequently, the details of construction, size configuration and arrangement of components, and in modes of application of the system, will be readily apparent to those familiar with the art, and may be resorted to without departing from the scope of the invention as set forth in the following claims.

We claim:

1. Apparatus for making prestressed concrete members comprising a plurality of hollow portable molds each defining a mold cavity and including gripping means to receive and releasably grip reinforcing strand placed within the mold cavity, conveyor means to move said molds along a predetermined path of travel successively through a plurality of operating stations positioned along said path, the stations including a mold cleaning station, a mold oiling station, a strand placement station to place reinforcing strand in a selected position within each mold cavity, a strand tensioning station to apply a selected external pretensioning load to said strand emplaced with each mold cavity, with said gripping means engaged with said strand to substantially maintain said external pretensioning load, a mold filling and compacting station, a tension releasing station including a releasing head engageable with said molds to disengage said gripping means from the associated strand and thereby release said external pretensioning load after the concrete in said mold cavity is cured, and a demolding station to discharge the cured concrete members from said molds after said external pretensioning load has been released from said strand.

2. Molding apparatus in accordance with claim 2 including elevator means at each station to elevate said molds above said conveyor means during the operation of said stations, positioning means to orient said elevated molds into a selected position at each station, and means controlling said elevator means to operate said stations simultaneously.

3. The invention in accordance with claim 2 wherein said mold elevator positioned at said mold filling and compacting station includes vibrating means adapted to vibrate each of said molds as said mold is charged with said concrete mixture, and thereby facilitate the mold filling operation.

4. The molding apparatus in accordance with claim 4 wherein said tensioning station includes a tensioning head which applies a selected external pretensioning load to said strand by applying a measured tensioning force directly to said strand.

5. The molding apparatus in accordance with claim 1 wherein said tensioning station applies a selected pretensioning load to said strand by elongating said strand by a predetermined distance.

6. In a system for manufacturing prestressed concrete members, the combination comprising:

a plurality of portable molds, each of which includes a hollow mold body defining a mold cavity for forming a prestressed concrete member and having an open portion through which said concrete member can be discharged from said mold cavity, each of said molds further including strand gripping means releasably engageable with reinforcing strand emplaced within said concrete member through which an external pretensioning load can be applied to said strand;

means to support a plurality of said portable molds in longitudinally spaced relationship and operable to carry said filled molds along a selected path of travel; and

a tension releasing station to successively release the external pretensioning load on said strand after said strand is cast within each of said concrete members, said releasing station including a releasing head successively engageable with each of said molds at said releasing station to disengage said gripping means of each of said molds from the associated reinforcing strand to thereby release the external pretensioning load applied thereto.

7. A system in accordance with claim 6 wherein each of said molds includes movable ends joined to said body and movable between an open position with respect to said body and a closed position engaged with said body; wherein said strand gripping means are positioned on said movable ends and operable to apply an external pretensioning force to the associated strand when said mold ends are in said closed position and to disengage the strand when the mold ends are in

said open position; and further wherein said tension releasing head engages with and releases said gripping means and permits the removal of the strand from said gripping means by movement of said mold ends into said open position.

8. A system in accordance with claim 7 wherein said tension releasing head includes means to engage with and release said gripping means and means engageable with said mold ends to translate said mold ends from said closed position to said open position and thereby remove the strand from said gripping means.

9. In a system for manufacturing prestressed concrete members, the combination comprising: a mold body defining a hollow mold cavity; a mold end assembly movable between a closed position engaged with said mold body and an opened position spaced from said body; said end assembly including an end plate engageable with said body, a chuck plate aligned with and movable with respect to said end plate, strand gripping means on said chuck plate, grip releasing means, and locking means positioned between said end and chuck plates and operable to maintain a pretensioning load in strand engaged by said gripping means by spacing said chuck plate a predetermined distance from said end plate; and a releasing head for selectively releasing the strand pretensioning load; said releasing head comprising force-applying means engageable with said end and chuck plates to separate said plates and release said locking means; means to engage said strand gripping means with said grip releasing means to deactivate said gripping means; and means to translate said end assembly from said closed position to said opened position to disengage said gripping means from the reinforcing strand.

10. In a system for manufacturing prestressed concrete members, the combination comprising:

a plurality of molds each including a mold body defining a hollow mold cavity having an opened top portion and movable mold ends slidably connected to said mold body; strand gripping means on said mold ends to releasably grip reinforcing strand and apply an external pretensioning force thereto;

first conveyor means to carry said molds along a selected path of travel;

a tension releasing station positioned adjacent said first conveyor, said releasing station including a releasing head positioned above said first conveyor and operably engageable with the movable mold ends to successively disengage said gripping means from the free ends of the associated reinforcing strand, thereby releasing the external pretensioning load applied to the strand, and to translate said movable mold ends outwardly into an open position with respect to the body of the associated mold beyond the length of said free ends of said strand;

mold elevator means to receive said molds as said molds are carried to said releasing station by said first conveyor and operable to successively engage said molds with said releasing head;

positioning means at said tension releasing station to orient said molds into a selected position with respect to said releasing head;

second conveyor means positioned downstream from said tension releasing station engageable with said opened mold ends to support a plurality of said molds and the associated concrete members cast therein;

means to successively transfer each of said molds from said first conveyor to said second conveyor in an inverted position;

supporting means extending along said second conveyor for a selected distance to support the concrete members within said inverted molds as said molds are carried by said second conveyor;

a demolding station positioned along the path of said second conveyor to successively discharge the concrete members from said inverted molds, said demolding station including a platform movable into alignment with said supporting means to successively receive and support concrete members as the associated inverted mold becomes posi-

tioned at said demolding station, said platform being further movable to successively lower said concrete members between the opened movable ends of the associated mold;

means positioned adjacent said demolding station to receive and support said demolded members; and

a finishing station to successively finish each of said demolded concrete members, said finishing station including cutting means to sever the projecting free ends of reinforcing strand from each of said members.

11. The invention in accordance with claim 1 wherein said mold cleaning and oiling stations include a collection head to collect and remove the dust and debris loosened from each of said mold cavities and an oiling head to apply a coat of releasing agent to the cleaned interior wall portions of each of said mold cavities.

12. The invention in accordance with claim 1 wherein said mold filling and compacting station includes a filling head formed to store a measured volume of concrete mixture in a distribution pattern which substantially coincides with the predetermined distribution pattern for said concrete mixture within the cavity of each of said portable molds.

13. In a system for manufacturing prestressed concrete members, the combination comprising;

a plurality of portable molds, each of which includes a hollow mold body defining a mold cavity filled with a cured prestressed concrete member and having an open portion through which said cured concrete member can be discharged from said mold cavity, each of said molds further including strand gripping means releasably engaged with reinforcing strand cast within said cured concrete member through which an external pretensioning load is applied to said strand;

means adapted to support a plurality of said filled portable molds in a longitudinally spaced relationship and operable to carry said filled molds along a selected path of travel;

a tension releasing station to successively release said external pretensioning load on said strand cast within each of said concrete members, said releasing station including a releasing head successively engageable with each of said molds at said releasing station and further being operable to disengage said gripping means of each of said molds from the associated reinforcing strand to thereby release the external pretensioning load applied thereto;

means positioned adjacent said tension releasing station to successively receive said filled molds and engage said molds with said releasing head;

positioning means arranged at said tension releasing station to engage with and orient said molds into a selected position with respect to said releasing head;

support means positioned downstream from said tension releasing station to support a plurality of said filled molds in a longitudinally spaced relationship with said gripping means disengaged from said reinforcing strand;

a demolding station to successively discharge said cured concrete member from each of said filled molds, said demolding station including positioning means engageable with each of said molds and the associated concrete member to maintain said molds and concrete members in selected positions at said demolding station;

demolding means successively engageable with each of said cured concrete members as each of said filled molds is successively carried to said demolding station to separate said cured concrete member from the mold positioned at said demolding station, to thereby discharge said members from said molds; and

member-supporting means positioned adjacent said demolding means at said demolding station to receive each of said cured concrete members after said members are discharged from the associated portable mold.

14. The invention in accordance with claim 13 wherein said demolding means comprises an elevator mechanism positioned at said demolding station and wherein said member-

supporting means comprises a conveyor positioned adjacent said elevator mechanism, said elevator mechanism including a platform movable into alignment with said support means to engage with the cured concrete member associated with a mold as said mold becomes positioned at said demolding station, said elevator platform being further movable to transfer a cured concrete member to said conveyor, so that the controlled movement of said elevator platform removes the concrete member engaged with said platform from the associated mold and transfers said member to said conveyor.

15. The invention in accordance with claim 14 wherein said system includes a finishing station positioned adjacent said conveyor to successively receive said cured concrete members demolded at said demolding station, said finishing station including strand cutting means to sever said strands from said

cured concrete members as said members are carried through said finishing station.

16. The invention in accordance with claim 13 wherein said system includes mold turnover means positioned adjacent said support means downstream from said demolding station, said turnover means including a rotatable turnover head which is movable into alignment with said support means to successively receive empty molds from said demolding station, said turnover head being further rotatable into a position which inverts said empty molds received therein so that said empty molds are successively positioned with the open portions of said molds directed upwardly, whereby said turnover station orients said molds for recycling through said manufacturing system.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,577,610 Dated May 4, 1971

Inventor(s) Stanley V. Margolin, Paul W. Glaser; & Leonard V. Gallagher

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

ABSTRACT, line 18, before "cavities", change "mode" to --mold--;

Column 4, line 63, after the numeral "125", change "operated" to --operate--;

Column 6, line 45, change "curing" to -- during--;

Column 8, line 18, change "330D" to --300D--;

Column 8, line 41, change "334" to --344--;

Column 10, line 11, before "A-E", insert the numeral --300--;

Column 13, line 5, change the numeral "10" to --100--;

Column 14, line 27, change the numeral "1100" to --100--;

Column 22, claim 2, line 1, change "Claim 2" to --Claim 1--;

Column 22, claim 4, line 1, change "Claim 4" to --Claim 1--.

Signed and sealed this 25th day of April 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.

Attesting Officer

ROBERT GOTTSCHALK

Commissioner of Patents