July 7, 1964 | J. I. BOSWELL ETAL | 3,139,663

CONCRETE CASTING MACHINE

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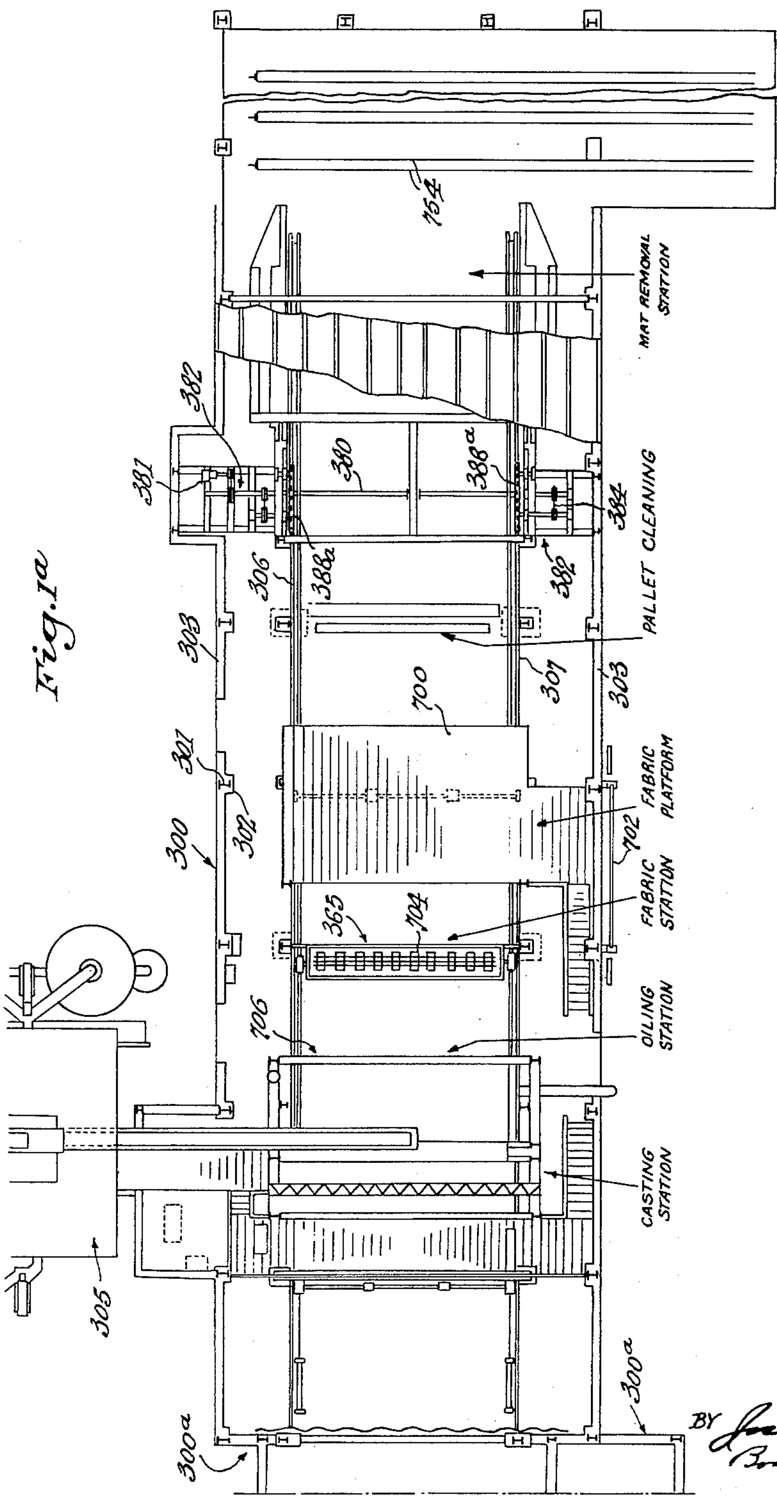

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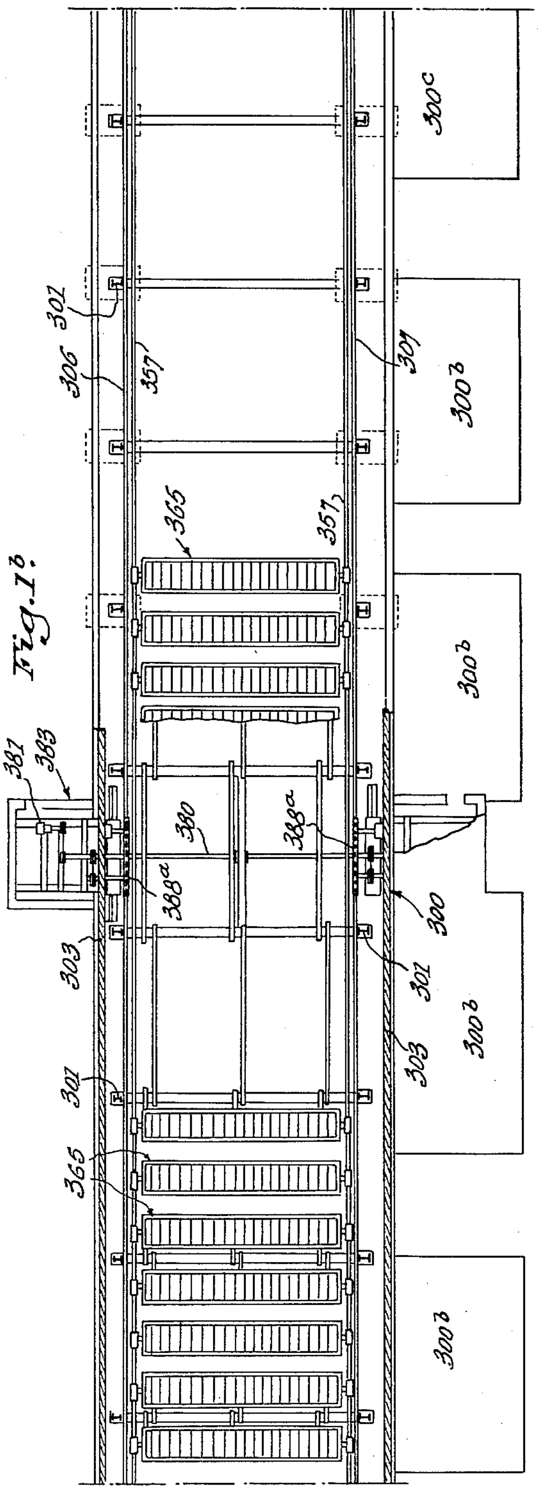

Fig. 1b

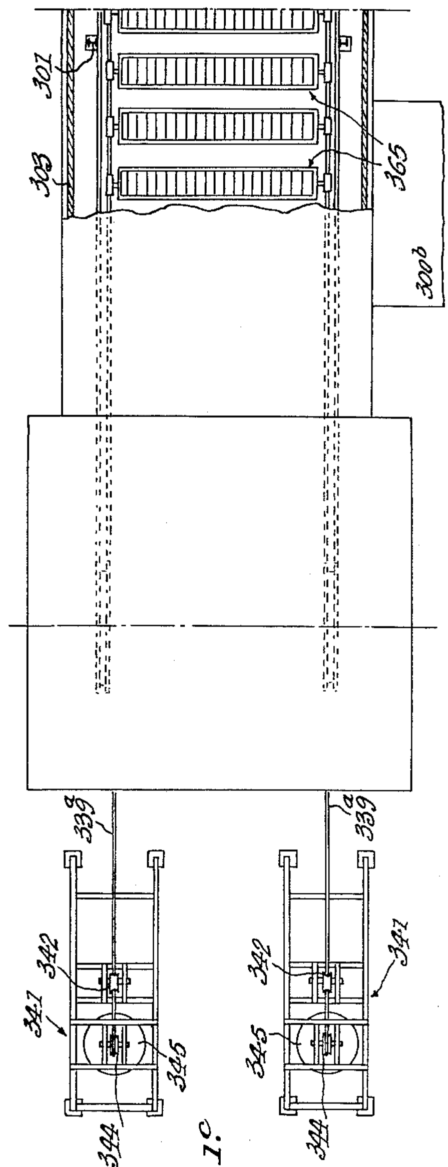

Fig. 1c

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CONCRETE CASTING MACHINE

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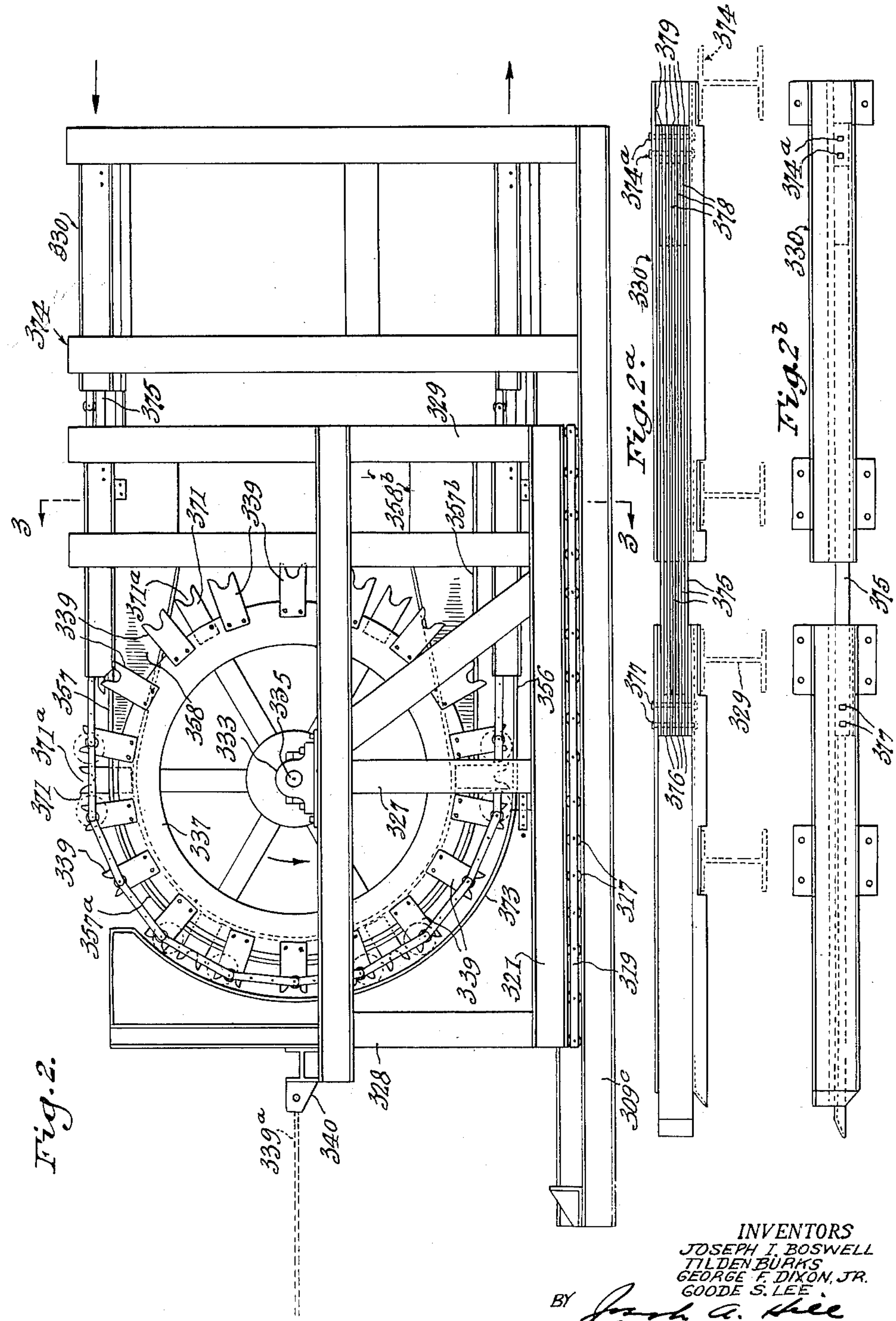

Fig. 2. Fig. 2a. Fig. 2b.

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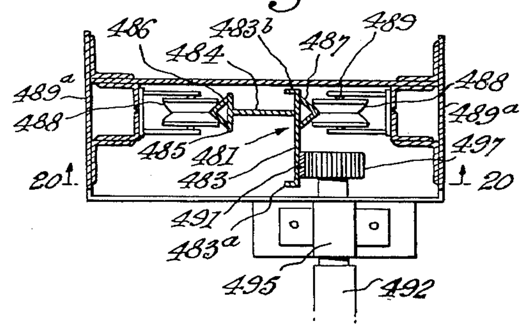
Fig. 19.



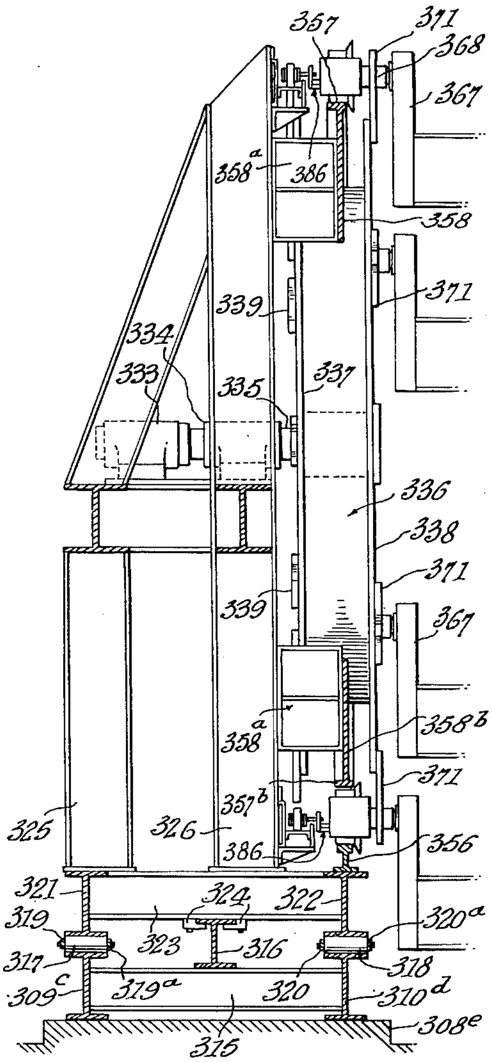


Fig. 3.

Fig. 20.

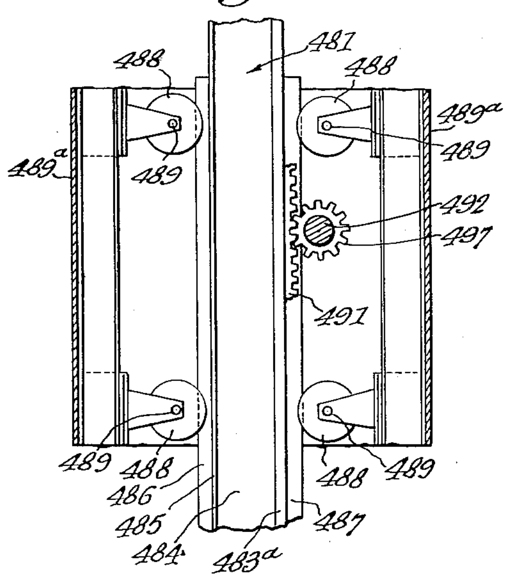


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Fig. 4a

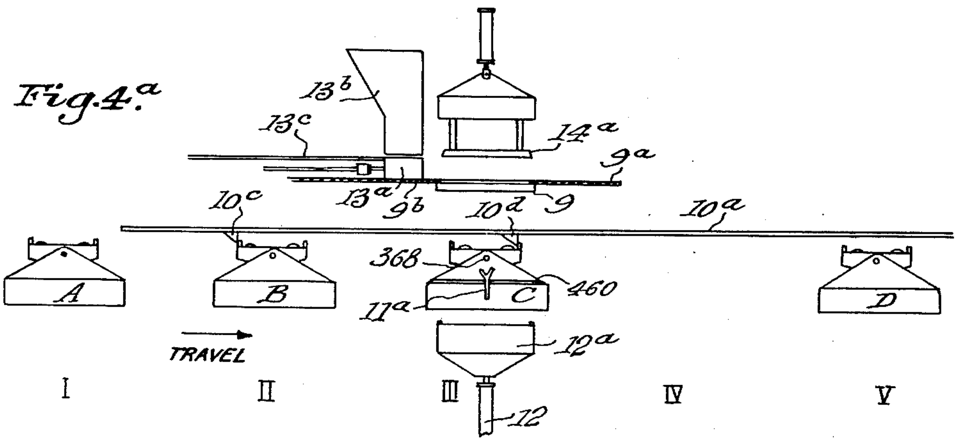

Fig. 4b

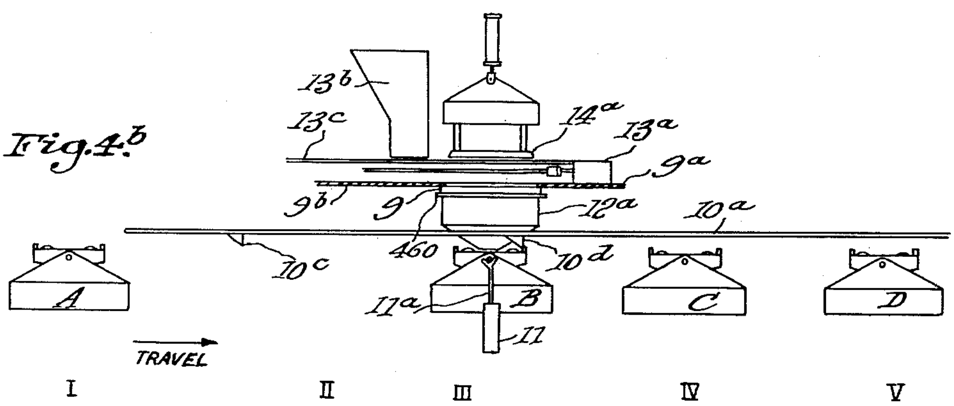

Fig. 4c

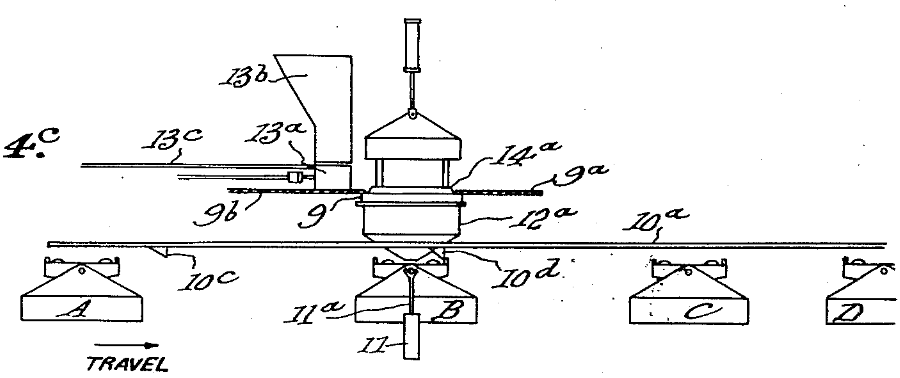

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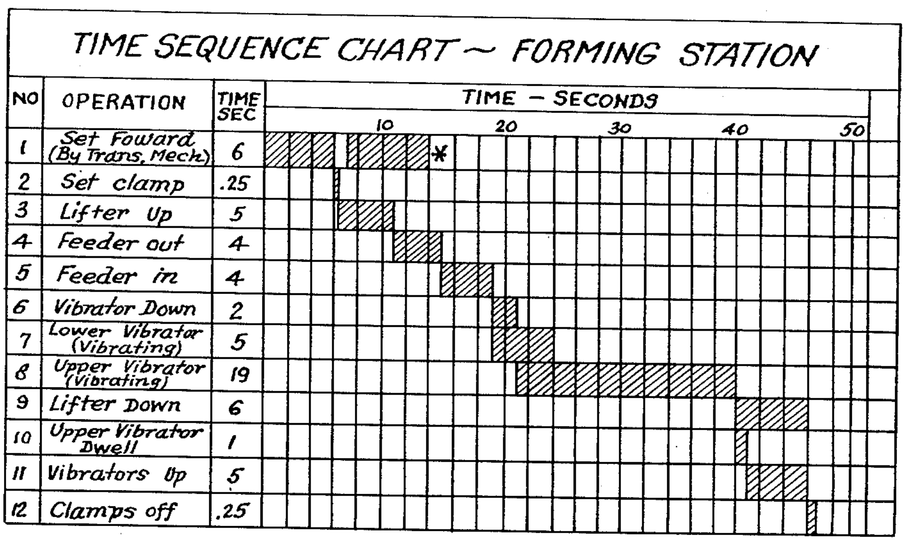
Fig. 5.



* Transfer Mech. Return

Fig. 6.

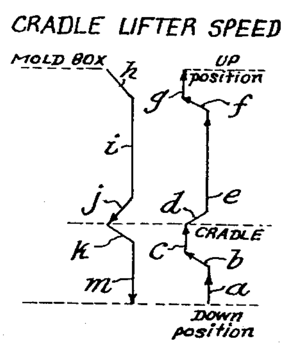


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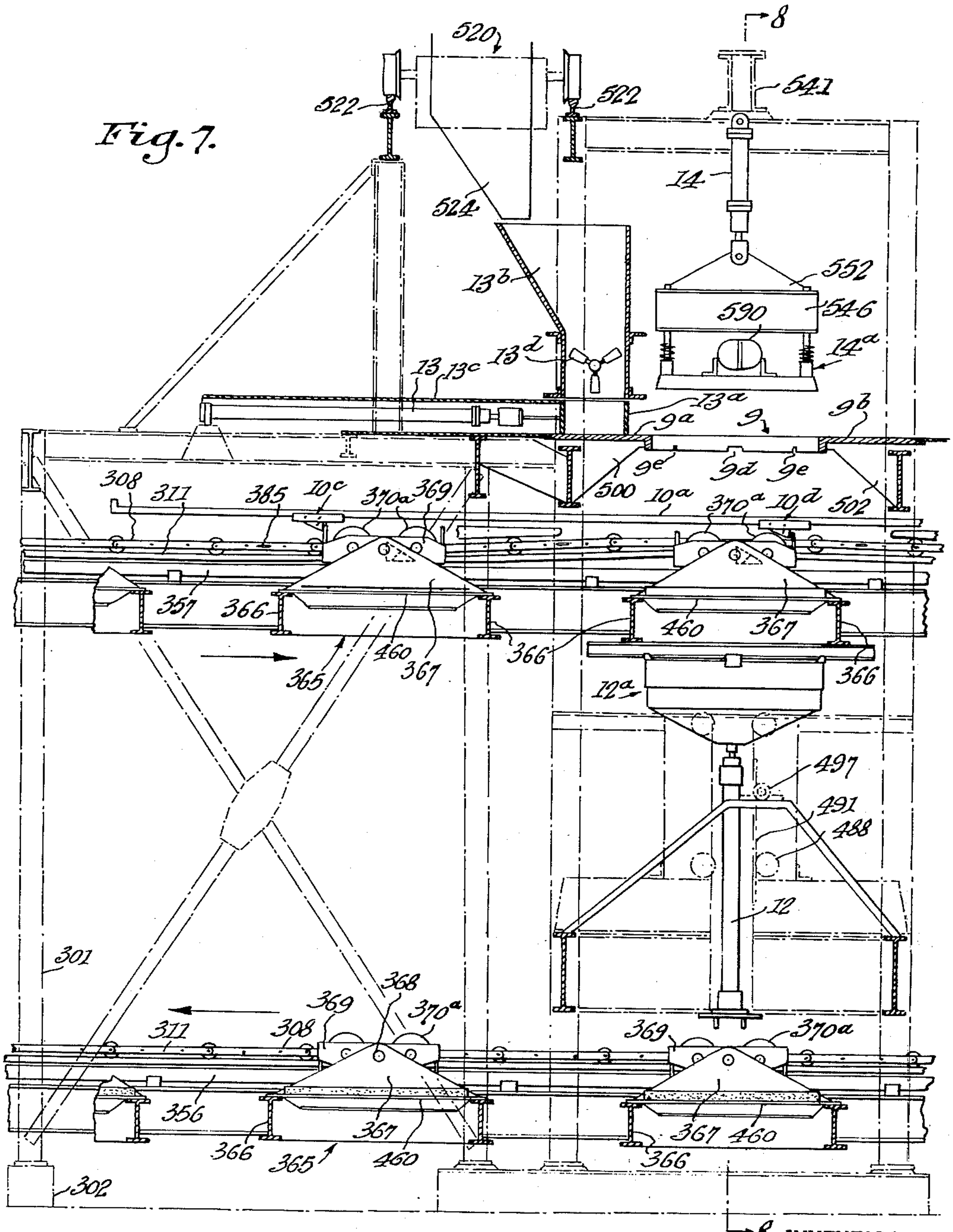
Fig. 7.



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CONCRETE CASTING MACHINE

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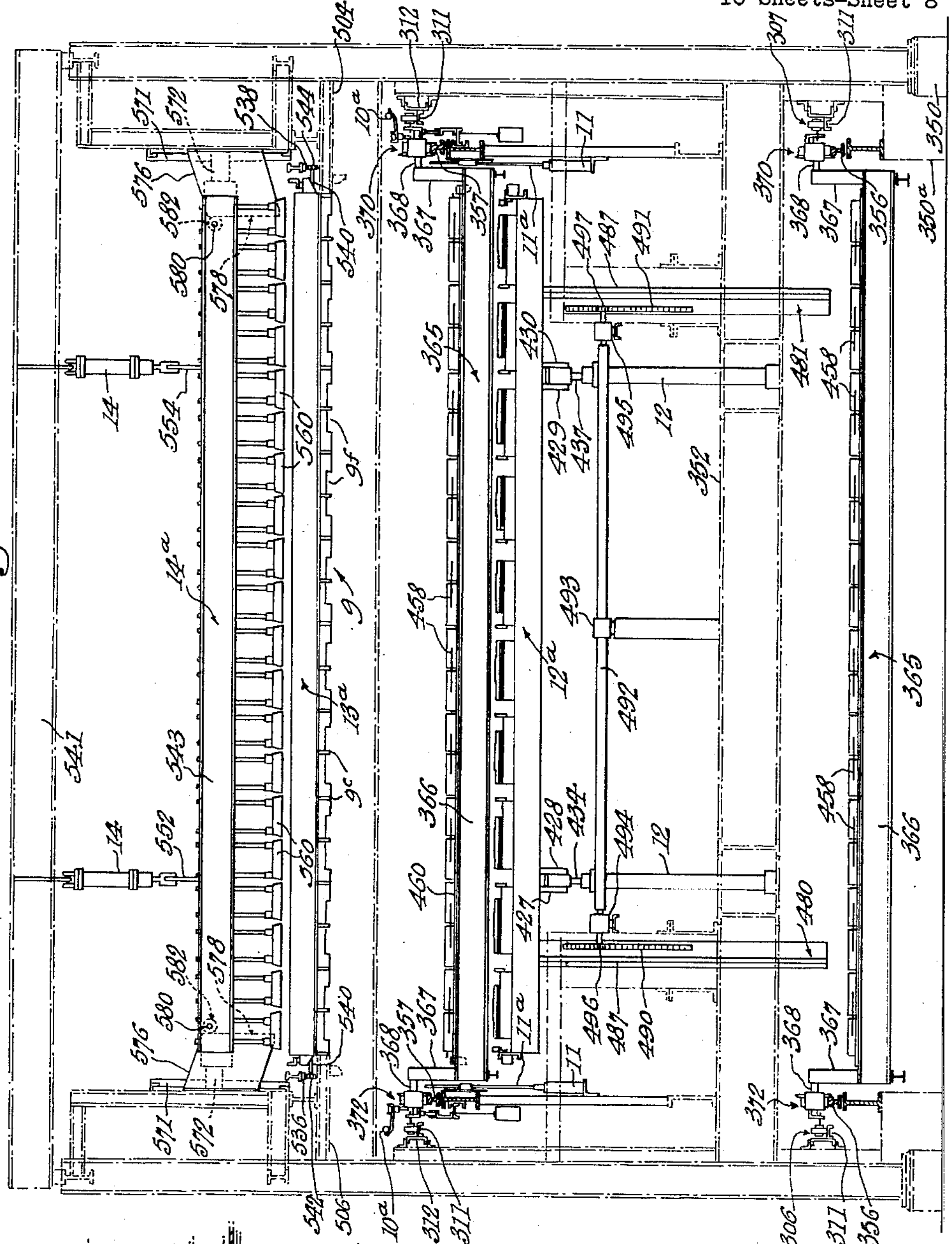

Fig. 8.

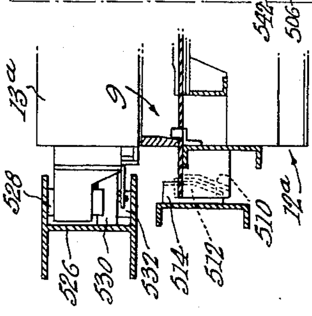

Fig. 9.

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CONCRETE CASTING MACHINE

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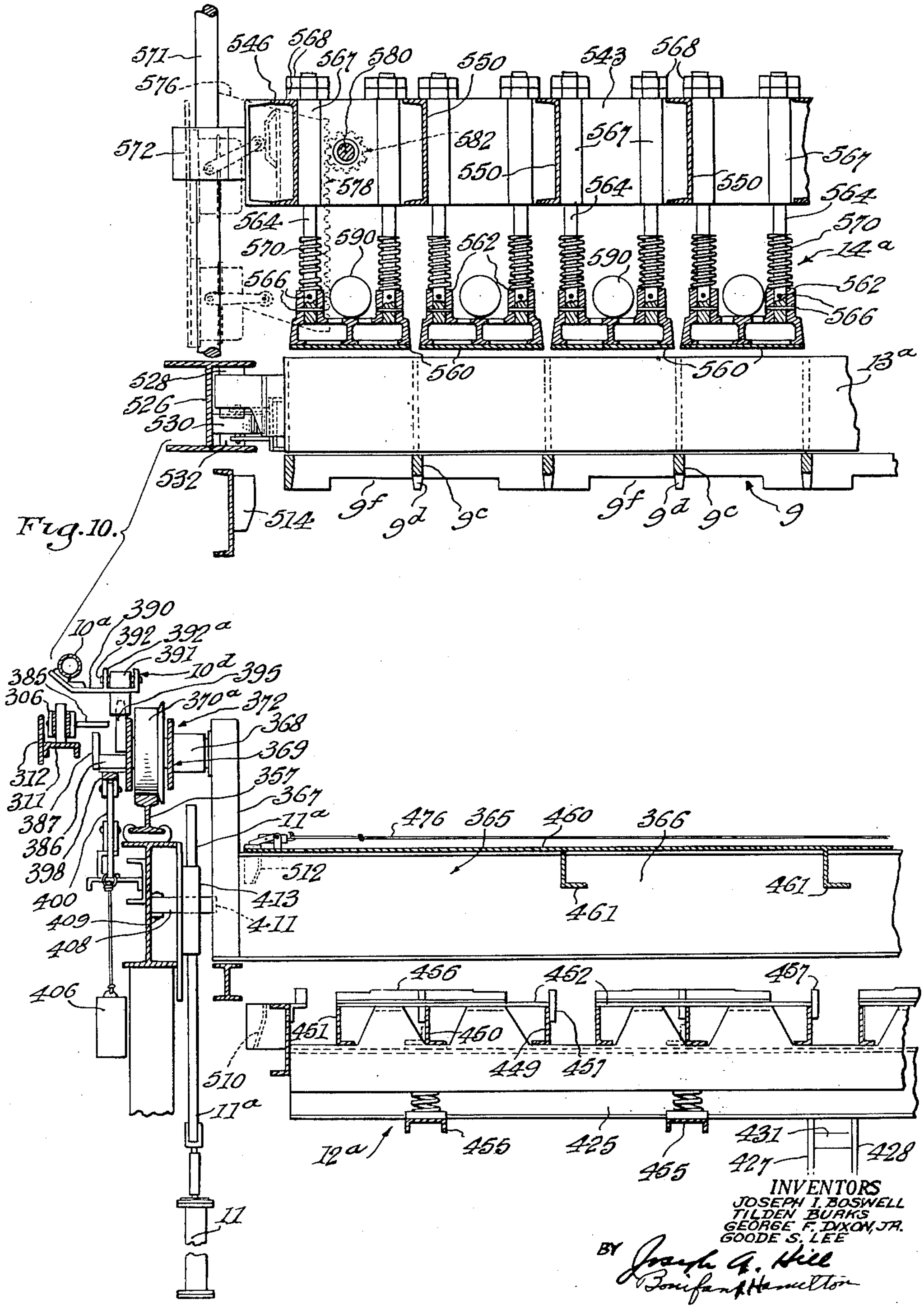

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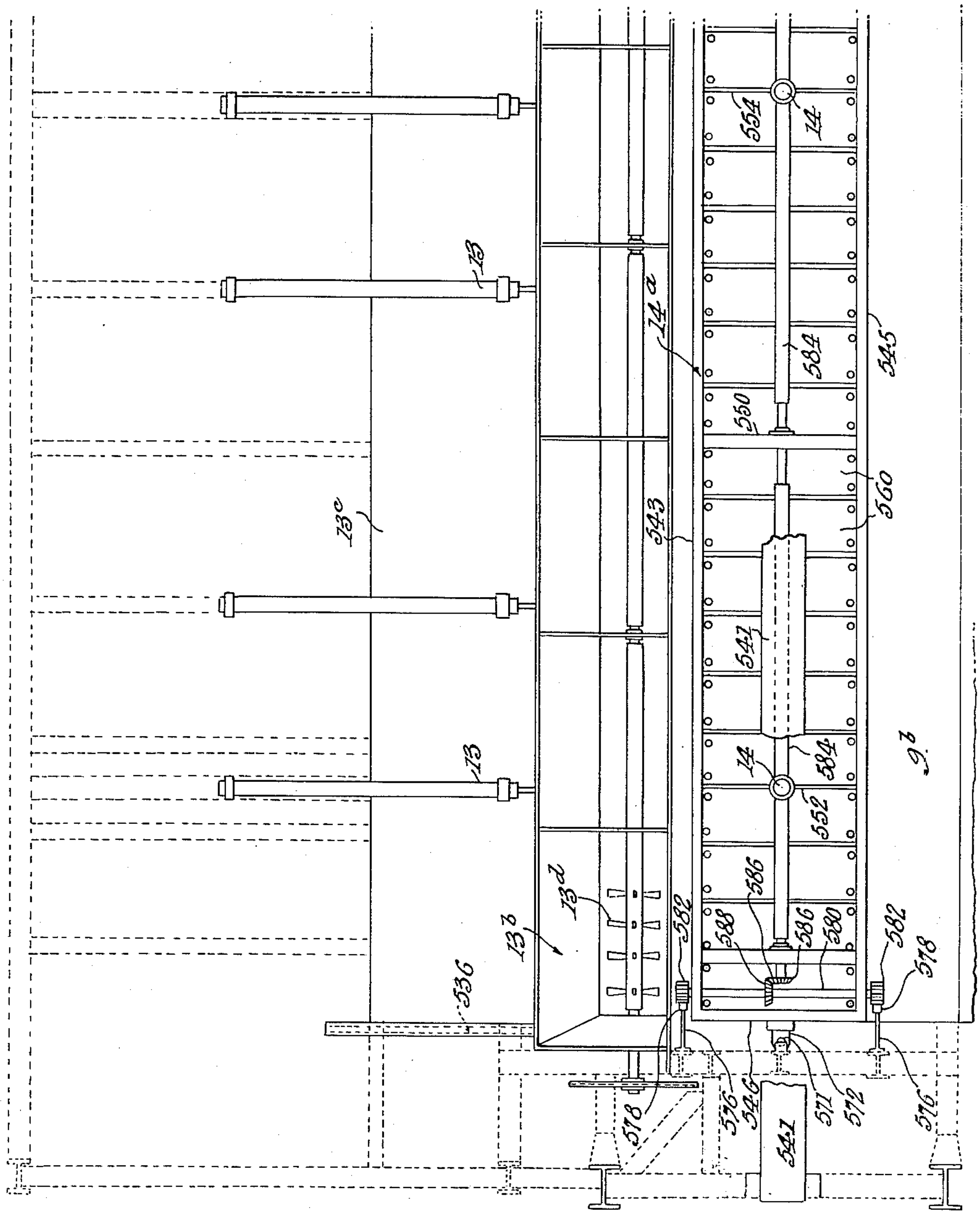

Fig. 11.

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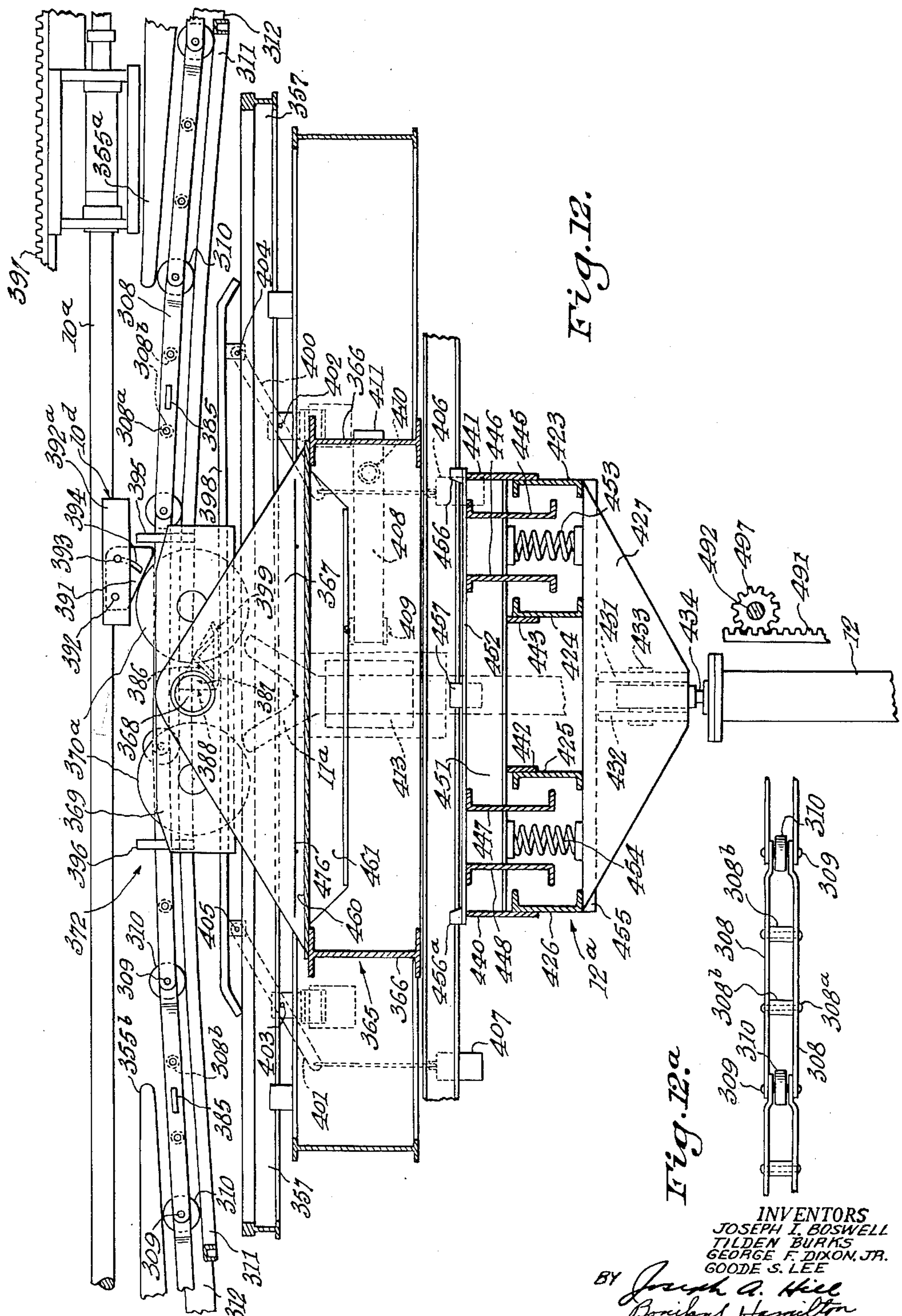

Fig. 12.

Fig. 12a.

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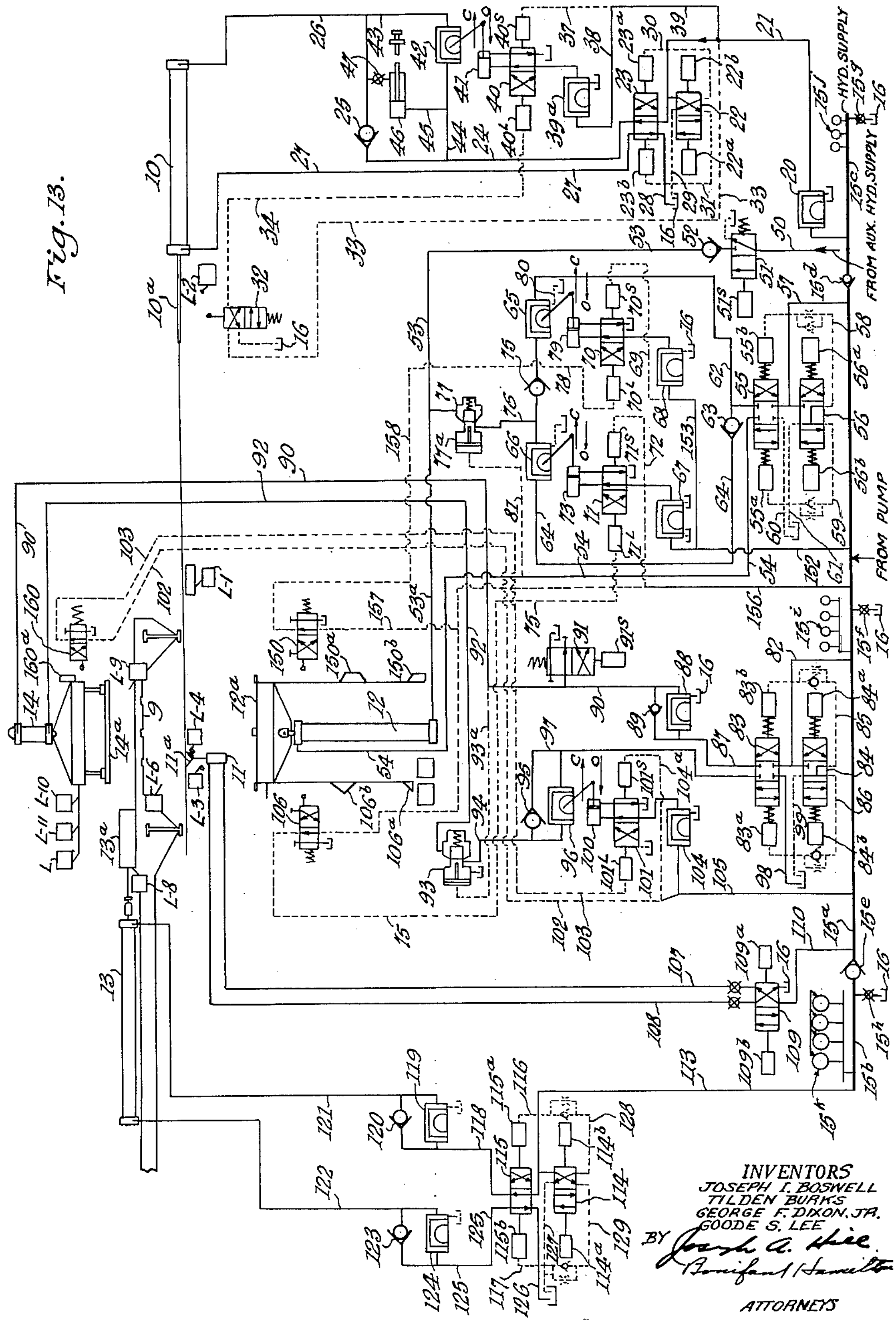

Fig. 13.

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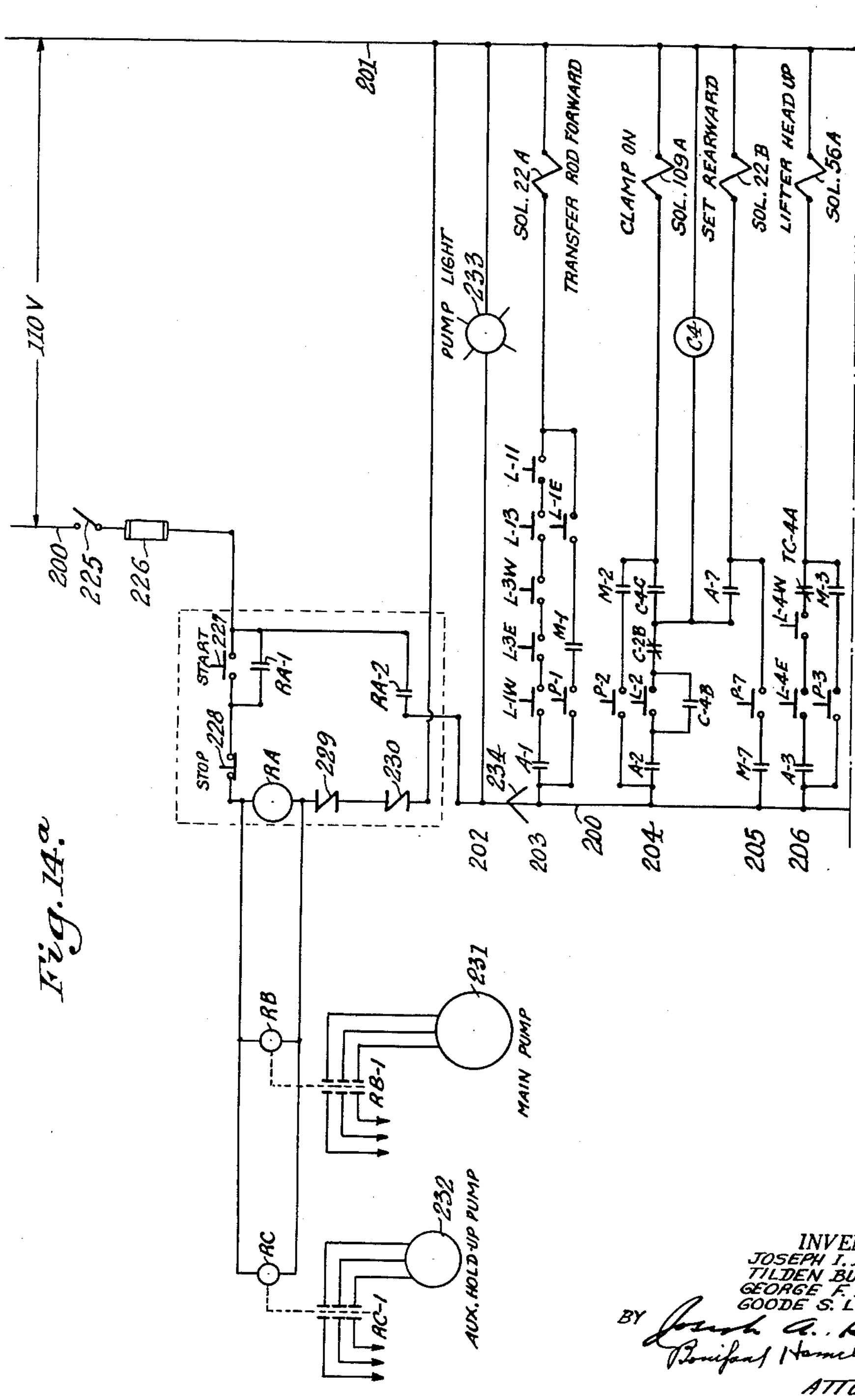

Fig. 14a.

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CONCRETE CASTING MACHINE

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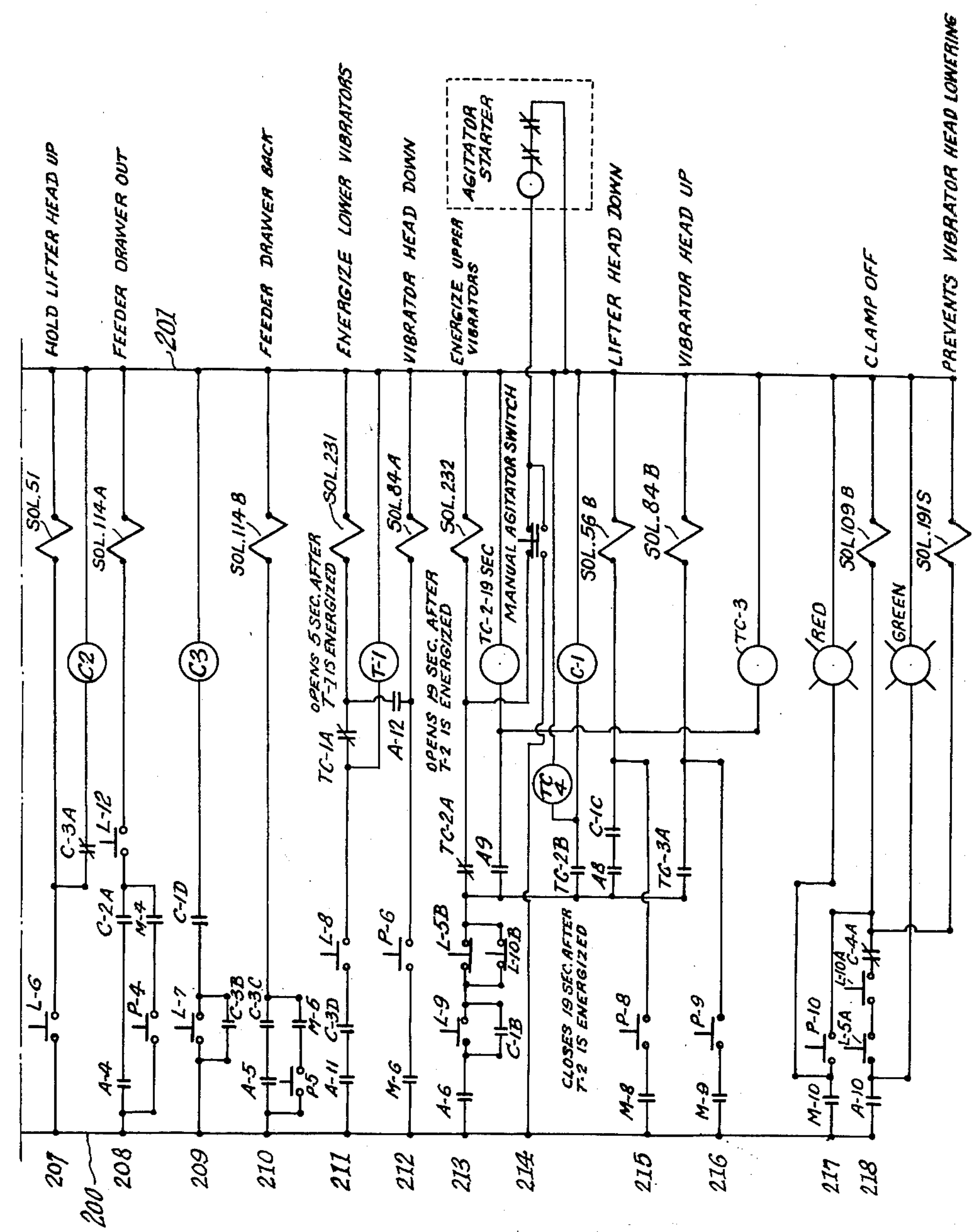

Fig. 14B

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CONCRETE CASTING MACHINE

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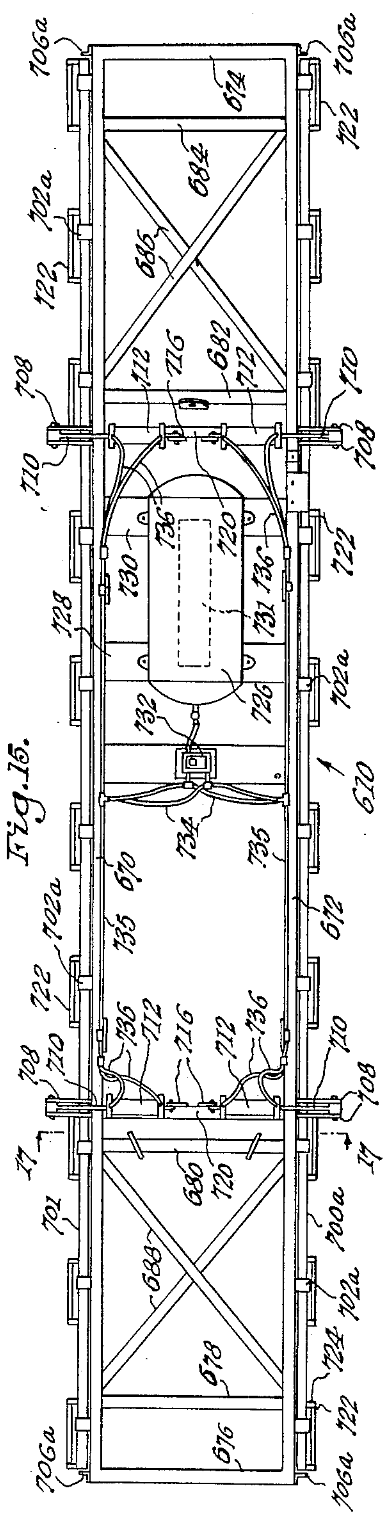

Fig. 15.

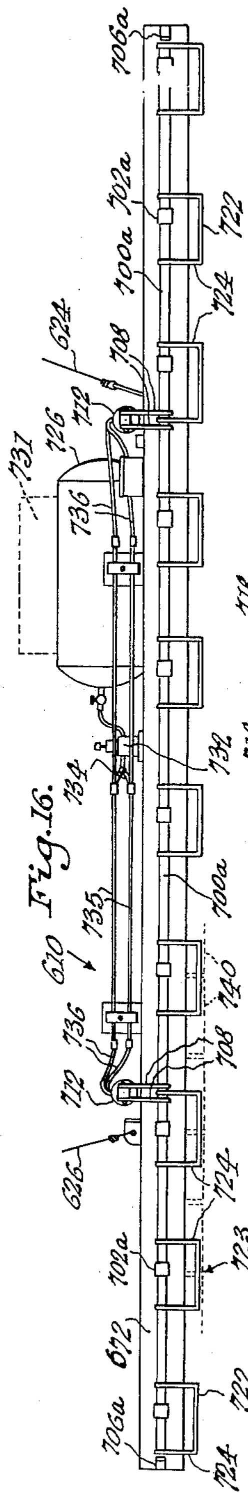

Fig. 16.

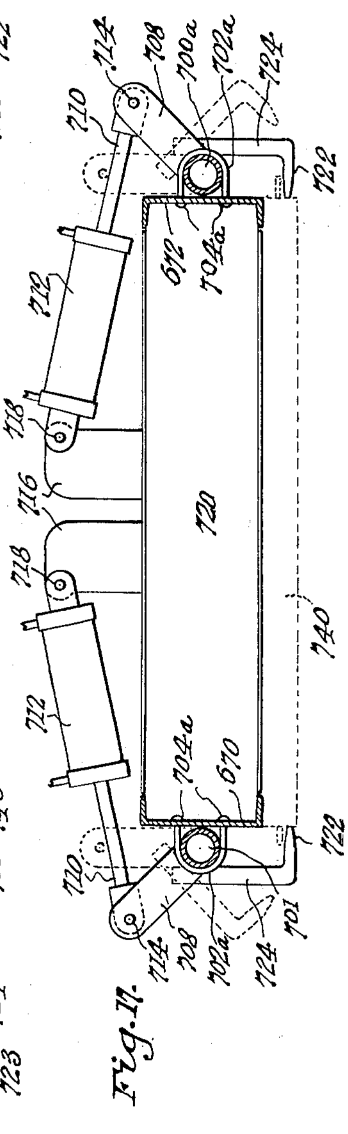

Fig. 17.

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CONCRETE CASTING MACHINE

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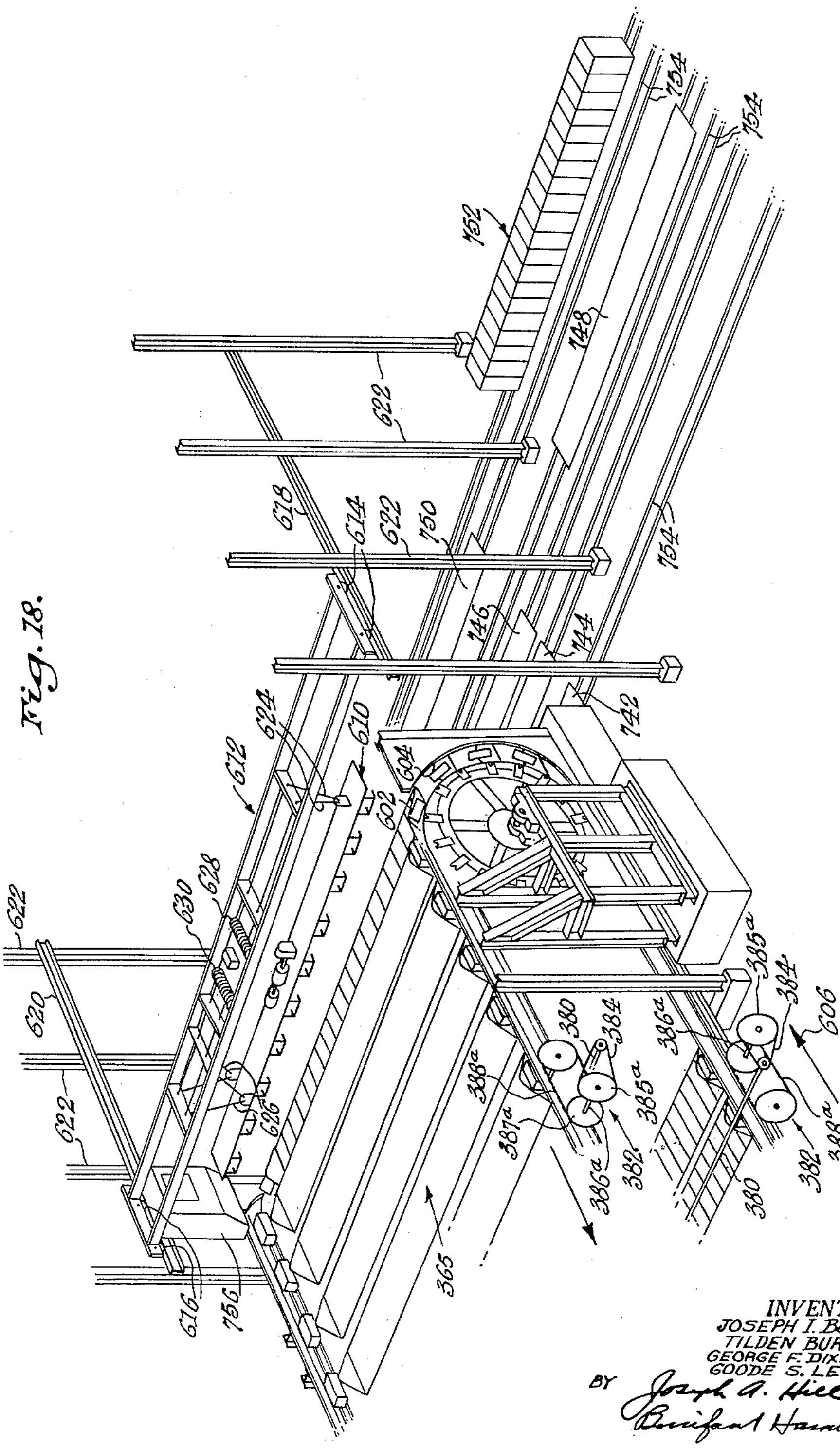
Fig. 18.



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3,139,663

Patented July 7, 1964

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3,139,663

CONCRETE CASTING MACHINE

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Filed Sept. 29, 1961, Ser. No. 141,914

6 Claims. (Cl. 25—2)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

The present invention relates to improvements in automatic apparatus for casting, on a production line basis, articulated concrete revetment mats employed to protect river banks and flood control levees from hydraulic erosion.

In particular, the present invention relates to improvements in casting plants of the type described in U.S. Patent No. 2,835,016, entitled "Concrete Casting Machine," issued to George F. Dixon, Jr., on May 20, 1958. Although concrete castings of virtually any shape could be produced in accordance with the present invention, the castings to be formed by the embodiment herein described in detail are of the standardized size and construction used by the U.S. Army Corps of Engineers in connection with flood control projects on the Mississippi River. The articulated mat castings are described in detail in the above-mentioned patent. Each casting is approximately four feet wide, twenty-five feet long and three inches thick. Each casting covers approximately one-hundred square feet installed and is commonly referred to as a "square." Each articulated square is comprised of twenty concrete slabs approximately one foot wide extending transversely of the casting and interconnected by a continuous wire "fabric" embedded in the concrete at a plane about the midpoint of the thickness of each slab. When installed, the squares are connected end to end and side to side to form a continuous flexible mat of any desired size.

While the above-cited patent discloses the general concept of a machine for producing cured concrete castings on a production line basis within a building to provide all-weather operation by mechanical forming means using vibration compacting and low water-cement ratios with accelerated curing in a kiln, the embodiment therein described has proven inefficient and therefore uneconomical to operate. This inefficiency is primarily caused by a low production rate due at least in part to the fact that the described apparatus required manual instigation of each of the various mechanical movements, with the conveyor system being stopped during each forming operation.

Therefore, the object of the present invention is to provide a substantially automatic casting apparatus of the type described having an increased output and therefore greater economy of operation.

Many additional objects and novel features of construction which directly contribute to an efficient and economic apparatus and the advantages which result therefrom will be obvious from a reading of the following detailed description in which:

FIGS. 1*a*, 1*b* and 1*c*, taken together, show a plan layout of a concrete casting plant constructed in accordance with the present invention;

FIG. 2 is a side elevation of a chain sprocket and asociated structure located at the slack take-up works shown in FIG. 1*c*;

FIG. 2*a* is a detailed plan view of an expansible rail joint shown in FIG. 2;

FIG. 2*b* is a detailed side elevation of the expansible rail joint of FIG. 2*a*;

2

FIG. 3 is a sectional elevation taken on line 3—3 of FIG. 2;

FIGS. 4*a*, 4*b* and 4*c* are schematic illustrations of the operation of the casting forming station of the plant shown in FIG. 1*a*;

FIG. 5 is a time and sequence chart for the casting forming station illustrated in FIGS. 4*a*, 4*b* and 4*c*;

FIG. 6 is a schematic illustration of the motion of a part of the casting station during operation;

FIG. 7 is a detailed diagrammatic elevational view, partly in section, of the casting station for the plant shown in FIGS. 1*a*, 1*b* and 1*c*;

FIG. 8 is a detailed diagrammatic, transverse elevational view of the casting station, shown partly in section, taken on line 8—8 of FIG. 7;

FIG. 9 is an enlarged view showing details of construction, partly in section, of the nesting guides hereafter described in detail;

FIG. 10 is an enlarged view of the casting station as viewed from the left end of FIG. 8 showing details of construction, partly in section;

FIG. 11 is a top view of a portion of the casting forming station of the plant shown in FIG. 7;

FIG. 12 is an enlarged longitudinal sectional view showing details of construction of the casting forming station;

FIG. 12*a* is a detailed top view of a part of a conveyor chain shown in FIG. 12;

FIG. 13 is a schematic diagram of the hydraulic system for actuating the various working elements of the casting forming station of the plant shown in FIG. 7;

FIGS. 14*a* and 14*b*, taken together, comprise a wiring diagram of the electrical system for controlling the sequential operation of the hydraulic system shown in FIG. 13 and hence the operation of the casting forming station;

FIG. 15 is a plan view of a device for engaging and removing cured concrete castings from the conveyor system of the casting plant;

FIG. 16 is a side elevation of the device of FIG. 15;

FIG. 17 is a sectional end elevation taken on line 17—17 of FIG. 15 with a concrete mat in phantom outline;

FIG. 18 is a diagrammatic perspective of the concrete casting removal station;

FIG. 19 is a detailed horizontal cross section of the cradle lifter guide shown generally in FIGS. 7 and 8; and

FIG. 20 is a detailed sectional view taken on line 20—20 of FIG. 19.

In accordance with the present invention, a continuously moving conveyor system transports a large number of flat pallets successively to a forming or casting station where a concrete casting is formed on each pallet. The pallets are then transported through a curing kiln where a relatively high temperature and maximum humidity is maintained, to a casting removal station where a novel hoist removes the cured castings from the pallets, past a pallet cleaning brush which removes concrete fragments which may remain on the pallets, to a station where two operators manually position a wire fabric on the pallets, past an oiling station where oil is dripped onto the pallets to prevent the concrete from sticking to the pallets, and once again to the forming station to complete the cycle. The entire operation is continuous and substantially automatic in that it requires only an operator for the conventional concrete mixing plant which supplies the forming station with plastic concrete, an operator stationed at the forming station to supervise and act in the event of a malfunction of the plant, an operator for the casting removal hoist, and two operators for positioning the wire fabric on the pallets.

FIGS. 1*a*, 1*b* and 1*c* taken together show a plan view of a plant layout in accordance with the present invention.

A suitable building indicated generally by **300** is of conventional design using vertical I beam columns **301** supported by a concrete foundation **302** and with siding **303** attached thereto. The building is divided into two general compartments, the first being that shown in FIG. 1*a* which houses the casting forming and the removal stages of the operation, and the second shown in FIGS. 1*b* and 1*c* which comprises a curing kiln.

The kiln begins at the partition **300*a*** which has two openings therein to receive a conveyor system and includes all of the building structure shown in FIGS. 1*b* and 1*c*. The kiln is properly insulated in a suitable manner so that the area can economically be maintained at a high temperature by five heating units with blowers, located generally at **300*b***. A steam generator is also provided at **300*c*** to maintain the humidity within the kiln as high as practicable. The heaters, steam generator and kiln building structure can be of any conventional type as the details of these components are not critical to the present invention. In an actual embodiment, the kiln is maintained at 180° F. at the entrance and 210° F. at the take-up works with a humidity of approximately 90 percent.

A concrete mixing plant of conventional design is shown generally at **305** and provides a volume of plastic concrete as demanded by the casting operation. The actual embodiment has four 50 cubic feet capacity batch mixers capable of mixing 37 cubic feet every every four minutes, and suitable concrete and sand silos and a water tank.

An endless conveyor system for transporting the flat pallets upon which concrete castings are formed extends substantially the entire length of the building **300** and has an upper reach which travels from the part of the building shown in FIG. 1*a* into the kiln and a lower reach directly thereunder which travels in the opposite direction. By using this system, the freshly formed castings carried by the system travel twice the length of the kiln to provide a longer curing time.

The conveyor system has two endless chains **306** and **307**. The two chains are of the same link construction. Each link is comprised of a pair of parallel plates **308** which are interconnected by a pair of bradded bolts **308*a*** which pass through spacer bushings **308*b*** as shown in FIG. 12*a*. The successive links are pivotally connected at adjacent ends by pins **309**. A roller **310** is journalled on each pin **309**. The rollers travel on chain tracks **311** which support the weight of the chains along both the upper and lower reaches. A side plate **312** extends along the outside of each chain track to maintain the chain on the track.

Synchronous movement of the two chains is provided by four separate electric driving mechanisms, each being of substantially identical construction. Two of the drives are in superimposed relation so that only one can be seen in FIG. 1*a*, generally at **382**. One drives the upper reach of the conveyor system and the other drives the lower reach. Similarly, two drives are shown in superimposed relation in FIG. 1*b* generally at **383** with one driving the upper reach and the other the lower reach of the conveyor system.

Now, describing one of the four drive systems, reference is made to FIGS. 1*a*, 1*b*, 12*a*, and 18 wherein an electric motor **381** drives a shaft **380** by means of a chain and sprocket arrangement. At each end of the shaft **380**, which extends transversely across the building, a chain **384** drives a sprocket **385*a*** on a shaft **386*a*** which drives another sprocket **387*a*** which drives lug chains **388*a*** having lugs which mesh between the two spacer bushings **308*b*** of each chain link and thereby drive the chains. Since each of the drive mechanisms for the two parallel chains uses a single motor with interconnected speed reduction gearing, the two chains must remain synchronized.

The fields of the four motors **381** which drive the reduction gearing are individually controlled by rheostats which are manually adjusted in a conventional manner to distribute equally the load between the four drive motors so that chain slack is fed to the take-up sprockets.

The conveyor system also includes a large plurality of cradles indicated generally at **365**, each of which supports a pallet **460** upon which the concrete castings are formed. Each cradle is suspended like a seat on a "Ferris Wheel" from a pair of two-wheel dollies shown generally at **370** and **372** in FIG. 8. As shown in FIG. 10, the cradle frame is formed of two end plates **367** which are interconnected by I-beams **366** to form an open rectangular structure. Axles **368** protrude horizontally from the end members **367** and are journaled in a rectangular chassis frame **369**. A pair of wheels **370*a*** are disposed within the chassis and rotate on axles connected within the chassis frame **369**.

The dollies **370** and **372** travel on cradle dolly tracks **356** which are located between and slightly below the chain tracks **311**. On the upper reaches of the conveyor system, the cradle dolly tracks are indicated at **357** as in FIG. 7. The dollies, it will be noted, are so constructed as to operate in one position as the cradles are traversing the upper reach and in an inverted position as the cradles are traversing the lower reach.

Each of the two endless chains has a plurality of pairs of corresponding lugs **385**, best shown in FIGS. 10 and 12, spaced at uniform intervals of about four and one-half feet. The lugs on the chains are so arranged that two opposing lugs are always in alignment as the chains are synchronously propelled by the driving means. Each dolly of each cradle has an inverted angle iron arm **386** extending outwardly from the chassis toward the chains. A right triangular wedge-shaped plate **387** is vertically disposed and connected to the end of arm **386**. The vertical edge of the wedge plate **387** is aligned with the center of the stub axle **368** of the dolly. A pair of corresponding lugs **385** of the chain engages the vertical edges **388** of the two wedges **387** of a cradle and push the cradle along the cradle tracks.

As previously mentioned, each of the four turn around sprockets are of identical construction, with only the support structure for the various sprockets being different. The sprocket illustrated in FIGS. 2 and 3 has an axle **335** which extends outwardly from the conveyor system and is journaled in two bearings **333** and **334** which are supported by suitable I-beam structure hereafter described. Each sprocket has an inner radial flange **338** and an outer radial flange **337** which are supported by suitable spoke structure radiating from the axle. A plurality of teeth **339** are equally spaced around the periphery of the outer radial flanges so that generally U-shaped notches **371*a*** in the outer ends thereof will receive each roller of the chain as the chain passes around the sprocket. Teeth **371** are spaced around the inner radial flange to receive the axles **368** of the cradles. The notches **371*a*** of the teeth **371** are tapered so that the cradles are set slightly ahead of the chain as the two pass around the sprocket to insure that the chain lugs do not interfere with the cradle lugs and that the chain readily re-engages the cradles as they are released on the lower reach by the sprocket teeth.

A curved continuation of each cradle track is attached to each sprocket support structure. Referring specifically to FIGS. 2 and 3, for example, the cradle tracks **357** of the upper reach extend from a curved portion **357*a*** completely around the sprocket to straight portion **357*b***. This curved continuation is supported by plates **358** and **358*b*** positioned between the two sets of teeth on the sprocket which plates are supported by structure **358*a***. The lower cradle track begins in a curved portion **373** and curves around to a straight portion **356** which is the lower reach.

As the cradles are engaged by the sprocket teeth, the curved continuation of the upper track **357** slowly turns the chassis frame from the horizontal. As the cradle approaches the horizontal position with the sprocket axle, the dollies slide outwardly into engagement with the lower track extension **373** and are lowered at a constant rate until they are inverted and released on the lower reach **356** where they are re-engaged by the chain lugs and moved along the lower reach. Similar curved tracks for the chains **306** and **307** are not required because tension on the chain will keep the chains engaged with the sprocket teeth. Substantially the same operation occurs at the head-works sprockets, except of course the conveyor is moving the cradles from the lower reach to the upper reach.

Each of the four sprockets is associated with similar curved track and support structure as described heretofore. However, the support structure at the head-works, shown in FIGS. 1*a* and 18, is stationary while the take-up support structure located in the kiln, FIG. 1*c*, is horizontally movable to provide a means for taking up slack in the chains due to thermal expansion. A generally rectangular floating structure bounded by members **328**, **329** and **327** supports the track continuations of both the upper and lower reaches. This rectangular structure has lower beams **321** and **322** which ride on sets of rollers **317** and **318**, respectively, as shown in FIG. 3. The axles of rollers **317** are interconnected by bars **319** and **319*a*** and the axles of rollers **318** are similarly interconnected by bars **320** and **320*a***. These roller sets travel on I-beams **309*c*** and **310*d***, respectively, which rest on concrete foundation **308*e***. Transverse beams **315** support a third I-beam **316**. Brackets **324** are connected to cross beams **323** of the riding structure and embrace and slide along beam **316** to maintain the riding sprocket structure in proper alignment on rollers **317** and **318**.

A cable **339*a*** is connected to eyelet **340** of the riding structure and passes outside the kiln to weight tower generally indicated at **341**, shown in FIG. 1*c*. The cable passes under a sheave **342** and over a second sheave **344** and supports a weight **345**. The weight **345** continually exerts a force on the riding sprocket structure in such a manner as to keep the chains taut during thermal expansion and contraction. A similar take-up sprocket, riding support and weight tower therefor is provided for the other chain.

Each of the two chain tracks and each of the trolley tracks has an expansible joint between the permanent structure **374** in both the upper and lower reaches to permit free movement of the take-up works and yet provide a continuous uninterrupted track for the rollers. One type of expansible joint which has proven successful is shown in FIGS. 2*a* and 2*b*. A plurality of flat plates **375** are turned on edge, separated by spacers **376** and are connected to the riding structure by pins **377**. A similar set of flat plates **378** are alternately disposed between plates **375** within channel **330**. Plates **378** are alternately separated by spacer plates **379** and are connected to stationary conveyor system support structure **374** by bolts **374*a***. Plates **375** slide relative to plates **378** as the floating take-up structure moves and continually provide a level track for the chain or cradle rollers as the case may be.

The conveyor system continuously transports the casting pallets in a complete cycle, which for convenience of discussion can be considered as beginning at the fabric station. As the pallets approach the fabric station, they are clean and ready for the casting operation. A platform **700** extends transversely of the conveyor system above the upper reach of the chain. A sliding access door **702** in building **300** provides a means where a bail of preformed fabric units can be conveniently placed on the platform by a suitable traversing hoist. Each preformed fabric element is comprised of copper coated steel wire and has three parallel longitudinal links interconnected at spaced intervals by ten rectangular loops extending transversely thereof as can readily be seen at **704** in FIG. 1*a*. Each pallet is provided with three spring loaded, boomer-type snatch latches at each end thereof which engage the ends of the long strands of the fabric. Two operators manually place a fabric element on each pallet as it emerges from under the platform.

The pallets with fabric latched thereon proceed under an oiling station **706** where a small quantity of oil is dripped from a perforated tube onto the surface of the pallets to prevent the concrete from sticking thereto. A suitable reservoir (not shown) feeds oil to the tube by gravity. Of course some oil will wet the fabric wires also, but since the wires are completely encased by concrete, this is unimportant, and oiling the pallets after the fabric station provides cleaner working conditions for the fabric operators.

Next the pallets proceed to a casting station where a concrete square is cast on each pallet. The operation of the casting station is schematically illustrated in FIGS. 4*a*, 4*b*, and 4*c* taken in conjunction with time and sequence chart FIG. 5.

Referring specifically to FIG. 4*a*, the conveyor system is moving from left to right as indicated by the arrow. Cradle D, position V, has a freshly formed casting thereon and is being transported away from the casting station. Cradle C is resting at the casting station, position III, after having a casting formed thereon and is waiting to be re-engaged with the conveyor system. Cradles A, position I, and B, position II, are being transported by the conveyor and are approaching the casting station.

As cradle B reaches position II, a pair of limit switches are actuated which causes the transfer rod **10*a*** to rapidly move both cradles B and C in advance of the normal chain travel. Cradle C is moved to position IV where it is almost immediately re-engaged by the chain lugs. Cradle B is moved to the casting forming station, position III. Six seconds are required to set the two cradles forward as can be seen by reference to operation No. **1**, FIG. 5.

When the cradles reach the set forward position, additional limit switches are actuated which cause rod **10*a*** to return to the original position, that shown in FIG. 4*b*. Two Y-shaped clamps **11*a***, one positioned at each end of the cradle, are raised by hydraulic motors and engage cradle stub axles **368** to clamp the cradle in position III.

Lifter head **12*a*** is then raised by hydraulic motors **12** and passes through the open rectangular frame of the cradle and engages and lifts the pallet **460**, pressing it against the bottom of mold box **9** as shown in FIG. 4*b*. The mold box is an outline of the castings to be formed. Aprons **9*a*** and **9*b*** are flush with the top of the mold box **9** and extend horizontally therefrom. The pallet **460** comprises the bottom of the casting mold, the mold box forms the sides, and the top of the mold is open.

Plastic concrete is deposited in hopper **13*b*** and falls downward into feeder drawer **13*a***. The volume of concrete in the feeder drawer **13*a*** is precisely that required to fill the mold box **9** to the desired level. Feeder **13*a*** is then forced outwardly across the mold box to the position shown in FIG. 4*b*. As the feeder passes over the mold box, the plastic concrete is deposited and fills the mold. The feeder immediately returns to the initial position in register with hopper **13*b*** where it is refilled with plastic concrete for the next cycle. An apron **13*c***, which is flush with the top of the feeder drawer, serves as a valve on the bottom of the hopper **13*b*** as the feeder passes over the mold box.

As the feeder returns to its dwell position, operations Nos. 6 and 7, FIG. 5, begin simultaneously. The upper vibrator **14*a*** is lowered into the top of the plastic concrete in mold box **9**, as shown in FIG. 4*c*. At the same time the upper vibrator **14*a*** begins to lower, eccentric vibrators connected to lifter head **12*a*** start to vibrate. The lower vibrators on lifter head **12*a*** serve to begin settling the plastic concrete and insure that the upper vibrator **14*a*** will be properly seated within the mold box. As the upper vibrator reaches the down position it also starts vibrating, operation No. 8. The lower vibrator stops vibrating three seconds after the upper vibrator starts. The upper vibrator vibrates for a total of nineteen seconds to thoroughly compact the plastic concrete into a homogeneous mass.

When the upper vibrator stops vibrating, the lifter **12a** starts down, operation No. **9**. The weight of the upper vibrator remains on the plastic casting for one second and aids in forcing the freshly formed casting from the mold. Then the upper vibrators return to the up position, operation **11**. When the lifter head and the upper vibrator have reached their dwell positions, those shown in FIG. 4*a*, clamps **11a** are lowered, operation **12**. The casting station remains inoperative with all elements in the positions shown in FIG. 4*a* until cradle A is advanced by the normal motion of the chain to position II. Then the cycle repeats with transfer rod **10a** moving cradle A into position III where a casting will be formed thereon and moving cradle B into position IV where it will be re-engaged by the conveyor system and moved into the kiln.

After the cradles with the freshly formed castings thereon are re-engaged by the conveyor system, they proceed along the upper reach into the kiln where the temperature upon entrance is maintained at approximately 180° F. The cradles continue along the upper reach to the take-up sprockets where the temperature rises as high as 230° F. and then back along the lower reach to the kiln exit. The trip through the kiln requires less than two hours depending upon the speed of the chain. As previously mentioned, the humidity in the kiln is maintained as high as possible. The semicured castings then cool as they proceed along the lower reach to the mat removal station, hereafter described in detail.

FIGS. 7–13 show various detailed views of the casting station. The two transfer rods **10a** can be seen above the upper reach on opposite sides of the cradles in FIG. 8. Each transfer rod **10a** has two legs indicated generally at **10c** and **10d**. Referring to FIGS. 10 and 12, each lug is comprised of a wedge **391** pivotally carried on an axle **392** which is connected to a pair of vertical plates **392a** on arm **390**. Arm **390** is welded to rod **10a**. Each wedge also has an arcuate slot **394** through which a pin **393** passes. The pin **393** is also secured to the plates **392a**. This construction permits upstanding spikes **395** and **396** connected to the cradle dollies to pass under the inclined portion of the wedge **391** thereby pivoting the wedge upward until the wedge drops down behind the upstanding spike so that the rod can move the cradle dollies forward. Each of the four transfer rod lugs are of identical construction.

A rack and pinion arrangement is provided to insure that the two transfer rods **10a** are always synchronized in movement. A rack **397** is mounted on top of each rod. A shaft (not shown) extends from one gear rack **397** transversely of the conveyor system to the other gear rack mounted on the other transfer rod. Pinions (not shown) are splined on each end of the shaft and mesh with the gear racks **397** to insure that motion of one transfer rod is mechanically transmitted to the other. This arrangement insures that the movement of the rods is synchronized despite unequal forces which might be exerted by the two hydraulic motors **10**, shown in FIG. 13.

As previously mentioned, the transfer rods simultaneously set two cradles in advance of the chain travel. The forward cradle is re-engaged with the chain while the rear cradle is disengaged from the chain and left at the casting station. The chain track as it passes the casting station is raised so that chain lugs **385** pass over the triangular cradle lugs **388** which are connected to the dollies. To insure that tension does not lift the chain too soon and disengage a cradle before it reaches position II, upper rail **355b** is positioned above the rollers to hold the chain down. Similarly, upper rail **355a** holds the chain down at position IV to insure that the chain lugs re-engage the cradle. As a cradle is moved from the casting station forward to be re-engaged with the chain, the leading edge of the triangular cradle lug **387** connected to the dolly actually wedges under the chain lug **385**, forcing it upwardly until the chain lug drops down behind vertical edge **388**.

Several means are employed to decelerate the cradles which are moved rapidly by the transfer rods to a stop at the casting station. At each end of the cradle, a drag brake **398** rides against plate **399** which is connected to the bottom of angle iron extension **386** which extends outwardly from each cradle dolly. The drag brake is supported by levers **400** and **401** which are pivotally mounted on suitable support structure at **402** and **403**, respectively, and are pivotally connected to the drag brake shoes at **404** and **405**, respectively. Weights **406** and **407** are suspended at the other ends of the levers **400** and **401**, respectively, and continually urge the drag brake upwardly against plate **399**.

Also provided at each end of the cradle is a spring biased detent device having an arm **408** which is pivotally mounted at one end **409** and is biased outwardly by spring **410** into engagement with the leading edge of the cradle. A cylindrical lobe **411** retains the cradle as it engages the leading edge thereof until the detent is depressed by excessive force exerted on the cradle, which force occurs when the transfer rod moves the cradle from the casting station to the point of re-engagement with the chain.

Y-shaped clamps **11a** are provided at each end of the cradle and slide in sleeves **413** when raised and lowered by hydraulic motors **11**. The clamps are raised into engagement with the stub axles **368** of the cradles to hold the cradles in position at the casting forming station.

The lifter head **12a** is comprised generally of a rectangular frame which is raised and lowered by two hydraulic motors **12** supported by transverse beam **352**. Four channel beams **423**, **424**, **425**, and **426** extend longitudinally of the lifter head and are supported in spaced relation by triangular plates **427**, **428**, **429**, and **430**. Plates **427** and **428** are interconnected by spacer plates **431** and **432** which form a trunnion for pin **433** which is connected to rod **434** of one motor **12**. Similar spacer plates and a pin pivotally connect the piston rod **437** of the other motor **12** to the lifter head.

Ten vibrator segments are spring supported on the rectangular lifter frame. Each vibrator section has end plates **440** and **441** and plates **442** and **443** shown in FIG. 12 which are so spaced as to embrace the longitudinal beams **423**, **424**, **425** in close-fitting, sliding engagement to permit independent vertical movement of each vibrator section. Each vibrator section also has cross bracing members **445**, **446**, **447**, and **448** which extend longitudinally of the lifter head and cross braces **449**, **450**, and **451** which extend transversely of the lifter head, and a flat, horizontally disposed plate **452**. Each vibrator section is supported by stiff coil springs **453** and **454** which are connected to channel beam braces **455**. A conventional vibrator (not shown) comprised of an electrically driven eccentric is mounted on each spring supported vibrator section.

Each lifter head vibrator section has side lugs **456** and **456a** and a center lug **457** projecting above the plate **452**. The lifter head is so dimensioned as to pass through the cradle between the longitudinal beams **366** of the cradle and engage and lift the pallet **460** carried by the cradle. Pallet **460** is reinforced by cross braces **461** which are tapered at each end so that the pallet will align itself between the I-beams **366** to a certain extent. Pallets **460** have slots (not shown) which register and receive the lugs **456**, **456a**, and **457** of each vibrator section of the lifter head, so that the lugs protrude through the pallets and support wire fabric **476** at a height above the pallet corresponding to the midpoint of the casting.

A pair of guideposts **480** and **481** which are connected to the lifter head **12a** are shown in FIGS. 8, 19, and 20. A wide flange **483** is stiffened by flanges **483a** and **483b** and is connected to web **484** of the **T** beam having a flange **485**. A pair of angle iron members **486** and **487** are aligned on opposite sides of the guide post. Four rollers **488** having **V** shaped rolling surfaces are disposed in pairs, one on each side of the post, and are supported by trunnions **489**, which in turn are supported by suitable brackets within rectangular housings comprised of plates **489***a*. These guide posts and associated roller insure that the lifter head remains properly aligned as it is raised through the cradle and presses the pallet against the mold box.

Gear racks **490** and **491** are mounted on guide posts **480** and **481**, respectively. An axle **492** is mounted in bearing **493**, **494**, and **495**, as shown in FIG. 8. Pinions **496** and **497** are splined on the axle **492** and mesh with the gear racks **490** and **491**. This rack and pinion system insures that the lifter head **12***a* always remains exactly horizontal during raising and lowering regardless of unequal lifting forces which may be exerted by hydraulic motors **12**.

A mold box **9** and associated aprons **9***a* and **9***b* are supported by a plurality of triangular plates **500** and **502** and by pairs of end braces **504** and **506** at each end thereof as shown in FIG. 7. The mold box constitutes the vertical boundaries of the casting mold, which in this particular embodiment is a flexible mat comprised of twenty individual concrete slabs interconnected by wire fabric. The general rectangular outline of the mold box is interconnected by transverse members **9***c*, FIGS. 8 and 10, to form the twenty separate rectangular compartments. Each transverse member **9***c* is tapered at the bottom to permit easy lowering of the freshly formed casting from the mold. Each transverse member **9***c* has a rectangular notch **9***d*, FIG. 7, in the center thereof and smaller notches **9***e* on each side thereof to accommodate the three longitudinal strands of the wire fabric which must be supported at the midpoint of the casting. The two longitudinal side members of the mold box have large notches **9***f* which interconnect adjacent compartments of the mold box and which are sized to receive the upstanding lugs **456** and **456***a* of the lifter head. The center notches **92** are proportioned so as to receive center lugs **457** of the lifter head.

As previously mentioned, the lugs on the lifter head protrude through slots in the pallet and engage the wire fabric. The lugs **456** and **456***a* engage the loops **458** as in FIG. 8 which extend from the sides of the completed mat squares and which interconnect adjacent slabs of the squares. The center lugs **457** engage the center longitudinal strand of the fabric. Therefore, when the lugs on the lifter head are seated in the slots of the mold box, the wire fabric is clamped between the mold box and lifter head lugs so that the fabric is suspended at a distance from the pallet approximating the center of the concrete casting. By placing the lugs on the lifter head rather than on each of the pallets, only one set of lugs is required rather than putting a set of lugs on each of the pallets.

It is essential that the lifter head lugs be properly aligned so as to pass through the slots in the pallet and also properly aligned to engage the notches in the mold box. Therefore a pair of nesting guides are provided. Reference is made to FIG. 10 wherein a first nest member **510** is secured to each end of the lifter head and has downwardly converging sides to provide a smaller bottom than top. A similar but smaller member **512** is connected to each end of each pallet. A third similar but still smaller element **514** is connected to appropriate supporting structure adjacent each end of the mold box. As the lifter head rises, the tapered point of the number **512** easily engages the enlarged top portion of the nest **510** and the weight of the pallet acting against the inclines of the nest **510** will center the pallet as the point **512** seats in the tapered lower portion of the nest **510**. As the lifter head and pallet reach the mold box, the same system is used with member **512** serving as a nest for the wedge **514**. Therefore, when the three nesting members are firmly seated one within the other, it is assured that the lifter head, pallet, and mold box are properly mated.

Plastic concrete is provided as required by a shuttle conveyor **520** which travels on track **522** transversely of the conveyor system as in FIG. 7. The shuttle conveyor is of conventional design and does not comprise a part of the present invention. The conveyor has a depending spout **524** into which the plastic concrete drops from conveyor **520**. The shuttle conveyor and spout is moved from one end of the hopper **13***b* to the other by suitable electric motors each time that a mat square is cast and deposits a layer of concrete in hopper **13***b* to replenish the supply for the next casting operation. An agitator **13***d* extends longitudinally of a lower part of the hopper and is rotated periodically to agitate and prevent the concrete from setting in the hopper.

With the feeder drawer **13***a* in position shown in FIG. 7, the concrete falls downward into the feeder drawer which is merely a rectangular box having a suitable transverse bracing which is of a measured volume to deposit the precise volume of plastic concrete in the mold box.

The feeder drawer or box actually slides along the upper surface of aprons **9***a*, **9***b*, and mold box **9**. However, due to aggregate in the plastic concrete there are considerable forces tending to force the feeder drawer out of the proper path. Therefore, connected to each end of the feeder drawer is a set of three rollers to insure that the feeder drawer travels in the proper path. An I-beam **526** is provided at each end of the feeder drawer and a roller **528** engages the underside of the upper flange of the beam as shown in FIG. 9. Another roller **530** travels on the web of the beam, and a third roller **532** rolls on the lower flange of the I-beam. The guide rollers **528**, **530**, and **532** have been omitted in FIG. 8 for purposes of illustration. As previously mentioned, an apron **13***c*, shown in FIG. 7, extends from the top of the feeder **13***a* and serves as a valve on the bottom of the hopper **13***b* as the feeder travels out and back across the mold box **9**.

Hydraulic motors **13** move the feeder out and back across the mold box. Referring to FIG. 11, the two outside motors **13** force the feeder box **13***a* out and an additional two motors are required to bring the feeder box back due to the reduced power of the hydraulic motors when the fluid is acting on the rod side of the pistons.

A gear rack and pinion arrangement shown in FIGS. 8 and 11 is provided to insure that the feeder will not be forced out of alignment by unequal forces exerted by the several hydraulic motors **13**. Two gear racks **536** and **538** are secured to the support structure with the gear teeth facing downwardly. A shaft **540** journaled in bearings (not shown) connected to the feeder structure has a pair of pinions **542** and **544** splined on each end. The shaft and pinions are arranged so that the pinions are under the gear racks and mesh therewith. Motion of one end of the feeder is mechanically transmitted to the other by the rack and gears to maintain the feeder in exact alignment.

The upper vibrator head indicated generally at **14***a* in FIGS. 8 and 11 is raised and lowered by hydraulic motors **14** which are suspended from overhead box beam **541**. A rectangular frame is comprised of longitudinal members **543** and **545** and end member **546** with the other member not shown is braced by cross members **550**. Triangular plates **552** and **554** are connected by pins to the piston rods of the motors **14**.

Twenty individual vibrator heads indicated at **560** in FIGS. 8 and 10 are so dimensioned as to fit into and cover each separate compartment of the mold box. Each vibrator head **560** is cast with four upstanding sleeves **562**. A rod **564** is inserted into each of the sleeves and connected thereto by a pair of pins **566**. Each rod **564** extends upwardly through a sleeve **567** which is welded to the frame of the vibrator head. A pair of nuts **568** are threaded onto the upper portion of the rods **564** and are adjusted at a height so that the lower face of the individual vibrator **560** is substantially horizontal. The two nuts are then locked one against the other so as not to loosen under vibration. A coil spring **570** encircles each of the rods **564** and is disposed between the individual heads **560** and the frame. An electrically driven eccentric vibrator **590** is mounted on each individual vibrator head **560**.

A guide post **571** is located at each end of the upper vibrator and suitably connected to rigid support structure. A sleeve **572** is connected to the midpoint of one end of the vibrator frame and slidingly embraces post **571** to insure that the individual vibrator heads remain properly aligned with the mold box as they are raised and lowered.

A rack and pinion system is also provided to maintain the vibrator level during raising and lowering. Plates **576** support vertically disposed gear racks **578** adjacent each of the four corners of the vibrator frame. A shaft **580** is journaled in each end of the frame, extends transversely thereof, and has pinions **582** splined on each end. A longitudinal shaft **584** extends longitudinally of the frame and has bevel gears **586** splined to each end which mesh with bevel gears **588** splined at the midpoint on the corresponding shaft **580**. Therefore, if any corner of the frame is moved, the movement is transmitted by the gear, shaft and rack arrangement to each of the other corners of the frame.

When the frame **14***a* is lowered by motors **14**, the individual vibrator sections **560** rest on top of the plastic concrete in each compartment of the mold box. The rectangular frame continues to lower with the sleeves **567** sliding down rods **564** until the weight of the frame is resting on the coil springs **570**. The weight of the frame does not aid materially in compacting the concrete, but does prevent excessive bouncing of the individual heads **560** during the vibrating period. The added weight of the frame also aids in forcing the compacted casting from the mold box as the lifter head is lowered after vibration is completed, as previously described.

FIG. 13 is a diagram of the electrically controlled hydraulic system which provides the actuating power for the various movements of the casting station mechanism. Standard hydraulic symbols are used throughout FIG. 13. All hydraulic fittings are commercially available items. The moving parts of the casting mechanism are shown in their approximate relative positions. For example, cylinder **10** represents the two hydraulic motors which actuate the two transfer rods **10***a*. Cylinder **11** represents the two motors which raise and lower the two Y-shaped clamps **11***a*. Cylinder **12** represents the two motors which raise and lower the lifter heads **12***a*. Cylinder **13** represents the two motors which push feeder drawer **13***a* on the outstroke across the mold box **13***b* and also the two additional motors which are actuated only to aid in returning the feeder drawer back across the mold box. Cylinder **14** represents the two motors which lower and raise the upper vibrator head **14***a*. In all cases, where two or more hydraulic motors are used for the same purpose, the motors are connected in parallel and fluid is fed to both simultaneously.

The hydraulic system is provided with a fluid supply tank which is represented throughout the diagram by the symbol shown at **16**. An electrically driven, pressure compensating hydraulic pump takes fluid from the supply tank and pumps it into a header at pressures up to 1500 p.s.i. The header is divided into sections **15***a*, **15***b*, and **15***c* by check valves **15***d* and **15***e*. The sections are provided with bleed valves **15***f*, **15***g*, and **15***h* respectively, which return fluid to the supply tank **16** when manually opened. The check valves permit fluid to flow from the center section **15***b* to the outer sections, but not from the outer sections back to the center section. In this manner, a reserve of fluid at operating pressure is always assured in the outer sections.

Associated with each header section is a set of accumulators, sets **15***i*, **15***j*, and **15***k* being connected to header sections **15***a*, **15***b*, and **15***c*, respectively. The accumulators are steel cylinders each having a neoprene envelope preinflated with nitrogen to a pressure of 900 p.s.i. As the noncompressible hydraulic fluid is pumped into the accumulators, the nitrogen is compressed to 1500 p.s.i. When the fluid is released from the accumulator, the nitrogen expands and provides a relatively large volume of fluid at pressures decreasing from 1500 p.s.i. down to 900 p.s.i.

The transfer rod **10***a* is actuated by cylinder **10**. Solenoid **22***a* is energized to move rod **10***a* to the right on what has heretofore been termed the "set forward" stroke. When solenoid **22***a* is energized, valve **22** is shifted to the right. Hydraulic fluid then passes from header **15***c*, through control valve **20**, conduit **21**, valve **22**, conduit **30**, to pilot cylinder **23***a*, which shifts valve **23** to the left. Fluid then passes from conduit **21** through valve **23** and through conduit **27** to the rod end of motor **10** and the transfer rod **10***a* is forced to the right. Fluid leaves the head end of motor **10** through conduits **26** and **43**, through flow control valve **42**, conduits **44** and **24**, valve **23** and through conduit **28** which returns the fluid to the supply tank. Check valve **25** forces the fluid to pass through control valve **42**. Cylinder **46** is provided to accommodate the large volume of fluid which results from the rapid advance of the rod **10***a*.

Transfer rod **10***a* contacts two cradles and moves them forward at a relatively high rate of speed as previously described. Since the cradles are large and have high moments of inertia, it is necessary that the cradles be accelerated uniformly from the stationary or very slow speed to the high speed and then decelerated at the end of the stroke to a smooth stop. Variable flow control valve **42** is provided to control the speed of rod **10***a* by metering the fluid as it leaves the head end of cylinder **10**. The control arm of valve **42** is actuated by motor **41**. The position of motor **41** is controlled by valve **40**. The position of valve **40** is controlled by pilot cylinders **40S** and **40L**. Pilot cylinder **40L** has a greater effective area than pilot cylinder **40S** and when the two cylinders are subjected to the same pressure, the larger area of cylinder **40L** will overcome the smaller cylinder **40S**, and the valve **40** will be moved to the right. The smaller pilot cylinder **40S** is always supplied with fluid at substantially header pressure by conduits **37**, **39**, **21** and manual control valve **20**. Hydraulic fluid to the large pilot cylinder **40L** is supplied through valve **20**, conduit **21**, conduit **33**, valve **32**, and conduit **34**. Valve **32** is spring biased into the up position and is cam actuated into the down position.

At the beginning of the "set forward" stroke, valve **32** is depressed by a cam (not shown) attached to rod **10***a* and valve **32** is in the down position as shown. Hydraulic fluid is bled from the larger pilot cylinder **40L** through conduit **34** and valve **32** and returned to tank **16**. The smaller pilot cylinder **40S**, which is always subject to header pressure, shifts valve **40** to the left, the position shown. Fluid then passes through valve **20**, through conduit **21**, conduit **39**, conduit **38**, manually adjustable valve **39***a*, and through valve **40** to the head end of cylinder **40** which forces the piston to the right and moves the control lever of valve **42** to the closed or most restrictive position indicated by arrow C. Fluid is then metered out of cylinder **10** at a very slow rate and the initial movement of rod **10***a* is very slow.

As soon as the transfer rod **10***a* contacts the cradles, the cam passes valve **32** and the spring biases the valve **32** into the up position. Hydraulic fluid at header pressure passes from conduit **33** through valve **32** and through conduit **34** to the larger pilot cylinder **40L** which overcomes the smaller pilot cylinder and shifts valve **40** to the right. Fluid then passes through valve **40** to the rod end of cylinder **41** and moves the piston and hence the control lever to the left or full open position represented by arrow **O**. The transfer rod then moves forward at maximum speed until just prior to the end of the "set forward" stroke when a second cam (not shown) again depresses valve **32** down to the position shown. Hydraulic fluid will again be bled almost instantaneously from pilot cylinder **40L** and valve **40** will be shifted to the left, and the piston in cylinder **41** will be moved to the right and valve **42** closed. As the valve **42** is closed, rod **10***a* will decelerate to almost zero speed as the cradles reach the set forward position.

The rate of acceleration and deceleration of rod **10***a* is controlled by manually adjustable control valve **39***a* which feeds fluid to cylinder **41**. By increasing or decreasing the rate of fluid flow through control valve **39***a*, the rate of travel of the piston in cylinder **41** is respectively increased or decreased and the rate at which valve **42** is closed or opened likewise is increased or decreased. With valve **42** in either the full open or full closed position, rod **10***a* moves at a constant fast or slow speed. The length of time it takes the valve **42** to change from full open to full closed and vice versa, is the period of acceleration or deceleration of the rod **10***a*.

When the rod **10***a* is to be returned to the "set rearward" position, solenoid **22***b* is energized and valve **22** shifts to the left, the position shown. Fluid then passes from conduit **21** through valve **22** and through conduit **31** to pilot cylinder **23***b* which shifts valve **23** to the right, the position shown. Fluid then passes from conduit **21** through valve **23**, conduit **24**, check valve **25** and conduit **26** to the head end of motor **10**, which forces the rod **10***a* to the left. Hydraulic fluid returns from the rod end of cylinder **10** through conduit **27**, through valve **23** and conduit **28** back to the supply tank represented by symbol **16**. Fluid is bled from pilot cylinder **23***a* through conduit **30**, valve **22** and conduit **29** to tank **16**. It is not necessary to vary the speed of rod **10***a* on the return travel, and the constant speed is determined by the setting of manually adjustable control valve **20**.

The Y-shaped clamps **11***a*, which secure the cradle in position during the casting operation, are raised and lowered by motors **11**. The supply of hydraulic fluid to motors **11** is controlled by solenoid-actuated valve **109**. To raise the clamps to the "clamp-on" position, the solenoid **109***a* is energized which moves the valve **109** to the left, the position shown. Hydraulic fluid then passes from header **15***a* through conduit **110**, through valve **109** and conduit **107** to the head end of cylinder **11**, and the Y-shaped clamp is raised to the "clamp-on" position. Hydraulic fluid leaves the rod end of cylinder **11**, passes through conduit **108**, valve **109**, and returns to the supply tank.

To lower the Y-shaped clamp to the "clamp-off" position, the solenoid **109***b* is energized which shifts valve **109** to the right. With valve **109** shifted to the right, hydraulic fluid passes through conduit **110**, valve **109** and through conduit **108** into the rod end of motor **11**, thereby lowering the Y-shaped clamp into the "clamp-off" position. The hydraulic fluid leaves the head end of motor **11**, passing through conduit **107** and valve **109** back to the supply tank.

The lifter head is raised and lowered by the action of hydraulic motor **12**. Fluid to actuate motor **12** is taken from the header **15***a* by conduit **57**. Three position valve **56** is spring centered and is actuated by solenoids **56***a* and **56***b*. To raise the lifter head, solenoid **56***a* is energized which shifts valve **56** to the left. Hydraulic fluid then passes from conduit **57** through valve **56**, and through conduit **59** to pilot cylinder **55***a* which shifts valve **55** to the right. Hydraulic fluid then passes from conduit **57**, through valve **55**, conduit **62**, flow control valve **65**, check valve **75**, conduit **76**, through hydraulic actuated check valve **77** and through conduit **53***a* to the head end of motor **12** which raises the lifter head.

In order to save time, the motor **12** should raise the lifter head as fast as possible. However, to have a smoothly operating device, it is necessary that the speed of the lifter head be slowed almost to zero as the lifter head engages and lifts the pallet and again as the pallet is pressed against the mold box. Flow control valve **65** is provided to control the speed at which the motor **12** raises the lifter head. The rate of flow through control valve **65** is controlled by hydraulic motor **79**, valve **70**, and cam-actuated spring biased valve **150**. Hydraulic motor **79** is connected directly to the control lever of valve **65**. The position of motor **79** in turn is controlled by valve **70**. Valve is a differential valve in that it is actuated by one hydraulic pilot cylinder **70L** which has an effective area greater than that of the other hydraulic pilot cylinder **70S**. The smaller hydraulic cylinder **70S** is always supplied with fluid at header pressure by conduits **152**, **153**, and **69**. Hydraulic supply to cylinder **70L** is controlled by cam-actuated valve **150**. Valve **150** is spring biased into the position shown. With valve **150** in the position shown, fluid at header pressure is supplied to cylinder **70L** through conduit **157**, valve **150**, and through conduit **158**. Fluid at header pressure is supplied to pilot cylinder **70S** by conduits **152**, **153**, and **69**. Since the pressures on cylinders **70L** and **70S** are equal, both being under header pressure, the larger area cylinder **70L** will overcome the small area cylinder **70S** and force the valve **70** to the right. Hydraulic fluid then passes through valve **70** and forces motor **79** to the left thereby opening valve **65** to the full open position. So long as valve **150** is in the spring biased position shown, valve **70** will be full open and the lifter head will travel upwardly at maximum rate. However, when cam **150***a* contacts valve **150**, biasing the valve to the right, the pressure on hydraulic cylinder **70L** is bled off to the supply tank pressure which is zero and the header pressure which is always in the small cylinder **70S** forces the valve **70** to the left which in turn causes the piston **79** to move to the right and close the flow control valve **65** to the most restricted flow position. Cam **150***a* is positioned to contact valve **150** just prior to the time the lifter head contacts the pallet. When the flow control valve **65** is closed, the rate of movement of the cylinder **12** is slowed to almost zero. As the lifter head contacts the pallet, the cam **150***a* passes the valve **150** and the spring returns the valve to the position shown. The cylinder **70L** is again supplied with fluid under pressure, the valve **70** is shifted to the right, the motor **79** is shifted to the left, the valve **65** is open to maximum flow and the cylinder **12** again rises at maximum rate. Just before the pallet contacts the mold box, cam **150***b* actuates valve **150** in the same manner as cam **150***a* and the rate of travel of the lifter head is again slowed almost to zero as the pallet contacts the mold box.

FIG. 6 schematically illustrates the speed of the lifter head **12***a* as it is raised and lowered. Beginning at line *a*, the valve **65** is open and the pallet proceeds upwardly at full speed. When cam **150***a* shifts valve **150** left, valve **65** is moved to the fine-feed or closed position. The time required to close valve **65** is the deceleration period illustrated by line *b*, FIG. 6. The lifter continues upwardly at a very slow speed for the distance *c* as the lugs on the head pass through the slots in the pallet. When the pallet is engaged, cam **150** passes valve **150** which shifts left and opens valve **65**. The acceleration period *d* is while valve **65** is opening. The lifter raises at full speed for the distance *e* until cam **150***b* contacts valve **150** and valve **65** is again closed during the deceleration period *f* and the pallet is gently seated under the mold box at slow speed *g*.

As the pallet is pressed against the mold box, solenoid **56***a* is de-energized and the valve **56** returns to center position. With valve **56** in the center position by springs, the pressure on the hydraulic pilot cylinder 55a is bled to tank through conduits 59 and 61, and valve 55 also returns to center position. With valve 55 in center position, all flow of fluid to motor 12 is stopped. The lifter head must hold the pallet against the mold box for the time it takes the feeder drawer to fill the mold box and for the upper vibrators to compact the concrete. However, because of the combined weight of the lifter head, the pallet, the concrete which is deposited on the pallet within the mold box, and of the upper vibrator head during vibration, the slightest leakage past the piston in cylinder 12 during this time will cause the lifter head to lower. If the lifter head lowers the slightest amount, concrete will be forced between the mold box and the pallet and the castings will be aborted. To prevent the lifter head from lowering, an auxiliary hydraulic fluid supply is provided by a separate pump (not shown) which is driven by a separate electrical motor (not shown). The auxiliary supply is introduced by conduit 50 through spring-biased, solenoid actuated two-way valve 51. Until solenoid 51S is energized, the spring biases valve 51 into the position shown and the auxiliary hydraulic fluid supply is pumped through conduit 50 directly to tank. However, when the pallet contacts the mold box, solenoid 51S is energized and the valve 51 is shifted to the right. With valve 51 shifted right, the fluid then passes through conduit 50, through valve 51, through check valve 52, through conduits 53 and 53a to the head end of motor 12, and the continuous supply of fluid holds the pallet securely against the bottom of the mold box despite any leakage. Check valve 77 is provided to keep the fluid from the auxiliary supply from escaping out conduit 76 and through valve 66.

When a lifter head is to be lowered, solenoid 51S is de-energized and valve 51 shifts to the left thereby switching the auxiliary hydraulic supply directly to the supply tank. Solenoid 56b is simultaneously energized. Valve 56 is then shifted to the right and fluid in conduit 57 passes to conduit 58 and to pilot cylinder 55b, which shifts valve 55 to the left. Fluid passes from conduit 57 through valve 55 and conduit 54 to the head end of motor 12 which is forced downward. Fluid also passes from conduit 54 through conduit 81 and opens check valve 77 by acting against the piston 77a therein. Hydraulic fluid can then leave the head end of the cylinder 12 by passing through conduit 53a, check valve 77, conduit 76, and because of check valve 75 through control valve 66, conduit 64, check valve 63, valve 55 and through conduit 60 to the supply tank.

Flow control valve 66 controls the speed of the downward travel of the lifter in substantially the same manner that flow control valve 65 controls the speed of the upward travel. Flow control valve 66 is operated by piston 73, valve 71, valve 106 and cams 106a and 106b. When the lifter head is up so that the pallet is pressed against the mold box, cam 106a is positioned to depress valve 106 the left. With valve 106 shifted to the left, the pressure on hydraulic pilot cylinder 71L is released through conduit 75 and valve 106 to tank. Pilot cylinder 71S, which is under pressure from conduits 72 and 156, forces valve 71 left to the position shown. Hydraulic pressure through conduit 152, control valve 67, and valve 71 then pushes the motor 73 to the right closing control valve 66 to permit minimum flow therethrough so that the initial downward movement of the motor 12 is very slow. This slow initial movement is required because the concrete has been formed in the mold box and any sudden movement of the concrete relative to the mold box could easily break off the corners of the freshly cast concrete. As soon as the cam 106a passes valve 106, the valve is shifted to the right by the action of the spring. With the valve 106 in the position shown, fluid passes from the header through conduit 156, valve 106 and conduit 175 to the pilot 71L. Due to the larger area of the pilot cylinder 71L, valve 71 is shifted to the right against the pressure of the pilot valve 71S. Piston 73 is then shifted to the left by fluid from flow control valve 67 and conduit 152. As the piston 73 is shifted to the left, the flow control valve 66 is opened to permit maximum flow therethrough and the lifter head is lowered at maximum speeed. Just before the pallet strikes the cradle on the downward travel, the cam 106b again moves valve 106 to the left which again releases the pressure from pilot cylinder 71L so that the flow control valve 66 is again closed as previously described. In this manner, the downward speed of the pallet is decelerated to almost zero and the pallet with the freshly formed concrete square thereon is gently set onto the cradle. As soon as cam 106b has passed valve 106, the lifter head again accelerates to the maximum speed and lowers to the down position. The downward motion of the lifter head is shown in the left-hand line of FIG. 6. The slow acceleration as the casting is lowered from the mold box is represented by line *h*, full speed lowering by line *i*, deceleration to set the pallet on the cradle by line *j*, and acceleration *k* to full speed *m* until the down position is reached.

The feeder drawer 13a which supplies concrete to the mold box is pushed across the mold box (out stroke) and pulled back across the mold box (return stroke) by hydraulic motor 13. A relatively large volume of high pressure hydraulic fluid is required to operate the feeder drawer because the stroke is long and the drawer heavy and concrete slides directly on the mold box 9 and apron 9a and 9b to produce large friction resistances. Therefore, the feeder drawer motor 13 is connected to receive hydraulic fluid from section 15b of the header which is associated with four accumulators 112. The accumulators always assure an ample supply of fluid at operating pressure.

To force the feeder drawer on the out stroke to deposit concrete in the mold box, solenoid 114a is energized which shifts valve 114 to the right. Hydraulic fluid then passes from conduit 113, through valve 114, through conduit 128 to pilot cylinder 115a which shifts the valve 115 to the left. With the valve 115 shifted left, fluid passes from conduit 113, through valve 115 to conduit 125, through check valve 123, conduit 122 to the head end of motor 13 which forces the feeder drawer on the outstroke across the mold box. Fluid leaves the rod end of motor 13, passes through conduit 121, and because of check valve 120, passes through flow control valve 119, conduit 118, valve 115 and through conduit 126 to tank. Flow control valve 119 is manually adjustable to control the rate of travel of the feeder drawer out across the mold box.

To force the feeder drawer on the back stroke into alignment with the concrete hopper, solenoid 114b is energized which causes valve 114 to shift left, the position shown. Fluid then passes through conduit 113, valve 114, and conduit 129 to pilot cylinder 115b which moves the valve 115 to the right, the position shown. Fluid then passes from conduit 113 through valve 115, conduit 118, check valve 120 and through conduit 121 to the rod end of motor 13. Fluid leaves the head end of motor 13, passes through conduit 122, and because of check valve 123, passes through flow control valve 124, conduit 125, valve 115, and through conduit 126 back to tank. Flow control valve 124 is manually set to control the rate of travel of the feeder drawer on the back stroke. Bleed line 127 is provided to vent fluid from pilot cylinders 115a and 115b as required.

The vibrator head 14a is lowered by energizing solenoid 84a which shifts valve 84 to the left. Fluid then passes from header 15a through conduit 82, valve 84 and conduit 86 to hydraulic pilot cylinder 83a which shifts valve 83 to the right. With the valve 83 shifted right, fluid passes from conduit 82 through valve 83, conduit 87, check valve 89 and conduit 90 to the head end of motor 14 which lowers the vibrator head. Hydraulic fluid leaves the rod end of motor 14 by conduit 92. The cylinder of check valve **93** is pressured by fluid through tap **93***a* from conduit **90**. The fluid passes through the check valve **93**, conduit **94**, flow control valve **96** because of check valve **95**, conduit **97**, valve **83** and conduit **98** to the hydraulic supply tank. The vibrator head **14***a* is lowered at maximum speed from the top of a stroke until just before the vibrator head contacts the concrete in the mold box. The speed at which the upper vibrator head is lowered can be adjusted by control valve **96** which meters the hydraulic fluid as it leaves the head end of motor **14**. Flow control valve **96** is controlled by piston **100**, differential valve **101**, and spring biased, cam actuated valve **160**. When the vibrator head is in the up position, the valve **160** is biased to the left, the position shown, by the spring. Hydraulic fluid then passes from header **15** through conduit **105**, conduit **102**, valve **160**, and conduit **103** to hydraulic pilot cylinder **101L** which biases the valve **101** to the right. With valve **101** shifted right, fluid passes through conduit **105**, control valve **104** and valve **101**, and moves the motor **100** to the left which opens control valve **96** to maximum flow position and lowers the vibrator at maximum speed. Pilot cylinder **101S** is always provided with fluid at substantially the pressure at the header by conduit **105** and conduit **104***a*. However, the effective area of pilot cylinder **101L** is greater than the effective area of pilot cylinder **101S**. Therefore the larger cylinder **101L** will overcome the smaller cylinder **101S** and force the valve **101** to the right.

As the upper vibrator head is lowered, cam **160***a* contacts and biases valve **160** to the right. With valve **160** shifted right, pressure is bled from cylinder **101L** through conduit **103** and valve **160** to the supply tank. With no pressure on pilot cylinder **101L**, pilot cylinder **101S** shifts valve **101** to the left, the position shown. Fluid then passes through valve **101**, moving piston **100** to the right, which closes control valve **96** to its most restricted position, and vibrator head **14***a* is lowered at the slowest possible speed and is set gently upon the concrete in the mold box.

When the vibrator head reaches the end of its downward travel, solenoid **84***a* is de-energized and valve **84** shifts back to the center position. Fluid is then bled from pilot cylinder **83***a* through conduit **86**, valve **84** and conduit **99** back to supply tank. With the pressure bled from pilot cylinder **83***a*, valve **83** shifts back to center position and no flow of fluid to or from cylinder **14** results.

When it is desired to raise vibrator head **14***a*, solenoid **84***b* is energized and valve **84** shifts to the right. With valve **84** shifted right, fluid passes through conduit **82**, valve **84**, and conduit **85** to pilot cylinder **83***b*, which shifts valve **83** to the left. Hydraulic fluid then passes through conduit **82**, valve **83**, conduit **97**, check valve **95**, check valve **93**, and through conduit **92** to the rod end of motor **14**. Hydraulic fluid leaves the head end of motor **14** and passes through conduit **90**, control valve **88**, conduit **87**, valve **83**, conduit **98**, and returns to the supply tank. The rate at which the vibrator head is raised can be controlled by manual adjustment of control valve **88**.

As the vibrator head reaches the top of its travel, solenoid **84***b* is de-energized and solenoid **91S** is momentarily energized. When solenoid **84***b* is de-energized, the valve **84** returns to center position. Hydraulic fluid is then bled from pilot cylinder **83***b* through conduit **85**, valve **84**, and conduit **99** to tank, and valve **83** also returns to center position. With the valve **83** centered, no fluid either to or from the cylinder **14** is permitted.

Solenoid **91S** is energized momentarily as the vibrator head reaches the up position and valve **91** is shifted upwardly so that hydraulic fluid is bled from conduits **90** and **93***a* to the hydraulic supply tank. In this manner it is assured that all fluid is bled from the piston of check valve **93** so that the spring will positively seat the valve **93**. With valve **93** seated, no fluid can leave the cylinder **14** and the vibrator head is maintained in the "up" position. The solenoid **91S** is energized only momentarily and when de-energized the spring biases the valve **91** back to the position shown and the system is ready for the next cycle.

The hydraulic system previously described is automatically operated by an electrical control circuit which is diagrammatically shown in FIGS. 14*a* and 14*b*, FIG. 14*a* being the top half and FIG. 14*b* the lower half. Leads **200** and **201** are connected to an electrical power source. A switch **225** and fuse **226** are provided in the circuit for safety purposes. Normally open start button switch **227** and normally closed stop button switch **228** are connected in series with the coils of relays RA, RB, and RC. When the start button is pressed, relay RA is energized and contact RA–**1** which is connected in shunt around the normally open start button is closed thereby maintaining relay RA energized. Contact RA–**2** in conductor **200** closes to energize the control circuit. Energization of relay RB closes contact RB–**1** and starts the main hydraulic pump motor **231**. Energization of relay RC closes contact RC–**1** and starts the auxiliary hydraulic supply pump motor **232** which provides fluid to hold the lifter head up as previously mentioned. Included in the circuit with relays RA, RB, and RC are pressure safety switches **229** and **230** which stop the main and auxiliary pump motors respectively if excessive hydraulic pressure is built up. A light **233** on the control panel indicates that the hydraulic pumps are in operation.

Master switch **234** has three positions; off, automatic, and manual. When the master switch is set on automatic, contacts A–**1** through A–**6** and A–**8** through A–**12** are closed and the control circuit is ready for automatic operation. When the master switch is set on manual, the automatic contacts are open and contacts M–**1** through M–**10** are closed. Each individual operation can then be manually controlled by pressing the corresponding push button contact P–**1** through P–**6** and P–**8** through P–**10**, as is hereafter explained in detail.

Now assume that the master switch has been set on automatic, that the transfer rod **10***a* is set rearward, that the cradle clamps **11***a* are in the off position, that the lifter head **12***a* is down, that the upper vibrator head **14***a* is up, and that the feeder drawer **13***a* is in register with the concrete hopper or at the "back" position. Referring to line **203**, master switch automatic contact A–**1** is closed, limit switch contact L–**1**W is closed because the transfer rod is set rearward, limit switch contacts L–**3**E and L–**3**W are closed because the clamps are off, and limit switch contact L–**11** is closed because the upper vibrator head is up. As a cradle is moved into position II, FIG. 4*a*, by the chain, limit switch L–**13** is closed and solenoid **22**A is energized which actuates the hydraulic system as previously described to set the transfer rod **13***a* forward. As soon as the transfer rod starts moving forward, limit switch L–**1**W opens. However, the hydraulic valve **22**, FIG. 5, remains in the same position and the rod continues to move forward. The shunt circuit containing push button contact P–**1**, manual contact M–**1** and limit switch contact L–**1**E provide means for manual operation to set the transfer rod forward.

When the transfer rod reaches the set forward position, limit switch contact L–**2** (line **204**) is closed. Since contact A–**2** is already closed and contact C–**2**B is normally closed, control relay C–**4** is energized which closes contact C–**4**C to energize solenoid **22**B which causes the transfer rod to immediately set rearward preparatory to the next cycle. Solenoid **109**A is also energized which actuates the hydraulic system to raise the cradle clamps to the "on" position. Contact C–**4**B of relay C–**4** is closed around limit switch contact L–**2** which is opened as the transfer rod is moved rearward thereby maintaining a closed circuit for relay C–**4** and solenoid **109**A. Push button contact P–**2** and manual contact M–**2** provide a circuit for manual operation of "clamp on" solenoid 109A. At line 205, contact M–7 and push button contact P–7 provides manual operation of transfer rod "set rearward" solenoid 22B.

As the cradle clamps move from "clamp off" to "clamp on" position, limit switch contacts L–3E and L–3W (line 203) are opened, and the transfer rod cannot set forward until the clamps return to off position. As the clamps reach the clamp on position, limit switch contacts L–4E and L–4W, line 206, are closed and since contact A–3 is closed and contact TC–4A is normally closed, solenoid *56a* is energized to actuate the hydraulic system and move the lifter head up as previously described.

The shunt circuit including contacts P–3 and M–3 provide a manual means for raising the lifter head. As the lifter head moves up and away from limit switches L–5B and L–5A, normally closed limit switch contacts L–5B (line 213) closes. Also, normally open contact L–5A (line 218) opens to insure that solenoid 109B cannot take the clamp off until the lifter head is back in the down position and also insure that solenoid 91S cannot be energized to interrupt the operation of check valve 93, FIG. 5, and will thereby insure proper lowering of the upper vibrator head. As the lifter head presses the pallet against the mold box, limit switch L–6 is actuated and contact L–6 (line 207) closes to energize solenoid 51S (line 207) which actuates valve 51 to introduce the high pressure auxiliary fluid supply to hold the lifter head up. Closing of contact L–6 also energizes control relay C–2 (line 207), thereby closing normally open contact C–2A (line 208) and opening normally closed contact C–2B (line 204). When contact C–2B opens, "clamp on" solenoid 109A is de-energized but the clamp remains on because of the mechanical nature of valve 109, and the clamp must remain on until the lifter head lowers because the "clamp off" solenoid 109B has been de-energized by opening contact L–5A. Opening of contact C–2B also de-energizes control relay C–4 and transfer rod "set rearward" solenoid 22B. Contact C–4B opens and the clamps cannot be put on or the transfer rod set rearward again until limit switch L–2 is closed at the next "set forward" position of the transfer rod. Contact C–4C also opens. Normally closed contact C–4A (line 218) closes, but no action occurs because both L–5A and L–10A are open.

When control relay C–2 is energized as the lifter head reaches the up position, contact C–2A (line 208) closes and since limit switch contact L–12 is closed because the upper vibrator head is up, solenoid 114A is energized and the feeder drawer travels on the "out stroke" across the mold box. As the feeder drawer starts moving out, limit switch contact L–8 (line 211) opens and the lifter head vibrators cannot be energized until the feeder drawer returns. When the feeder drawer reaches the out position, limit switch contact L–7 (line 209) is closed and since control relay C–1 has not yet been energized, normally closed contact C–1D is closed and control relay C–3 is energized. Holding contact C–3B (line 209) is closed and contact C–3C (line 210) is closed energizing solenoid 114B which returns the feeder drawer on the back stroke to the hopper. Contact C–3D (line 211) closes to prepare the lifter head vibrator circuit for energization. Normally closed contact C–3A (line 207) opens to de-energize control relay C–2 (line 207). Contact C–2A (line 208) opens to de-energize "feeder drawer out" solenoid 114A and permit the return of the feeder drawer as just mentioned. Normally closed contact C–2B (line 204) closes preparatory to the next cycle.

As the feeder drawer starts on the "back stroke" due to energization of solenoid 114B, limit switch contact L–7 (line 209) opens but has no effect because of holding contact C–3B. As the feeder drawer reaches the "back" position, which is in register with the concrete hopper, limit switch contact L–8 (line 211) closes. Since contact C–3D (line 211) was closed as the feeder drawer reached the "out" position, solenoid 231 is energized and the vibrators on the lifter head are started. Time control relay T–1 is energized and after a five second delay, operates to open normally closed contact TC–1A and stop operation of the lifter head vibrators.

At the same time the lower vibrators are energized, solenoid 84A (line 212) is energized through the circuit including contacts A–11, C–3D, L–8, TC–1A and A–12 and the upper vibrator head starts down. Solenoid 84A is also de-energized by opening of contact TC–1A, but the upper head descends rapidly and the five seconds before the time contact opens is sufficient for the head to be lowered. As the upper vibrator head leaves the "up position," normally open contact L–10A (line 218) closes and normally closed contact L–10B (line 213) opens to insure that the cradle clamps remain on and to be sure that solenoid 91S is not energized to block the lowering of the upper head. Limit switch contact L–12 (line 208) also opens as the upper vibrator head begins lowering and prevents the feeder drawer from traveling on the out stroke until the upper head is back in the up position. Limit switch contact L–11 (line 203) opens so that the transfer rod cannot be set forward while the upper head is away from the up position.

As the upper vibrator head contacts the concrete in the mold box, limit switch contact L–9 (line 213) is closed. Since contacts L–5B and L–10B have previously been closed, solenoid 232 is energized and in turn operates to energize the upper vibrators and to start the paddle agitation in the concrete hopper. Time control relays TC–2 and TC–3 are also energized when the upper head closes limit switch contact L–9 through the circuit containing automatic operation contact A–9. Nineteen seconds after time control relay TC–2 is energized, the relay operates to open normally closed contact TC–2A (line 213) which de-energizes solenoid 232 stopping the upper vibrators and also de-energizes the agitator starter relay to stop the agitation. Also, nineteen seconds after TC–2 is energized, normally open contact TC–2B (line 213) closes and energizes control relays C–1 and TC–4. Holding contact C–1B (line 213) closes and seals the circuit around limit switch contact L–9 so that as the vibrator head starts up and contact L–9 opens, the circuit will not be broken. Contact C–1C (line 213 through contact A–8) closes and energizes solenoid 56B which lowers the lifter head. Fluid pressure at each end of the lifter head cylinder is substantially equalized and the weight of the freshly cast mattress and head causes the lifter head to start down.

As soon as time control relay TC–4 is energized, normally closed contact TC–4A (line 206) opens. Opening of this contact is necessary because limit switch contacts L–4E and L–4W are closed, the clamps are on, and otherwise solenoid 56A would be energized and the lifter head would then go right back up. Contact TC–4A remains open for five seconds before closing and by that time the cradle clamps are off and limit switch contacts L–4E and L–4W are opened and the circuit remains open until the next cycle.

As the lifter head starts down, due to its own weight, limit switch contact L–6 (line 207) opens and de-energizes solenoid 51S and the auxiliary fluid supply which has been holding the lifter head up is cut off. The lifter head then lowers the rest of the way at a speed governed by the fluid flow setting on valve 66 (FIG. 5).

When the lifter head reaches its "down position," normally closed limit switch contact L–5B (line 213) opens and normally open contact L–5A (line 218) closes.

When time control relay TC–2 energized control relay C–1 through contact TC–2B, nineteen seconds after the upper vibrator head was lowered, normally closed contact C–1D (line 209) opens to de-energize control relay C–3, as mentioned. When relay C–3 is de-energized, normally closed contact C–3A (line 207) closes and normally open contact C–3B (line 209) opens to prepare the circuit for the next cycle. Normally open contact C–3C (line 210) also opens to de-energize solenoid **114B** so that the feeder drawer can be moved out on the next cycle. Also as relay C–3 is de-energized, contact C–3D (line 211) opens and de-energizes time control relay T–1.

Twenty seconds after the upper vibrator head reaches its lower position and closes limit switch contact L–9 to energize time control relays TC–2 and TC–3, which is one second after the 19 seconds time setting of TC–2, time control relay contact TC–3A (line 213) closes and energizes solenoid 84B which operates the hydraulic system to raise the upper vibrator head. It will be noted that the upper vibrator head is raised one second after the lifter head begins lowering and the force of the upper vibrator head springs serves to force the freshly cast concrete slab from the mold box.

As the upper vibrator head raises, limit switch contact L–9 (line 213) opens and as the upper head reaches the up position, normally closed limit switch contact L–10A opens. Since limit switch contact L–5B was opened when the lifter head reached the down position, the entire circuit of line 213 is opened and the circuitry is returned to normal condition preparatory to the next cycle. Time control relays TC–2 and TC–3 are de-energized. Contact TC–2A (line 213) closes, contact TC–2B (line 213) opens, and contact TC–3A (line 213) opens, control relays C–1 and TC–4 are de-energized and contacts C–1B and C–1C open. Contact C–1D closes. Also as the upper vibrator head reaches the up position, limit switch contacts L–11 (line 203) and L–12 (line 208) close preparatory to the next cycle.

When both the lifter head is in the down position and the upper vibrator head is in the up position, contacts L–5A and L–10A respectively are closed, and normally closed contact C–4A has already been closed by de-energization of relay C–4, so solenoid 109B is energized to lower the cradle clamps to the clamp off position, and also, solenoid 91–S is energized which operates as previously described to prevent the upper vibrator head from lowering.

As the clamps release the cradle, limit switch contacts L–4E and L–4W (line 206) are opened and the lifter head cannot be raised. Limit switch contacts L–3E and L–3W (line 203) close as the clamps reach the lower positions. Then as the chain moves the next cradle into position A, limit switch contact L–11 is closed and the transfer rod is set forward and another cycle commences.

The semicured concrete castings are removed from the moving conveyor system at a mat removal station shown generally in FIG. 18. A bridge crane 612 is supported by rollers 614 and 616 which travel on horizontally disposed rails 618 and 620 which in turn are supported by vertical columns 622. A novel head for engaging the concrete castings is indicated generally at **610** and is raised and lowered from the crane 612 by cables 624 and 626 which are wound around drums 628 and 630, respectively.

The head 610 is shown in detail in FIGS. 15–17, where the head frame is comprised of longitudinal channel beams 670 and 672 and transverse end channel members 674 and 676, which transverse bracing members 678, 680, 682 and 684. The frame is further rigidified by diagonal brace members 686 and 688. A pair of tubular shafts 700*a* and 701 are journaled in U-shaped members 702*a* which extend through the longitudinal channel members 670 and 672 and are bradded at 704*a*. Small angle iron tabs 706*a* are welded to the corners of the frame to prevent shafts 700*a* and 701 from shifting longitudinally of the frame.

Four pairs of arms 708 are rigidly fixed to the shafts 700 and 701. A rod 710 of a pneumatic motor 712 is pivotally connected to the ends of each of the pairs of arms 708 by a pin 714. The head end of each of the four pneumatic motors 712 are pivotally connected to members **716** by pins **718**. The upstanding members **716** are in turn connected to transverse channels **720**.

Ten gripper bars **722** are each rigidly connected to each of the shafts **700*a*** and **701** by a pair of bars **724**. The bars **724** make an angle of approximately 130° with the arms **708**. The bars **722** are so spaced as to engage parts of two adjacent slabs of a concrete mat as shown at **723**, the mat being shown in dotted outline. A pneumatic cylinder **726** is mounted on transverse beams **728** and **730** and a suitable air compressor is represented by dotted outline **731**. A suitable solenoid operated pneumatic valve is represented at **732** and controls the pneumatic pressure through flexible lines **734**, piping **735** and flexible lines **736** leading to the four pneumatic motors **712**.

As the pallets proceed along the lower reach in the direction of arrow **606** in FIG. 18, the concrete mat squares resting thereon have been cast for less than two hours, but have passed through the curing kiln. As each cradle passes upwardly around the station sprockets, shown in FIG. 18, at a very slow rate, the crane operator begins lowering the head **610** from the crane **612**. As soon as the preceding cradle **602** has moved around the sprocket to the point where the following cradle **604** is entirely exposed to the head **610**, the head is lowered until the rectangular frame of the head rests on the concrete mat. At this point, there is substantially no linear movement of the cradle since the cradle is passing primarily upward on its journey around the sprocket. However the bridge crane **612** can be moved in the direction of the cradle travel to compensate for any linear movement and maintain the crane directly over the cradle during the brief time required for engagement of the concrete square.

When the solenoid **732** is actuated, the pneumatic motors force the pistons **710** outwardly until the bars **722** engage the concrete mat shown in dotted outline at **740** in FIG. 15. The arms **708** and **724** are then in the position shown in solid lines in FIG. 17, the arms and gripper bars having moved from the open positions shown in dotted outline. As soon as the gripper bars **722** grip the concrete casting, the crane lifts the head **610** and the concrete casting gripped thereby from the pallet carried by cradle **365**.

It will be noted that the arms **724** are so dimensioned that the gripper bars **722** engage the casting **740** below the central axis of the casting. It is well known that a concrete beam such as each of the twenty slabs of the mat "square" is subjected to tension forces below the central axis and compression force above the central axis due to the weight of the concrete when the concrete is supported at each end. Since concrete is extremely weak under tension forces, the semicured castings frequently break if handled by supports only at each end of the slabs. Therefore, the gripper bars are automatically so positioned that they engage the slabs below the central axis and the gripping force tends to counteract the internal tension force in the concrete and prevent breakage.

As soon as the head **610** and the concrete casting carried thereby have cleared the pallet, the bridge crane **612** begins to move along rails **618** away from the conveyor system. Six rail flat cars **742, 744, 746, 748, 750** and **752** travel on six parallel tracks **754**. The operator, who rides in cab **756**, then positions the crane over one of the six flat cars and the casting is automatically lowered onto the car and releases gripper bars **722** of head **610** to release the casting.

As the successive castings are removed from the conveyor system, the castings are alternately placed on the six flat cars. Since the concrete castings at removal are only about two hours old, they are not cured to maximum strength. When the casting machine is in normal operation, a casting is removed therefrom approximately every 70 seconds. It is desired that the castings be stacked eleven high on each of the flat cars so that a straddle truck can lift the stack and transport it to storage. If the successive castings were stacked on one flat car, the stack would be made in about ten minutes and the weight of the upper castings would frequently fracture the lower castings in the stack. By alternately placing the concrete mats on six different flat cars, only every sixth mat is placed in one pile so that it takes over an hour to make a stack of eleven castings. This additional time is sufficient to allow the lower mats to cure to the degree that fractures due to weight of the upper mats are substantially eliminated.

When eleven castings have been stacked on one flat car, the car is pulled outward on its track **754** to the position shown by car **752**, which carries a completed stack. A straddle truck is then backed over the flat car and the stack of castings is transported to an open field for storage. A single completely cured casting is then placed on the flat car to serve as a carrying pallet for new green castings and the flat car is pushed back into position under the path of the bridge crane. The five or six minutes between the time the last casting is placed on a particular flat car, and the time the next casting is to be placed on the car is sufficient for the completed stack of castings to be moved away to storage and the flat car to be returned to position.

Having thus described the invention in detail, it will be understood that the plant described is but one embodiment and is capable of variations in details of construction and operation without departing from the spirit of the invention and that it is intended and desired to embrace within the scope of the invention such modifications and changes as may be necessary or desirable to adapt it to varying conditions and uses, within the scope of the appended claims.

We claim:

1. In a cyclic machine for producing large concrete mats having a plurality of pallets on which the mats are formed and carried, each pallet passing successively through stations for placing reinforcing fabric thereon, for oiling the pallet, for casting a mat thereon, for curing the mat, for removing the mat therefrom and for cleaning the pallet the improvement comprising:

(*a*) a pair of endless chains disposed in parallel relation to each other and extending through said stations;

(*b*) mechanism for driving said endless chains synchronously with each other;

(*c*) a plurality of pallet carrying cradles mounted on dollies and disengageably connected to said endless chains;

(*d*) a pair of cradle tracks, said dollies running on said tracks, said tracks generally parallel to said chains but spaced farther therefrom adjacent said mat casting station, whereby said cradles and dollies disengage from said chains adjacent said station;

(*e*) reciprocating transfer rod means, at the casting station adjacent said cradle tracks and parallel thereto, actuated when each cradle disengages from said chains, for sequentially centering and depositing the cradle at the casting station during a predetermined interval while a concrete mat is cast on the pallet, and thereafter when the succeeding cradle disengages from said chain advancing said cradle until it reengages the endless chains at the position thereon which it previously occupied.

2. An improved cyclic machine for producing large concrete mats as described in claim 1 having a casting station which comprises:

(*a*) a mold box open at top and bottom disposed above said chains and centered at the casting station;

(*b*) a pair of hydraulically elevated clamping forks adapted to selectively engage stub axles projecting from the sides of a cradle centered at said casting station;

(*c*) hydraulically operated lifter means having a head thereon adapted to pass through a cradle centered at the casting station and to lift the pallet carried thereby against the bottom of the mold box and to return the pallet with a freshly formed concrete mat thereon to said cradle, said lifter means having a plurality of vibrators attached to the head thereof;

(*d*) a source of plastic concrete;

(*e*) a hydraulically operated feeder box slidably mounted above the mold box adapted to receive a measured amount of concrete from said source and to fill the mold box therewith;

(*f*) upper vibrator means adapted to be selectively lowered into the top of the mold box and to compact the plastic concrete therein.

3. In a cyclic machine for producing large concrete mats having a plurality of pallets on which the mats are formed and carried, each pallet passing successively through stations for placing reinforcing fabric thereon, for oiling the pallet, for casting a mat thereon, for curing the mat, for removing the mat therefrom and for cleaning the pallet the improvement comprising:

(*a*) a pair of endless chains extending through said stations each chain passing around two spaced-apart sprockets forming generally horizontal upper and lower reaches to each chain, each chain including a plurality of rollers and a plurality of spaced chain lugs;

(*b*) generally horizontal upper and lower chain tracks supporting the rollers of the upper and lower reaches of each chain, said upper tracks being curved upward at the mat casting station to raise the upper reaches while passing through the mat casting station;

(*c*) mechanism for driving said endless chains synchronously with each other;

(*d*) a plurality of pallet carrying cradles each cradle pivotably mounted on a pair of dollies and having cradle lugs and upstanding spikes;

(*e*) a cradle track generally parallel to each chain track, said cradle dollies running on said cradle tracks, said cradle tracks spaced from said chain tracks so that said chain lugs engage said cradle lugs thereby propelling the cradles, along the upper and lower reaches everywhere except at the mat casting station;

(*f*) a pair of powered, reciprocating, transfer rods at said mat casting station adjacent said cradle tracks and parallel thereto, each of said transfer rods having a pair of pivoted lugs adapted to engage the upstanding spikes of said cradles, said transfer rods actuated when each cradle reaches the point where it no longer engages said chains to simultaneously advance said cradle to the center of the mat casting station and to advance the preceding cradle from the center of said station to the point where it reengages said chain, said transfer rods thereupon returning to their original positions.

4. An improved cyclic machine for producing large concrete mats as described in claim 3:

(*a*) wherein the casting station comprises:

(1) a mold box open at top and bottom disposed above said chains and centered at the casting station;

(2) a pair of hydraulically elevated clamping forks adapted to selectively engage stub axles projecting from the sides of a cradle centered at said casting station;

(3) hydraulically operated lifter means having a head thereon adapted to pass through a cradle centered at the casting station and to lift the pallet carried thereby against the bottom of the mold box and to return the pallet with a freshly formed concrete mat thereon to said cradle, said lifter means having a plurality of vibrators attached to the head thereof;

(4) a source of plastic concrete;

(5) a hydraulically operated feeder box slidably

mounted above the mold box adapted to receive a measured amount of concrete from said source and to fill the mold box therewith;

(6) upper vibrator means adapted to be selectively lowered into the top of the mold box and to compact the plastic concrete therein;

(b) wherein the mat removal station comprises:

(1) a bridge crane extending transversely of the endless chains and travelling on a pair of overhead rails extending parallel to said chains from a point over the mat removal station to a point sufficiently beyond the adjacent chain sprockets to permit mats to be stacked by said crane in a plurality of rows;

(2) said bridge crane adapted to selectively raise and lower an engaging head having a frame substantially the size of one of said mats;

(3) a plurality of coacting grippers disposed on opposite sides of said frame and extending a distance below the frame equal to approximately three-fourths the thickness of one of said mats; and

(4) means for moving the opposed grippers together to exert a compressive force on a mat to be lifted.

5. In a cyclic machine for producing large concrete mats having a plurality of pallets on which the mats are formed and carried, each pallet passing successively through stations for placing reinforcing fabric thereon, for oiling the pallet, for casting a mat thereon, for curing the mat, for removing the mat therefrom and for cleaning the pallet, the improvement comprising:

(a) a pair of endless chains extending through said stations each chain passing around two spaced-apart sprockets forming generally horizontal upper and lower reaches to each chain, each chain including a plurality of rollers and a plurality of spaced chain lugs;

(b) generally horizontal upper and lower chain tracks supporting the rollers of the upper and lower reaches of each chain, said upper tracks being curved upward at the mat casting station to raise the upper reaches while passing through the mat casting station;

(c) mechanism for driving said endless chains synchronously with each other;

(d) a plurality of pallet carrying cradles each cradle pivotably mounted on a pair of dollies and having cradle lugs and upstanding spikes;

(e) a cradle track generally parallel to each chain track, said cradle dollies running on said cradle tracks, said chain tracks spaced farther from said cradle tracks adjacent said mat casting station than at other points whereby said chain lugs engage said cradle lugs and propel said cradles everywhere except adjacent said mat casting station;

(f) a pair of transfer rods disposed for reciprocating movement parallel to said cradle tracks, each transfer rod having a pair of pivoted lugs adapted to simultaneously engage the upstanding spikes of first and second consecutive cradles; and

(g) transfer rod control means including power means for moving said transfer rods and first and second limit switches regulating said power means, said first limit switch, actuated when a first cradle is disengaged from said chains adjacent said mat casting station, causing said transfer rods to simultaneously advance said first cradle to the center of said mat casting station and said second cradle from the center of the mat casting station to a point where said second cradle is reengaged by said chains, said second limit switch, actuated after said first cradle is centered in said mat casting station, causing said transfer rods to return to their starting positions.

6. An improved cyclic machine for producing large concrete mats as described in claim 5:

(a) wherein the casting station comprises:

(1) a mold box open at top and bottom disposed above said chains and centered at the casting station;

(2) a pair of hydraulically elevated clamping forks adapted to selectively engage stub axles projecting from the sides of a cradle centered at said casting station;

(3) hydraulically operated lifter means having a head thereon adapted to pass through a cradle centered at the casting station and to lift the pallet carried thereby against the bottom of the mold box and to return the pallet with a freshly formed concrete mat thereon to said cradle, said lifter means having a plurality of vibrators attached to the head thereof;

(4) a source of plastic concrete;

(5) a hydraulically operated feeder box slidably mounted above the mold box adapted to receive a measured amount of concrete from said source and to fill the mold box therewith;

(6) upper vibrator means adapted to be selectively lowered into the top of the mold box and to compact the plastic concrete therein; and

(b) wherein the mat removal station comprises:

(1) a bridge crane extending transversely of the endless chains and travelling on a pair of overhead rails extending parallel to said chains from a point over the mat removal station to a point sufficiently beyond the adjacent chain sprockets to permit mats to be stacked by said crane in a plurality of rows;

(2) said bridge crane adapted to selectively raise and lower an engaging head having a frame substantially the size of one of said mats;

(3) a plurality of coacting grippers disposed on opposite sides of said frame and extending a distance below the frame equal to approximately three-fourths the thickness of one of said mats; and

(4) means for moving the opposed grippers together to exert a compressive force on a mat to be lifted.

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