United States Patent

DiDonato

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[54] PROGRAMMABLE APPARATUS FOR CONVEYING ARTICLES THROUGH SUCCESSIVE PROCESS STEPS

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[52] **U.S. Cl.**.....**214/89,** 134/76, 134/141, 294/81

[51] **Int. Cl.**.....**B66b 17/00**

[58] **Field of Search**.....214/89; 294/81, 86; 134/76, 134/77, 140, 141, 83, 164

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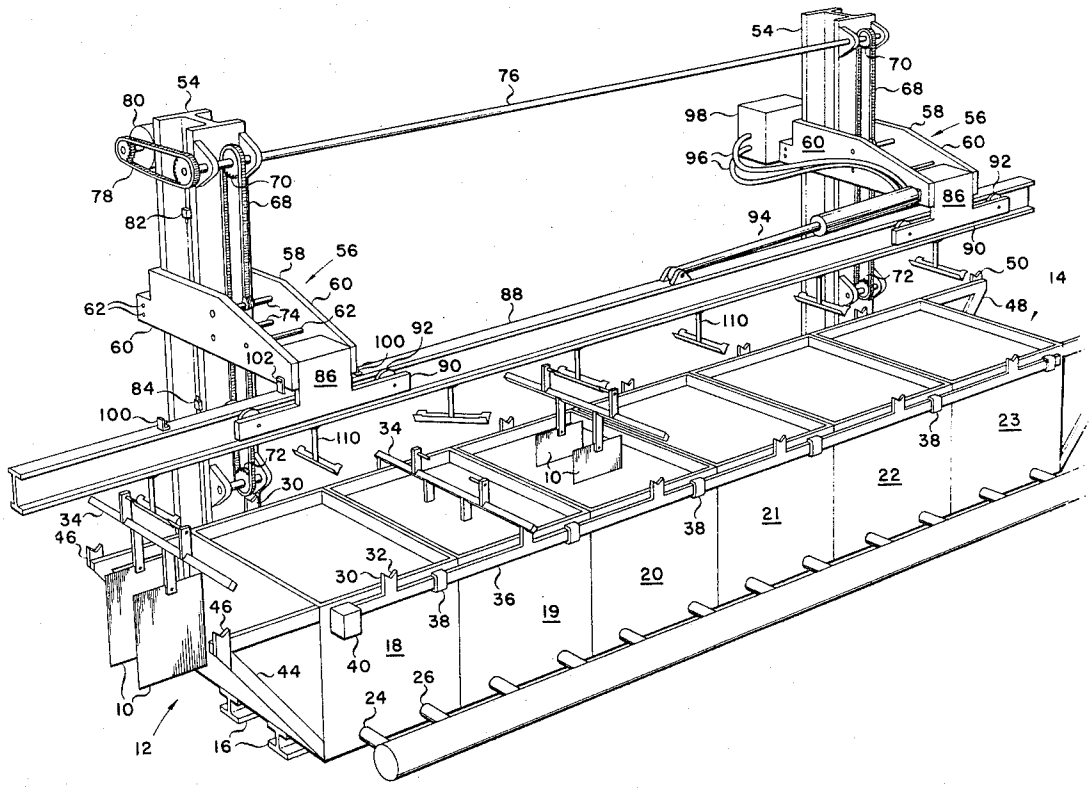
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[57] **ABSTRACT**

The displacements of a reciprocable horizontal beam and a series of pickup assemblies suspended from the beam are programmed for intermittently and selectively picking up and transferring discrete articles from one tank to the next in a row of immersion tanks adapted to contain process solutions for treating the articles in accordance with a predetermined series of process steps, the duration of immersion of the articles usually varying between tanks.

3 Claims, 12 Drawing Figures



Patented April 25, 1972 3,658,197

6 Sheets-Sheet 1

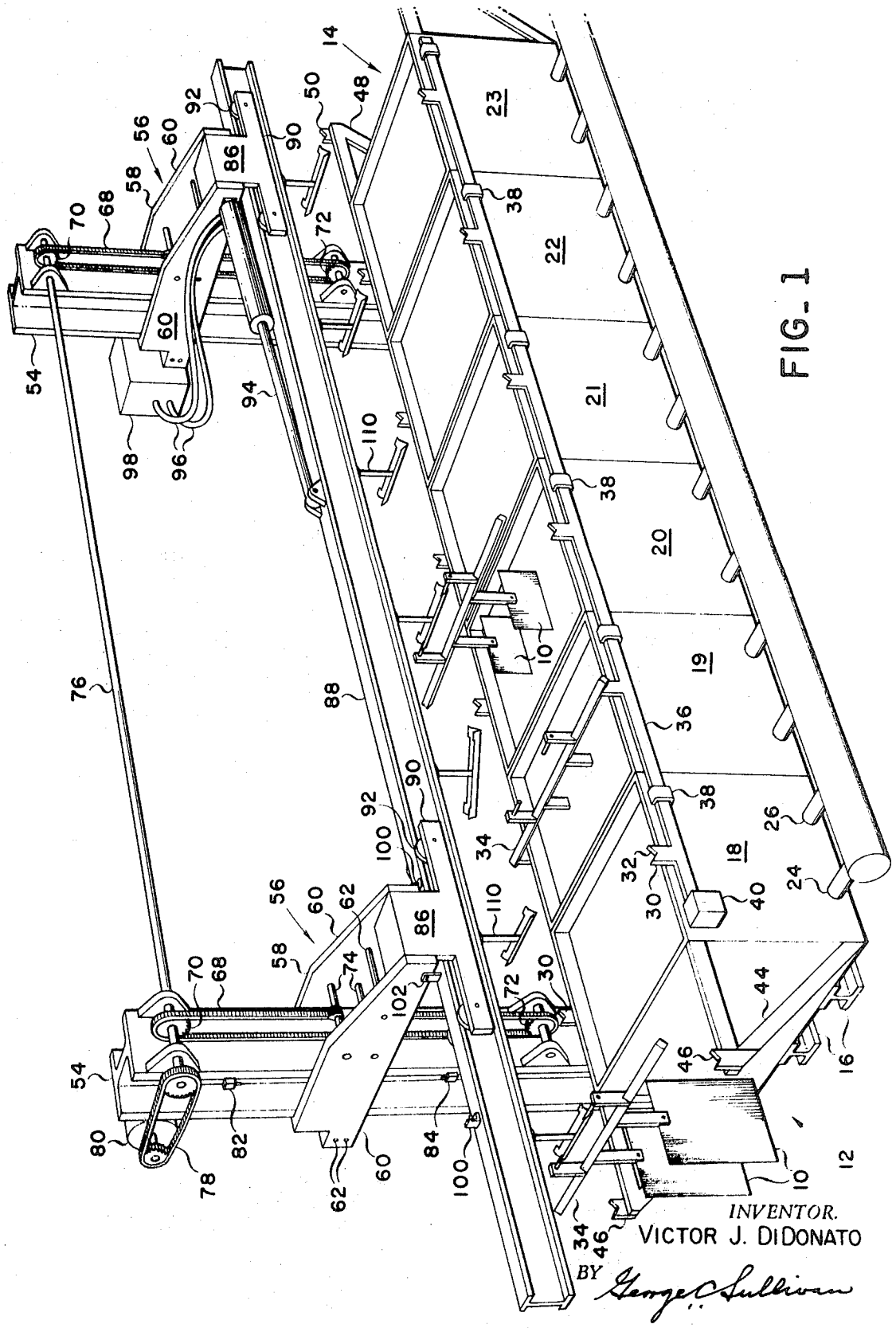


FIG. 1

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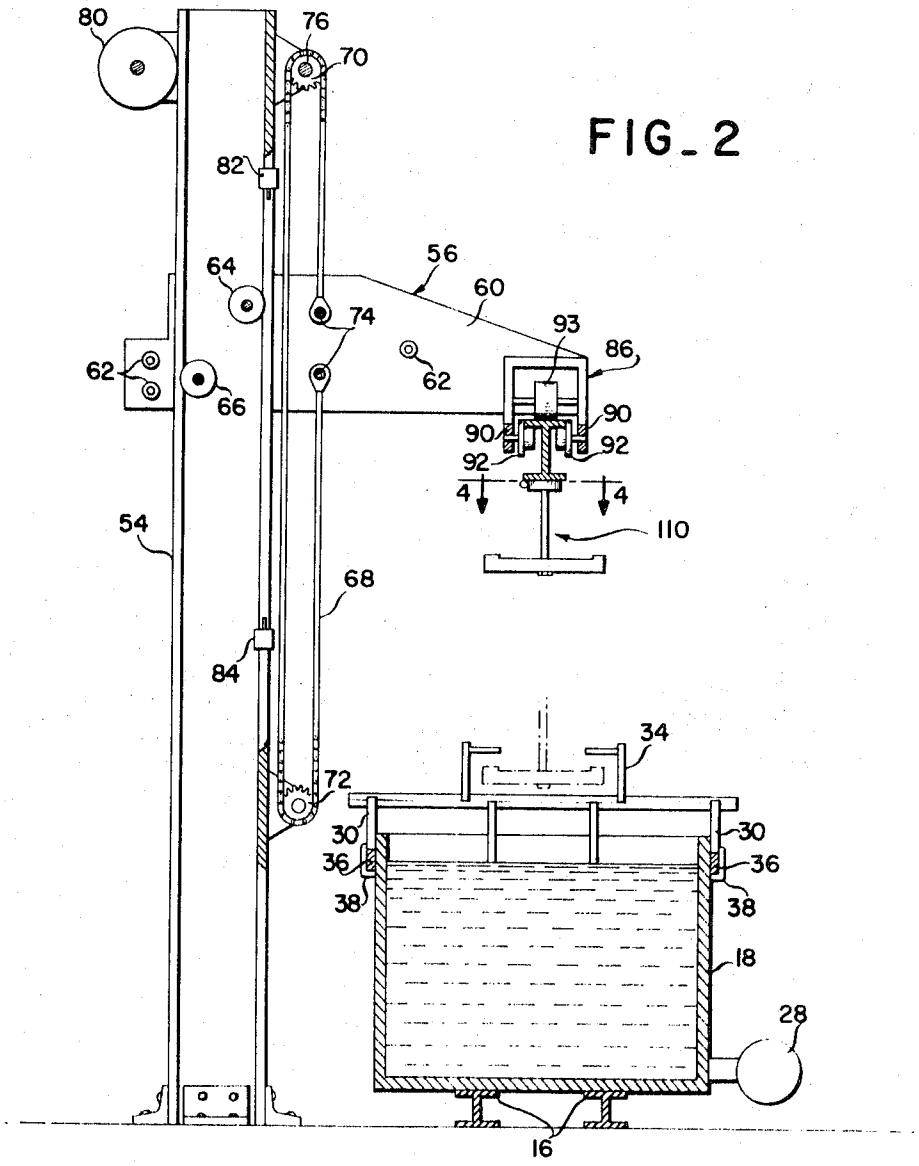


FIG_2

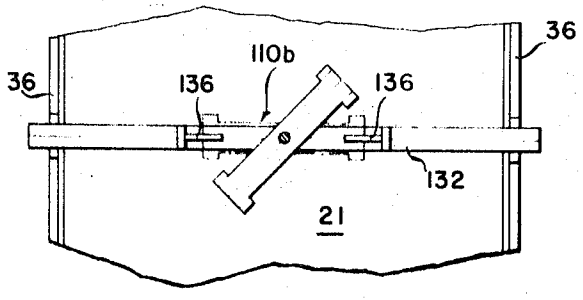
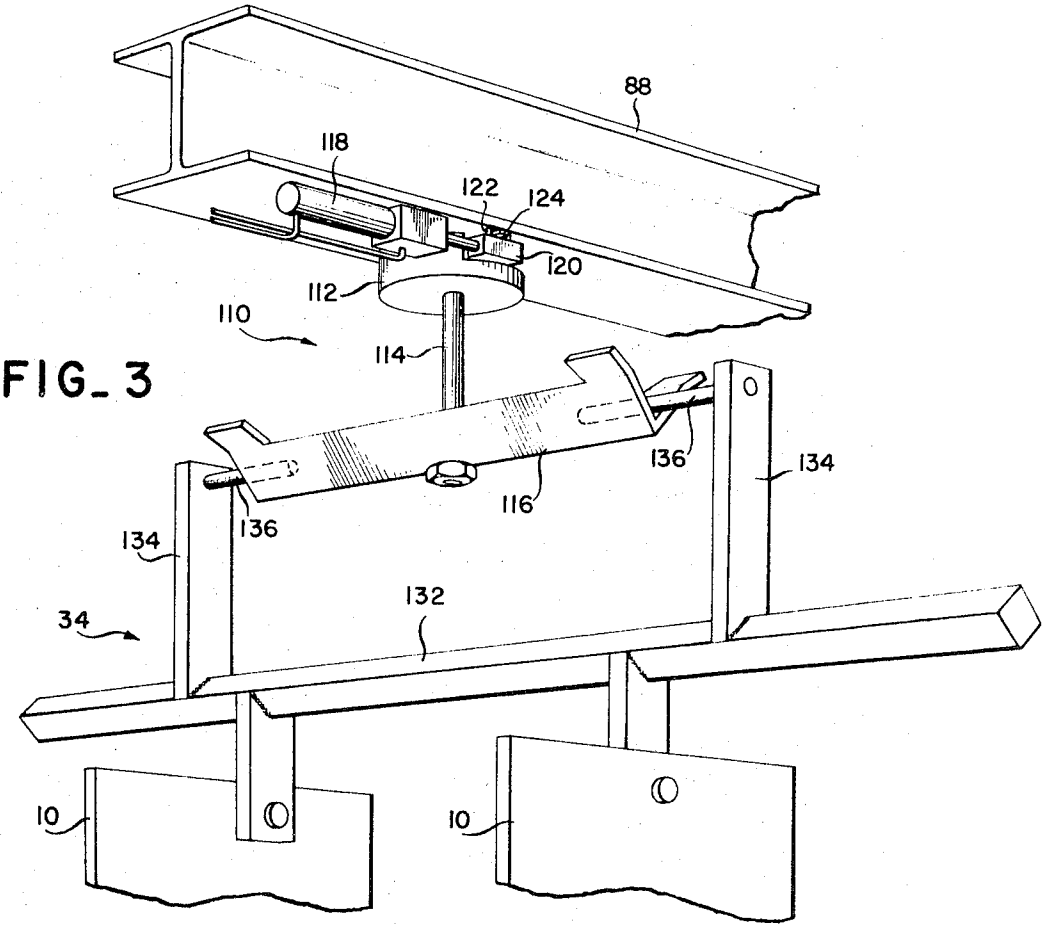


FIG_10

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FIG_3



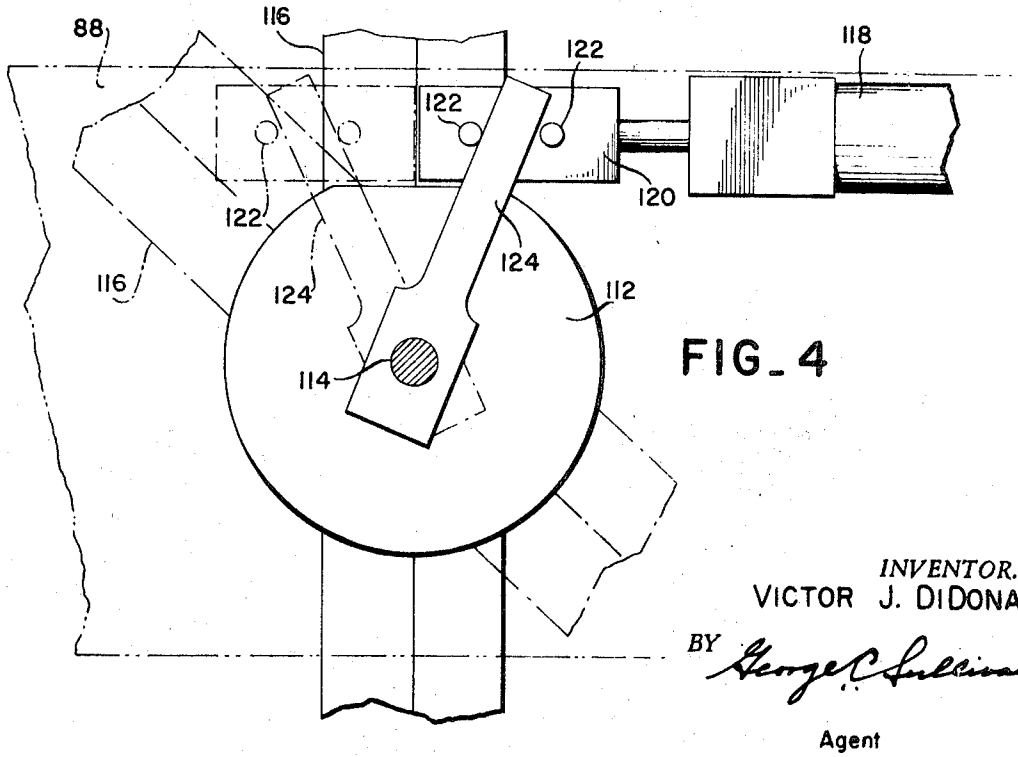


FIG_4

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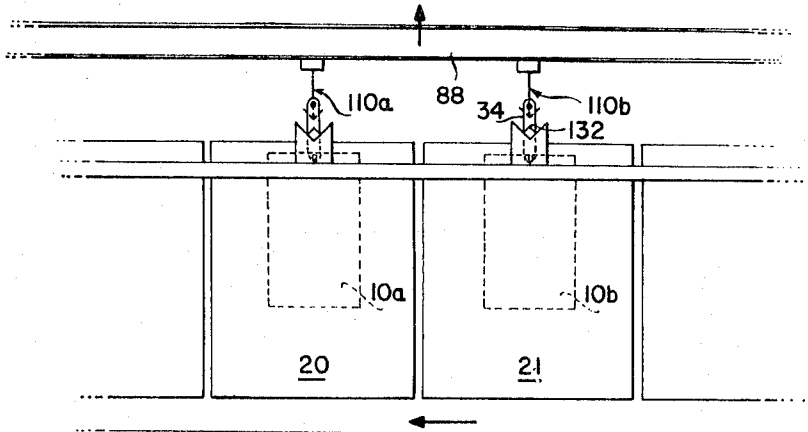


FIG_5

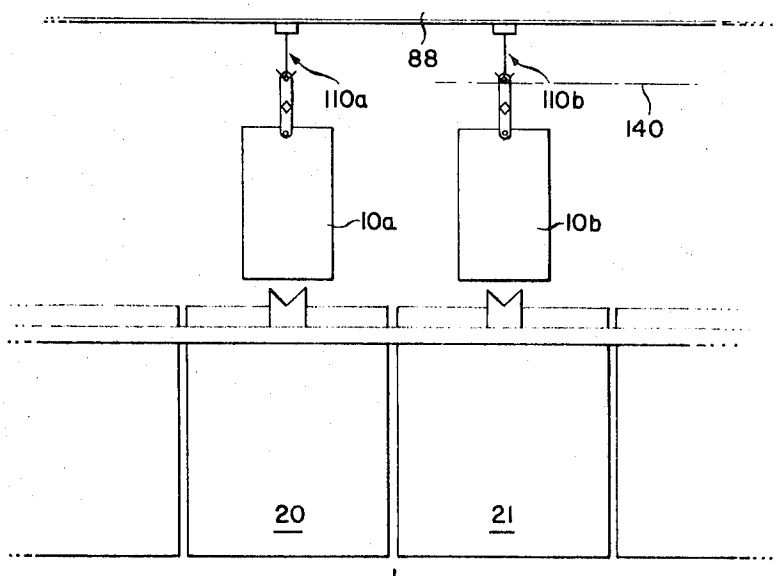


FIG_6

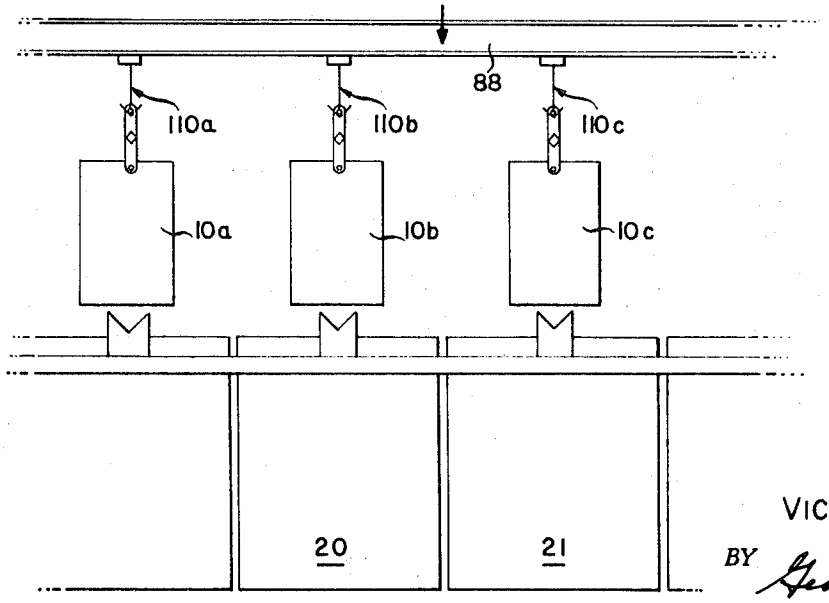


FIG_7

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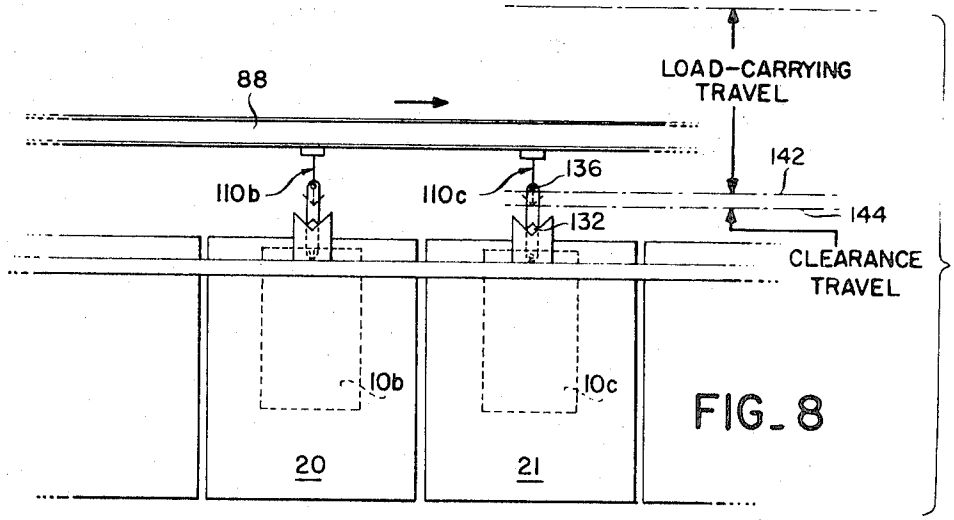


FIG_8

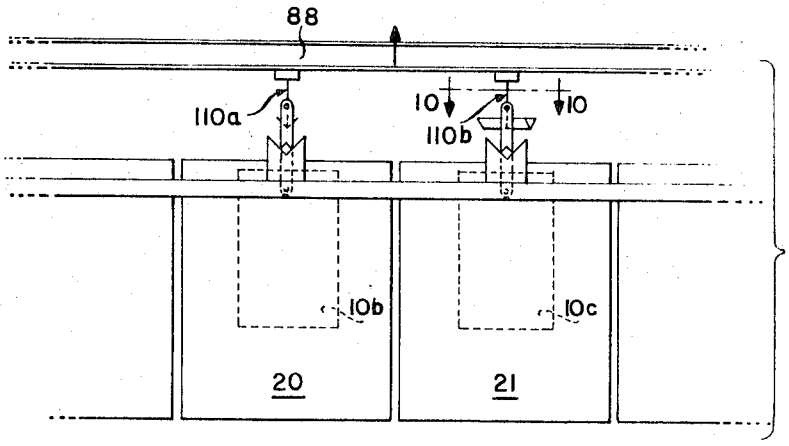


FIG_9

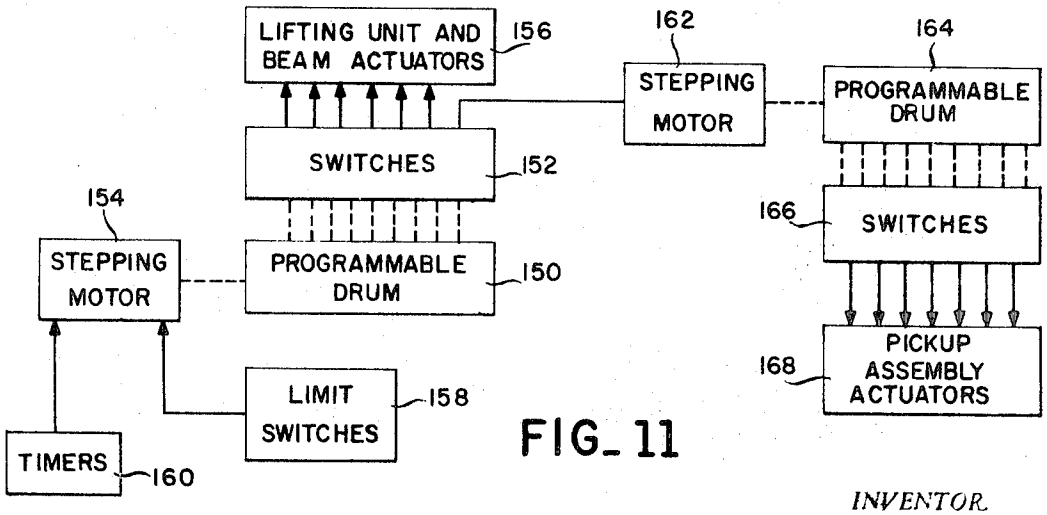


FIG_11

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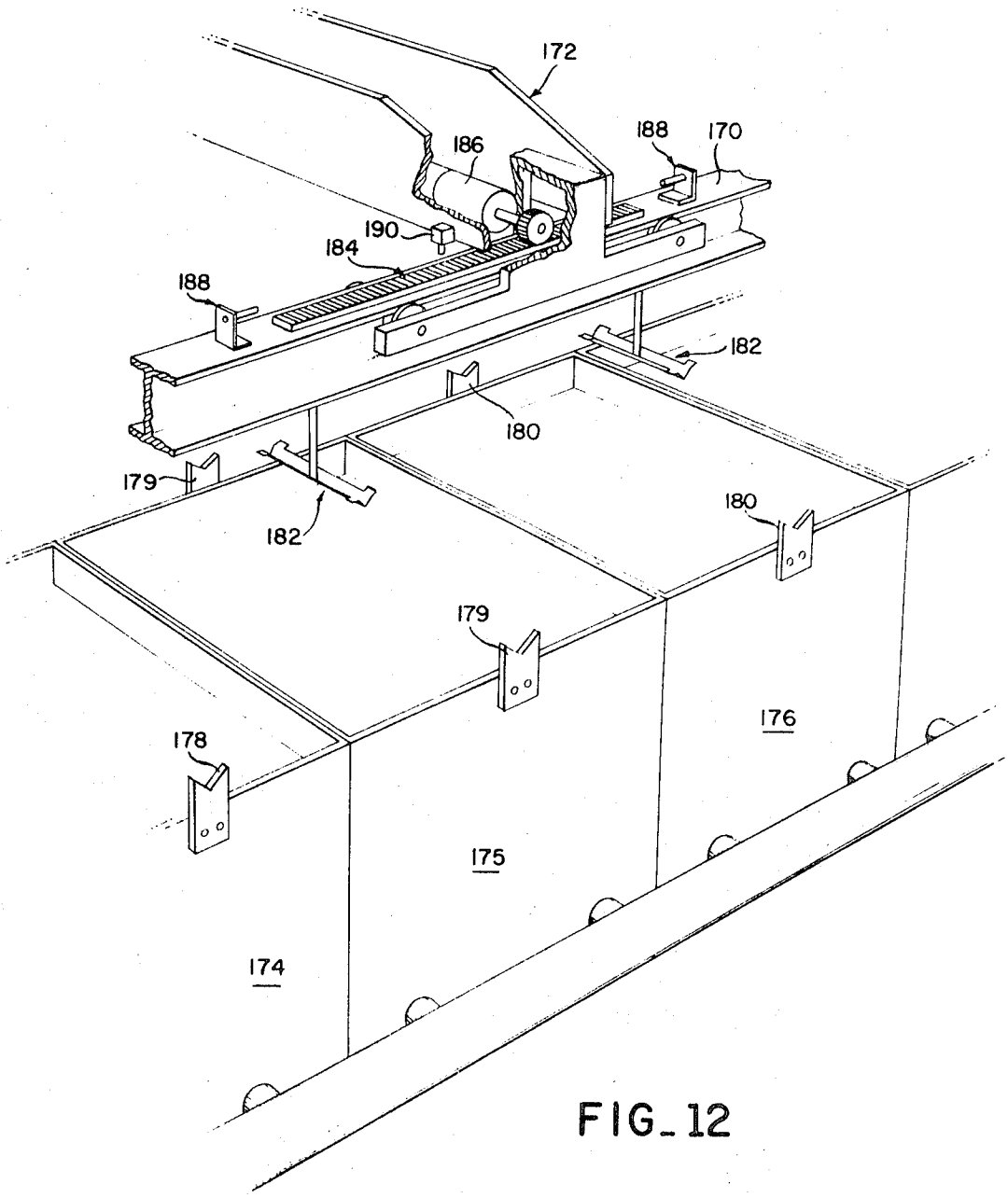


FIG_12

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PROGRAMMABLE APPARATUS FOR CONVEYING ARTICLES THROUGH SUCCESSIVE PROCESS STEPS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to material handling systems and particularly to programmable apparatus for conveying articles through a series of discrete article-treating process steps along said apparatus, each step having a predetermined duration.

2. Description of the Prior Art

In the fabrication of printed circuit boards, copper clad laminate is subjected to a variety of process steps including plating, etching, cleaning, rinsing and so forth, requiring the immersion of the laminate in successive treating solutions or baths. The duration of immersion varies substantially between steps and in a typical process may range upwardly from less than 1 minute for the step of shortest duration.

In existing systems, the transfer of the laminates from one processing solution to the next is performed by continuous chain drives carrying the articles from suspended hooks or baskets. The chain is typically guided by a monorail along a vertically undulating path with runs past the treating tanks into which the articles are dipped. In most of these systems, the articles being treated are continuously coupled to the chain and therefore all articles along the entire path move simultaneously whenever the chain is driven. Control of the duration of immersion is sometimes achieved by fixing the length of each tank at the outset and the length of the corresponding run of the drive chain. In another conventional drive chain system, the immersion tanks all have essentially the same length and the articles are connected to the drive chain by a clutching device whereby they may be manually or automatically decoupled from the drive chain and maintained in a particular tank for the length of time necessary.

The foregoing conventional systems have several disadvantages including the requirement for relatively large areas of floor space and difficulty in altering the process and the sequence and time duration of the various steps. These disadvantages are consequences of the inflexibility stemming from having major structural elements of the system, such as the monorail, from which the articles are suspended fixed to the building structure in which the system is housed. In the second system described, although better control is achieved over the time of immersion, bunching of the articles being treated occurs in those tanks where longer immersion is required reducing the efficiency of the particular process step. Furthermore, none of the known systems of the prior art are capable of accurately controlling the duration of immersion of the articles being treated. This becomes very important in processes wherein particular immersion times must be regulated to within a small fraction of a second.

SUMMARY OF THE INVENTION

According to the broad aspects of an apparatus according to the present invention, a series of process stations are arranged at substantially equal intervals along the apparatus, the articles to be treated being conveyed in stepwise fashion from station to station. The articles are maintained at each station for a predetermined duration and these durations will typically vary in some fashion, according to the particular process, from station to station. The articles are transferred by article pickup means suspended from a transfer member overhanging the stations. The transfer member is reciprocable both horizontally and vertically by appropriate drive means programmed in a predetermined, timed sequence. Both the horizontal and vertical displacements of the transfer member can be programmed to vary during a particular process in accordance with the requirements thereof; the horizontal displacement, however, will normally be some multiple of the distance between adjacent stations, such multiple including unity in which case the displacement is equal to the distance between

adjacent stations. Furthermore, in accordance with another important aspect of the invention, the article pickup means may be made movable and its movements programmed between an article pickup or engaging position and a non-engaging position. The programmable nature of the apparatus renders the apparatus extremely flexible from the standpoint of the range of processes which can be performed by a single machine.

In accordance with one specific form of the present invention, the process stations take the form of a series of substantially identical rectangular process tanks disposed in a row in end-to-end relation along a base between an article loading station and an article unloading station. Each tank has a pair of support brackets mounted midway between the ends of the tank and projecting above the upper side edges thereof for receiving a succession of transversely oriented hanger assemblies from which the articles to be treated are suspended.

Located adjacent one side of the row of tanks is a plurality of spaced, vertical columns. A lifting unit is mounted on each column for vertical movement therealong. A suitable drive means, such as a motor-driven sprocket chain, is coupled to the lifting units to move them up or down in unison along the columns between an uppermost level at which the articles are transferable between tanks and a lowermost level at which the articles are positioned completely within the tanks for treatment by the various process solutions maintained therein. At an intermediate level in the downward travel of the lifting units, close to the lowermost level, the article hanger assemblies engage the support brackets and seat therein.

The lifting units carry a horizontally extending beam over the longitudinal center line of the row of process tanks. The beam is mounted for horizontal reciprocation by a suitable actuator between limits spaced apart a distance equal to the distance between support brackets on adjacent tanks. A plurality of pickup assemblies depend from the beam and are spaced along the beam at equal intervals equivalent to the distance between adjacent pairs of support brackets. At either end of the travel of the beam, the pickup assemblies are in vertical alignment with corresponding pairs of support brackets below.

By means of actuators mounted along the horizontal beam, the pickup assemblies are rotatable between article-engaging and non-engaging positions.

A programmable device is coupled to energize the lifting unit drive means and beam and pickup assembly actuators in accordance with a sequence and dwell periods determined by the particular article-treating process.

In accordance with another aspect of the apparatus of the invention, which has particular applicability to the fabrication of circuit boards with plated-through holes, the support brackets on each side of the apparatus may be secured to an agitator mechanism for moving the articles, in longitudinally reciprocating fashion, while they are submerged in the process solutions. The agitator mechanisms are energizing in out-of-phase relationship, so as to impart a slight rotational or twisting motion to the circuit boards which enhances the through-plating process.

Pursuant to an alternative embodiment of the invention, the pickup assemblies are fixedly secured to the horizontal beam so that all articles are immersed for an identical, fixed time period.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, advantages and features of the present invention will become apparent from the detailed description which follows when read in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of an apparatus of the present invention in accordance with a preferred embodiment thereof;

FIG. 2 is a partly broken away, end elevation view, in section, of the apparatus of FIG. 1;

FIG. 3 is a perspective view of a portion of the apparatus of FIG. 1 showing a typical pickup assembly;

FIG. 4 is a plan view, in section, of part of a pickup assembly as seen along the plane 4—4 in FIG. 2;

FIGS. 5–9 are schematic, side elevation views of a portion of an apparatus according to the invention to assist in understanding the sequence of operation of the apparatus;

FIG. 10 is a plan view; in section, of a portion of the apparatus of FIG. 9 as seen along the plane 10—10;

FIG. 11 is a simplified block diagram of a programming system used in conjunction with the apparatus of FIG. 1; and

FIG. 12 is a perspective view of a portion of an apparatus according to an alternative embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The invention will be described with particular applicability to the fabrication of circuit boards in which copper clad laminates are subjected to various etching, plating, cleaning and other process steps. It will be evident, however, that the invention has broader utility, being applicable to other processes requiring a stepwise transfer of discrete articles through a series of immersion steps of various durations, for example, in the plating of semiconductor devices and in the fabrication of integrated circuits wherein it is especially important that the time of immersion be very accurately controlled.

Turning to the drawings, FIGS. 1–4 show an apparatus, according to a preferred embodiment of the invention, for conveying articles **10**, such as circuit board laminates, from a loading station **12** at one end of the apparatus to an unloading station **14** at the other end. The apparatus includes a base comprising longitudinal rails **16** along which are mounted a plurality of identical, open topped, rectangular process tanks **18–23** having side walls and end walls and arranged linearly in end-to-end relation. Tank **18** comprises the first station in the process, tank **23** the last, the articles **10** being transferred from tank to tank and immersed in the solution contained in each tank for a predetermined time duration.

In one practical example involving a plating process for circuit boards, sixteen tanks are used containing various acids, cleaners, rinse solutions, and so forth, and arranged in the appropriate sequence. It will, of course, be appreciated that any number of tanks may be utilized, the number depending on the particular process being employed.

The tank **18**, which typifies all of the tanks, has in the lower portion of one of its side walls process solution inlet and outlet pipes **24** and **26** that are connected, respectively, to appropriate supply and discharge conduits (not shown) within a common duct **28**. The tank **18** further has along each of its upper side edges a support bracket **30** positioned approximately midway between the end walls of the tank and having an upper portion which projects above the upper side edge. The upper portion of each bracket **30** is notched at **32** to receive hanger assemblies **34** from which the articles **10** are suspended.

With the support brackets of each tank being mounted midway between the end walls thereof, it will be evident that the distance between support brackets of adjacent tanks is the same. The support brackets may be permanently secured to the side walls or upper side edges of the tanks but alternatively, as shown in the embodiment of FIG. **1**, the brackets on each side of the line of tanks are mounted on an agitator bar **36** running essentially the entire length of the apparatus. Each bar **36** is carried by guide channels **38** fastened to the sides of the tanks and is coupled at one end to a suitable actuator **40** which gently reciprocates the bar **36** longitudinally through a small displacement. The agitator mechanism is typically operated in plated-through-hole processes and enhances the metal deposition in the through-holes and rinsing thereof by forcing the metallizing and rinsing solutions through the holes. It has been found that even better and more consistent results are obtained by out-of-phase reciprocation of the bars **36** thereby imparting both a linear movement and rotational or swiveling movement to the circuit boards. The stroke of each bar **36**, as well as the frequency of reciprocation, may be varied by appropriate control means (not shown) to optimize the through-plating or rinsing process.

The loading station **12** comprises a framework **44** projecting forwardly from the tank **18** and having a pair of opposed support brackets **46**, similar to the brackets **30**, and spaced therefrom a distance equal to the interval between support brackets of adjacent tanks. Similarly, the unloading station **14** includes a rearwardly projecting framework **48** fastened to the last tank **23** and carrying a pair of support brackets **50** spaced from the support brackets of tank **23** the aforedescribed distance.

Positioned along one side of the apparatus is a pair of vertical I-beam columns **54** each of which serves as a guide rail for a lifting unit **56** designed to travel up and down the column. The apparatus specifically shown in FIG. **1** has two columns **54** but it will be understood that these may be augmented with additional columns as the number of tanks and consequently, the length of the apparatus are increased. The columns **54** may be affixed permanently to the floor as shown; alternatively, they may be attached to the base rails **16** to facilitate dismantling and transportation for relocation of the apparatus.

Each lifting unit **56** includes an arm **58** cantilevered over the tanks **18–23** and formed basically of a pair of spaced plates **60** astride the associated column **54** and interconnected by suitable bolts and spacers **62**. Upper and lower flanged rollers **64** and **66** attached to the plates **60** and riding in contact with the forward and rear flanges, respectively, of the column **54**, retain the lifting unit **56** on the column and guide its vertical travel therealong.

The lifting units **56** are moved in unison by a drive system including, in connection with each lifting unit, a vertically oriented sprocket chain **68** looped around a drive sprocket **70** rotatably mounted at the upper end of the column **54**, and an idler sprocket **72** mounted along the lower portion of the column. The ends of the drive chain **68** are securely fastened to pins **74** connected to the plates **60**. The drive sprockets **70** are keyed to a common shaft **76** which in turn is driven via a suitable positive transmission such as sprocket and chain drive **78**, by an electric motor **80** mounted on one of the columns **54**.

The lifting units **56** are always in horizontal alignment and for a given displacement of the drive motor, the lifting units all move a proportional linear distance up or down the vertical columns. Limit switches **82** and **84**, mounted on one of the columns **54**, and connected to the circuitry of motor **80**, cooperate with one of the plates **60** to limit the vertical travel of the lifting units along the columns.

Depending from each lifting unit arm **58** and secured thereto at its outer end, is a carriage **86** supporting a horizontal I-beam **88** for longitudinal, reciprocating movement. The carriage **86** comprises a pair of spaced, inverted T-shaped frames **90** having a pair of flanged guide wheels **92** at each end riding in contact with the undersurface of the upper flange of the beam **88**. A roller **93** rotatably mounted between the frames **90** rides in contact with the top surface of the upper flange to further stabilize the beam.

The beam **88** is moved horizontally by means of a hydraulic cylinder and piston actuator **94** through a displacement equal to the longitudinal distance between the support brackets of adjacent tanks, or some multiple thereof. The piston of the actuator **94** is connected to the beam **88**, and the cylinder is connected to one of the lifting unit arms **58**. The actuator **94** is supplied by hydraulic lines **96** extending from a control box **98** housing appropriate solenoid-operated valves (not shown).

The length of travel of the beam **88** is initially set by fixing the position of limit switch actuators **100** mounted on top of the beam **88** and cooperating with limit switches **102** secured to plates **60** of one of the lifting units **56**.

Suspended from the lower flange of the horizontal beam **88** is a plurality of pickup assemblies **110** spaced along the beam at equal intervals equivalent to the distance between support

brackets of adjacent tanks. The number of such pickup assemblies **110** is equal to the number of tanks plus one to accommodate either the loading station or unloading station, depending upon the position of the beam.

Referring now in particular to the detailed drawings of FIGS. **3** and **4**, a typical pickup assembly **110** includes a cylindrical block **112** bolted to the lower flange of the beam **88** and housing the upper end of a vertical, rotatable shaft **114**. Attached to the lower end of the shaft **114** for rotation therewith is a horizontal, V-shaped pickup angle **116**. The angle **116** is rotatable between a pickup or article-engaging position shown by solid lines in FIG. **4**, in which the longitudinal axis of the angle lies transverse, that is, perpendicular to the longitudinal axis of the beam **88**, and a non-engaging position in which the angle is angularly displaced, as shown by the broken lines in FIG. **4**. The shaft **114** is rotated between the article-engaging and non-engaging positions by a pneumatic cylinder/piston actuating device **118**, the connecting rod of which is coupled to a slide **120** having a pair of vertical pins **122** straddling a crank **124** secured to the upper end of the shaft **114**.

As best shown in FIGS. **1** and **3**, the articles **10** are suspended from hanger assemblies **34** adapted to be engaged by the pickup angles **116** and lifted and carried thereby for transfer between process stations. Each hanger assembly **34** chiefly comprises a square hanger bar **132** of sufficient length to span the distance between the support brackets of the immersion tanks **18–23**. To preclude rotation of the hanger bar **132** when seated in the support brackets, the bar is oriented so that it nests within the notched portions of the brackets. Projecting upwardly from the hanger bar **132** is a pair of spaced lifting hooks **134** including inwardly directed pins **136** adapted to be engaged by the outer portions of the pickup angle **116** when the angle is in the engaging position. The distance separating the inner ends of the pins **136** is sufficient so that the pickup angle **116**, in its non-engaging position, will clear the pins when the angle **116** is moved vertically between the pins, as shown in FIG. **10**.

Turning now to FIGS. **5–9**, a typical sequence of operations of the apparatus of FIGS. **1–4** will be described. In FIG. **5**, articles **10***a* and **10***b* are shown immersed in adjacent tanks **20** and **21**, being suspended from hanger assemblies **34** whose bars **132** are seated within the notched portions of the support brackets of these tanks. FIG. **5** also shows two typical pickup assemblies **110***a* and **110***b* suspended from the horizontal beam **88**. In the position of FIG. **5**, the beam **88** is about to be lifted as indicated by the arrow and as this motion is effected, the pickup angles, which are in their engaging positions, will engage the pins **136** of the hanger assemblies to lift the articles **10***a* and **10***b* out of the process tanks **20** and **21** to an uppermost level **140** as shown in FIG. **6**. The beam **88** is then moved to the left to the position shown in FIG. **7** in which articles **10***b* and **10***c*, carried by pickup assemblies **110***b* and **110***c*, respectively, are suspended over the tanks **20** and **21**. The beam is next lowered, thereby immersing the articles **10***b* and **10***c* into the tanks **20** and **21** as shown in FIG. **8**. It will be noted in FIG. **8** that the vertical displacement of the beam comprises a (1) load-carrying travel between the uppermost level **140** and an intermediate level **142** at which the hanger bar **132** first engages the notched support brackets and (2) a short clearance travel to a lowermost level **144** at which the pickup angles are positioned between the pins **136** and the hanger bar **132** in the vertical direction. In this connection, reference is also made to FIG. **2** in which the pickup angle is shown in broken lines in its lowermost position. The beam **88** is now ready for displacement toward the right, as shown by the arrow in FIG. **8**, to the position of FIG. **9**, in which the pickup assemblies **110***a* and **110***b* are once again over the tanks **20** and **21** and in alignment with the hanger assemblies carrying articles **10***b* and **10***c*. The beam will remain in this position for a predetermined dwell period during which processing of the various article **10** takes place. During immersion of the articles **10** for the appropriate length of time the bars **36** can be reciprocated, in the manner already described, to agitate the various solutions in the case of processes involving plating and rinsing of through-holes in the articles. Assuming now that article **10***c* is to remain immersed in tank **21** for a greater length of time than the article **10***b* in tank **20**, pickup assembly **110***b* is rotated to the non-engaging position so that when beam **88** is lifted once more, article **10***b* will be lifted from the tank **20** while article **10***c* will remain in the tank **21**. In this regard, see also FIG. **10**.

In the apparatus discussed so far, individual tanks **18–23** of substantially identical size have been described. However, it will be appreciated that one or more of the tanks may be longer than the remaining tanks and provided with a plurality of pairs of support brackets, the distances between adjacent pairs of brackets being equal along the length of the tank and equal to the spacing between support brackets of the remaining tanks. Thus, the articles may be transferred from station to station within the same tank in those cases in which particularly long periods of immersion are necessary. Furthermore, since the vertical displacement of the lifting units can be controlled and varied on a stepwise basis, by appropriate programming of the apparatus, the vertical displacement of the pickup assemblies can be limited to a short distance—sufficient to have the hanger assemblies clear the support brackets but not enough to lift any portion of the articles out of the process solution—to effect the transfer between stations within the longer tank. This is especially advantageous in electroplating processes in which the horizontal beam and the support brackets are connected by buses to an electrical current supply for plating articles moved, in stepwise fashion, through an electrolyte maintained in a single, long tank. Electrical continuity is at no time broken because the articles remain dipped in the electrolyte, even during the transfer of the articles between stations. Furthermore, since transfer is accomplished in the absence of any sliding contact, arcing and other electrical discontinuities or disturbances are avoided.

FIG. **11** shows a simplified, schematic diagram of a programmable system for controlling the operation of the lifting unit motor **80**, the beam actuator **94** and the pickup assembly actuators **118**. The sequence of operations of the lifting units and beam actuator and the dwell periods are all predetermined for a given process by means of a first programmable drum **150**. The drum **150** is of the type provided with a series of circumferential rows of perforations adapted to receive pegs for actuating switches (shown as block **152**) positioned adjacent each row. The drum **150** and switches **152** are available as a single, commercial unit such as the Agastat Stepping Switch manufactured by the Agastat Division of Amerace-Esna Corporation, Elizabeth, N. J. The drum **150** is rotationally stepped by means of a stepping motor **154**. The system is programmed simply by inserting pegs in the appropriate holes to obtain the desired sequencing and time delays. The system can also be programmed to control the length of horizontal movement of the beam **88**, as a multiple of the distance between stations, the direction of transfer of the articles (forward or back along the apparatus) and the vertical lift of the beam. The switches **152** operate the lifting unit motor **80** directly and through a solenoid operated valve (not shown), the beam actuator **94**.

The stepping motor **154** may be energized by limit switches shown collectively as block **158**, and which in practice will typically comprise the switches **82**, **84** and **102**. The motor **154** is also energized by a series of timers **160**, the number of which are determined by the number of cycles in a given process. For example, if a process, such as the one described below by way of example, has five cycles, five timers are employed and each will control the dwell period at the end of one of the cycles.

One of the switches **152** energizes a second stepping motor **162** which operates a second programmable drum **164** and associated switches **166**. The switches **166** control the energization, through various solenoid valves, of the pickup assembly actuators **118** (shown collectively as block **168**); in this way, the articles **10** may be selectively picked up and transferred to their next stations.

The following is an example of what may be termed a multiple cycle process and the programming that is required. In this process sequence, which represents an actual electroless copper plating operation, each article is transferred from a loading station L through 16 process tanks, numbered 1–16, to an unloading station UL with the immersion time in seconds in each tank shown below the tank:

L	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	UL
	240	120	120	120	60	120	120	120	120	300	120	120	300	120	300	120	

The lowest number of cycles required is the ratio of the longest to the shortest time in any tank, in this case:

$$300/60 = 5 \text{ cycles}$$

Since the immersion times are all multiples of 60, then the time between each cycle is adjusted by means of the timers **160** so that there is a cycle every 60 seconds. The time in each tank can now be replaced by the number of cycles in that tank as follows:

L	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	UL
	4	2	2	2	1	2	2	2	2	5	2	2	5	2	5	2	

The process sequence may then be described as follows:

1. Pickup from the loading station L and transfer to tank 1.
2. After four cycles, pickup from tank 1 and transfer to tank 2.
3. After two cycles, pickup from tank 2 and transfer to tank 3, and so forth.

Thus, for each cycle, the pickup assemblies **110** will be programmed for pickup as shown in the following table:

Cycle No.	Pickup assembly programmed for pickup (by tank number)
1	L, 4, 7, 14, 15
2	**2, 5, 11**
3	**8, 16**
4	**3, 6, 12, 13**
5	1, 9, 10

Thus, once the sequence and cycle time have been established for a particular process, the foregoing tables may be constructed and it is a simple matter to program the drums **150** and **164** and timers **160** to accomplish the necessary operations.

Turning now to FIG. **12**, there is shown a portion of an alternative embodiment of the apparatus of the present invention. The apparatus includes a reciprocable, horizontal beam **170** suspended from a plurality of lifting units **172**, only one of which is shown. The beam **170** overhangs a line of process tanks, including the tanks **174–176**, having pairs of equallyspaced, notched support brackets **178–180** fixed to the opposing sides of the tanks. Secured to the lower flange of the beam **170** is a series of pickup assemblies **182**. Because the pickup assemblies **182** are fixed to the beam **170** and are therefore not capable of the rotational motion of the assemblies **110** in the embodiments previously described, the apparatus of FIG. **12** may be termed a fixed cycle machine. Thus, the capability of this machine extends only to the transfer of articles from station to station at fixed time intervals and simultaneous transfer of all articles is made each cycle. A single, elongated tank can be substituted for the row of process tanks shown; the number of pairs of support brackets and the spacing therebetween will remain as in the case of plural tanks and this form of the apparatus may be used for the electroplating process previously described in which the articles are lifted only to the extent necessary to effect transfer to the next stations.

The horizontal beam **170** is reciprocated between its extreme positions by a rack and pinion mechanism **184** driven by an electric motor **186** carried within one of the lifting units **172**. The length of travel of the horizontal beam **170** is limited by the spaced microswitch actuators **188** secured to the upper flange of the beam **170** and cooperating with microswitches **190** attached to one of the lifting units **172**.

What is claimed is:

1. Apparatus for conveying articles through a sequence of article-processing steps, comprising:

a series of equally spaced article-processing stations arranged linearly between an article loading station and an article unloading station;

a longitudinally extending beam disposed over said stations;

actuating means coupled to said beam for reciprocating said beam through horizontal and vertical displacements;

a plurality of movable article pickup devices suspended from said beam, said pickup devices being equally spaced at intervals equal to the distance between adjacent stations, said pickup devices being in vertical alignment with said stations at the limits of said horizontal displacement of said beam;

an actuator coupled to each said pickup device for moving said device between article-engaging and non-engaging positions, said pickup devices including horizontally oriented pickup angles adapted to cooperate with transversely oriented hanger assemblies from which said articles are suspended, each said angle being rotatable by said actuator between a transverse position in which said hanger assemblies are adapted to be engaged by said angle and a non-transverse, non-engaging position; and

a programmer connected to operate said beam actuating means in a predetermined, timed sequence to control said horizontal and vertical displacements and the duration of dwell periods of said beam, and further connected to operate said pickup device actuators to selectively pick up articles, whereby the duration of processing at a given station is regulated.

2. Apparatus for transferring articles, carried by hanger assemblies including lifting hooks, through a sequence of process steps, said steps having preselected durations and occurring at linearly arranged stations equally spaced along said apparatus, said apparatus including:

article pickup assemblies spaced along said apparatus above said stations at intervals equal to the distance between adjacent stations, each of said assemblies including a horizontal, V-shaped pickup angle secured to a central, vertical shaft and an actuator coupled to said shaft for rotating said shaft and angle between a first position in which said angle is adapted to engage said lifting hooks as said angle is raised from a lowermost level at which processing of said articles takes place, and a second position in which said angle fails to engage said lifting hooks as said angle is raised from said lowermost level;

transfer means carrying said article pickup assemblies;

means for moving said transfer means horizontally through a displacement equal to the distance between stations or a multiple thereof;

means for moving said transfer means vertically through a displacement spanning said lowermost level and an uppermost level at which transfer of said articles takes place; and

means coupled to control the movements of said horizontal and vertical moving means and said pickup assembly actuator, said control means being programmable to predetermine for a given process a repetitive sequence of said movements, said sequence comprising a series of

distinct cycles, the number of said cycles being equal to the duration of the longest process step divided by the duration of the shortest process step, each cycle including a series of movements of said transfer means and a dwell period.

3. Apparatus, as defined in claim 2, in which said programmable control means includes:

a first programmable, rotatable stepping switch having outputs connected to selectively energize said horizontal and vertical moving means;

limit switches mounted for sensing the limits of horizontal and vertical travel of said transfer means and connected to effect rotation of said first stepping switch;

a timer for each said cycle connected to introduce into said first stepping switch a time delay determinative of said dwell period for said cycle; and

a second programmable, rotatable stepping switch coupled to said first stepping switch for periodic rotation thereby, said second stepping switch having outputs coupled to selectively energize said pickup assembly actuators.

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