Aug. 16, 1938. A. H. HANNON 2,127,406

REVERSING MOVEMENT FOR PLATING MACHINES

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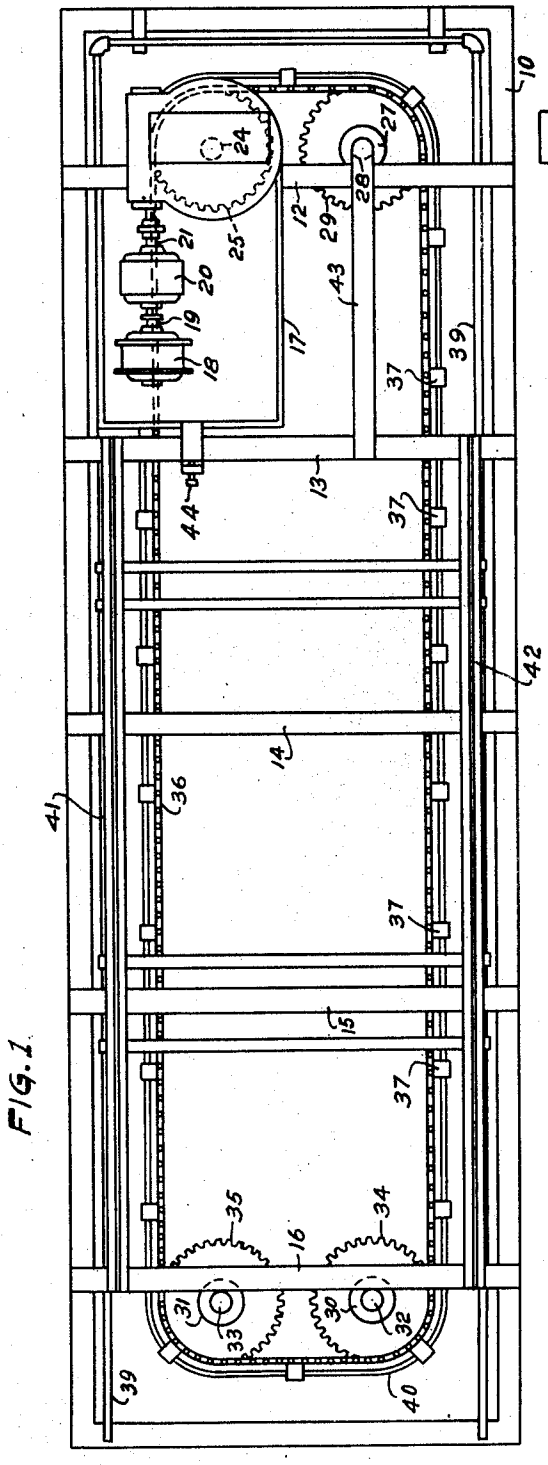


FIG. 1.

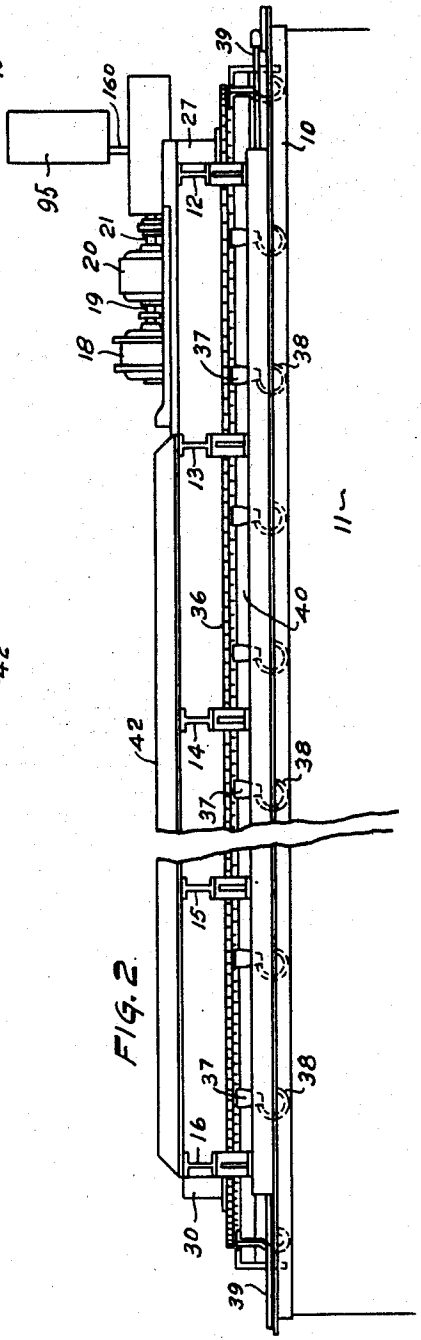


FIG. 2.

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FIG. 3.

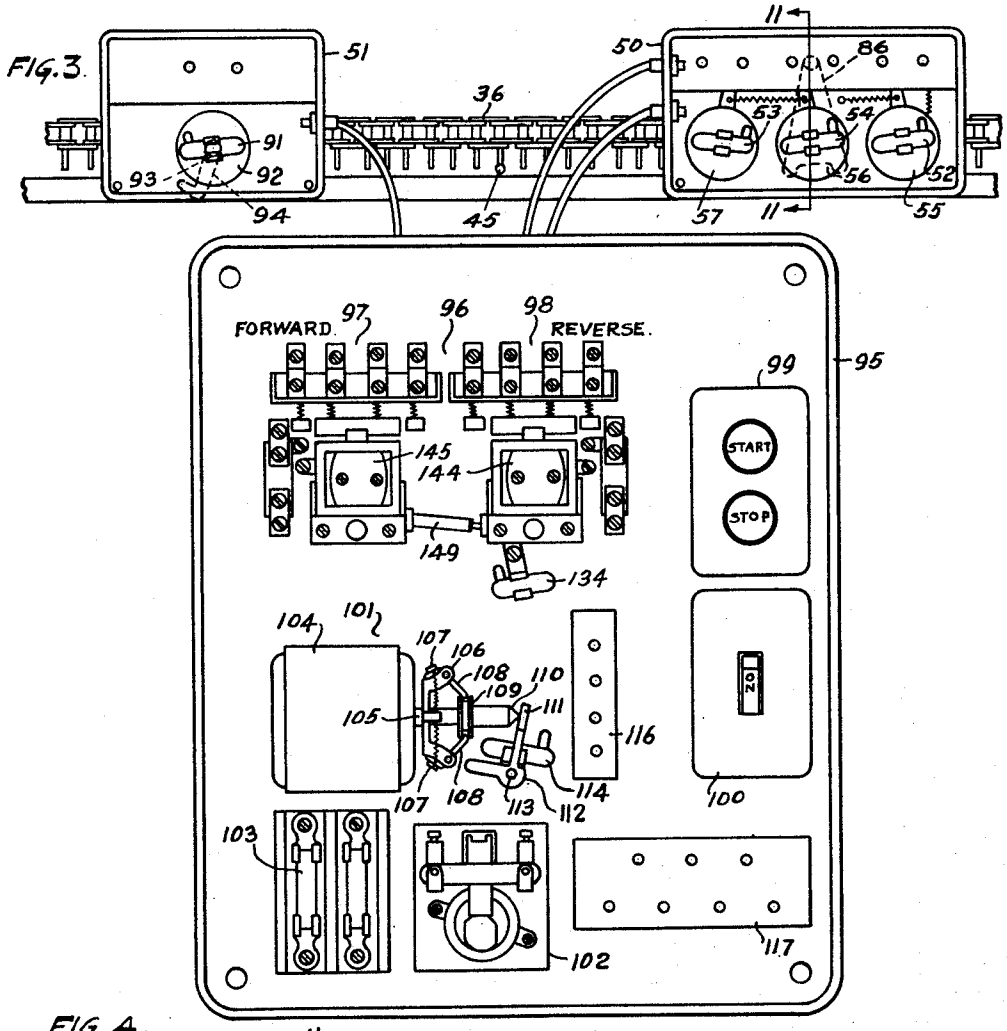
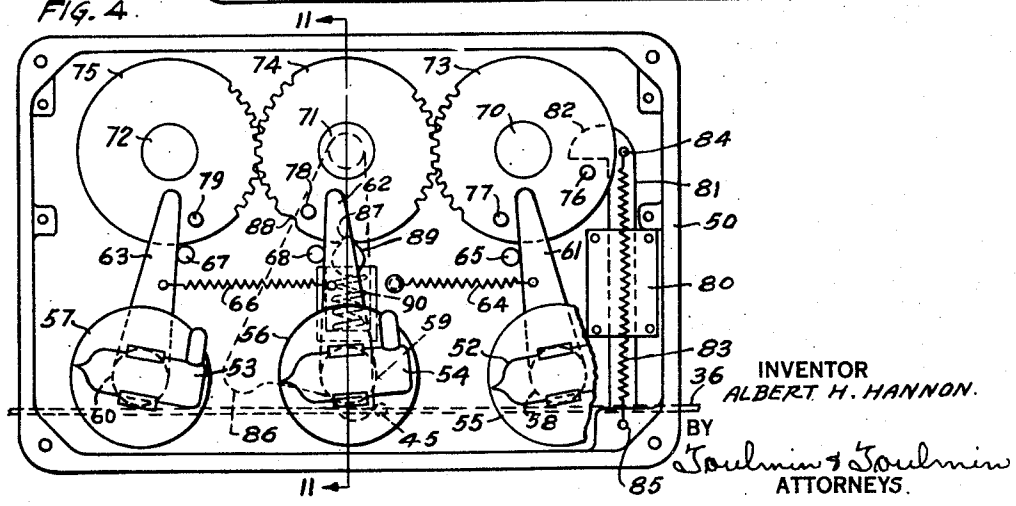


FIG. 4.



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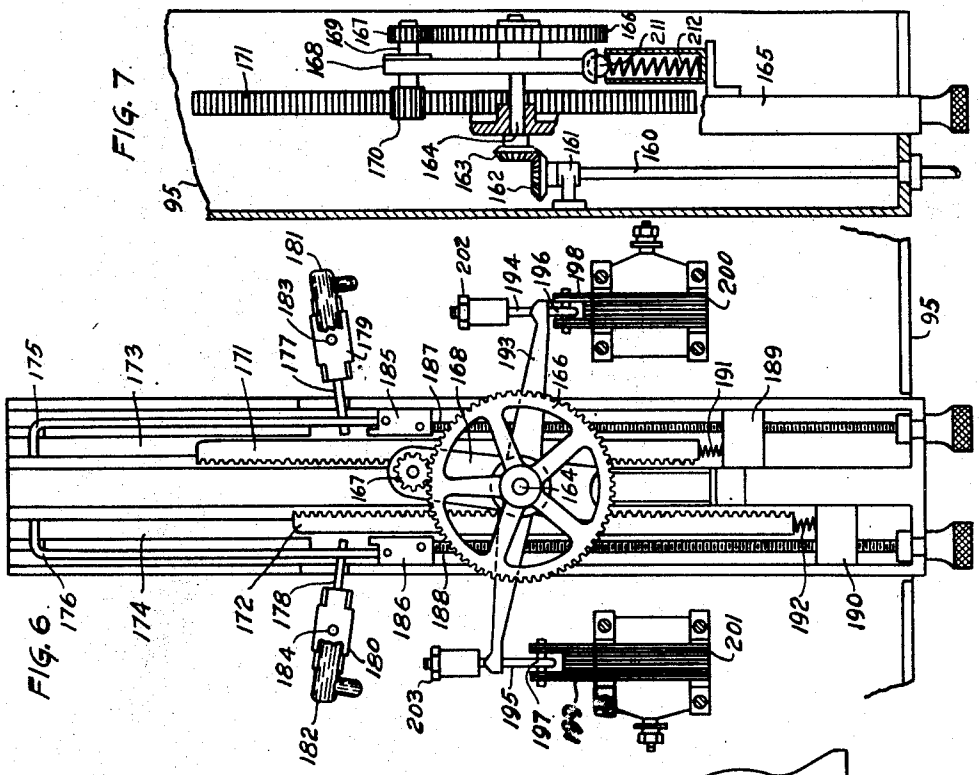


FIG. 7.

FIG. 6.

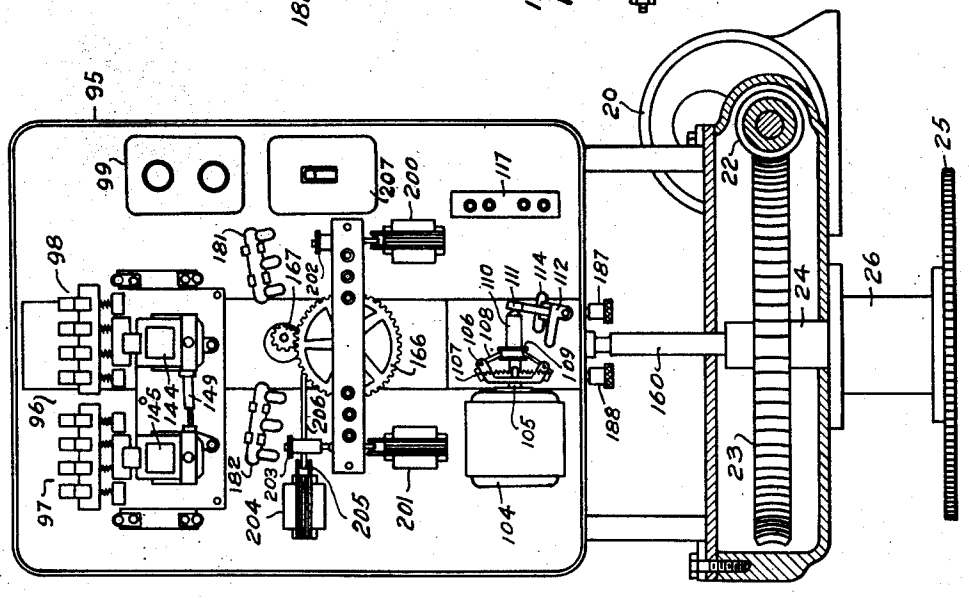


FIG. 5.

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FIG. 8.

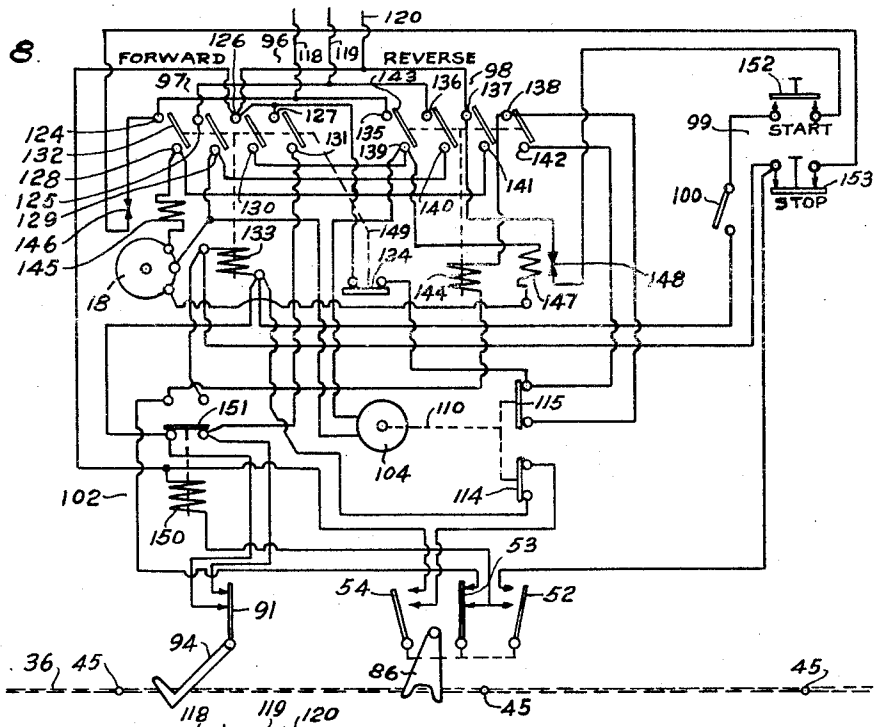
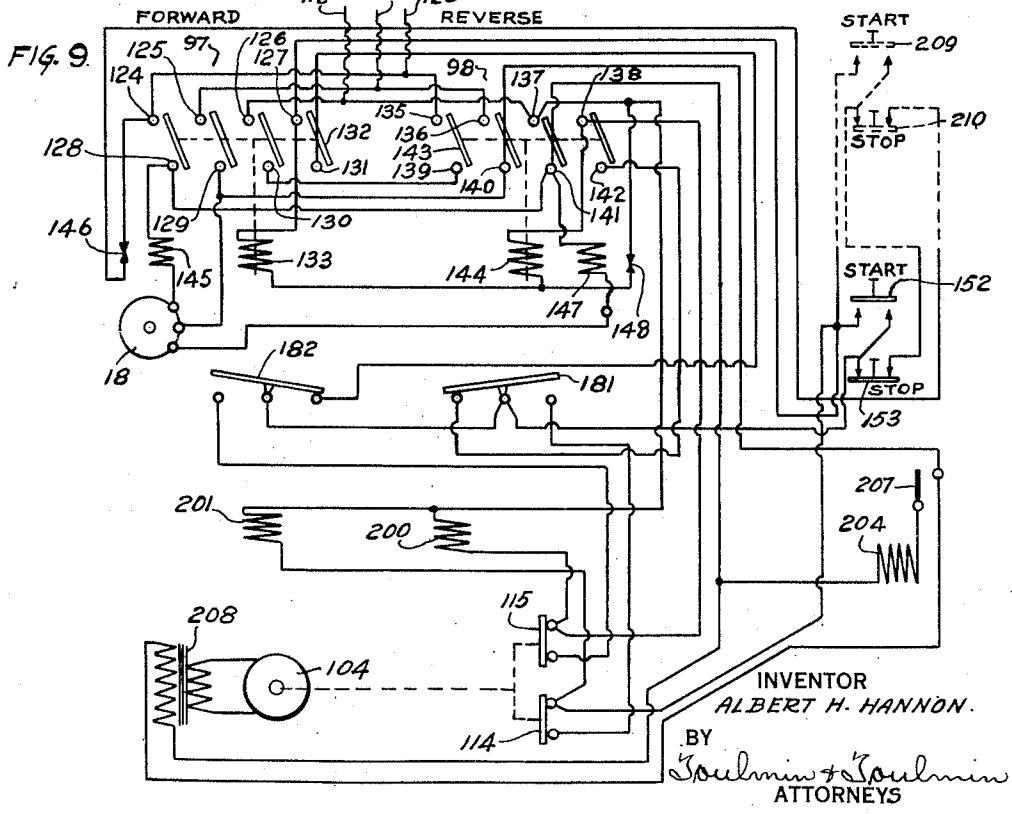


FIG. 9.



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FIG. 10.

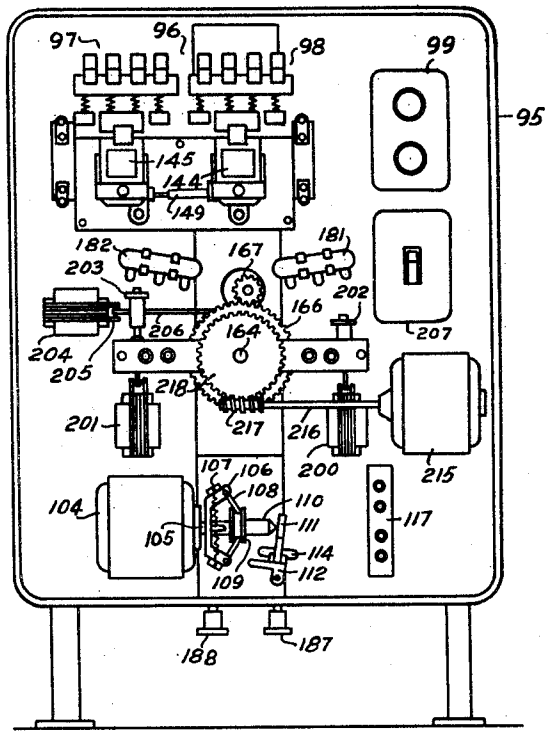
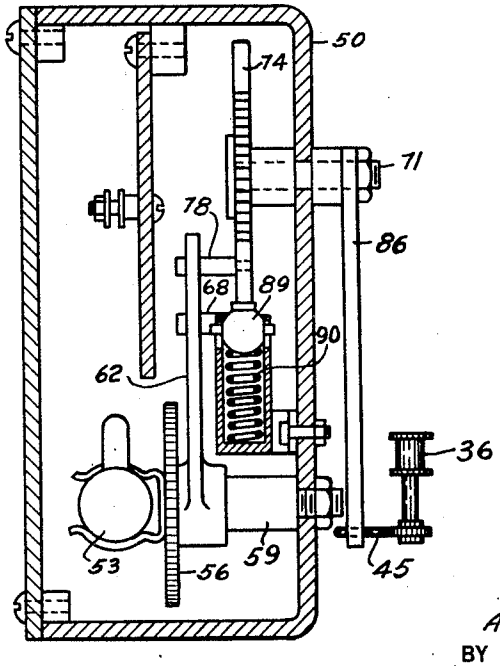


FIG. 11.



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Patented Aug. 16, 1938 2,127,406

UNITED STATES PATENT OFFICE

2,127,406

REVERSING MOVEMENT FOR PLATING MACHINES

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Application March 5, 1935, Serial No. 9,461

24 Claims. (Cl. 204—5)

This invention relates to electro-processing apparatus, and in particular, to such apparatus wherein the articles to be electroplated are carried by a moving conveyor.

One object of my invention is to provide an electro-processing machine wherein the moving conveyor has a reversing motion applied thereto so as to move the work back and forth as it goes through the solution.

Another object is to provide an electrical reversing movement to an electro-processing machine of this nature, thereby eliminating mechanical variable speed mechanism and obtaining a variation of time in the plating solution by varying either or both the backward and forward movements of the conveyor.

Another object is to provide an electro-processing machine of the traveling chain type, wherein the chain is provided with spaced pins which actuate electrical switches in such a manner that the chain is given an alternate forward and backward movement, transferring this movement to the articles carried by the chain.

Another object is to provide an electro-processing machine having a traveling conveyor chain, whereof the driving motor is also caused to operate the reversing switches so as to reverse this motor and with it the direction of motion of the conveyor chain.

Another object is to provide electrically-actuated mechanism of this sort, wherein a pilot motor is operated in conjunction with the driving motor of the machine, this pilot motor operating the reversing switches, which in turn, reverse the driving motor of the machine at predetermined intervals, thereby causing the conveyor chain to operate in reversible directions as it moves through the solution.

Another object is to provide an electro-processing machine having a conveyor chain operated by a driving motor, the conveyor chain having spaced pins thereon, and electrical switches operated thereby, these electrical switches being arranged to control a reversing switch for reversing the direction of motion of the driving motor, these switches and their associated mechanism being so arranged that the driving chain first moves forward by the space between three pins, then backward by the space between two pins, then forward by the space between three pins, etc., this giving the effect of making two steps forward and one step backward while moving through the solution.

Referring to the drawings:

Figure 1 is a plan view of the electro-processing machine of my invention.

Figure 2 is a side elevation of the electro-processing machine shown in Figure 1.

Figure 3 is a front elevation, with the cover removed, of the electrical motor reversing apparatus used in the machine shown in Figure 1.

Figure 4 is an enlarged side elevation, with the cover removed, of the triple unit switch shown in Figure 3 as operated by the pins on the conveyor chain.

Figure 5 is a front elevation, with the cover removed, of a modified type of motor-reversing arrangement, similar to that shown in Figure 3 but with the motor reversed by switches operated by gearing and racks connected to the main driving motor of the machine instead of by pins on the conveyor chain.

Figure 6 is a front elevation of the gearing, operating solenoids and racks of the mechanism shown in Figure 5.

Figure 7 is a central vertical section through the mechanism shown in Figure 6.

Figure 8 is an electrical wiring diagram of the principal form of my invention, as shown in Figure 3.

Figure 9 is an electrical wiring diagram of the modified form of my invention, as shown in Figure 5.

Figure 10 is a front elevation of apparatus similar to that of Figure 5, but with the racks and their associated mechanism operated by a pilot motor in synchronism with the main driving motor instead of by the main driving motor itself.

Figure 11 is a section along the line 11—11 of Figures 3 and 4, showing the triple switch as operated by the pins on the conveyor chain.

Electro-processing machine in general

Referring to the drawings in detail, Figure 1 shows the machine of my invention as having a frame generally designated 10, surmounting and surrounding an electro-processing tank generally designated 11. The frame 10 is provided with cross members 12, 13, 14, 15 and 16, the cross members 12 and 13 serving to support a base plate 17, upon which there is mounted the main driving motor 18.

The main driving motor is operatively connected by the shaft 19 to the gear box 20, which in turn, is connected by the shaft 21 to the worm 22 (Figure 5). The latter meshes with the worm gear 23 mounted upon the main drive shaft 24, and which carries the main driving sprocket 25 on its lower end. The main drive shaft 24, between

the sprocket 25 and the worm gear 23, is rotatably supported in the bearing 26 mounted upon the frame cross member 12.

Also mounted upon the frame cross member is the bearing 27, carrying a shaft 28 which rotatably supports the sprocket 29. The cross member 16, at the opposite end of the machine, similarly carries bearings 30 and 31 rotatably supporting the shafts 32 and 33, respectively, which in turn, carry the sprockets 34 and 35, respectively.

Arranged to travel in an orbital path around the sprockets 25, 29, 34 and 35 is the conveyor chain 36, by which the articles to be plated are moved through the solution. The conveyor chain 36 is provided at intervals with hangers 37 having hooks 38 from which the articles are suspended. Accordingly, as the conveyor chain 36 is moved through the solution, the hangers 37 move the plated articles, and thus tend to present fresh quantities of plating solution as well as to wash hydrogen bubbles from the surfaces of the plated articles. It is to the conveying chain 36 that the reversing motion of the machine is applied.

The anode bars of the metal to be plated are suspended from the anode rods 39, arranged at the edges of the tank 11, whereas the cathode charge is communicated to the article-carriers 37 by their sliding contact with the track 40 (Figure 1), which generally follows the path of the conveyor chain 36. This track 40 is connected to the negative pole of the plating current, whereas the anode rods 39 are connected to the positive pole thereof.

By the apparatus hereinafter described the conveyor chain 36 is caused to move forward for a predetermined time or distance, then backward and again forward, thus alternating its movements to and fro as it passes through the solution. It may also be mentioned that the cross members 13, 14, 15 and 16 are interconnected by longitudinal members 41 and 42 (Figure 1). The cross members 12 and 13, on the other hand, are interconnected by the longitudinal member 43, the base plate 17 of the driving unit forming the other longitudinal member. An adjusting screw arrangement 44 (Figure 1) serves to adjust the driving mechanism so as to take up any slack in the conveyor chain 36.

Reversing apparatus operated by conveyor chain

In the arrangement shown in Figures 3, 4 and 8, the reversing of the chain is accomplished by control mechanism operated by the chain itself. To this end the conveyor chain 36 is equipped with spaced pins 45, shown in Figures 8 and 11.

Arranged at the sides of the tank 11, as on the longitudinal frame member 41, are switch boxes 50 and 51, respectively, (Figure 3). The switch box 50, better shown in Figure 4, contains three mercury switches 52, 53 and 54, mounted on the supporting plates 55, 56, and 57, rotatably supported on the shafts 58, 59 and 60, respectively. Each of the plates 55, 56 and 57 carries an arm, respectively designated 61, 62 and 63. A spring 64 urges the arm 61 of the switch 52 toward the left against the stop 65, whereas the spring 66 interconnects the switch arms 62 and 63 so as to urge them toward the stop pins 67 and 68, respectively.

In the switch box 50 is mounted a plurality of shafts 70, 71 and 72, which respectively carry the intermeshing gears 73, 74 and 75. The gear 73 is provided with pins 76 and 77, arranged on one face thereof, whereas the gears 74 and 75 are similarly provided with pins 78 and 79, respectively. The pins 77, 78 and 79 are arranged to engage the switch arms 61, 62 and 63, respectively, as the gears rotate.

The switch box 50 is also provided with the slide bearing 80, which reciprocably supports the slide member 81 having a projecting arm 82 extending therefrom, and adapted to engage the pin 76 on the gear 73. A spring 83, attached at one end to the pin 84 on the slide member 81 and at its other end to the pin 85 on the switch box 50, serves to urge the slide member 81 downward against a stop lug in the bottom of the switch box 50.

Also mounted on the central gear shaft 71 is the forked arm 86 (Figures 8 and 11) the two tines of which engage the pins 45 on the conveyor chain as they pass by it. The rotation of the shaft 71 by engagement of the forked member 86 with the conveyor pins also rotates the gears 73 and 75 in mesh with the gear 74, so that the three mercury switches may be operated by the single forked arm 86, in the manner subsequently to be described. The edge of the gear 74 has notches 87 and 88, which are adapted to be engaged by the spring stop 89, urged therein by the spring 90 (Figure 4 and Figure 11).

The switch box 51 contains but a single mercury switch 91, mounted upon the rotatable plate 92. The latter is carried by the shaft 93, which carries thereon an L-shaped arm 94. The latter is also adapted to engage the conveyor pins 45 in a manner subsequently to be described, thereby tilting the mercury switch 91 (Figures 3 and 8).

The machine of my invention is additionally provided with a control box 95 (Figures 2 and 3), which contains the electrical apparatus for reversing the main driving motor in accordance with the motions of the pins 45. Mounted in this control box 95 is the electrical starting switch, generally designated 96, and having the forward and reverse portions 97 and 98, respectively, (Figure 3). The control box 95 also contains a starting and stopping push button switch 99, a manual switch 100, a motor-operated centrifugal switch, generally designated 101, a relay, generally designated 102, and fuses 103. The specific details of these parts will be described under the operation thereof.

The centrifugal switch 101, however, consists of a motor 104 connected to the same circuit as the main driving motor 18. The shaft 105 of the motor 104 carries the arm 106, on which are pivotally mounted the centrifugal governor weights 107 having the bell-crank arms 108. The ends of the latter engage a grooved wheel 109 attached to the sleeve 110, slidably mounted on the motor shaft 105. The free end of the sleeve 110 engages the arm 111 of the mercury switch base 112, this being pivotally mounted on the shaft 113 and carrying mercury switches 114 and 115 (Figures 3 and 8), the connections from which are brought out to the terminals mounted upon the insulated plate 116. The terminals of the control box 95 as a whole are brought out to the insulated terminal plate 117 (Figure 3).

Electrical circuit in the chain-controlled apparatus

The electrical circuit for the reversing apparatus controlled by the pins 45 on the conveyor chain 36 (Figures 3 and 4) is shown in Figure 8. The electrical elements which go to make up this apparatus have been briefly described above, and are contained mainly within the control box 95.

The arrangement of Figure 8 shows the main driving motor as operated by a three-phase alternating current, but it will be understood that other arrangements employing a two-wire circuit may also be used.

The three-phase alternating current is received from the power lines 118, 119 and 120. These join the first three contacts of the forward portion 97 and reverse portion 98 of the reversing switch 96. The forward portion is provided with contacts 124, 125, 126 and 127 on one side, together with contacts 128, 129, 130 and 131 on the other side, these being joined by the switch bars 132 connected to the armature of the operating coil 133 (Figure 8). Also mechanically connected to the switch blades 132, as by the link 149, so as to be operated by the opening and closing thereof, is the mercury switch 134.

The reverse portion 98 of the reversing switch 96 similarly contains contacts 135, 136, 137 and 138, opposite which are mounted the contacts 139, 140, 141 and 142, these being adapted to be interconnected by the switch blades 143 operated by the armature of the operating coil 144. The forward side of the reversing switch 96 contains the overload relay coil 145, arranged to separate the contacts 146 when a current overload occurs. Similarly, the reverse side 98 contains an overload relay coil 147, arranged to similarly separate the relay contacts 148 when an overload occurs in that circuit.

The main driving motor 18 is of any suitable type, the three-phase reversible type being shown. The three terminals of this motor are connected respectively to the terminals 128, 129 and 139 of the reversing switch 96, with the heating coils 145 and 147 of the overload relays intervening.

The relay 102 is actuated by its operating coil 150, by which the switch bar 151 is operated to connect either its lower or its upper pair of contacts. The circuit shown in Figure 8 is completed by the provision of the push button switch station 99, having the "start" push button switch 152 and the "stop" push button switch 153.

Operation of the chain-controlled reversing apparatus

To start the chain-controlled reversing circuit in operation the "start" push button switch 152 is depressed, the manual switch 100, of course, having been closed. This completes the circuit energizing the operating coil 133 of the forward side 97 of the reversing switch 96 from the contact 126 of the forward side 97 to the contact 137 of the reverse side 98, thence through the contacts 148 of the overload relay 147, the starting switch 152, the operating coil 133 of the forward switch 97, the "stop" switch 153, the contacts 146 of the overload relay 145 to the contact 124 of the forward switch 97.

The operating coil 133 being thus energized, closes its switch blades 132. This completes the circuit from the power lines 118, 119 and 120 to the terminals of the main driving motor 18. The circuit from the line 118 proceeds by way of the contacts 124 and 128 and the overload relay heating coil 145; that from the line 119 proceeds by way of the contacts 125 and 129; that from the line 120 proceeds by way of the contacts 126, 130 and 139, and the overload relay heating coil 147.

The closing of the forward starting switch 97 also closes the switch blade connecting the contacts 127 and 131 thereof. This completes a holding circuit for maintaining the energization of the operating coil 133 when the starting push button 152 is released. This circuit proceeds by way of the contact 127, the contact 131, the switch bar 151 connecting the lower contacts of the relay 102, the operating coil 133 of the forward starting switch 97, the "stop" push button switch 153, and the contacts 146 of the overload relay coil 145 to the contact 124 of the forward switch 97, completing the circuit. This action locks the forward switch 97 in position regardless of the opening of the starting push button switch 152 by its release.

The main driving motor 18 thus energized, starts rotating, transmitting power through the mechanism previously described, to the main driving sprocket 25, causing the chain 36 to start moving in its orbital path. As the chain 36 moves, one of its pins 45 travels forward and engages the forked arm 86 connected to the shaft 71 in the switch box 50 (Figures 4 and 8).

This movement of the forked arm 86 rotates the gears 73, 74 and 75, causing the pins 77, 78 and 79 to move circumferentially. This urges the switch arm 61 away from its stop 65 and closes the mercury switch 52, but does not affect the mercury switches 53 and 54 because their switch arms 62 and 63 are prevented from further motion by their being already against the stops 67 and 68. The circuit is now completed from the contact 124, through the contacts 146 of the overload relay 145, the "stop" push button 153, the chain-operated mercury switch 52 and the operating coil 150 of the relay 102 to the contact 126 of the forward switch 97. The relay 102 being thus energized, moves its switch bar 151 from its lower to its upper contacts. The switch bar 151 becomes locked up in this position by the holding circuit proceeding by way of the contact 126, the relay coil 150, the chain-operated mercury switch 53, the upper contacts of the relay 102 by way of the switch bar 151, the "stop" push button switch 153, the contacts 146 of the overload relay 145 to the contact 124 of the forward switch 97, completing the circuit.

The spring 64 causes the switch 52 to open again after the chain pin 45 has passed under the fork 86, whereupon the switch 52 assumes the position shown in Figure 8. The pin 45 then passes beneath the arm 94 and opens the mercury switch 91 in the switch box 51 (Figures 3 and 8). As the switch 91 is bridged around the lower contacts of the relay 102 and as the switch bar is engaging the upper contacts thereof, the opening of the switch 91 breaks the holding circuit of the operating coil 133 of the forward switch 97, opening this switch and deenergizing the main driving motor 18.

At the same time the opening of the forward switch 97 moves the link 149 and closes the mercury switch 134 connected thereto. Meanwhile the centrifugal switch motor 104 has also been deenergized, being connected in the same circuit as the main driving motor 18. As it comes to a stop its governor weights 107 move inward (Figure 3), and the sleeve 110 moves to the right along the motor shaft 105, closing the mercury switches 114 and 115. This places the reversing switch 98 in a condition for operation, the operating coil 144 thereof being energized by the circuit proceeding by way of the contacts 126 and 127 on the forward switch 97, the mercury switches 134 and 115, the contact 138 of the reversing switch 98, the operating coil 144 of the latter, the upper contacts and switch bar 151 of the relay 102 (which at this time is locked up), the stop switch 153 and the contacts 146 of the

overload relay 145 to the contact 124 of the forward switch 97, completing the circuit. Thus the centrifugal switch 101 prevents the reversal of the driving motor 18 until the latter has completely slowed down and stopped. The over-run of this motor and the inertia of the moving parts are thus counteracted and no damage results.

The energization of the operating coil 144 of the reverse switch 98, as just described, closes its switch blades 143 and reversely energizes the main driving motor 18 so that it rotates in a reverse direction. The chain 36 also moves in a reverse direction, and the pin 45 passing back from the switch bar 94 of the mercury switch 91, permits this switch to close again and comes into the forked arm 86 associated with the mercury switch 53, thereby opening the latter and closing the mercury switch 54.

The opening of the mercury switch 53, which lies in the circuit holding the operating coil 150 of the relay 102, energized with its switch bar 151 locked up against the upper contacts thereof, deenergizes the relay 102 and releases the switch bar 151 thereof, causing it to close its lower contacts. This, in turn, deenergizes the operating coil 144 for the reverse switch 98 by breaking the circuit previously described, deenergizing the main driving motor 18 and stopping its rotation with the assistance of the centrifugally-operated switches 114 and 115.

The main driving motor 18 now becomes forwardly energized by the energization of the forward switch coil 133 through the circuit proceeding by way of the forward switch contact 126, the chain-operated mercury switch 54, the centrifugally-operated mercury switch 114, the forward switch coil 133, the "stop" push button switch 153 and the contacts 146 of the overload relay 145 to the forward switch contact 124, completing the circuit. The forward switch blades 132 are closed upon their contacts by the energization of the forward switch operating coil 133, and locked in position through the lock-up circuit proceeding from the contacts 127 and 131, in the manner previously described.

The main driving motor 18 now rotates in a forward direction, causing the pins 45 to move the forked arm 86 of the mercury switch 53 to the left, thereby closing the switch 53 and opening the mercury switch 54. When this pin passes under the arm 94 operating the mercury switch 91, inasmuch as the switch bar 151 is now engaging the lower contacts of the relay 102, the switch 91 is opened without disturbing the control or deenergizing any of the operating coils so that the following pin 45 on the chain now actuates the forked arm 86 of the mercury switch 53, thereby starting a new cycle of operations.

Reversing apparatus operated by main motor drive shaft

The modified form of reversing apparatus operated by the drive shaft of the main driving motor is shown in Figures 5, 6, 7 and 9. The main driving motor 18, as previously described, drives the worm gear 23 through the worm 22, and accordingly, drives the shaft 160 which is, in effect, an extension of the main driving shaft 24 (Figures 5 and 7). Mounted on the upper end of the shaft 160, beyond the bearing bracket 161, is a bevel gear 162 meshing with a second bevel gear 163, mounted on the shaft 164 and journalled in the frame 165.

The shaft 164 transmits its rotation to the gear 166 mounted on the end thereof, and the latter, in turn, rotates the pinion 167 mounted on the swinging arm 168, pivoted around an axis coinciding with the axis of the shaft 164. The pinion 167 is mounted upon a shaft 169, journalled in the end of the arm 168, and carries on its opposite end a pinion 170 which is adapted to mesh selectively with the teeth upon either the right-hand rack 171 or the left-hand rack 172 (Figure 6).

The racks 171 and 172 are reciprocable vertically in the guide grooves 173 and 174, respectively, until at the top of their strokes they engage the L-shaped push rods 175 and 176, respectively. The latter are arranged to reciprocate vertically, and are connected near their lower ends to the arms 177 and 178 of the mountings 179 and 180 for the mercury switches 181 and 182, respectively (Figure 6). These are pivoted upon the pivot shafts 183 and 184, respectively. The lower ends of the push rods 175 and 176 are prevented from dropping beyond the desired amount by the blocks 185 and 186 (Figure 6), anchored to the frame and serving also as bearing supports for the ends of the screw shafts 187 and 188. Mounted as nuts upon the screw shafts 187 and 188 are the movable blocks 189 and 190. By these the distance to which the racks 171 and 172 will fall is adjusted. The springs 191 and 192 soften the shock of the fall of the racks. By the same means it will be obvious that the distance to which one rack will fall may be made different from that to which the other will fall, thus causing the work-conveying chain to move to and fro, but by greater increments in one direction than in the other. Thus, the article being plated is moved back and forth in the solution, but by greater distances in one direction than in the other so that the result is an oscillation of the article, combined with a general movement in one direction.

Also attached to the swinging arm 168 and at right angles thereto is the cross bar 193 (Figure 6), the ends of which engage the rods 194 and 195, connected as at 196 and 197 to the armatures 198 and 199 of the solenoids 200 and 201, respectively. The point of engagement of the cross bar 193 with the rods 194 and 195 may be adjusted by means of the adjusting nuts 202 and 203, mounted on the upper ends of the rods.

An additional solenoid 204 (Figure 5) is provided with an armature 205, connected by the rod 206 to the swinging arm 168. This solenoid 204 serves, when energized, to hold the arm 168 in an intermediate position so that its pinion 170 will engage neither of the racks 171 nor 172, when movement of the chain 36 in one direction only is desired.

The remainder of the electrical circuit, and the elements thereof, is similar to that of the chain-operated apparatus previously described and shown in Figures 3, 4 and 8. Accordingly, the corresponding parts are given the same numerals. It may be added, however, that a manual switch 207 (Figure 9) is provided for the energization of the solenoid 204, whereas a transformer 208 serves to provide current for the centrifugal switch motor 104. Figure 9, in dotted lines, shows an additional push button switch station for remote control, consisting of the additional starting switch 209 and stop switch 210.

The solenoids 200 and 201 for operating the swinging arm 168 are connected in parallel with the operating coils 133 and 144 of the forward and reverse switches 97 and 98, respectively. In

this way the sets of solenoids always work together and in the manner described below.

The swinging arm 168 mounting the oscillating pinion 170 is provided with a ball 211 and spring 212, serving to form a toggle in such a manner that the solenoid pulls through part of the stroke and the toggle action completes the stroke, as well as holds the arm 168 in position until the opposing solenoid is energized.

Operation of the shaft-controlled reversing apparatus

The forward switch 97 and the reverse switch 98 are composed of similar switch blades and contacts to those previously described in connection with Figure 8. Similar overload relays with contacts 146 and 148, operated by coils 145 and 147, are also provided, as before, and require no further description.

To start the machine in operation (Figure 9), the push button starting switch 152 is depressed. This energizes the central contacts of the mercury switches 181 and 182 by way of the forward switch contact 124, the overload relay contacts 146, the stop switch 210, the stop switch 153 to the central contact of the mercury switches 181 and 182, these tubes being normally tipped with their adjoining ends down. The circuit continues at the branch line of the stop switch 153, through the starting push button switch 152, the forward switch contact 127, the forward switch-operating coil 133, the overload relay contacts 148 and the reverse switch contact 137, completing the circuit energizing the forward switch-operating coil 133. The switch blades 132 thereof then close upon their contacts in the manner previously described, and the main driving motor 18 becomes energized by the same circuits described in connection with Figure 8.

By the same action the solenoid 201 is energized, it being connected in parallel with the forward switch-operating coil 133. The current proceeds from the forward switch contact 126, the reverse switch contact 137 to the solenoid 201, thence through the centrifugally-operated switch 114 to the push button switch bar 152, where it is energized in the same manner as the forward switch coil 133, the starting push button switch 152 being still depressed. The closing of the forward switch 97 also closes the holding circuit for the operating coil 133 through the contacts 127 and 131, except that the mercury switch 182 is included in this circuit instead of the bar 151 of the relay 102 of Figure 8. This locks the forward switch 97 in its closed position, regardless of the subsequent release of the starting push button 152.

The energization of the solenoid 201 causes its armature 199 to be drawn downward and with it the cross arm 193, causing the swinging arm 168 to move to the left and engage the oscillating pinion 170 with the left-hand rack 172. The latter thereupon begins to lift, and moves upward to the end of its stroke. Here it engages the push rod 176, which mechanically tilts the mercury switch 182. The latter first makes contact on its outer end and then breaks its inner or holding contact. The holding circuit, through the forward switch contacts 131 and 127 being thus broken, the forward switch coil 133 is deenergized. This causes the forward switch 97 to be opened, deenergizing the main driving motor 18 and stopping the machine. The centrifugal switch motor 104 also slows down, closing its mercury switches 114 and 115 in the manner previously described in connection with Figure 8.

In the meantime the tipping of the mercury tube 182 to close its outer contact has placed the reverse switch-operating coil 144 and the solenoid 200 in a condition for energization as soon as the centrifugal switch 115 permits this. Energization takes place by way of the forward switch contact 124, the overload contacts 146, the stop switch 210, the stop switch 153, the mercury switch 182 through its central and left-hand contacts (now closed) to and through the centrifugally-operated mercury switch 115. Here the circuit divides, one branch energizing the solenoid 200 by way of the line leading to the reverse switch contact 137, whereas the other branch energizes the reverse switch-operating coil 144 by way of the branch leading through the reverse switch contact 138, and on its other side through the overload relay contacts 148 to the reverse switch contact 137.

This closes the reversing switch 98 and locks it in closed position through the circuit controlled by the switch bar joining the switch contacts 138 and 142, in which circuit the mercury switch 181 is placed. The main driving motor 18, thus energized, starts rotating in a reverse direction, and at the same time the solenoid 200 shifts the swinging arm 168 to the right so that its pinion 170 engages the right-hand rack 171 and releases the left-hand rack 172. The latter thereupon drops until its spring 182 engages the moving block 190, causing the mercury switch 182 to tilt back to its original position (Figure 6). The right-hand rack 171 rises until it engages the push rod 175, tilting the right-hand mercury switch 181 in such a manner as to engage its right-hand contact before it releases the left-hand contact.

The breaking of the circuit with the left-hand contact of the mercury switch 181 deenergizes the solenoids 144 and 200 by deenergizing the holding circuit through the switch contacts 138 and 142 of the reverse switch 98, thus opening the reverse switch 98 and stopping the reverse rotation of the main driving motor 18 and the centrifugal switch motor 104. The centrifugally-operated mercury switch 114 then closes in the manner previously described. The forward switch coil 133 now is energized through the circuit proceeding by way of the forward switch contact 124, the overload relay contacts 146, the stop switch 210, the stop switch 153, the central and right-hand contacts of the mercury switch 181, the centrifugally-operated mercury switch 114, the forward switch contact 127, the forward switch-operating coil 133, the overload relay contacts 148, and the reverse switch contact 137.

The solenoid 201 is energized by the same circuit as far as the upper contact of the centrifugally-operated mercury switch 114 (where the line branches), thence through the solenoid 201 to the reverse switch contact 137, completing the circuit. This brings the operation to the point at which the description commenced, and the cycle of operations repeats itself indefinitely as long as desired.

If, however, it is desired to operate the chain 36 in one direction only, the manual switch 207 is closed, thereby energizing the solenoid 204 (Figures 5 and 9). The arm thereof moves to the left, under the influence of the armature 205, pulling the swinging arm 168 into its neutral position out of engagement with both of the racks 171 and 172. This prevents the mercury switches

181 and 182 from operating, and the circuit becomes a simple one for operating the main driving motor 18 in one direction only.

Reversing apparatus operated by synchronous motor

The arrangement shown in Figures 5, 6, 7 and 9 may be modified in the manner shown in Figure 10 so that it may be operated as a self-contained unit in synchronism with the main driving motor but mechanically independent thereof. Pilot motor 215 (Figure 10), whose drive shaft 216 carries the worm 217 meshing with the worm gear 218, mounted on the shaft 164, is connected in multiple with the drive motor 18, and is of a reversing type. The latter carries the gear 166, which drives the pinion 167 on the swinging arm 168, and this in turn, drives the pinion 170 (Figure 7) on the common shaft 169 in the manner previously described. The pilot motor 215 is connected with the main driving motor 18, the shaft 166 (Figure 5) being removed from connection with the main drive shaft 24. In this manner the control box containing the electrical control parts may be moved to any desired location instead of being placed in a position immediately over the main drive shaft 24. The operation and the electrical arrangements otherwise remain the same.

It will be understood that I desire to comprehend within my invention such modifications as come within the scope of my claims and my invention.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In an electro-processing machine, an electro-processing tank arranged to receive work-pieces, a work-conveying chain associated therewith for supporting work-pieces in said tank to convey them therethrough, a reversible motor to drive said chain, means for alternately reversing the direction of rotation of said motor for unequal periods and adapted to drive said chain alternately to and fro by unequal amounts in opposite directions with a resultant advance in one direction, and means for delaying the reverse energization of said motor until said motor has ceased rotation.

2. In an electro-processing machine, an electro-processing tank arranged to receive work-pieces, a work-conveying chain associated therewith, for supporting work-pieces in said tank to convey them therethrough, a reversible motor to drive said chain, means for reversing the direction of rotation of said motor at a predetermined point in the operation of said machine, and a centrifugally-operated switch for delaying the reverse energization of said motor until said motor has ceased rotation.

3. In an electro-processing machine, an electro-processing tank, a work-conveying chain associated therewith, a reversible motor to drive said chain, means for reversing the direction of rotation of said motor at a predetermined point in the operation of said machine, and means for selectively rendering said reversing means inoperative, whereby to operate said chain either to and fro or in a single direction only.

4. In an electro-processing machine, an electro-processing tank arranged to receive work-pieces, a work-conveying chain associated therewith for supporting work-pieces in said tank to convey them therethrough, a motor to drive said chain, and means responsive to a predetermined amount of motion of said chain for alternately reversing the direction of the application of power from said motor to said chain unequally in one direction at predetermined points in the travel of said chain, whereby to cause said chain to progressively advance in one direction while reciprocating alternately in opposite directions.

5. In an electro-processing machine, an electro-processing tank, a work-conveying chain associated therewith, a motor to drive said chain, means operated by the motion of said chain for reversing the direction of the application of power from said motor to said chain at a predetermined point in the travel of said chain, and means for delaying the application of said reversal until said motor stops rotating.

6. In an electro-processing machine, an electro-processing tank, a work-conveying chain associated therewith, a reversible motor to drive said chain, switches arranged to control the delivery of electric current to said motor to operate said motor forwardly or reversely, means operatively connected to said chain arranged to operate said switches at predetermined locations in the travel of said chain, and means responsive to the action of said switches to operate said reversible motor to drive said chain alternately to and fro by unequal amounts in opposite directions whereby to cause said chain to progressively advance in one direction while reciprocating alternately in opposite directions.

7. In an electro-processing machine, an electro-processing tank, a work-conveying chain associated therewith, a reversible motor to drive said chain, switches arranged to control the delivery of electric current to said motor to operate said motor forwardly or reversely, switch-operating members on said chain arranged to operate said switches at predetermined locations in the travel of said chain, and means responsive to the action of said switches to operate said reversible motor to drive said chain alternately to and fro by unequal amounts in opposite directions whereby to cause said chain to progressively advance in one direction while reciprocating alternately in opposite directions.

8. In an electro-processing machine, an electro-processing tank, a work-conveying chain associated therewith, a reversible motor to drive said chain, switches arranged to control the delivery of electric current to said motor to operate said motor forwardly or reversely, switch-operating members on said chain at spaced intervals therealong and arranged to operate said switches at predetermined locations in the travel of said chain, and means responsive to the action of said switches to operate said reversible motor to drive said chain alternately to and fro by unequal amounts in opposite directions whereby to cause said chain to progressively advance in one direction while reciprocating alternately in opposite directions.

9. In an electro-processing machine, an electro-processing tank arranged to receive work-pieces, a work-conveying chain associated therewith for supporting work-pieces in said tank to convey them therethrough, a reversible motor to drive said chain, switches arranged to control the delivery of electric current to said motor to operate said motor forwardly or reversely, switch-operating means arranged to operate said switches alternately at unequal time intervals and adapted to operate said motor reversibly to drive said chain alternately to and fro by unequal amounts in opposite directions with a re-

sultant advance in one direction, and means for delaying the application of said reversal until said motor stops rotating.

10. In an electro-processing machine, an electro-processing tank, a work-conveying chain associated therewith, a reversible motor to drive said chain, an electrically-operated starting switch, an electrically-operated reversing switch, chain-operated switches arranged to selectively control the delivery of current to the operative means for said starting switch or said reversing switch, respectively, whereby to deliver current to operate said motor forwardly or reversely, and means operatively connected to said chain to operate said chain-operated switches.

11. In an electro-processing machine, a work-conveying chain, a reversible motor to drive said chain, an electrically-operated starting switch, an electrically-operated reversing switch, chain-operated switches arranged to selectively control the delivery of current to the operative means for said starting switch or said reversing switch, respectively, whereby to deliver current to operate said motor forwardly or reversely, means operatively connected to said chain to operate said chain-operated switches, holding circuits for alternately holding said starting switch and said reversing switch in closed positions, and relay means to control the delivery of current selectively to one of said holding circuits at a time, the energization of said relay means being controlled by said chain-operated switches.

12. In an electro-processing machine, a work-conveying chain, a reversible motor to drive said chain, an electrically-operated starting switch, an electrically-operated reversing switch, chain-operated switches arranged to selectively control the delivery of current to the operative means for said starting switch or said reversing switch, respectively, whereby to deliver current to operate said motor forwardly or reversely, and means operatively connected to said chain to operate said chain-operated switches, said switches being arranged to cause said chain to move forwardly by different distances than rearwardly.

13. In an electro-processing machine, a work-conveying chain, a reversible motor to drive said chain, means operated by the rotation of said motor to alternately reverse the direction of rotation thereof after a predetermined number of revolutions thereof, and means arranged to cause said motor to operate said chain to move forwardly by different distances than rearwardly.

14. In an electro-processing machine, a work-conveying chain, a reversible motor to drive said chain, means operated by the rotation of said motor to alternately reverse the direction of rotation thereof after a predetermined number of revolutions thereof, means arranged to cause said motor to operate said chain to move forwardly by different distances than rearwardly, and means for adjustably varying the distance of operation in one direction relatively to the distance of operation in the other direction.

15. In an electro-processing machine, a work-conveying chain, a reversible motor to drive said chain, an electric circuit for operating said motor in a forward direction, an electric circuit for operating said motor in a rearward direction, an electric switch for controlling the energization of each circuit, and means operatively controlled by said motor for operating said switches alternately after a different predetermined number of revolutions of said motor in one direction than in the other direction.

16. In an electro-processing machine, a work-conveying chain, a reversible motor to drive said chain, an electric circuit for operating said motor in a forward direction, an electric circuit for operating said motor in a rearward direction, an electric switch for controlling the energization of each circuit, a switch-operating member connected to each switch, and means controlled by said motor for alternately actuating said switch-operating members to operate said switches after a different predetermined number of revolutions of said motor in one direction than in the other direction.

17. In an electro-processing machine, a work-conveying chain, a reversible motor to drive said chain, an electric circuit for operating said motor in a forward direction, an electric circuit for operating said motor in a rearward direction, an electric switch for controlling the energization of each circuit, a switch-operating member connected to each switch, and means controlled by said motor for alternately actuating said switch-operating members to operate said switches after a predetermined number of revolutions of said motor in each direction, said motor-controlled means being arranged to operate said switches after a different predetermined number of revolutions of said motor in one direction than in the other direction.

18. In an electro-processing machine, a work-conveying chain, a reversible motor to drive said chain, an electric circuit for operating said motor in a forward direction, an electric circuit for operating said motor in a rearward direction, an electric switch for controlling the energization of each circuit, a switch-operating member connected to each switch, means controlled by said motor for alternately actuating said switch-operating members to operate said switches after a predetermined number of revolutions of said motor in each direction, said motor-controlled means being arranged to operate said switches after a different predetermined number of revolutions of said motor in one direction than in the other direction, and means for adjustably varying the interval of operation in one direction relatively to the interval of operation in the opposite direction.

19. In an electro-processing machine with a work-conveying chain, a driving arrangement comprising the combination of a reversible motor to drive said chain, an electric circuit for operating said motor in a forward direction, an electric circuit for operating said motor in a rearward direction, an electric switch for controlling the energization of each circuit, and means operatively controlled by said motor for operating said switches alternately after a predetermined number of revolutions of said motor in each direction, said switch-operating means comprising a pair of racks each adapted to operate one of said switches, and said motor-controlled means comprising a gear operatively connected to said motor and movable to alternately engage said racks.

20. In an electro-processing machine with a work-conveying chain, a driving arrangement comprising the combination of a reversible motor to drive said chain, an electric circuit for operating said motor in a forward direction, an electric circuit for operating said motor in a rearward direction, an electric switch for controlling the energization of each circuit, means oper-

atively controlled by said motor for operating said switches alternately after a predetermined number of revolutions of said motor in each direction, said switch-operated means comprising a pair of racks each adapted to operate one of sadi switches, and said motor-controlled means comprising a gear operatively connected to said motor and movable to alternately engage said racks, and solenoidally-operated means to shift said gear from one rack to the other.

21. In an electro-processing machine with a work-conveying chain, a driving arrangement comprising the combination of a reversible motor to drive said chain, an electric circuit for operating said motor in a forward direction, an electric circuit for operating said motor in a rearward direction, an electric switch for controlling the energization of each circuit, means operatively controlled by said motor for operating said switches alternately after a predetermined number of revolutions of said motor in each direction, said switch-operated means comprising a pair of racks each adapted to operate one of said switches, and said motor-controlled means comprising a gear operatively connected to said motor and movable to alternately engage said racks, solenoidally-operated means to shift said gear from one rack to the other, and solenoidally-operated means to hold said gear from engaging either of said racks.

22. In an electro-processing machine, an electro-processing tank through which work-pieces are conveyed, a work-conveying chain associated therewith to convey work-pieces through said tank, a motor to drive said chain, and means for alternately reversing the direction of power application from said motor to said chain and adapted to drive said chain alternately to and fro by unequal amounts in opposite directions with a resultant advance in one direction of the work-pieces in the tank.

23. In an electro-processing machine, an electroprocessing tank through which work-pieces are conveyed, a work-conveying chain associated therewith to convey work-pieces through said tank, a reversible motor to drive said chain, and means for alternately reversing the direction of rotation of said motor for unequal periods and adapted to drive said chain alternately to and fro by unequal amounts in opposite directions with a resultant advance in one direction of the work-pieces in the tank.

24. In an electro-processing machine, an endless work-conveying chain having means associated therewith for supporting work-pieces, a tank arranged to receive said work-pieces, a motor for driving said chain, reversing means for reversing the direction of motion of said chain, electrical means for operating said reverser, and a movable current distributor arranged to distribute current alternately to operate said reverser to move said chain for longer periods in one direction than in the other direction.

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