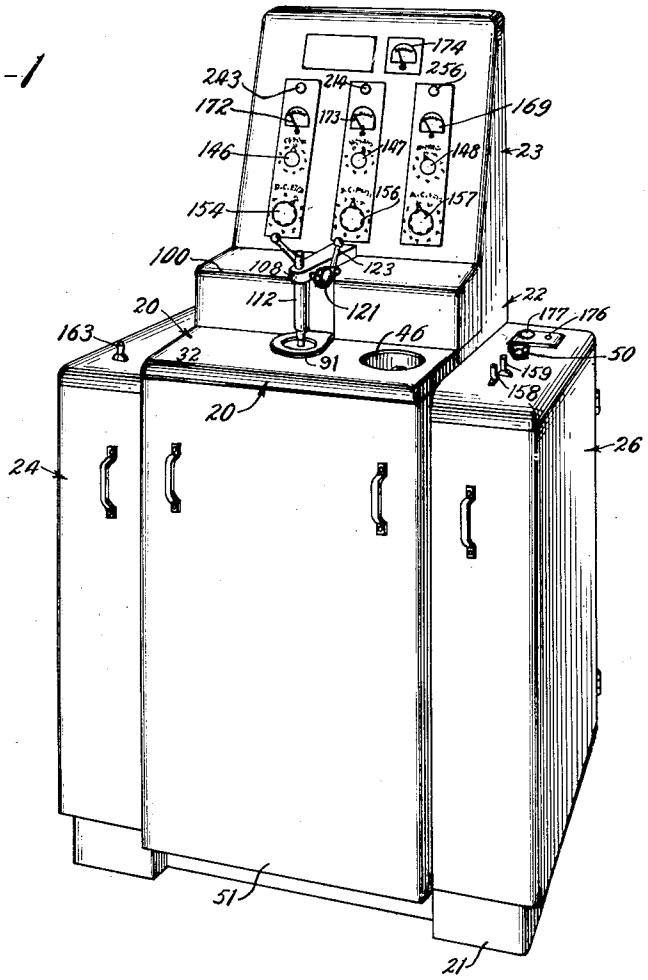
Dec. 5, 1950 C. W. HANGOSKY ET AL 2,532,908

ELECTROLYTIC PROCESSING APPARATUS

Filed Nov. 8, 1946 7 Sheets-Sheet 1

Fig-1



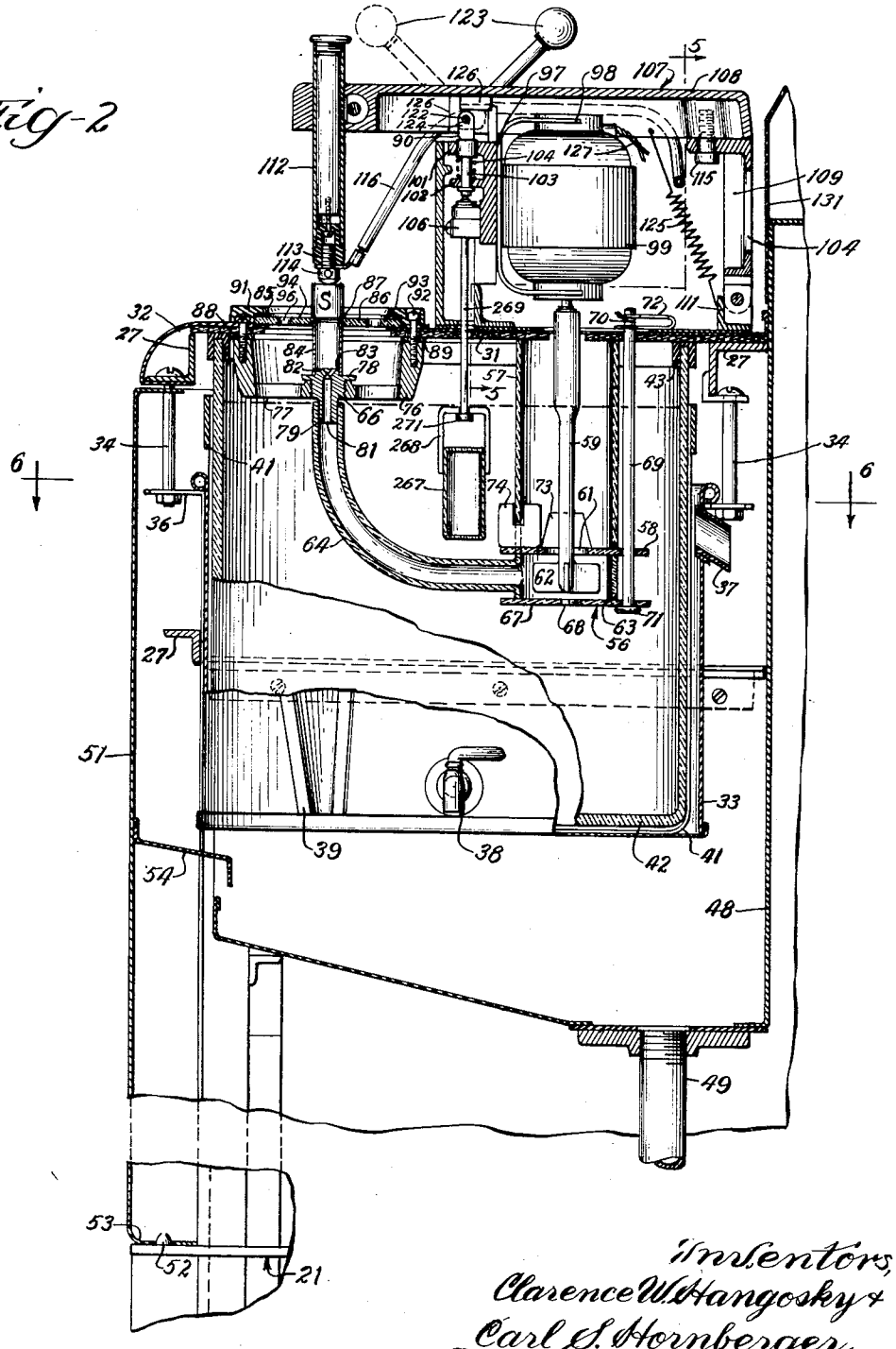
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ELECTROLYTIC PROCESSING APPARATUS

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Fig-2



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ELECTROLYTIC PROCESSING APPARATUS

Filed Nov. 8, 1946 7 Sheets-Sheet 3

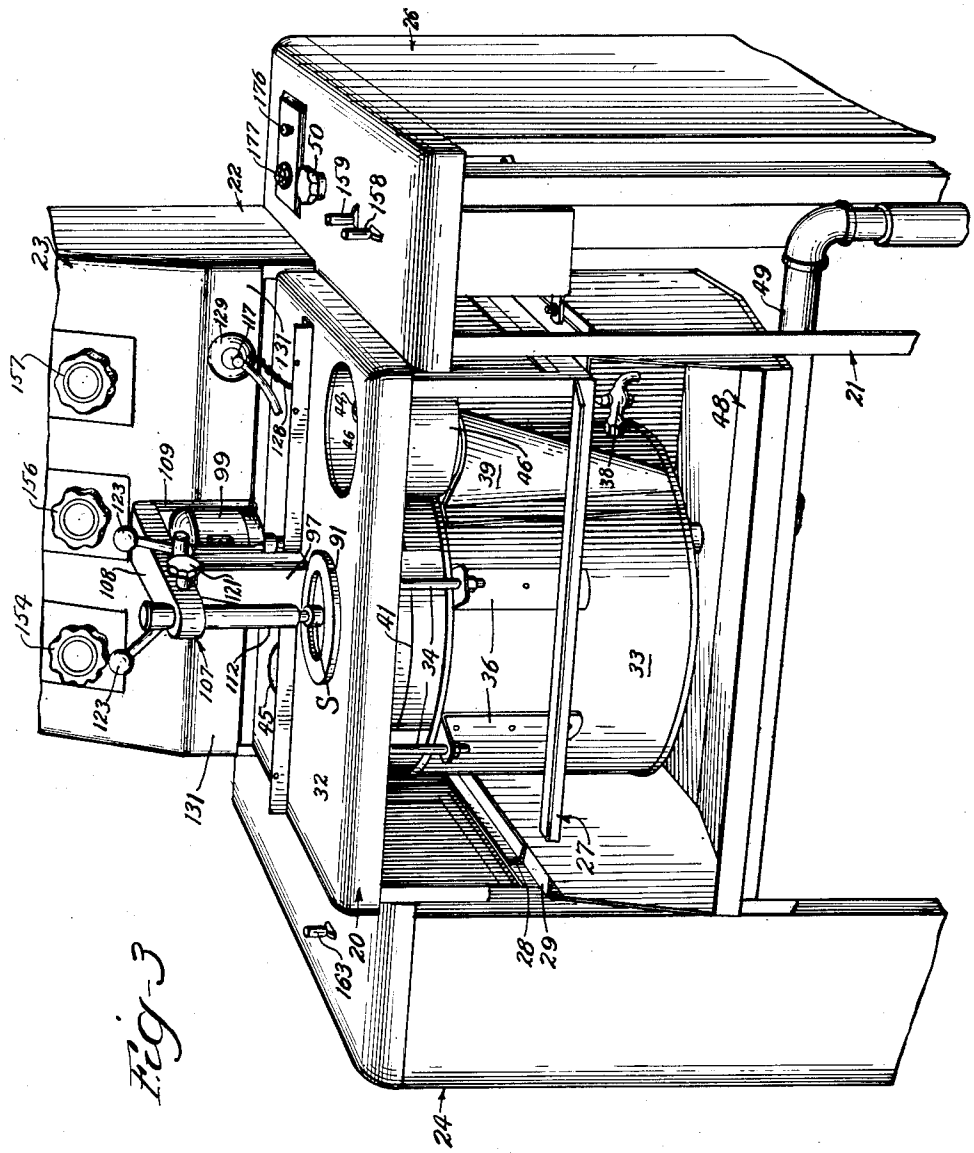


Fig. 3

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ELECTROLYTIC PROCESSING APPARATUS

Filed Nov. 8, 1946 7 Sheets-Sheet 4

Fig-4

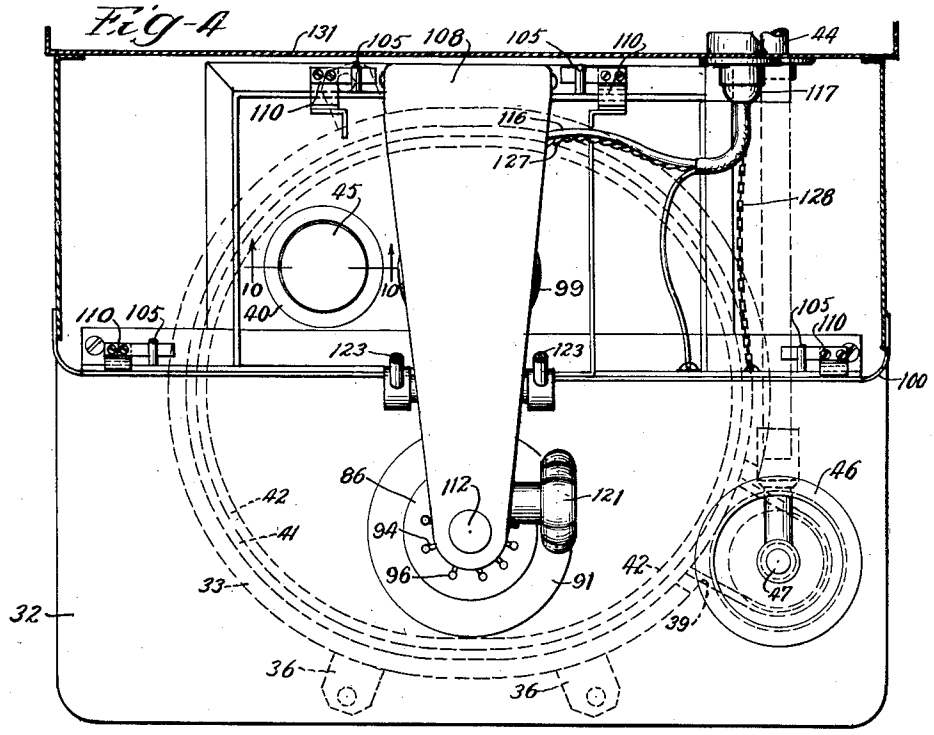
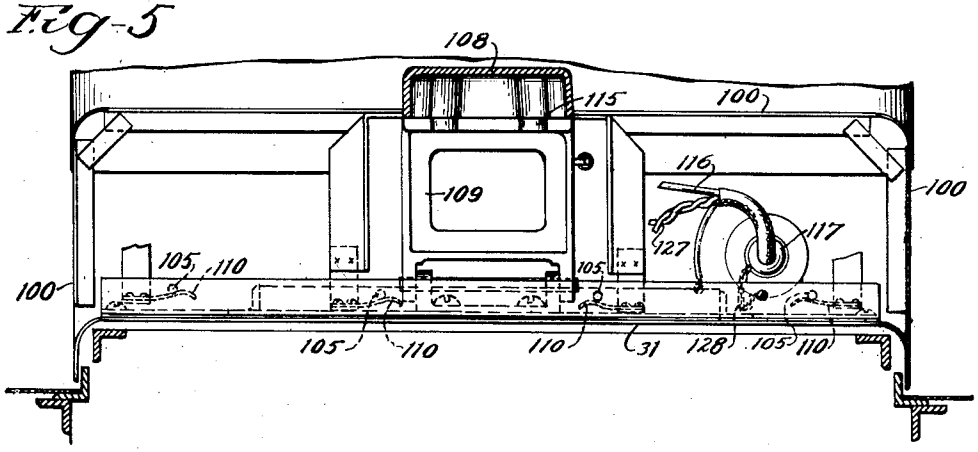


Fig-5



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ELECTROLYTIC PROCESSING APPARATUS

Filed Nov. 8, 1946 7 Sheets-Sheet 5

Fig-6

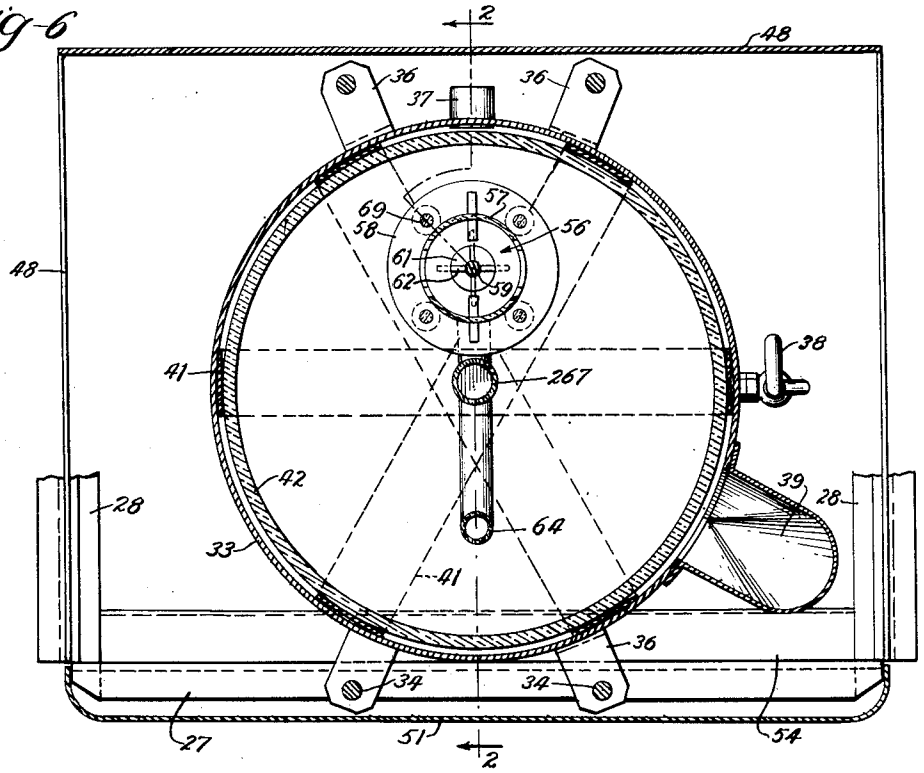


Fig-11

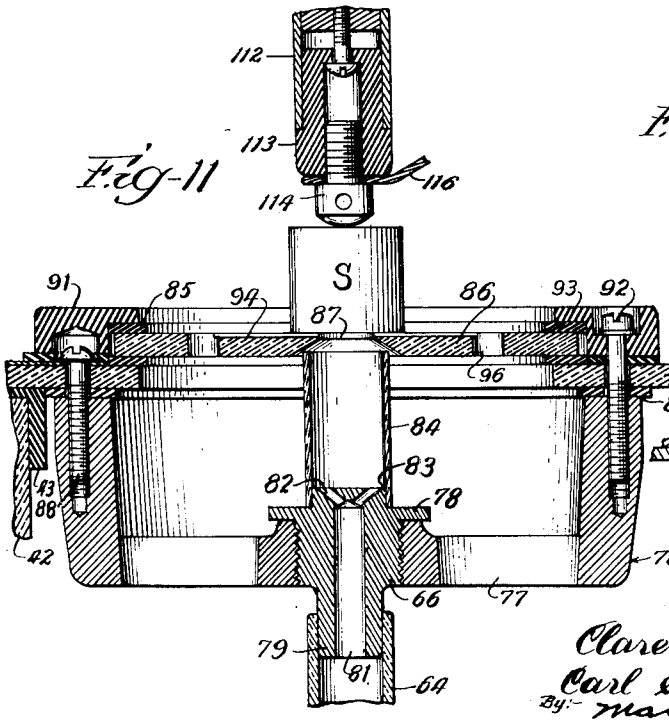


Fig-7

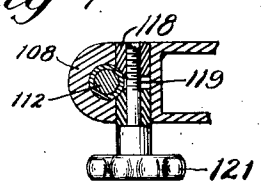
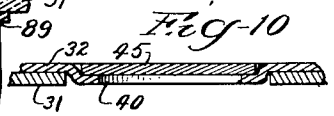


Fig-10



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ELECTROLYTIC PROCESSING APPARATUS

Filed Nov. 8, 1946 7 Sheets-Sheet 6

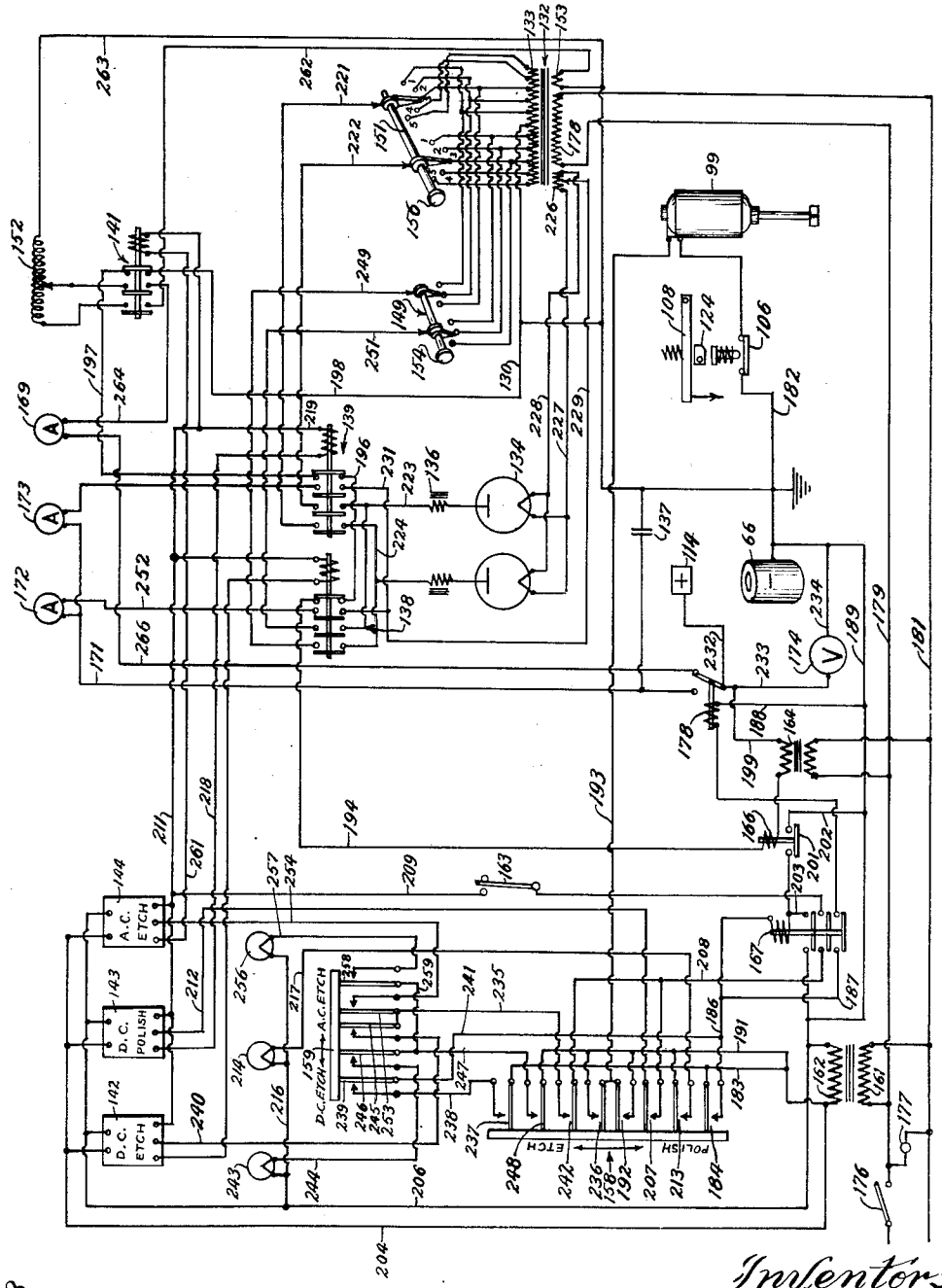


Fig. 8

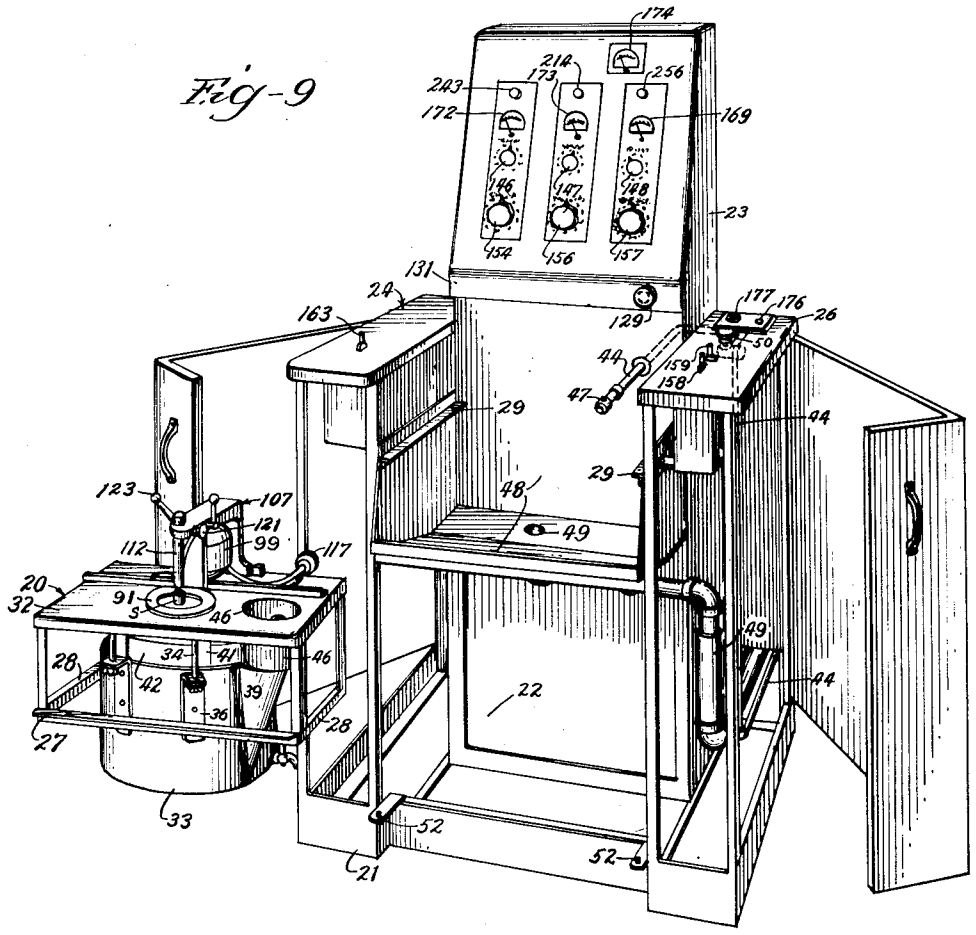
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Dec. 5, 1950 C. W. HANGOSKY ET AL 2,532,908

ELECTROLYTIC PROCESSING APPARATUS

Filed Nov. 8, 1946 7 Sheets-Sheet 7

Fig-9



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Patented Dec. 5, 1950 2,532,908

UNITED STATES PATENT OFFICE

2,532,908

ELECTROLYTIC PROCESSING APPARATUS

Clarence W. Hangosky, East Lansing, Mich., and Carl S. Hornberger, Glen Ellyn, Ill., said Hornberger assignor to Central Scientific Company, a corporation of Illinois

Application November 8, 1946, Serial No. 708,580

6 Claims. (Cl. 204—229)

1

Our invention relates to improvements in a process and apparatus for electrolytically treating metal surfaces with special reference to electrolytically polishing and etching the surfaces of metallurgical samples and other objects, the general process and apparatus having been disclosed in U. S. patent applications Serial No. 548,841 filed August 10, 1944, now abandoned, and Serial No. 697,765 filed September 18, 1946 in the name of Clarence W. Hangosky, the disclosures whereof, in so far as consistent herewith, being hereby incorporated and made a part hereof by reference.

An important object of our invention is the provision of a compact and efficient apparatus which, even in the hands of a relatively unskilled operator, will safely and consistently reproduce polished and etched surfaces of a superior character on many metals and alloys.

Further objectives include the provision of novel means for safely employing combustible or explosive reagents, for supplying various necessary electric currents having predetermined characteristics, and the provision of a new and improved cathode structure adapted to increase the quality of the etched or polished surface.

Other objects and advantages will become apparent from the following specification and from the drawings in which

Figure 1 is a perspective view of our assembled device;

Figure 2 is a partially sectioned view of the processing unit of our device together with a portion of the housing therefor;

Figure 3 is a partially sectioned perspective view showing the relative disposition of the components;

Figure 4 is a partially sectioned top view of our processing unit;

Figure 5 is a section taken along the lines 5—5 of Figure 2;

Figure 6 is a partially sectioned top view taken along the lines 6—6 of Figure 2;

Figure 7 is a partially sectioned top view of a clamping device;

Figure 8 is a circuit diagram of the current supply and control means;

Figure 9 is a perspective view showing the processing unit removed;

Figure 10 is a vertical section of an explosion safety device; and

Figure 11 is an enlarged section of an object

2

support and associated structure illustrated in Figure 2.

To obtain satisfactory and reproducible electrolytically polished and/or etched surfaces, particularly on metallurgical samples, it has been found necessary to control not only the current but also the character of the interface between the electrolyte and the sample or metal object which constitutes the anode of a suitable electric circuit.

In the present invention we obtain satisfactory control of the interface by supporting the sample or object to be treated over an aperture into which is directed a fountain of electrolyte carrying the etching or polishing current. The structure of our device and the arrangement of the component parts is such that there is imparted to the fountain of electrolyte at the point of contact with the sample a low and substantially even cross-sectional velocity which is characterized in free flow (i. e., when the sample is removed) by a substantially flat crest, and which provides means for uniformly and continuously eliminating from the interface bubbles formed during the process. Since some of the most desirable reagents used in the preparation of electrolytic solutions are inflammable, corrosive and, in some instances, explosive, we have incorporated mechanical and electrical safety devices in conjunction with a novel electrical circuit to prevent accidental ignition or detonation of the electrolyte thereby allowing the practical use of these materials.

General organization

These and other features have been embodied in a compactly arranged unit having a novel cabinet which houses the necessary regulating and supply means and provides convenient separation of the processing unit from the current supply apparatus when desired. The general organization and relationship of parts is best illustrated in Figures 1, 3 and 9, from which it may be seen that the processing unit, generally designated 20, includes frame 27 having parallel horizontal members 28 formed of angle iron or the like. A main cabinet frame, generally designated 21, includes a pair of horizontal angle iron members 29 spaced to receive and slidably support the processing unit 20 by engagement with members 28 of the processing unit frame 27.

When assembled, the processing unit 20 is removably supported between left and right side housings 24 and 26, and in front of a main hous-

ing 22. An easel 23 extends upwardly from the main housing 22 above the processing unit 20, and in combination with the main housing 22 encloses a majority of the current supply and control apparatus. An apron 48 is interposed between the processing unit 20 and the main housing 22, and extends outwardly beneath the processing unit 20.

All of the elements essential to electropolishing or etching metal surfaces, except for current supply or control means, are included in the processing unit 20, which may therefore be easily removed from the cabinet by sliding the unit outwardly along the horizontal angle member 29 until free. This permits movement of the processing unit to practically any desired location for cleaning, inspection or use, power being supplied by flexible leads from the cabinet or other suitable source. Cooling water, if required by the nature of the electrolyte employed, can be conducted to the unit by flexible hose, but this is not always necessary.

Processing unit in general

A horizontal plate 31 of insulating material such as plastic or glass extends over the top of frame 27 and is surfaced with a suitably formed strip 32 of stainless steel. Other materials may, of course, be employed but due to the corrosive characteristics of reagents ordinarily employed in the process, materials resistant to such reagents should be selected.

A water jacket 33 of non-corrosive metal such as copper is attached to the frame 27 by bolts 34 extending through the frame 27 and through suitable lugs 36 attached to the water jacket 33. The water jacket 33 is provided with an overflow spout 37 disposed adjacent its upper edge, a drain cock 38, and an inlet spout 39 which extends upwardly to the lip of the water jacket and communicates with the interior through an opening in the water jacket adjacent the bottom of the spout 39. A suitably shaped basket 41, formed for example of metal strips, fits into the water jacket 33 supporting a container 42 of non-corrosive material such as glass in contact with the under end of plate 31 and in spaced relation to the water jacket 33. A suitable gasket 43 may be interposed between the container 42 and the plate 31 to form a tight seal. An opening 40 through the plate 31 and strip 32 communicates with the interior of the container 42 and is closed by a light, loosely fitting disk 45, which prevents evaporation but is easily blown off if detonation of the electrolyte should occur, or if excessive pressure should otherwise develop within the container.

A water pipe 44 (Figure 4) having a valve 50 (Figures 1 and 3) extends outwardly from the main housing into the processing unit 20 through an opening in a wall of a cup 46 and terminates in an orifice 47 forming an upwardly directed water fountain conveniently disposed for washing metal objects before or after processing. The bottom of the cup 46 is open and is disposed immediately over the spout 39 thus supplying cooling water to the water jacket 33 around the container 42. Overflow from the water jacket 33 emerges from the overflow 37 and is caught by an apron 48 which forms the front section of the main housing. The bottom of the apron 48 is provided with a drain 49 which may be connected with a sewer to dispose of the used cooling water. The apron 48 extends forwardly and upwardly beneath the processing unit 20 in order to receive any electrolyte which might flow downwardly as a result of accidental fracture in the container 42.

A suitable cover 51 is provided with a lower flange 53 having openings loosely engaging pins 52 secured to frame 21. Suitable detents are disposed on the cover to engage other members of the frame 21 for holding the cover in position in front of the processing unit 20. A deflector 54 is attached to the inner surface of the cover 51 and protrudes into the space between the apron 48 and the lower surface of the water jacket 33 in order to deflect into the apron any liquid which may drip down between the processing unit and the cover 51.

A pump, generally designated 56, extends downwardly from the plate 31 into the electrolyte container 42 and may include a cylindrical tube 57 supported by an upper cylinder plate 58. A propeller shaft 59 extends downwardly through the tube 57 and through an aperture 61 in the upper cylinder plate 58 terminating in a four-vaned impeller 62 which is surrounded by a cylindrical pump cylinder member 63. A tube 64 is attached to the pump cylinder to conduct electrolyte from the pump upwardly to a cathode 66. Cylinder 63 is closed by a bottom plate 67 having a small drain 68 formed therein. Two or more rods 69 having heads 71 extend upwardly through the lower plate 67, the upper plate 58, the plate 31, and the strip 32 holding the component parts of the pump together with the tube 57 in contact with the plate 31. Rods 69 are notched above the strip 32 as at 70 to receive spring clips 72, which support the rods.

Openings 73 are formed in the tube 57 immediately above the upper cylinder plate 58 to permit the entrance of liquid. The tube 57 may also be notched to receive one or more anti-vortex plates 74 which extend radially inwardly from the wall of the tube to approximately the boundaries of the aperture 61 and serve to decrease the turbulence of electrolyte within the tube 57 and the cylinder 63. Preferably the joint between the plate 31 and the tube 57 is not gas tight and the level of electrolyte in the container is maintained above the upper limit of the openings 73 thus preventing entrainment of gas in the liquid passing through the pump.

As will be apparent, liquid electrolyte is sucked into the pump tube 57 through the openings 73, and is then carried downwardly through the opening 61 into the pump chamber where the impeller 62 forces the electrolyte with smooth even flow into the tube 64.

A cup-shaped processing chamber 76 having a series of perforations 77 through the bottom thereof is provided with a threaded axial opening to receive the cathode 66. Both the cathode 66 and the processing chamber 76 may be formed of a suitable metal such as lead, Monel metal, stainless steel, or the like, adapted to conduct an electric current and to resist the corrosive effect of the electrolytic solution. The cathode 66 includes a threaded body having an upper flange 78 which may be hexagonal to assist in inserting or removing the cathode, and a nipple 79 which extends downwardly below the processing chamber 76 and fits loosely within the tube 64. An axial passageway 81 extends upwardly into the nipple 79 and the threaded body of the cathode 66 terminating in a series of passageways 82 formed in an integral boss 83 which extends outwardly from the flange 78.

A tube 84 of insulating material such as glass fits over the boss 83 to conduct electrolyte upwardly from the cathode.

The passageways 82 may be three in number and are disposed at an angle to the axis of the tube 84 and to the axis of the passageway 81. Thus an electrolyte is pumped through the cathode, any initial surge of liquid is directed against the walls of the tube 84 and not upwardly into possible temporary contact with an object S being treated. Since the upper end of the tube 84 is disposed in close proximity to the metal object S, it is obvious that the tube 84 must be filled before electrolyte can contact the object. Furthermore, when the angle of the passageways 82 with respect to the axis of the tube 84 is between approximately 20 and 70 degrees, the velocity imparted to the liquid adjacent the walls of the tube 84 is increased thus aiding in overcoming the inherent fluid friction adjacent the walls and assisting in the production of a fountain at the end of tube 84 which has a substantially equal upward velocity in every portion of its cross section. In practice, we have found that an angle of approximately 45 degrees is generally satisfactory, although as the length of the tube 84 increases sharper angles may be employed. While we prefer to employ a number of passageways 82, it is not to be understood that more than one is essential, nor is it essential that the passageways themselves be straight since curved passageways adapted to produce a spirally upward movement of electrolyte in the tube is permissible provided a cross-sectional velocity of the fountain is substantially constant.

It should be noted that the fit between the nipple 79 and the tube 64 need not be tight and a certain amount of electrolyte may be permitted to flow between the nipple and the tube in order to eliminate any air which may be unintentionally entrained therein by the pump 56. The surface of the boss 83 is preferably flat but may be slightly convex if desired. It is not essential that the surface be smooth or polished. Since the resistance of the electrolyte between the cathode 66 and the object S which usually forms the anode of the processing circuit affects the current flow, cathodes having bosses 83 of varying heights may be provided for insertion in the processing chamber 76 or the boss 83 may be removably attached to the cathode as by threads.

Object support and clamp

A disk 86 having an aperture 87 extends over the top of the processing chamber 76 resting on gaskets 85 which are in turn supported by the plate 31 and the strip of stainless steel 32. The processing chamber 76 is held in position against the plate 31 by screws 88 extending into suitably tapped holes in the walls of chamber 76. If desired, a gasket 89, preferably of insulating material such as rubber or plastic, may be interposed between the chamber 76 and the plate 31. Since the screws 88 are in contact with the metal strip 32, it may be seen that an electrical contact is established between the cathode 66 and the strip 32 through the chamber 76.

A ring 91 is secured in position by screws 92 extending through the ring and into the chamber 76 and is provided with an inwardly extending flange 93 bearing against gaskets 87 thus holding the disk 86 in position. The side walls of the aperture 87 taper upwardly, the minimum diameter of the aperture 87 at its upper surface being somewhat less than the internal diameter of the tube 84, which extends upwardly into close proximity but not into contact with the walls of the aperture 87. Channels 94 formed in the surface of the disk 86 extend radially from the aperture 87 to drains 96 permitting electrolyte flowing from the channels to drain downwardly through the perforations 77 in the bottom of the processing chamber 76 into the container 42 for recirculation.

In the processing of a metal object, bubbles are generated at the interface of the fountain of the electrolyte and the object S which, if not removed, adversely affect the character of the etched or polished surface produced on the object. The continuous flow of electrolyte outwardly across the face of the object drives the bubbles outwardly and by entrainment with the electrolyte into the channels 94. Other entrained gas bubbles may follow the electrolyte escaping between the upper edge of the tube 84 and the walls of the aperture 87.

A motor support frame 97 is secured to the plate 31 and to the strip 32 by suitable means and is provided with a spring clip 98 which supports a motor 99 connected to the propeller shaft 59. The support frame 97 includes upper and lower flanges 101 and 102 having aligned openings in which is disposed a plunger 103 urged upwardly by a spring 104. The lower end of the plunger 103 contacts the plunger of a micro-switch 106 of the normally closed type mounted on the frame 97. An arm 107 having a horizontal leg 108 and a vertical leg 109 rigidly connected as by screws 115 is disposed above the plate 31, the vertical leg 109 being pivotally secured to an angle iron 111 which is in turn secured to strip 32. Horizontal leg 108 is a channel member extending outwardly over the motor 99 and the motor support frame 97.

A vertical tube 112 extends through an opening formed adjacent the outer end of the horizontal arm 108 and is provided at its lower end with an insulating plug 113 suitably tapped to receive a contact screw 114. An anode wire 116 is connected to the contact screw 114 and extends along the horizontal leg 108, terminating in a plug connector 117. The tube 112 is secured in place by a pair of suitably shaped dogs 118 disposed in the horizontal leg 108. One of the dogs 118 is threaded to receive a rod 119 which extends through the other dog terminating in an exposed knob 121, as seen in Figure 7. Rotation of the knob 121 thus causes the dogs 118 to grip or release the tube 112 thereby permitting it to be raised and lowered as desired in order to bring the contact screw 114 to a point adjacent the object S interposed between the contact screw 114 and the disk 86.

A transverse shaft 122 is journalled in the horizontal arm 108 and is provided with a rigid external handle 123 adapted to produce rotation of the shaft 122. A generally rectangular cam 124 having a rounded corner 90 is secured to the shaft 122 and disposed to engage the plunger 103 operating the switch 106. The width of the cam 124 is somewhat greater than the diameter of the plunger 103 so that in the absence of an object S, the weight of the arm 107 is transmitted through the cam 124 to flange 101, depressing the plunger 103 to a corresponding level and holding the switch 106 open. Movement of the rectangular cam 124 moves the arm 107 about its pivot causing the contact screw 114 to be raised and lowered, but as long as the cam 124

supports the arm 107, switch 106 remains open regardless of the position of the cam. Insertion of an object S between the disk 86 and the contact screw 114 supports the arm 107 thus removing the weight of the arm from the cam 124 and permitting the plunger 103 to rise under the pressure of spring 104 as the cam 124 is rotated thus permitting switch 106 to close. A spring 125 secured to angle iron 111 and to the arm 107 may be employed to supplement the weight of the arm 107 and thereby assist in clamping the object S to the disk 86.

Since the switch 106 controls the operation of the pump motor 99, and cannot close unless the sample is in position under the contact screw 114, it is obvious that the motor 99 cannot operate the pump until a sample is in place, thereby preventing the fountain of electrolyte from splashing through the aperture 87 into possible contact with the hands of the operator.

Leads 127 extend from the motor 99 and switch 106 to the plug 117. An additional wire extends from the plug 117 to the strip 32 of stainless steel thereby establishing a connection to the cathode 66 through the processing chamber walls 76. To prevent accidental damage, a chain 123 is connected to the plug and to the strip 32 to withdraw the plug 117 from its receptacle as the processing unit 20 is withdrawn from the frame 21. A suitable four-contact receptacle 129 for the plug 117 may be mounted on a plate 131 extending transversely across the main housing directly below the easel 23. Removable covers 100 having pins 105 engaging clips 110 which are secured to the strip 32 extend outwardly from both sides of the arm 107 to the edge of the processing unit and are suitably shaped to enclose the motor 99, the motor support frame 97, and disk 45, as well as wires 116 and 127.

Current supply and control

Polishing, which requires greater current than etching, is usually accomplished with direct current, while etching may require either direct or alternating current. Our current supply means is therefore adapted to supply either for closely controlled periods of time. Since in most instances alternating current is available, we describe herein a circuit including rectifying means, but it is obvious that other current sources, such as a D. C. generator may be employed, eliminating the rectifying means from the circuit. Also it should be understood that the terms "anode" and "cathode" are used to designate the two electrodes, even though in an A. C. circuit they of course function merely as electrodes.

Electrolytic polishing may in some instances require currents on the order of 10 amps at 200 volts, and since the electrolytic solution through which the current flows is often combustible or explosive, it is obvious that adequate safety precautions must be taken. As may be seen from the foregoing description, the circuit includes a fountain of electrolyte extending from cathode to anode which is renewed for each operation, thus creating an arcing condition as contact is made or broken which could cause combustion or detonation. Among our novel circuit features is the provision of means which prevents the full current from flowing through the fountain as contact with the object is being made or broken. To prevent accidental completion of the circuit, or splashing of corrosive electrolyte, means are provided to prevent the formation of the fountain of electrolyte unless a metal object is properly positioned for processing. The circuit units have also been arranged in such manner that both of the operator's hands are necessarily in a safe position during processing, and in addition the circuit provides means for automatically preventing energization of more than one main processing circuit at a time.

In general, the circuit includes a main transformer 132 having a main secondary 133 provided with a grounded center tap 130. The secondary 133 supplies current to paired half-wave rectifier tubes 134. The tubes, with associated choke coils 135 and condensers 137, supply a highly rectified substantially linear direct current to the anode contact 114 and cathode 66, which is grounded. Each of the three principal circuits, namely, D. C. etch, D. C. polish, and A. C. etch includes a main relay such as relays 138, 139, and 141, respectively, controlled by suitable timers 142, 143, and 144, respectively. The timers are adjustable by knobs 146, 147, and 148 (Figure 1) and preferably are of the electronic type. Current control is obtained by selector switches 149 and 151 connected to taps on opposite sides of the ground tap 130 on the main transformer secondary 133 and by a variable voltage transformer 152 in the A. C. etch circuit which operates from a secondary winding 153 on the transformer 132.

Suitable control knobs 154, 156 and 157 are mounted on easel 23 and connected to the selector switches 149 and 151 and to the variable voltage transformer 152. Selection of the desired circuit is obtained in part through a normally open double throw gang switch 158 which in one position closes four contacts energizing the D. C. polishing circuit and in the other position closes four contacts energizing one of the two etching circuits. Selection of whether the etching is to be accomplished by alternate and direct current is obtained by a double throw snap type gang switch 159. Current for the timers 142, 143, and 144, and for the switches 158 and 159 is obtained from a transformer 161 having a secondary 162 or from a suitable secondary on the main transformer 132.

A normally open safety switch 163 is in series with the timers 142, 143, and 144 and secondary 162, and must be held in closed position by the operator to render any of the timer circuits effective. Since both the switch 158 and the switch 163 will remain in closed position only in response to hand pressure, it may be seen that by mounting the switches more than one hand's span apart, as indicated in Figure 1, the operator's hands will be fully occupied during the process thus making it impossible to accidentally contact the anode or the electrolyte.

A low voltage transformer 164 supplies current on the order of, say, 24 volts and of approximately 10 milliamperes to a safety circuit which includes at least one normally closed contact on the relays 138, 139, and 141, the anode contact 114, the cathode 66, and the coil of a relay 166 which controls circuits controlling the timers 142, 143, and 144, and therefore also controlling the relays 138, 139, and 141. As subsequently explained, when the processing operation is started, all of the contacts of relays 138, 139, and 141, except the safety circuit contact, are open and therefore the full potential of the processing current does not exist between the anode and the cathode. As the stream of electrolyte first contacts the object S which is

in contact with the anode contact screw 114, the safety circuit is completed thus energizing the coil of relay 166. This relay in turn closes contacts permitting actuation of the timers 142, 143, and 144, which in turn actuate the main circuit relay 138, 139, and 141. Thus it may be seen that the potential between the anode and cathode at the time the fountain of electrolyte is first established is of such low voltage that no spark is generated as the circuit is completed thereby eliminating a possible cause of detonation or combustion of the eyectrolyte. The main circuit relays 138 and 139 in their unenergized or normal position have three normally open and three normally closed sets of contacts and the relay 141 in the A. C. circuit has two normally open and one normally closed pairs of contacts. Since the safety circuit includes the normally closed contacts of all three relays, it may be seen that energization of any one of the relays breaks the safety circuit and establishes the main circuit by closing the normally open pairs of contacts. The main circuit is maintained by a relay 167 until de-energized by one of the timers 142, 143, and 144.

A relay 178 controlled through the relay 167 by switches 158 and 159 normally directs current through the A. C. etch ammeter 169 and into the A. C. etch circuit. If, however, either D. C. polish or D. C. etch circuit is selected by switches 158 and 159, a circuit to the coil of the relay 178 is closed actuating the relay and thus connecting the D. C. power supply to the anode object S through lead 171, D. C. etch ammeter 172, and D. C. polish ammeter 173. A main switch 176 is placed in series with the primary winding 178 of the main transformer 132 and is provided with a pilot light 177 across main leads 179 and 181 to indicate the condition of the circuit.

Assuming it is desirable to polish a metal object S and that a suitable solution has been placed in the container 42, the object is placed over the aperture 87 and the tube 112 lowered with the arm 107 in raised position until almost in contact with the upper surface of the specimen. The handle 123 is then moved towards the operator lowering arm 107 and permitting the anode contact screw 114 to come in contact with the object S. This supports the arm 107 permitting the switch 106 to close. Closing the switch 106 completes the circuit from the motor 99 to the cathode 66 through lead 182. Switch 176 is closed allowing current to flow through leads 179 and 181 and through the primary 178 illuminating the pilot light 177.

Operation

To polish the specimen, the switch 158 is moved to the left, the position of switch 159 being immaterial in so far as the polishing circuit is concerned. The switch 158 is held in position with the right hand of the operator while the left hand closes safety switch 163. Selector switch 149 is adjusted to give the desired current and timer 143 is similarly adjusted to control the duration of treatment. As the switches 158 and 163 are closed, current flows from transformer secondary 162 through lead 183 to blade 184 of the switch 158 to leads 186 and 187 to relay 178, leads 188 and 189 to ground. A lead 191 is also energized from the transformer secondary 162 completing a circuit through contacts 192 and lead 193 to motor 99. Operation of the motor establishes the jet of electrolyte which establishes electrical connection between the cathode 66 and the object S. This permits current to flow through the safety circuit energized by transformer 164 and extending through the coil of relay 166, lead 194, through the normally closed contact to relay 138, lead 196, the normally closed contact of relay 139, lead 197, the normally closed contact of relay 141, and lead 198 to ground. The other side of the secondary of transformer 164 is connected by lead 199 to the object S thus completing the circuit.

Completion of the safety circuit, as previously explained, energizes the coil of relay 166 closing contacts 201 and completing a circuit including a lead 189, lead 202, the coil of relay 167, lead 186, a blade 184 of switch 158, lead 183, and transformer secondary 162 thus closing the contacts of the relay 167. A lead 203 establishes a connection between the coil of the relay 167 and one of the pairs of contacts thereof to ground lead 199 thus permitting the relay 167 to remain closed regardless of the condition of the relay 166 which initially energizes the coil of relay 167.

Power input to the timers 142, 143, and 144 is obtained through leads 204 and 206 connected directly to the secondary 162. Contacts 207 on switch 158 complete the circuit through the output side of the timer 143 through leads 208, the contacts of relay 167, safety switch 163, lead 209, lead 211, timer 143, and lead 212. A fourth set of contacts 213 in switch 158 completes the circuit to pilot light 214 which includes leads 206, 216, lead 217, contacts 213 and lead 191. Operation of the timer establishes a circuit through lead 218, the coil of relay 139, lead 219, and lead 211 back to the timer thus energizing the coil 139, opening the normally closed contact thereof to break the safety circuit, de-energize the coil of relay 166, and closing the three normally open contacts of the relay 139. The main secondary 133 of the main transformer 132 then passes current through the selector switch 149 through leads 221 and 222 through contacts of relay 139 through leads 223 and 224 through choke coils 136 and rectifier tubes 134. Filament current to the tubes 134 is obtained from a center tapped secondary 226 connected by leads 227 and 228 to the tubes 134. Common lead 229 conducts the rectified current through lead 231, relay 139, ammeter 173, lead 171, relay 178, lead 232 to the anode S, through the fountain of electrolyte and to the cathode 66 which is grounded.

A voltmeter 174 is connected by lead 233 to the anode object S and the circuit continues through lead 234 to ground. When the desired time of treatment has been completed, the circuit established by the timer 143 through the coil of relay 139 is broken by the timer thereby de-energizing relay 139 and breaking the circuit. At the completion of the operation, the safety switch 163 and the gang switch 158 may be released, the release of switch 158 stopping the motor 99 and breaking the circuit through the pilot light 214.

Assuming further that the sample selected is to be etched by D. C. current, the desired etching current is set on selector switch 151 and the timer 142 set to give the desired etching time. The switch 158 is then thrown in the opposite direction and snap switch 159 thrown to D. C. etch. Closing of the switch 158 again energizes the motor 99 through lead 191, contacts 236, lead 193, contacts 106 and lead 182. The safety circuit is energized in a manner previously described, the circuit through relay 167 being completed through leads 183, contacts 237, lead 238, contacts

239 on switch 159, lead 241, lead 186, the coil of relay 167, lead 203, through the contacts of relay 167 to ground. Energization of lead 187 also actuates relay 178, grounded by leads 188 and 189. The circuit to the timer 142 includes lead 240 extending from the timer to contacts 245 on switch 159, lead 235, contacts 242 on switch 158, lead 208, contacts on relay 167, lead 209, and lead 211. A pilot light 243 is energized by lead 216, lead 244, contacts 246 on switch 159, lead 247, contacts 248 on switch 158, and lead 191 to transformer secondary 162. Completion of the circuit through timer 142 closes relay 138 breaking the safety circuit and establishing the D. C. etch circuit through selector switch 149, leads 249 and 251, contacts of relay 138, leads 224 and 223 to the rectifier tubes. The rectified current from the tubes flows through lead 229 through the contacts of relay 138, lead 252, ammeter 172, lead 171, contacts of relay 178, and lead 232 to the anode.

If, however, a sample is required to be etched by alternating current, the switch 158 may be left in the etching position and the snap switch 159 thrown in the other direction to establish the A. C. etch circuit. The timer 144 is energized through contacts 242, lead 235, contacts 253, lead 254, lead 209, safety switch 163, contacts of relay 167, and lead 208. A pilot light 256 is also energized through lead 216, lead 257, contacts 258, lead 259, lead 247, contacts 248 and lead 191. Actuation of the timer 144 establishes a circuit through lead 261 and 211 to the coil of relay 141. Actuation of the relay 141 breaks the safety circuit and establishes a circuit through secondary 153 of the main transformer 132, leads 262 and 263, contacts of relay 141, lead 264, ammeter 169, lead 266, the contacts of unenergized relay 178, and lead 232 to the anode. The condenser 137 may be connected across leads 171 and 182 to cooperate with the choke coils 136 in smoothing the D. C. current output of tubes 134.

Although variations in the solutions employed cause variations in the resistance of the circuit and hence influence the current values, various general ranges may be cited as illustrative of the desired conditions. The etching timers 142 and 144 should have an approximate range of 0.5 to 3.0 seconds and the polishing timer 143 a range of about 2 to 50 seconds. In the polishing circuit, voltages of from 100 to 200 volts and from 0.5 to 10 amps may be required while each of the etching circuits should be capable of supplying 0.5 to 3 amps at about 35 to 125 volts.

A solution generally adapted to etch and polish iron, steel and other metals may be prepared by mixing together 800 cc. of methyl alcohol containing 3% ether, 146 cc. of tap water, and 54 cc. of 70 to 72% perchloric acid. This solution, which should be used at temperatures below 90 degrees F., and when used in conjunction with a tube 84 having dimensions of approximately 1¼" by 15 millimeters bore will produce a circuit resistance of approximately 25 to 50 ohms which can be increased or reduced by changing the diameter of the tube or the distance between the anode object S and the cathode 66.

As a specific example of a procedure for obtaining highly satisfactory results on low carbon steel, polishing may be continued for 10 seconds at room temperature using 3.4 amps at 120 volts. A sample of this metal polished as described may be etched by alternating current using 21 volts and 0.6 amps for ten seconds. Austenitic stainless steel may be satisfactorily polished in 10 seconds using 2.0 amperes at 70 volts and ferritic stainless steel may be polished in 4 seconds using 2.8 amperes at 100 volts.

The solutions herein described are only representative of many which may be employed. Other more violently explosive mixtures incorporating, for example, higher percentages of perchloric acid and acetic anhydride may be safely employed but glass or other inorganic materials should be substituted for any plastic parts disposed to contact the solution. The use of violently explosive mixtures such as those employing high percentages of perchloric acid with acetic anhydride require the provision of additional safety means for insuring the uninterrupted supply of electrolyte since even a temporary interruption in flow, as for example that which might be caused by a large bubble, would break and perhaps subsequently reestablish the main circuit at the anode thus producing an arcing condition between the object S and the electrolyte.

I therefore provide a float 267 having upwardly extending arms 268 telescoped over a stem 269 having a head 271 disposed between the arms 268 and engageable thereby. The parts are disposed in such manner that the arms 268 form a lost motion linkage with the stem 269 and the head 271 producing a downward motion of the stem 269 whenever the electrolyte in which the float 267 is immersed drops below a predetermined level. The stem is connected to a suitable switch such as switch 196 controlling the motor 99 and modified to permit actuation by downward movement of the stem 269 or a similar switch disposed in series with either the main or timer circuits adapted to stop the processing operation when such level is reached.

Since the processing unit includes the electrolyte container 42, pump 56, motor 99, arm 107, cathode 66, and all associated apparatus necessary to process metal objects except current supply and control means and cooling water, it is obvious that the processing unit 20 may be satisfactorily operated at a distance from the balance of the herein described device. Flexible leads from socket 129 and a hose from pipe 44 may be used to supply current and water, or other more convenient sources of current may be utilized. Furthermore, inspection and repair is greatly simplified because of the ease with which the processing unit 20 can be removed. This is accomplished by first removing the cover 51, and then grasping the processing unit frame 27, drawing it outwardly. The unit 20 slides outwardly like a drawer on members 28 and 29, the plug 117 being withdrawn by chain 128, and may be supported after withdrawal by the water jacket 33. The plug 117 is the only mechanical connection between the processing unit 20 and the main frame 21, since the water pipe 44 projects from main housing 22 into cup 46 through an opening therein, but is not in any way mechanically attached to processing unit 20.

Our device may, of course, be simplified by using only one timer connected to the three circuits by suitable switches, and the polishing circuit may be made to function as a direct current etching circuit, if desired. Greater accuracy and ease of operation, however, is obtained by the use of separate circuits having independent control elements as described.

Since the operation is purely mechanical, once the proper current and time values have been determined, relatively unskilled labor can consist-

ently obtain highly satisfactory polished or polished and etched surfaces, the greatest economy of time being obtained in the polishing operation. Should occasion arise, the surface of the object can be plated, instead of polished, by reversing the direction of current flow and substituting a suitable solution for the electrolyte described. Since the cathode under such conditions becomes the anode, it should be formed of the metal being plated.

In the foregoing specification we have described in detail a preferred embodiment of our invention as required by R. S. 4888, but it is not to be understood that in so doing we limit ourselves to the precise details, procedure and materials herein described except in so far as defined by the appended claims.

We claim:

1. In an apparatus for electrolytically treating metal surfaces, an apertured plate for supporting a metallic object to be treated, means containing a body of electrolyte beneath said plate, means for projecting a column of electrolyte from said body onto the exposed surface of the object overlying the aperture in said plate, a main circuit including said body of electrolyte, said column and said object arranged to pass an electric current between said column and said object across said exposed face of said object, a first relay having contacts included in said main circuit for controlling the latter, auxiliary circuit means actuated by the impingement of electrolyte upon said object for controlling said first relay to close said main circuit, whereby energization of said main circuit is dependent upon the column of electrolyte being in contact with said object, a transformer, means for producing a rectified direct current from the transformer, a second relay having contacts for connecting the rectified current to said main circuit, a control circuit including a timer for actuating said second relay, and a plurality of hand-operated switches in series in said control circuit, said switches being normally biassed to open position and being spaced apart a distance greater than can be spanned with a human hand.

2. In an apparatus for electrolytically treating metal surfaces, an apertured plate for supporting a metallic object to be treated, means containing a body of electrolyte beneath said plate, means for projecting a column of electrolyte from said body onto the exposed surface of the object overlying the aperture in said plate, an electrode arranged in the path of electrolyte projected from said body, and a hollow tube of insulating material extending from said electrode to a point adjacent the exposed surface of said object, said electrode having a passageway communicating with electrolyte projected from said body and with said tube, and at least that portion of said passageway adjacent said tube being disposed at an angle of approximately 45° to the axis of said tube.

3. In an apparatus for electrolytically treating metal surfaces, an apertured plate for supporting a metallic object to be treated, means containing a body of electrolyte beneath said plate, means for projecting a column of electrolyte from said body onto the exposed surface of the object overlying the aperture in said plate, a cathode electrode having a passageway for said column directed toward the exposed surface of said object, and a hollow cylindrical conduit extending from the aperture in said plate to said passageway, said passageway having a smaller diameter than said conduit and being inclined at an angle of approximately 45° to the axis of said conduit so as to produce in said conduit a column of electrolyte having a substantially constant cross-sectional velocity.

4. In an apparatus for electrolytically treating metal surfaces, an apertured plate for supporting a metallic object to be treated, means containing a body of electrolyte beneath said plate, a cathode electrode located beneath said plate and having a passageway in communication with said body of electrolyte in said containing means, a hollow insulating tube telescoped over said electrode for conducting electrolyte emanating from said passageway onto the exposed surface of the object overlying the aperture in said plate, means for projecting electrolyte from said body into the passageway, and a plurality of connecting passages leading from said passageway and into said tube, said passages being disposed at an angle of approximately 45° to the axis of said tube.

5. In an apparatus for electrolytically treating metal surfaces, an apertured plate for supporting a metallic object to be treated, means containing a body of electrolyte beneath said plate, a first electrode disposed within said containing means for contacting electrolyte therein, a second electrode spaced from said first electrode and located outside said containing means for contacting the object supported by said plate, means for projecting a column of electrolyte from said body towards the object supported by said plate, a main circuit including said electrodes, said body of electrolyte, said column and said object arranged to pass an electric current between said column and said object, a relay control circuit including a relay having contacts, said contacts being included in series with said main circuit to control the flow of current therein, and a switch responsive to the level of electrolyte in said containing means, said switch being in said relay control circuit and in series with the coil of said relay whereby to interrupt said main circuit when the level of electrolyte in said containing means drops below a predetermined level.

6. In an apparatus for electrolytically treating metal surfaces, an apertured plate for supporting a metallic object to be treated, means containing a body of electrolyte beneath said plate, a pump for projecting a column of electrolyte from said body onto the exposed surface of the object overlying the aperture in said plate, a clamp adjacent said plate for urging the object to be treated against said plate, switch means controlled by said clamp and arranged to energize said pump only when an object is urged by said clamp against said plate, a main circuit including said body of electrolyte, said column and said object arranged to pass an electric current between said column and said object across said exposed face of the object, a relay having contacts included in said circuit for controlling the latter, and auxiliary circuit means actuated by the impingement of electrolyte upon said object for controlling said relay to close said main circuit, whereby energization of said main circuit is dependent upon the column of electrolyte being in contact with said object.

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