

June 2, 1970

H. J. McVEY

3,515,094

AUTOMATIC CONTROL APPARATUS FOR LIQUID TREATING SOLUTIONS

Filed Feb. 5, 1968

4 Sheets-Sheet 1

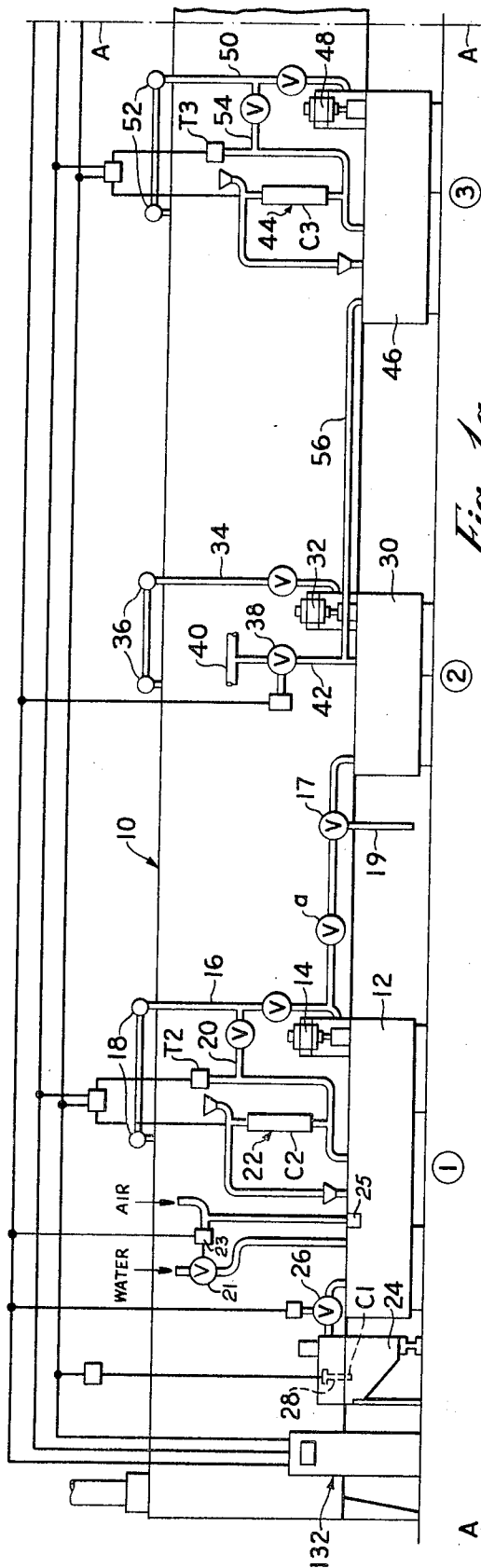


Fig. 1a

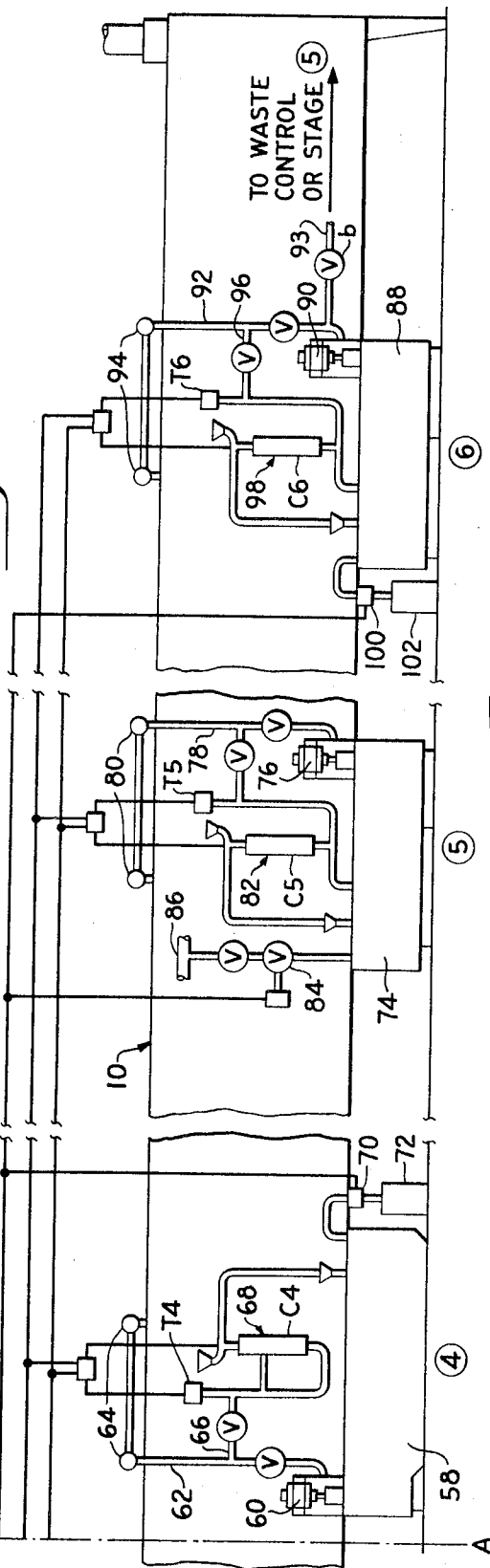


Fig. 1b

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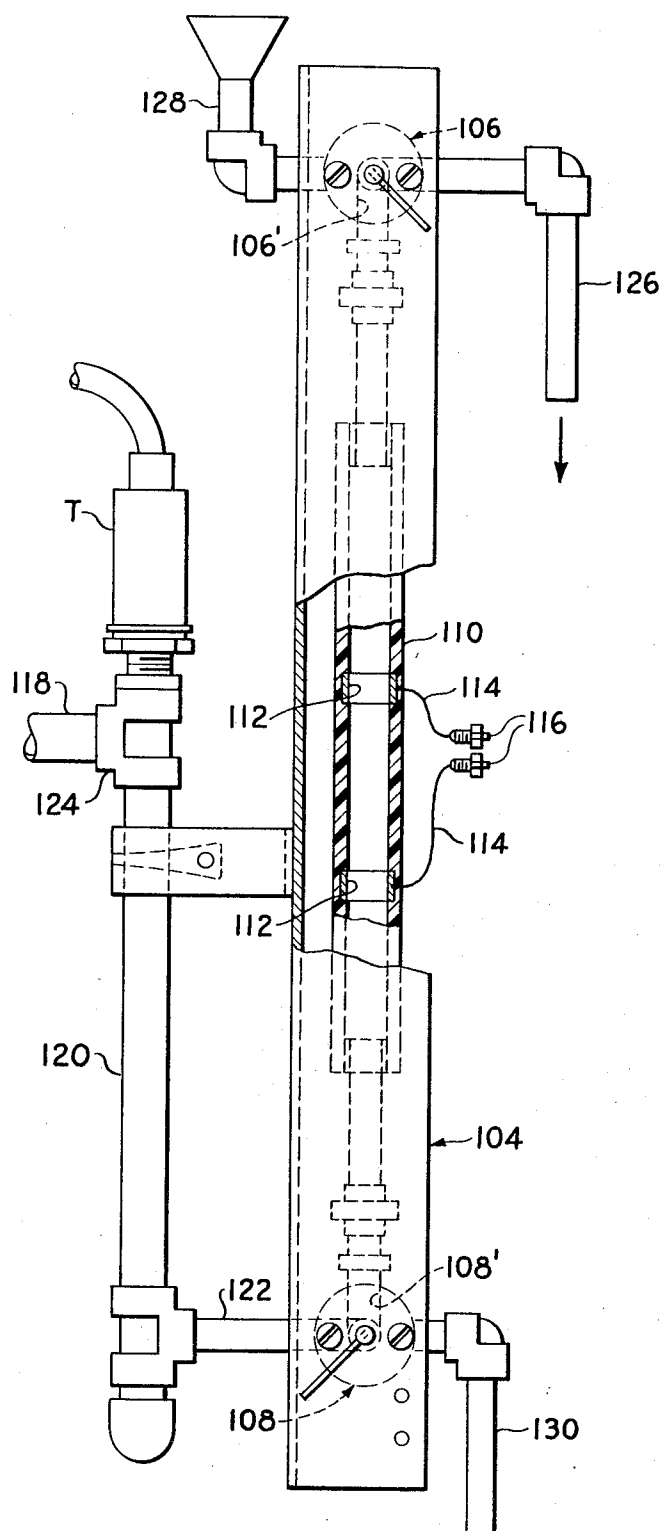


Fig. 2

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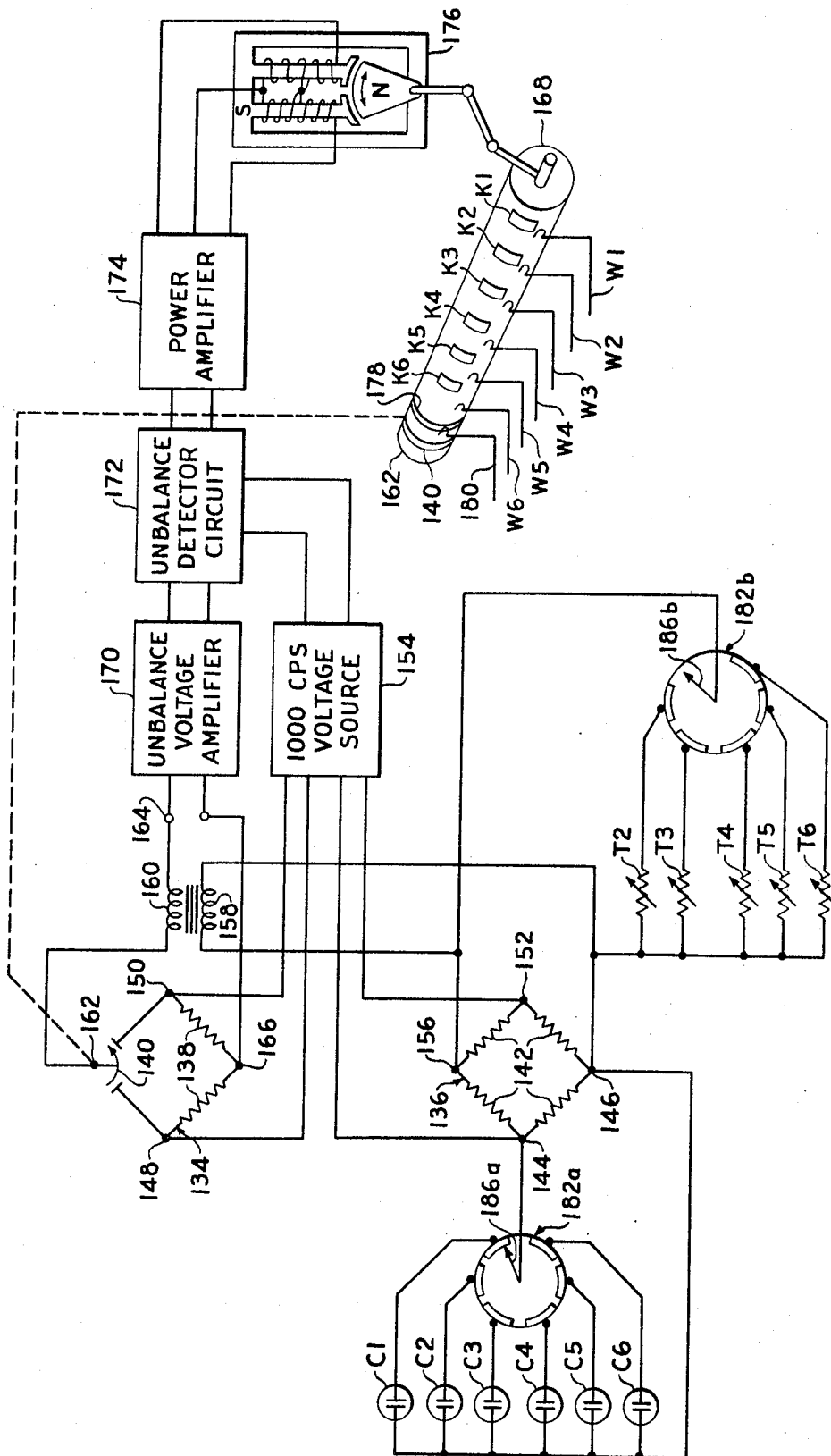


Fig. 3

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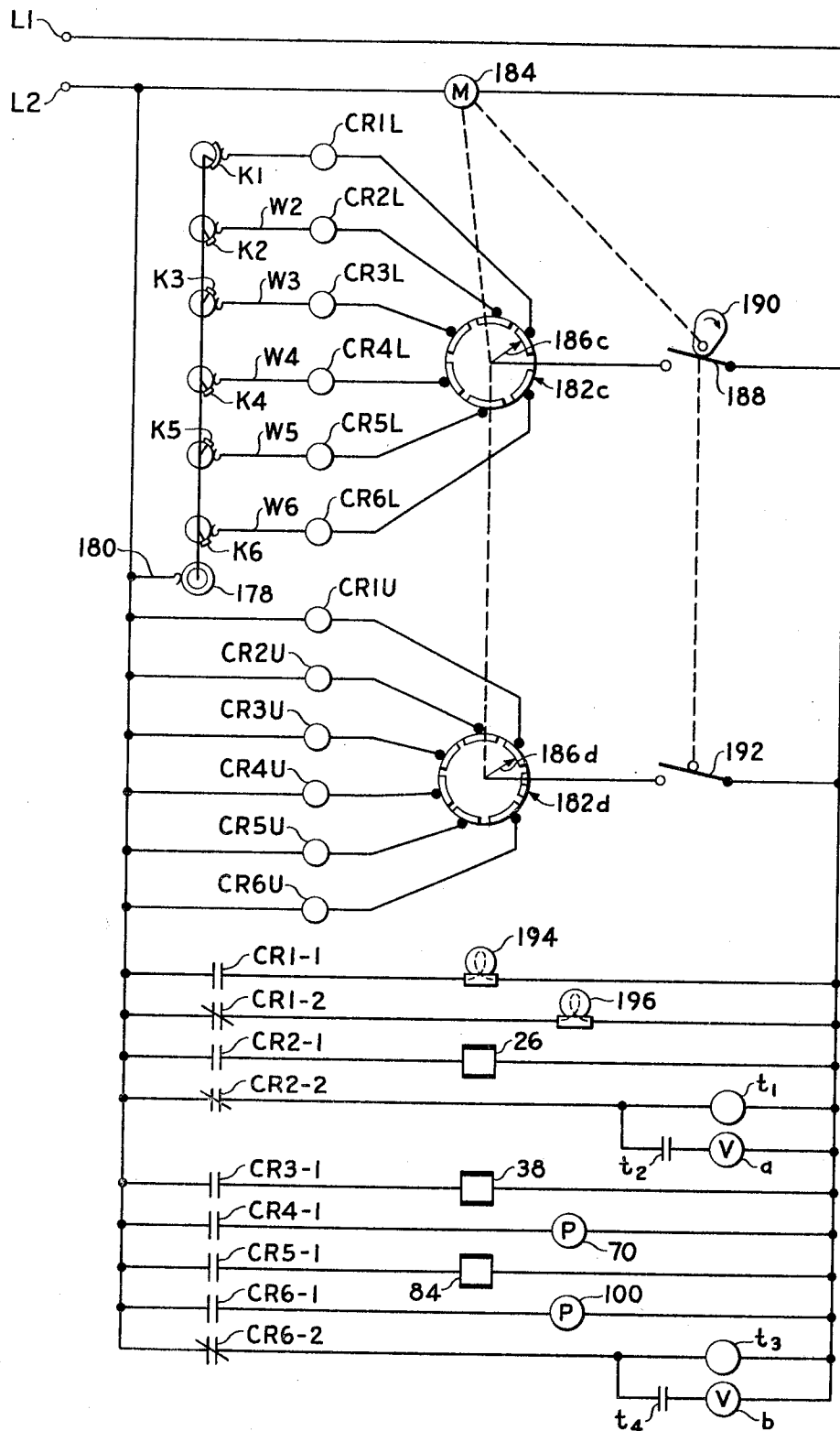


Fig. 4

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AUTOMATIC CONTROL APPARATUS FOR LIQUID TREATING SOLUTIONS

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Continuation-in-part of application Ser. No. 333,058, Dec. 24, 1963. This application Feb. 5, 1968, Ser. No. 702,838

Int. Cl. B05c 11/10

U.S. Cl. 118—5

7 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for forming chemical conversion-type coatings on the surfaces of metals including a plurality of treating stations, each incorporating a conductivity cell for sensing the electrical conductivity of the solution at that station, and a control system including a measuring bridge and a balancing bridge for electrically connecting one of each of the conductivity cells to the measuring bridge and a balancing bridge for electrically connecting one of each of the conductivity cells to the measuring bridge in accordance with a preselected ordered sequence for monitoring the composition of the treating solution as indicated by its electrical conductivity and to automatically apply an appropriate corrective action if the conductivity thereof deviates from a preselected magnitude.

This application is a continuation-in-part of my co-pending application, Ser. No. 333,058, filed Dec. 24, 1963, now abandoned.

The present invention broadly relates to an improved apparatus for use in forming chemical conversion type coatings on the surfaces of metals and more particularly to an improved apparatus for forming chromate and phosphate chemical conversion coatings on metal substrates wherein each of a series of liquid treating stations include conductivity sensing means which in response to the conductivity of the solutions are operative to maintain the compositions and concentrations thereof within preselected limits.

Chemical conversion coatings including chromate coatings and phosphate coatings of either the coating or non-coating type are in widespread commercial use for improving the corrosion resistance of a variety of metallic substrates. Chromate coatings are produced nonelectrolytically on zinc, cadmium, aluminum, copper, brass, bronze, silver, magnesium as well as ferrous sheets having a plating thereon consisting of one of the aforementioned metals. Chromate coatings thus produced provide for improved corrosion protection either as a final surface finish or as a more receptive base for paints or other organic finishes applied thereover. Chromate coatings can also be effectively dyed so as to provide an improved decorative finish to the metallic article coated therewith.

In chromate coatings, hexavalent chromium compound such as chromic acid, dichromates or chromates as well as mixtures thereof in combination with suitable activators and catalysts are employed in an aqueous solution and can be either applied by spraying, flooding, brushing, or the like. Workpieces which are to be subjected to such a chromate coating process are conventionally passed through a series of successive stations in which treating solutions including cleaners, rinses, chromates, subsequent rinses and dye or bleaching solutions as well as a final rinse are applied to the surfaces of the workpieces followed thereafter by drying. The compositions of these solutions and the contamination of the rinse solutions

must be carefully controlled to provide a resultant chromate coating of the requisite quality.

Phosphate coatings similarly are applied to a variety of metal substrates for providing for improved corrosion protection, for providing a base more receptive to overlying organic coatings such as paint, and to precondition the surfaces for metal forming operations providing a base for drawing compounds and lubricants. Phosphate coatings are conventionally formed by sequentially passing the workpieces through a series of treating stations including an aqueous phosphate solution containing coating type phosphates such as zinc phosphate, manganese phosphate, and iron phosphate, as well as non-coating type phosphates including alkali phosphates as well as ammonium phosphate and magnesium phosphate. In addition to the phosphate constituent which can be generally employed in a range of about .3% up to about 3%, any one of a variety of suitable accelerators or activators of the types well known in the art are employed including nitrates, chlorates, nitrites, sulfites, peroxides, organic peroxides, such as nitro-organic compounds including nitrobenzene sulfonate and the like, which are conventionally included in amounts ranging from about 0.05% up to about 3%. In order to obtain consistently good phosphate coatings of uniform weight and distribution, it is necessary that the compositions of the phosphate solution, the preliminary cleaning and rinse solutions, as well as the after rinse and chromate rinse solutions, are maintained within relatively narrow controlled limits so as to achieve the desired results.

It has heretofore been common practice to perform analytical analyses of each of the several solutions employed in a chemical conversion type coating process in an effort to avoid relatively large fluctuations in the compositions and concentrations thereof. Tests conducted at intervals of one hour or less are not uncommon and in spite of such rigorous laboratory control, variations in workpiece configuration resulting in variations in solution drag out and drag in as well as the differences in the metallic composition of the workpieces processed resulting in variations in the type and amount of contaminating ions introduced into the solutions has caused significant fluctuations in the compositions thereof resulting in variation in the uniformity of the coatings produced. Such rigorous laboratory tests and control of the solutions constitutes a tedious and costly operation and in spite of such tests solution replenishments are sometimes inadvertently omitted resulting in still further variations in solution composition.

It is, accordingly, a principal object of the present invention to provide for an automatic control system for a process for forming chemical type conversion coatings on metallic surfaces which overcomes the disadvantages associated with manually controlled processes of the types heretofore known.

Another object of the present invention is to provide an automatic control system for phosphate and chromate coating processes whereby the solution composition and concentration is maintained within relatively narrow limits assuring thereby uniformity in quality of the coatings formed on successive workpieces.

A further object of the present invention is to provide an automatic control system for phosphate and chromate coating processes which is operative to sense the conductivity of each of the solutions at relatively short intervals and to apply the corrective action and maintain the corrective action until the next sensing interval to determine whether additional corrective action is required.

A still further object of the present invention is to provide an improved flow-through conductivity cell which provides for accurate sensing of the conductivity of a

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solution and which, moreover, facilitates simple cleaning and servicing of the cell, reducing down time and thereby increasing the efficiency of operation.

Yet still another object of the present invention is to provide an improved automatic control system for chromate and phosphate coating processes which is of simple design, durable and reliable operation, and of economical operation and manufacture.

The foregoing and other objects and advantages of the present invention are achieved by providing an automatic control system comprising series of liquid treating stations through which workpieces are sequentially advanced and wherein at least a portion of the treating stations are provided with conductivity sensing means for sensing the conductivity of each of the treating solutions in order that when a deviation in conductivity occurs beyond a preselected amount the system is operative to provide corrective action by effecting automatic replenishment of the solution so as to maintain the solutions within the prescribed limits. A further feature encompassed within the present invention relates to an improved flow-through type conductivity cell including an upright disposed tube having a pair of spaced-apart electrodes therein and which tube is provided at the upper ends thereof with valve means for selectively connecting conduits for passing solution through the cell or alternatively for passing a cleaning solution through the cell maintaining it in a clean and accurate sensing condition.

Other objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, wherein:

FIGS. 1A, 1B are side elevational views partly schematic which are interconnected along the line 4-A illustrating a typical multiple station system for use in applying chemical conversion coatings to metal surfaces and wherein each of the solutions are automatically controlled in composition and concentration in accordance with the present invention;

FIG. 2 is an elevational view partly in section of an improved flow-through type conductivity cell in accordance with the preferred practice of the present invention; and

FIGS. 3 and 4 are schematic diagrams of the circuitry for sensing the conductivity of the treating solutions and for applying the appropriate corrective action.

Referring now in detail to the drawings and as may be best seen in FIGS. 1A-1B, a processing arrangement of the type to which the automatic control system comprising the present invention is applicable. The process and arrangement of an apparatus as shown in FIGS. 1A-1B is typical of a six-station treating process numbered 1 through 6 consecutively, which is applicable to both phosphate and chromate coating processes for forming a coating on the surfaces of workpieces as well as continuous sheet material as it is sequentially conveyed through the treating steps. The workpieces or sheet stock is conveyed through a suitable tunnel or chamber indicated at 10 and the treating solutions at each station are applied to the surfaces thereof in the form of a liquid spray or, alternatively, by immersion, flooding, and the like. The arrangement as shown in FIGS. 1A-1B is typical of a process employing a monorail (not shown) on which work carriers are mounted having a plurality of work racks suspended therefrom which are conveyed continuously through the tunnel past each of the treating stations. It will be understood that the automatic control system is equally applicable for providing automatic control of a plurality of solutions through which workpieces are sequentially conveyed regardless of the particular means for transporting the workpieces or the manner by which the treating solution is applied thereto. The process as illustrated in FIG. 1 is typical of a six-step phosphate coating process wherein station 1 is a cleaning station; station 2 is a first hot water rinse; station 3 corresponds to a sec-

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ond hot water rinse; station 4 corresponds to a phosphate coating solution; station 5 corresponds to a cold water rinse; and station 6 corresponds to a dilute chromic acid rinse of the phosphate coated workpieces. The phosphate coated workpieces passing from station 6 conventionally are dried so as to remove therefrom the residuary liquid after which further processing such as painting can be performed thereon if desired. Similarly, the arrangement shown in FIGS. 1A-1B is also suitable as a six-step chromating process wherein station 4 corresponds to a chromating step.

Variations in the number of stations employed for effecting the formation of a phosphate or chromate coating on the surfaces of workpieces can be made such as, for example, the omission of one of the rinse stations 2 or 3; the combination of the cold water rinse and chromic acid rinse provided by stations 5 and 6 into a single station, the combined cleaning and preliminary phosphating conducted at station 1 followed by direct phosphating at station 4 without any intervening rinse steps, or the like. In either case, a series of two or more processing steps are involved including the application of a treating solution to the surfaces of the workpieces such that careful control of the composition and concentration of the solutions must be maintained.

In the typical embodiment shown in FIGS. 1A-1B, station 1 comprises a tank 12 incorporating a submerged pump 14 therein which is effective to pump solution from the tank 12 up through a supply line 16 to a pair of spray headers 18 formed with a plurality of nozzles (not shown) therein. A portion of the pressurized solution passing upwardly to the spray headers is diverted through a branch conduit 20 into a conductivity cell assembly generally indicated at 22 and a construction as will be subsequently described in great detail with reference to FIG. 2. The solution discharged from the nozzles in the spray headers 18 contacts the surfaces of the workpieces passing through the tunnel adjacent to the station and thereafter drains into the tank 12 for recycling to the spray headers. Cleaning solution in the form of a concentrate is stored in a mixing supply tank 24 disposed adjacent to the tank 12 and is connected by means of a supply line incorporating a remotely actuable solenoid valve 26 to the tank 12 for selectively replenishing the cleaner in accordance with the conductivity of the solution as sensed by the conductivity cell assembly 22. The mixing tank 24 further includes a conductivity cell 28 which is positioned in a recirculating line therein and which is operative to visually or audibly signal the operator when the makeup concentrate therein is depleted.

Makeup water may also be supplied to the tank 12 from a suitable source. The level of solution in the tank 12 is also controlled by a suitable liquid level control device, shown at station 1 as being made up of valve 21, air switch 23 and air probe 25, whereby the solution may be overflowed from the tank if the solution level exceeds that which is desired. The addition of make-up water may be controlled by the liquid level control device, when the solution level drops below a desired minimum or by a reset timer, as will be described in more detail hereafter. Additionally, a discharge line 17 from the supply line 16 is provided whereby solution from tank 12 may be directed to tank 30 in station 2 or through discharge line 19 to a waste control system. The passage of solution through line 17 and/or line 19 is controlled by the valve *a*, which valve is actuated in response to a reset timer, as will be described in more detail hereinafter.

Station 2 comprising in the typical embodiment shown, a hot water rinse station similarly comprising a tank 30 incorporating a submersible electrically driven pump 32 which is connected by a supply line 34 to a pair of spray headers 36 for discharging the water rinse solution against the surfaces of the workpieces so as to remove the residuary film of cleaner constituents from the surfaces thereof. Fresh makeup water is supplied to rinse tank

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30 through a solenoid-actuated valve 38 connected at one side to a fresh hot water supply header 40 and to an inlet line 42 on the other side disposed above the rinse tank 30.

Actuation of the solenoid valve 38 for introducing fresh makeup water to the rinse tank 30 is controlled by a conductivity cell assembly indicated at 44 at station 3 in a manner as hereinafter described. Station 3 corresponds to a second hot water rinse including a rinse tank 46 incorporating a submerged electrically driven pump 48 which is connected by means of a supply line 50 to a pair of spray headers 52 for discharging the rinse solution on the workpieces effecting a further rinsing of the surfaces thereof.

The rinse solution from station 3 drains from the surfaces of the workpieces back to the rinse tank 46 and is recycled by the pump 48 back through the spray headers 52. A portion of the pressurized rinse solution passing through the supply line 50 is diverted through branch line 54 through the conductivity cell assembly 44 which measures the conductivity thereof which is indicative of the contamination of the rinse solution. When the rinse solution attains a preselected maximum contamination, the conductivity cell is operative to actuate the solenoid valve 33 effecting a discharge of fresh makeup water into the tank 30 of station 2 as well as the rinse tank 46 of station 3 through a supply pipe 56 connected to the inlet line 42 above the tank 30.

The cleaned and thoroughly rinsed workpieces are thereafter advanced through the tunnel until they are disposed adjacent to station 4 at which, for example, a phosphate coating solution is applied to the surfaces thereof. Station 4 comprises a supply tank 58 incorporating an electrically driven submersible pump 60 having its discharge side connected to a supply line 62 which is connected to a pair of spray headers 64 through which the phosphate solution is discharged against the surfaces of the workpieces. The phosphate solution draining from the workpieces is again returned to the tank 58 and is recycled by the pump 60 back to the spray headers. A portion of the solution passing through the supply line 62 is diverted through a branch conduit 66 to a conductivity cell assembly indicated at 68 of the general type illustrated in FIG. 2.

When the concentration of the phosphating constituents in the aqueous treating solution at station 4 decreases below a preselected minimum as indicated by a reduction in the conductivity of the solution, the conductivity cell assembly 68 is effective to energize a chemical proportioning pump 70 effecting the pumping of makeup concentrate from a drum 72 conveniently disposed, e.g. adjacent to the supply tank 58.

The workpieces having a phosphate coating thereon are thereafter advanced to station 5 which comprises a cold water rinse station including a tank 74 having a submersible pump 76 therein which is connected at its discharge side to a discharge line 78 connected to spray headers 80 for discharging the rinse solution against the surfaces of the workpieces. The rinse solution drained from the surfaces of the workpieces is again returned to the tank 74 whereby it is recycled by the pump 76 back to the spray headers. The degree of contamination of the rinse solution at station 5 is controlled by a conductivity cell assembly indicated at 82 which is operative when a predetermined contamination occurs to actuate a remotely actuable solenoid valve 84 effecting the discharge of fresh makeup water from a supply header 86 into the rinse tank 74.

The rinse tank 74 may be provided with a constant drain provision so as to withdraw a portion of the solution continuously for discharge to a drain thereby further deterring the excessive buildup of contaminating ions in the rinse solution.

The workpieces having the rinsed phosphate coating on the surfaces thereof are thereafter advanced through the tunnel or chamber 10 to station 6 at which a dilute chromic acid rinse is applied to the surfaces of the work-

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pieces effecting a sealing of the phosphate coating and an improvement in its corrosion resistant properties. Station 6 comprises a solution tank 88 including a submersible pump 90 which is connected at its discharge side to a supply line 92 which is connected at its upper ends to a pair of spray headers 94 having a plurality of nozzles therein through which the chromic acid rinse is sprayed against the surfaces of the workpieces. The solution draining from the workpieces is returned to the solution tank 88 and is recirculated by the pump 90 back to the spray headers. A portion of the pressurized solution passing up the supply line 92 is diverted through a branch line 96 to a conductivity cell assembly indicated at 98 which senses the concentration thereof and is operative to selectively energize a chemical feed pump 100 for pumping makeup concentrate from a storage drum 102 conveniently disposed, e.g. adjacent to the tank. A discharge line 93 is provided through which solution from tank 88 may be passed, either back into tank 74 of station 5 or to a waste control system. The passage of solution through line 93 is controlled by valve *b*, which is actuated by a reset timer on the motor of pump 90, as will be described in detail hereinafter. Additionally, liquid level control means and means for adding makeup water are also provided, as described with respect to station 1.

The workpieces passing station 6 are thereafter subjected to a drying phase such as a treatment with hot air until the coatings on the surfaces thereof are substantially dry. It will be apparent from the description as hereinabove provided that each of the several solutions must be maintained within relatively close composition and concentration limits to maintain them within balance so as to provide coatings which are of the requisite weight and uniformity. Heretofore, frequent tedious and costly analytical techniques were employed for testing each of the solutions to determine whether replenishment was required in order to maintain them within balance. In accordance with the automatic system comprising the present invention, each of the solutions are automatically sensed at relatively short intervals and the appropriate replenishment or addition of fresh makeup water is accomplished maintaining them within relatively narrow limits providing for improved coatings which are substantially consistent in quality and uniformity over prolonged production runs.

A conductivity cell assembly of the type employed at stations 1, 3, 4, 5, and 6 will now be described in detail with reference to FIG. 2. The conductivity cell assembly illustrated in FIG. 2 is of a novel construction enabling continuous sensing of the conductivity of a solution which is continuously passed through the cell in response to the pumping action of the submersible pumps in the respective solution tanks. Since chemical conversion-type coatings are operative to form a coating on most metallic surfaces, the surfaces of the electrodes during operation also become coated affecting the conductivity reading obtained requiring periodic cleaning in order to assure consistently accurate conductivity readings. This is achieved in accordance with the construction of the conductivity cell comprising the present invention by simply repositioning a pair of selector valves enabling a cleaning solution to be passed through the conductivity cell without interfering with or interrupting of the flow of solution to the spray headers.

The conductivity cell assembly as shown in FIG. 2 comprises a frame indicated at 104 to the upper and lower ends of which a two-position valve, such as a plug valve 106, 108 respectively, is secured. An insulated tubular sleeve 110 extends between and is disposed in communication with axially aligned ports of the upper valve 106 and lower valve 108. The sleeve or tube 110 may be comprised of any suitable electrical insulating material which is chemically resistant to the acidic or alkaline solutions employed and may comprise for example, a synthetic plastic such as polyvinylchloride. In the specific ar-

rangement shown, a pair of cylindrical electrodes 112 are embedded in the tubular sleeve 110 and are disposed in contact with the liquid solution passing therethrough. The total area of the electrodes 112 and the distance therebetween determines the calibration or constant of the conductivity cell assembly and is calibrated so as to accurately indicate the conductivity of the solution when a preselected voltage is imposed between the electrodes. Each of the electrodes 112 is electrically connected by means of a conductor 114 to a binding post 116 which in turn is electrically connected to a central control system in a manner as subsequently described.

Solution which is continuously diverted from the spray headers enters the conductivity cell assembly through a conduit or branch line connected to the main discharge line from the submersible pump indicated at 118 in FIG. 2 which passes downwardly through a pipe 120 and thence through a nipple 122 into the lower selector valve 106. The upper end of the pipe 120 is provided with a T-fitting 124 into the upper end of which a temperature compensating bulb T is mounted for sensing the temperature of the solution and compensating for variations in its conductivity as influenced by its temperature. The temperature compensating bulb comprises a variable resistor and is employed in a manner as will subsequently be described in connection with FIG. 3.

With the lower selector valve 108 in the position as shown in FIG. 2, solution flows upwardly through the tubular sleeve 110 and past the electrodes 112 and thence into the upper selector valve 106 and is discharged through a return line 126 back into the treating solution tank. When an accumulation of contaminants on the surfaces of the electrodes 112 has occurred, the conductivity cell assembly is simply cleaned by rotating the upper and lower selector valves 90° in a clockwise direction as viewed in FIG. 2 so that the L-shaped ports 106', 108' respectively, are disposed in communication with the tubular sleeve 110 at one end thereof and with an inlet line 128 and a drain line 130 at the other ends thereof, respectively. The inlet line 128 is preferably formed with a funnel-shaped opening in which a suitable cleaning solution such as a 10% hydrochloric acid solution can be poured into the cell effecting a cleansing of the surfaces of the electrodes and removing deposits therefrom and is thereafter drained out through the drain line 130 into a suitable receptacle disposed therebelow.

After cleansing with an acid solution the interior of the cell can be flushed with a clean water rinse after which the selector valves can be again positioned in the on-stream position by rotating the valves 90° in a counter-clockwise direction as viewed in FIG. 2. In accordance with this arrangement, simple and efficient cleansing of the conductivity cell assembly is achieved without interfering with the discharge of treating solution against workpieces being processed. In addition, the cleaning of the cell can be achieved in a relatively short time without requiring any disassembly of the cell components enabling the cell to be placed on stream after only a relatively short time such that substantially no interruption in the control of the solution in accordance with its conductivity results.

The conductivity cells at each of the several stations are electrically connected to a central control unit indicated at 132 in FIGS. 1A-1B which is operative to sequentially read the conductivity as sensed by each of the conductivity cells and apply the appropriate corrective action if the conductivity deviates from a preselected valve. To facilitate a description of the automatic control circuit in accordance with the present invention, the conductivity cell in the conductivity cell assembly 23 in the mixing tank 24 of station 1 has been designated C1; the conductivity cell in the conductivity cell assembly 22 of the rinse tank at station 1 has been designated C2; the conductivity cell in the conductivity cell assembly 44 of station 3 has been designated C3; the conductivity cell

in the assembly 68 of station 4 has been designated C4; the conductivity cell in the assembly 82 of station 5 has been designated C5; and the conductivity cell in assembly 98 of station 6 has been designated C6. The temperature compensating means at each of these stations has been designated as T2 for the conductivity cell assembly at station 1, as T3 at station 3, as T4 at station 4, as T5 at station 5 and as T6 at station 6. The conductivity cell C1 in the mixing tank 24 is not provided with a temperature compensating device since, as hereinbefore mentioned, it serves solely to advise the operator of the process as to the depletion of the cleaner in the mixing supply tank requiring a refilling of the mixing tank with the appropriate aqueous cleaner concentrate.

The operation of the automatic control system as incorporated in the central control unit 132 will now be described with particular reference to FIGS. 3 and 4. As shown in FIG. 3, the balancing circuit incorporating each of the conductivity cells comprises an upper bridge 134 and a lower bridge 136. The upper bridge 134 comprises two fixed resistors 138 and a split-stator variable capacitor 140. The lower bridge 136 consists of four fixed resistors 142 and the conductivity cells C1-C6 are electrically connected in parallel to one of the resistors 142 across terminals 144, 146. Terminals 148 and 150 of the upper bridge and terminals 144 and 152 of the lower bridge are connected to a low voltage 1000 cycles per second alternating current supply unit indicated at 154. The output voltage from the lower bridge 136 taken across terminals 146, 156, is applied to the input transformer primary winding 158 and induces a voltage in the input transformer secondary winding 160 of a magnitude depending upon the conductivity of the solution under measurement.

The voltage induced in the secondary winding 160 is applied across terminals 162, 164, which is in series with the output voltage of the upper bridge 134 as taken across terminals 162, 166. The voltage across terminals 162, 166, is varied by changing the position of the variable capacitor 140 which is mounted on a rotor 168 as indicated by the dotted line in FIG. 3. The rotor 168 is rotated to a position such that the variable balancing capacitor 140 is positioned to make the output voltage 162, 166 of the upper bridge equal and opposite in phase to the voltage induced in the secondary winding 160 across terminals 162, 164 in a manner as subsequently described. When this position is attained, the voltage between terminals 166 and 164 is zero and an equilibrium condition is reached. When this equilibrium exists, the position of the capacitor and the rotor 168 on which it is mounted is indicative of the conductivity of the solution under measurement.

Terminals 164 and 166 are connected to an unbalance voltage amplifier unit indicated at 170 of a type well known in the art which in turn is electrically connected to an unbalance detector circuit unit 172 which compares the amplified voltage from the unbalance voltage amplifier 170 to a reference voltage produced by the 1000 c.p.s. voltage source unit 154. The output of the unbalance detector unit comprises two DC voltages of opposite polarity which differ in magnitude by an amount proportional to the bridge unbalance and provides signals to the grids of a push-pull power amplifier unit indicated at 174 of the type well known in the art which in turn is electrically connected to the windings of an induction or selsyn type motor 176. The rotor of the motor 176 is in turn mechanically connected to the rotor 168 to effect angular rotation thereof so as to position the variable balancing capacitor 140 in an equilibrium condition. In this position the upper bridge 134 is unbalanced by the same amount as the lower bridge 136 in response to the conductivity of the conductivity cell connected in parallel across the terminals 144, 146 whereupon an equilibrium condition is attained and the rotor 168 be-

comes stationary. This balancing action is achieved almost instantaneously.

In addition to the variable balancing capacitor 162, the rotor 168 incorporates a series of arcuate contacts designated K1, K2, K3, K4, K5, and K6 corresponding to the particular conductivity cell being read by the circuit which are positioned in a preselected fixed relationship on the periphery of the rotor 168 and are oriented relative to fixed wiper contacts W1-W6, respectively, which are adapted to make the electrical contact with the arcuate contacts in response to the angular positioning of the rotor 168. The rotor 168 further incorporates a continuous circular contact band 178 disposed in electrical contact with a wiper contact 180 and which contact band 178 is internally electrically connected to each of the arcuate contacts K1-K6 in a manner as shown in FIG. 4. It will be apparent from this arrangement that electrical energy supplied to the wiper contact 180 passes to the contact band 178 and thence from the appropriate arcuate contact to the wiper contact adjacent thereto if positioned in electrical contact with the arcuate contact in accordance with the angular positioning of the rotor.

The selection of the specific conductivity cell, its corresponding temperature compensating device and the appropriate arcuate contact and wiper contact is achieved by a rotary selector switch comprising sections 182a, 182b, 182c, and 182d (FIGS. 3 and 4) which are mechanically connected to each other and are driven by synchronous motor 184 as shown in FIG. 4, as illustrated by the dotted line. Each of the rotary selector switch sections incorporates a rotary wiper contact 186a, 186b, 186c, 186d, respectively, which is oriented relative to a series of arcuate contacts spaced circumferentially therearound. In accordance with this arrangement, the rotary selector switch 182a incorporating wiper contact 186a (FIG. 3) is operative to selectively connect the conductivity cells C1-C6 in response to its counterclockwise rotation. Similarly, rotary selector switch section 182b incorporating wiper contact 186b is effective in response to its counterclockwise rotation to connect the respective temperature compensating bulb T2-T6 in parallel to the output of the lower bridge 136 when its corresponding conductivity cell is connected in parallel to the resistor 142 across junctions 144, 146. The rotary selector switch section 182c (FIG. 4) incorporating wiper contact 186c is effective to electrically connect the appropriate wiper contact W1-W6 to the control circuit for sensing the position of its corresponding arcuate contacts K1-K6 in accordance with the specific conductivity cell in circuit. In the same manner, rotary selector switch section 182d incorporating wiper contact 186d is effective to selectively connect the appropriate unlatching coil of a latch relay to the circuit in accordance with the conductivity cell which is placed in circuit.

Since the balancing of the rotor 168 in accordance with the circuit shown in FIG. 3 occurs almost instantaneously, the speed of rotation of the wiper contacts 186a-186d can be selected to provide relatively rapid reading of the conductivity of each of the solutions maintaining constant vigil of variations in the solution compositions and concentrations. For the purposes of the present invention, it has been found that a speed of rotation of approximately 2 revolutions per minute providing a cell reading every 5 or 6 seconds or a reading of each individual cell approximately two times every minute provides for satisfactory control of the solutions. More or less frequent sensing of each of the conductivity cells can be achieved depending on the criticality of the solution composition and the tendency thereof to fluctuate from the preset composition and concentration.

The wiper contact 186c of the rotary selector switch section 182c is electrically connected to a switch 188 which is moved to and from an open position as shown in solid lines in FIG. 4 to a closed position in response to

the rotation of an eccentric 190 which is drivingly coupled to the synchronous motor 184 and rotates at the same speed as each of the wiper contacts of the several rotary switch sections. A second switch 192 is mechanically coupled to the switch 188 as indicated by the dotted line and similarly is movable to and from an open position and a closed position in response to the rotation of the eccentric 190. The orientation between the switches 188, 192 is such that switch 188 closes before the switch 192 closes and opens after the switch 192 opens, for a purpose which will become apparent later.

The rotary switch section 182c is positioned in series with the latching coil of a series of latch relays CR1L-CR6L, each of which in turn is disposed in series with a respective wiper contact W1-W6 located adjacent to the arcuate contact K1-K6. Accordingly, electrical current transmitted from conductor L2 in FIG. 4 passes through the wiper contact 180 to the contact band 178 and thence to each of the arcuate contacts K1-K6. If, for example, arcuate contact K1 is oriented in response to the rotation of the rotor 168 (FIG. 3) so as to provide equilibrium between the upper and lower bridges such that the contact K1 is disposed in electrical contact with the wiper contact W1, the latching coil CR1L of latch relay is energized when the wiper contact 186c of rotary selector switch section 182c is oriented in a position as shown in FIG. 4, and the switch 188 closes in response to the rotation of the eccentric 190. The energization of the latching coil CR1L effects a closing of normally open contact CR-1 effecting illumination of a green indicator light 194 signaling the operator that a sufficient quantity of cleaner concentrate is present in the mixing tank 24 as shown in FIG. 1A. At the same time normally closed contact CR1-2 is opened extinguishing a red warning light 196 on the central control panel. The unlatching coil CR1U of the latch relay which in FIG. 4 is shown in spaced relationship from its corresponding latching coil CR1L for the purposes of clarity similarly is energized when the wiper contact 186d of rotary switch section 182d is oriented in the position as shown in FIG. 4 in response to the closing of switch 192. Since the latching coil CR1L is energized, contact CR1-1 remains closed and contact CR1-2 remains open and is unaffected by the energization of the unlatching coil. As the eccentric 190 continues to rotate the switch 192 first opens effecting a de-energization of the unlatching coil CR1U followed thereafter by an opening of switch contact 188 effecting a de-energization of the latching coil CR1L. Under these conditions of the latch relay remains latched in which the green indicator light 194 remains illuminated.

This condition continues until the cleaning concentrate in the mixing tank 24 (FIG. 1A) has become depleted such that the conductivity cell C1 does not provide for any conductance resulting in the rotor 168 (FIG. 3) to rotate in response to the balancing capacitor 140 to a position where the arcuate contact K1 (FIG. 4) is out of contact with the wiper contact W1. Under these conditions when the wiper contact 186c of the rotary selector switch section 182c returns to the position as shown in FIG. 4 and upon a closing of the switch 188, no energization of the latching coil CR1L occurs. Immediately thereafter as the switch 192 closes and the unlatching coil CR1U is energized effecting an unlatching of the relay and a corresponding opening of its contact CR1-1 and a closing of its normally closed contact CR1-2. Accordingly, the green indicator light 194 is extinguished and the red warning light 196 is illuminated visually signalling the operator that a recharging of cleaning concentrate in the mixing storage tank 24 is required.

In a similar manner, conductivity cell C2 is effective to control the concentration of cleaning solution in the supply tank at station 1. Since the concentration of the cleaning solution is directly proportional to its conductivity, a presetting of the arcuate contact K2 (FIG. 4) relative to the wiper contact W2 is effective to translate the angular position of the rotor 168 directly into the con-

ductivity of the cleaning solution at station 1 is achieved when the wiper contacts 186a, 186b are rotated to a position wherein cell C2 is electrically connected to the circuit of FIG. 3 and the temperature compensating device T2 similarly is in the circuit. At the same time wiper contact 186c connects latching coil CR2L to the circuit while wiper contact 186d connects unlatching coil CR2U in the circuit of FIG. 4. If the conductivity of the cleaner solution is above a preselected minimum value, the arcuate contact K2 is disposed out of contact with the adjacent wiper contact W2. Under these conditions the latching coil CR2L of the latch relay is not energized in response to the closing of switch 188 by the eccentric 190, and the latching coil CR2U is energized maintaining control relay contact CR2-1 open such that the solenoid valve 26 at the discharge of the mixing supply tank 24 remains closed.

On the other hand, if the conductivity of the solution falls below a preselected magnitude indicating an insufficient concentration of cleaner in the solution, the balancing rotor 168 is rotated to a position consistent to maintain the upper and lower bridges of the circuit of FIG. 3 in an equilibrium unbalanced condition such that arcuate contact K2 is electrically connected to wiper contact W2 effecting energization of the latching coil CR2L effecting a closing of its contact CR2-1 and energizing the solenoid valve 26. The opening of solenoid valve 26 effects a flow of makeup cleaner concentrate from the mixing supply tank into the tank 12 at station 1 effecting a replenishment of the cleaner therein. Since latching relay CR2 remains in the latched condition, the solenoid valve remains energized as the wiper contact 186a-186d rotate counterclockwise to the next successive contacts. When the wiper contacts 186a-186d again are positioned so as to place the conductivity cell C2 in the circuit, a resensing of the conductivity of the cleaning solution occurs. If the conductivity still remains below a predetermined level, latch relay CR2 remains latched and further replenishment continues. In the event the concentration of the cleaner solution has been raised such that the conductivity of the solution is above a preselected minimum, the rotor 168 having the balancing capacitor 140 thereon is angularly disposed such that the arcuate contact C2 is positioned out of electrical contact with its corresponding wiper contact W2. When this occurs, the relay is unlatched by unlatching coil CR2U in response to a closing of switch 192 effecting an opening of contact CR2-1 and a closing of solenoid valve 26. Reenergization of the solenoid 26 and an opening thereof does not occur until the concentration of the cleaner solution at station 1 has again fallen below a preselected level.

It has been found that although the components of the cleaning solution are, in fact, depleted as the solution is used to clean metal surfaces, there may not be a corresponding drop in the conductivity of the solution. This condition may result from the introduction of various extraneous materials into the cleaner solution with the metal surfaces which are cleaned, such as, welding or soldering fluxes, various alkaline or acidic materials and the like, which may be on the metal surface, as well as the removal of metal from the workpiece by the cleaner. Additionally, the aforesaid condition in the cleaning solution may also result in the processing of parts which effect little or no dragout of cleaning solution from the cleaner bath. In these cases, an appreciable period of time may elapse without activation of the system as described above so that there is no replenishing of the cleaner in the cleaning tank even though, in fact, there has been a depletion of the cleaner components with the resulting reduction in the effective cleaner action of the cleaning solution.

The system at station 1 is provided with means whereby cleaning solution is automatically removed from the tank 12, to the extent that the cleaner replenishing system, as described above, is activated and the cleaning solution is replenished to reestablish the proper con-

centration of components therein. This is achieved by providing a reset timer, indicated as t_1 in FIG. 4 of the drawing, which timer may be set to activate the makeup with supply source, after any desired interval of time. When the reset timer t_1 is set, the contact CR2-2 is closed. If in the time interval for which the timer has been set, replenishment of the cleaning solution is not effected, the timer activates the water supply system, causing makeup water to be supplied to the tank 12, while the liquid level control in the tank causes the overflow of cleaning solution. This continues until the solution is sufficiently diluted that its conductivity drops below the set point and the conductivity cell C2 activates the system for supply replenishing cleaning chemicals to the cleaning solution in tank 12. As indicated above, the contact CR2-1 is closed with the consequent energizing of the solenoid valve 26. When this happens, the contact CR2-2 is opened, contact t_2 is closed and the supply of makeup water is stopped. When the concentration of the cleaner solution has been raised such that the conductivity of the solution is again above the preselected minimum level, the contact CR2-1 opens and CR2-2 again closes, resetting the timer t_1 mechanism. In the event that the replenishing of the cleaner solution takes place within the time interval for which the reset timer was set, the closing and opening of the contacts CR2-1 and CR2-2 act to reset the timer again. Thus, so long as the cleaning solution is replenished within the desired specified time interval, the reset timer mechanism will not be actuated to effect the automatic removal of cleaning solution from the tank.

Alternatively, the reset timer t_1 may operate to open the valve a in line 17 on the pressure side of pump 14. Solution is then passed to tank 30 at station 2 or to a waste control system, through line 19. When this occurs, the level of solution in the tank 12 drops and the liquid level control device actuates the flow of makeup water to bring the level back to the desired point. This sequence continues until, as above, the solution is diluted to the point that its conductivity drops below the set point and the cleaner replenishing system is activated by conductivity cell C2. When the desired conductivity is reestablished, the timer t_1 resets and the sequence is repeated, as indicated above.

The level of contamination of the rinse solutions stations 2 and 3 is sensed by conductivity cell C3 which through its arcuate contact K3 is effective through wiper contact W3 to energize the latching coil CR3L effecting a closing of its contact CR3-1 and an opening of fresh water solenoid valve 33 enabling fresh makeup water to enter both rinse tanks 30 and 46 reducing the degree of contamination thereof below a preselected minimum, in the same manner as has been described above with respect to the cleaner at station 1.

Similarly, the concentration of the solution at station 4 is maintained above a preselected magnitude in response to the relative orientation between arcuate contact K4 and its wiper contact W4 so as to selectively latch its control latching relay comprising latching coil CR4L and unlatching coil CR4U effecting the selective closing of its contact CR4-1 and controlled energization of chemical proportioning pump 70 for pumping makeup concentrate from the drum 72. The degree of contamination of the rinse solution at station 5 is similarly controlled in response to the relative arcuate positioning arcuate contact K5 and its wiper contact W5 as controlled by its latching relay including latching coil CR5L, unlatching coil CR5U, and contact CR5-1 effecting selective energization and opening of the solenoid valve 84, permitting fresh makeup water to be discharged into rinse tank 74.

The concentration of the chromic acid rinse solution at station 6 similarly is replenished from drum 102 by feed pump 100 which is selectively energized in response to the closing of contact CR6-1 as determined

by the selected energization of latching coil CR6L and unlatching coil CR6U as established by the angular disposition of arcuate contact K6 relative to wiper contact W6 in response to the sensing of conductivity provided by conductivity cell C6.

There is also provided, at station 6, a reset timer system, similar to that described above in regard to station 1. This system includes the contact CR6-2, reset timer t_3 , contact t_4 and valve b . These function in the same manner as the system set forth for station 1 to remove chromate rinse solution from the tank 88 of station 6, by line 93, passing it either to tank 74 of station 5 or to a waste control system.

It is to be appreciated, of course, that although the reset timer system has been described as being used with two stations of the present apparatus, if desired, it may be also used with more or less than two stations, e.g., with one, three, four, five or all stations.

The relatively stringent control provided in accordance with the automatic system comprising the present invention will now be further illustrated in accordance with the following examples. It will be appreciated that the examples included are provided for the purposes of further illustration and are not intended to limit the scope of the present invention as set forth in the subjoined claims.

EXAMPLE 1

In a typical six-step phosphating process in accordance with the arrangement as schematically shown in FIGS. 1A, 1B, the cleaner solution at station 1 was comprised of about 4.5 parts tetrasodium pyrophosphate, 4.5 parts sodium metasilicate and 1 part of a colloidal titanium phosphate compound as a crystal refining agent. The cleaner can be employed conventionally in amounts ranging from about 0.35% up to about 0.75% by weight in an aqueous solution. In a specific case, the cleaning solution was controlled at a minimum concentration of about .35% by weight corresponding to a conductivity of the solution of about 5000 mmhos. Periodic automatic replenishment of the cleaning solution was achieved in accordance with the arrangement as hereinbefore described such that the concentration of cleaner in the solution was maintained within 0.35% to 0.37% or a variation of only 0.02%. Alternatively cleaner compositions can be satisfactorily employed consistent with the nature of the workpiece, the degree of surface conditioning desired, and the type of conversion coating to be subsequently applied. Employing cleaning compositions of the types heretofore known, the conductivity of the cleaner solution can usually range from a level as low as about 2500 mmhos to a level as high as around 250,000 mmhos typical of caustic cleaners.

At station 2 the contamination of rinse solution was allowed to rise at an undetermined level above that of station 3 which in turn was controlled so as to have a degree of contamination not more than about $\frac{1}{5}$ to about $\frac{1}{100}$, and preferably less than $\frac{1}{10}$ of the conductivity of the cleaning solution employed at station 1. It will be appreciated that fresh makeup water itself will possess a certain degree of conductivity which will vary from one locality to another and frequently ranges from about 200 mmhos up to about 600 mmhos. For a makeup water having a conductivity of about 200 mmhos, a maximum contamination of cleaner in the second rinse solution corresponding to a conductivity of about 550 mmhos was provided whereupon automatic replenishment of the rinse solution was achieved rendering the workpieces substantially free of any residual cleaner constituents on passing into the next phosphating step. By controlling the conductivity of the second rinse solution, the degree of contamination of the first rinse solution is usually held below $\frac{1}{5}$ of the conductivity of the cleaner solution. When a single rinse is used, it is preferred to control its conductivity below about $\frac{1}{10}$ of that of the previous cleaning solution.

The phosphating solution applied to the surface of the workpieces at station 4 comprised a coating type phosphate solution including the following constituents in the proportions as indicated in the following table.

Ingredient:		Percent by weight
Zinc ion	-----	0.25
Nickel ion	-----	0.2
Phosphate ion (PO ₄)	-----	1.2
Nitrate ion (NO ₃)	-----	0.35
Fluoride ion (F)	-----	0.2

The solution was maintained at a total acid pointage of between about 25 to 27 points as determined by the number of milliliters of .1 N sodium hydroxide required to neutralize 10 milliliters of the treating solution to a phenolphthalein end point. The free acid pointage of the solution range between 2 points to 2.5 points as determined by the number of milliliters of .1 N sodium hydroxide solution required to neutralize 10 milliliters of the phosphating solution to a bromophenol blue end point. The phosphating solution was applied to the surfaces of the workpieces at a temperature of about 145° F. and exhibit a conductivity of about 27,000 mmhos. In accordance with the automatic control system comprising the present invention, the concentration of the several constituents comprising the phosphating solution were held within a concentration of about 0.01% by weight.

Alternative phosphate coating solutions can be satisfactorily controlled in the same manner incorporating constituents of the types well known in the art consistent with the type of metal to be coated and the desired characteristics of the resultant coating formed. Solutions of this type will conventionally range from about 7,000 mmhos to about 60,000 mmhos and higher in conductivity.

The cold water rinse at station 5 similarly was controlled so as to maintain a level of contamination of from less than $\frac{1}{10}$ to less than $\frac{1}{100}$ of the total acid pointage of the phosphate solution employed at the preceding treating station. This corresponds to a conductivity of the cold water rinse at station 5 of from about $\frac{1}{10}$ to about $\frac{1}{100}$ of that of the phosphating solution. A conductivity of about $\frac{1}{100}$ corresponds to about 450 mmhos employing 200 mmhos makeup fresh cold water. This limited degree of contamination was automatically maintained in accordance with the system comprising the present invention assuring adequate rinsing of the phosphate coated surfaces of the workpieces.

The 6th and last station of the phosphating process comprised a chromic acid rinse which generally contains from about 0.1% to about 0.2% of chromic acid calculated at CrO₃. Rinses of this type generally have a free acidity ranging from about 0.2 to 0.4 point as determined by the number of milliliters of .1 N sodium hydroxide required to neutralize a 25 milliliter sample of rinse solution to a bromocresol green end point. The solution conventionally has a total acid content of between about 3 and 6 points and is maintained in accordance with the present invention below 6 points. Chromic acid rinse solutions of the types well known in the art usually range in conductivity from about 500 mmhos to about 10,000 mmhos, and more usually, from about 2,500 to about 4,000 mmhos. Employing a chromic acid rinse containing 0.1% chromate, the rinse solution had a conductivity of about 3,000 mmhos and was found to be maintained within 0.01% of the limit by the conductivity cell and control system comprising the present invention.

The process for phosphating workpieces in accordance with this example was effective to assure adequate cleaning, rinsing, phosphating, rinsing and chromic acid rinsing of the workpieces with solutions of the requisite concentration resulting in coatings of substantially consistent quality and uniformity. The control system in accordance with the process as described in the example effected a reading of a conductivity cell every six seconds, and a reading of the same cell every 36 seconds.

15 EXAMPLE 2

A similar 6-step phosphating process was employed including controls in accordance with the present invention wherein station 4 was of an iron phosphate coating composition and the remaining stations were identical to that previously described in Example 1. The iron phosphate solution contained about 1% by weight of phosphoric acid calculated as PO_4 and 3.5% by weight of a chlorate accelerator calculated as ClO_3 . These constituents were replenished separately employing two concentrate tanks and chemical proportioning pumps adjusted to provide makeup concentration in the relative proportions employed in the final solution. The solution had a total acid of 10.8 points and a negative free acid of 0.1 as established by titrating 10 milliliters of the solution to a bromocresol green end point from a blue color, employing a .1 N sulfuric acid solution. The operating solution had a conductivity at this concentration of about 40,000 mmhos and the constituents were maintained within a concentration within about 0.02%.

EXAMPLE 3

A chromate type chemical conversion coating similarly was applied to the surfaces of metals employing the same cleaning and rinsing steps as previously described in Example 1 but wherein station 4 incorporated an operating solution containing the following constituents.

Ingredient:	Percent by weight
Hexavalent chromium (calculated as CrO_3)	0.5
Potassium ferricyanide	0.05
Aluminum (an impurity)	0.6
Trivalent chromium ions	0.3
Nitrate ions	1.1
Fluoride ions	1.3

The foregoing operating chromating solution was employed for chromating an aluminum alloy material and had conductivity of about 25,000 mmhos. During an eight hour operating period, maximum variations in the content of each of the active ingredients from that specified in the foregoing table were as follows: Chromate 0.02%; potassium ferricyanide 0.005%; nitrate 0.01%; and fluoride 0.01%. Due to variations in the quantity of aluminum contaminant in the solution resulting from a dissolution of a portion of the work material being processed resulting in the formation of complexes with the trivalent chromium and fluoride ions, periodic adjustments in the conductivity of the solution at an interval of about every eight hours is preferably made ranging from about 100 mmhos so as to maintain the active constituents within the aforementioned limits.

Other chromate coating solutions of the types heretofore known in the art have conductivities ranging from about 8,000 up to about 60,000 mmhos. Combination phosphate-chromate solutions have conductivities as high as 100,000 mmhos.

It will be understood that the electrical conductivities of the various solutions disclosed herein and as set forth in the subjoined claims represent values that are corrected to room temperature or about 80° F.

While it will be apparent that the preferred embodiments herein illustrated are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope of fair meaning of the subjoined claims.

What is claimed is:

1. An apparatus for forming chemical conversion coatings on metallic workpieces comprising a plurality of treating stations each including means for supplying a solution to the surfaces of the workpieces as they are sequentially advanced through the treating stations, each of

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such solutions having an electrical conductivity indicative of the concentration of soluble constituents therein, conductivity sensing means at each station for sensing the conductivity of each of such solutions, replenishing means at each of said stations for supplying a replenishing liquid to each of said solutions, and control means including means for measuring the conductivity of each of said solutions sensed by said sensing means, in a repetitive preselected ordered sequence and operative to separately actuate each of the said replenishing means in response to a preselected deviation in the conductivity of each of said solutions from a pre-established value and for continuing the supply of replenishing liquid until a conductivity corresponding to said pre-established value is attained, said means for measuring the conductivity comprising a measuring bridge and a balancing bridge and a selector switch for electrically connecting one of said conductivity sensing means to said measuring bridge in a repetitive, preselected, ordered sequence, and wherein the conductivity sensing means at each of said stations is a conductivity cell assembly which comprises a frame, a conduit on said frame having a substantially circular and uniform bore throughout the length thereof and composed of an electrical insulating material, a pair of electrodes in said conduit disposed in spaced apart relationship and adapted to be electrically connected respectively to a voltage source, each of said electrodes comprising a cylindrical sleeve of an electrically conductive material embedded in and disposed substantially flush with the surface of said bore through said conduit, first supply means for supplying a treating solution to said conduit, second supply means for supplying a cleaning liquid to said conduit, first drainage means for draining the solution from the conduit, second drainage means for draining the cleaning liquid from said conduit, and valve means at each end of said conduit selectively movable to and from a first position in communication with said first supply means and said first drain means for passing the treating solution through said conduit in contact with the said electrodes therein and a second position in communication with said second supply means and said second drain means for passing cleaning liquid through said conduit.

2. The apparatus as claimed in claim 1 wherein at least one of the said treating stations also includes means for changing the conductivity of the treating solution at said station, which means is activated after a selected, predetermined period of time has elapsed without activation of the solution replenishing means in response to the normal, repetitive, preselected, ordered, sequential conductivity measurement of the treating solution.

3. The apparatus as claimed in claim 2 wherein the means for changing the conductivity of the treating solution comprises a reset timer, and a liquid level control means for controlling the level of treating solution at said station, the reset timer, in conjunction with the liquid level control means, effecting removal of treating solution at said station, and a consequent change in the conductivity of the treating solution at said station, which change is sufficient to activate the solution replenishing means.

4. The apparatus as claimed in claim 3 wherein the replenishing means at least one of said stations includes a conductivity sensing means for sensing the conductivity of the replenishing liquid supplied to the station, the conductivity sensed by said means being sequentially measured by the control means which is operative to provide a warning signal to the depletion in supply of the replenishing liquid in response to the absence of any conductivity, as sensed by said sensing means.

5. The apparatus as claimed in claim 4 wherein there are at least four treating stations, including in order, a cleaning station having an aqueous cleaning solution, a rinse station having an aqueous rinse solution, a coating station having an aqueous coating solution and a final rinse station having a final rinse solution.

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6. The apparatus as claimed in claim 5, wherein the conduit is disposed in a substantially upright position on said frame.

7. The apparatus as claimed in claim 6 wherein the conductivity cell assembly is provided with temperature compensating means comprising a variable resistor disposed in contact with the solution passing through said conduit for sensing the temperature thereof, and control means for measuring the conductivity of the solution and for compensating for the temperature as sensed by said temperature compensating means.

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JOHN P. McINTOSH, Primary Examiner

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118—7, 9; 134—57

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,515,094 Dated June 2, 1970

Inventor(s) Harold J. McVey

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

Column 1, line 28, delete "appropriate" and insert ---appropriate---;

Column 3, line 11, delete "sysem" and insert ---system---;

Column 4, line 34, delete "and a construction" and insert ---and of a construction---;

Column 4, line 39, delete "ino the tank" and insert ---into the tank---;

Column 5, line 47, delete "soution" and insert ---solution---;

Column 5, line 53, delete "avanced" and insert ---advanced---;

Column 9, line 46, delete "connet" and insert ---connect---;

Column 11, line 20, delete "rotateed" and insert ---rotated---;

Column 15, line 68, delete "scope of fair" and insert ---scope or fair---; and

Column 16, line 67, delete "to the depletion" and insert ---of the depletion---.

SIGNED AND
SEALED
NOV 10 1970

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents