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3,014,178

DRY CLEANING PROCESSES AND DEVICES

Filed April 5, 1957

4 Sheets-Sheet 1

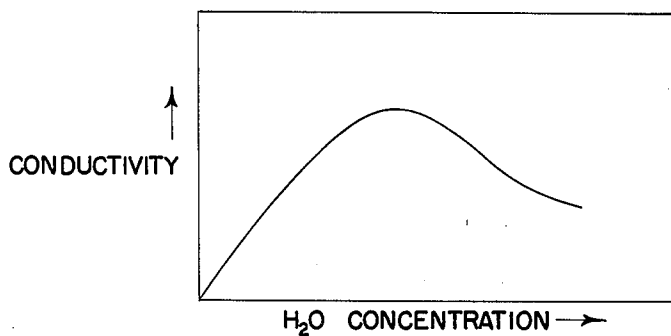


FIG. 1
CONDUCTIVITY VS. H₂O
CONCENTRATION FOR
FIXED PROPORTIONS OF
DETERGENT AND SOLVENT.

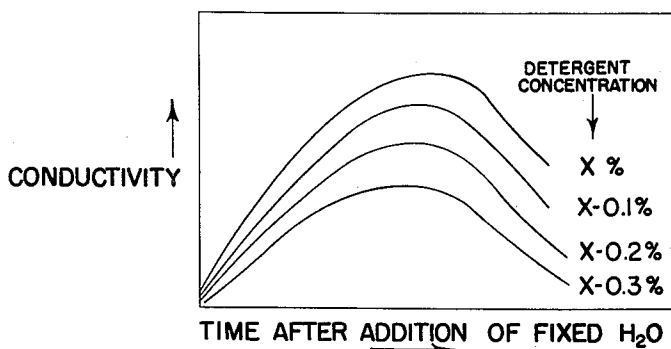


FIG. 2
CONDUCTIVITY VS. TIME
FOR PERIOD FOLLOWING
ADDING FIXED AMOUNT
OF H₂O TO DETERGENT-
H₂O-SOLVENT, DIFFERENT
CURVES REPRESENTING
DIFFERENT CONCENTRATIONS

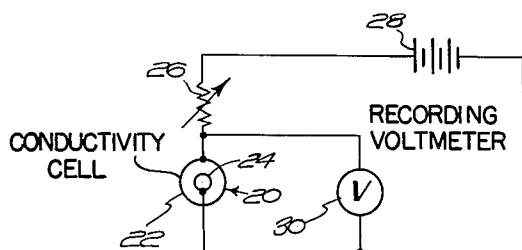


FIG. 3

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4 Sheets-Sheet 2

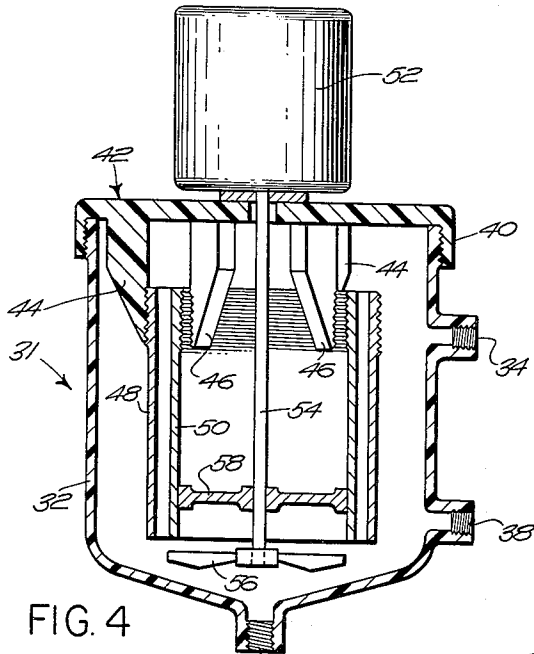
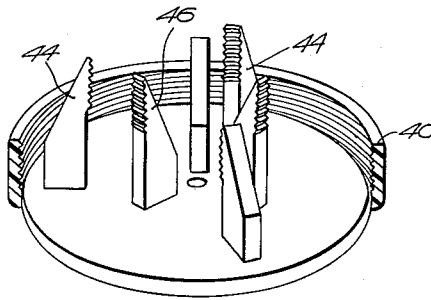


FIG. 5

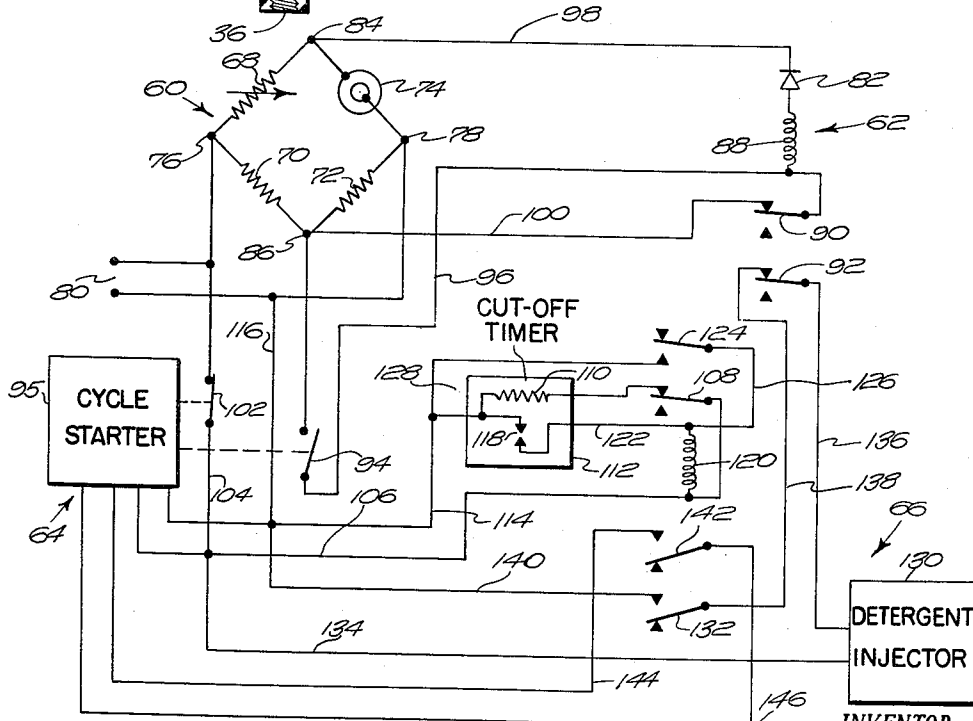


FIG. 6

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4 Sheets-Sheet 3

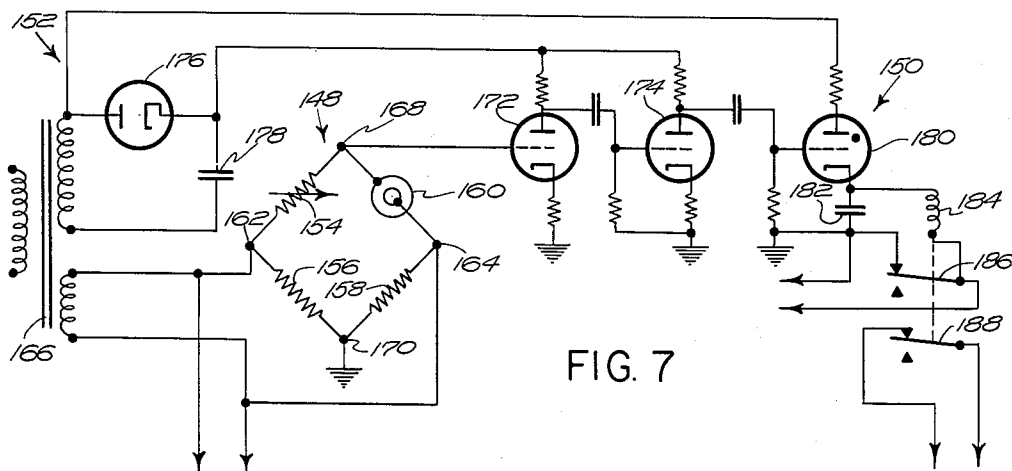


FIG. 7

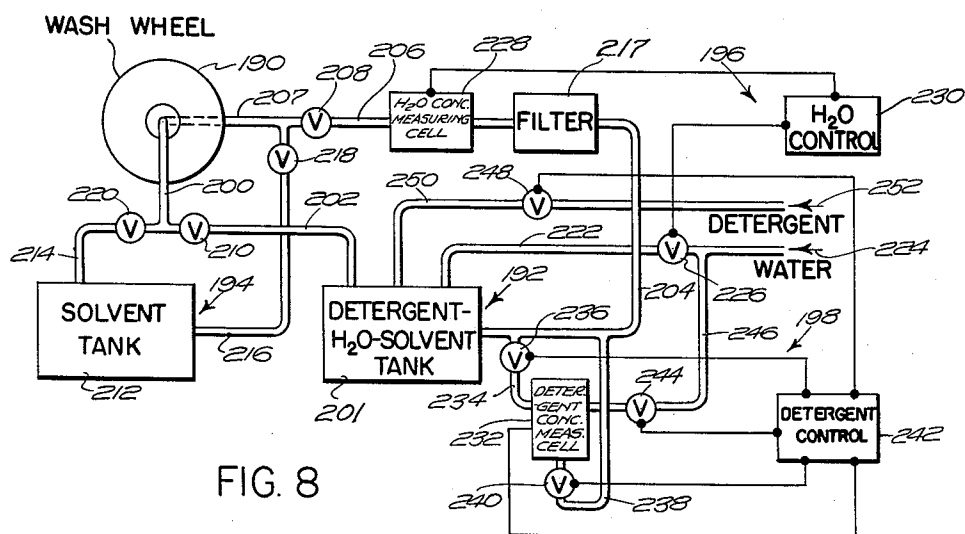


FIG. 8

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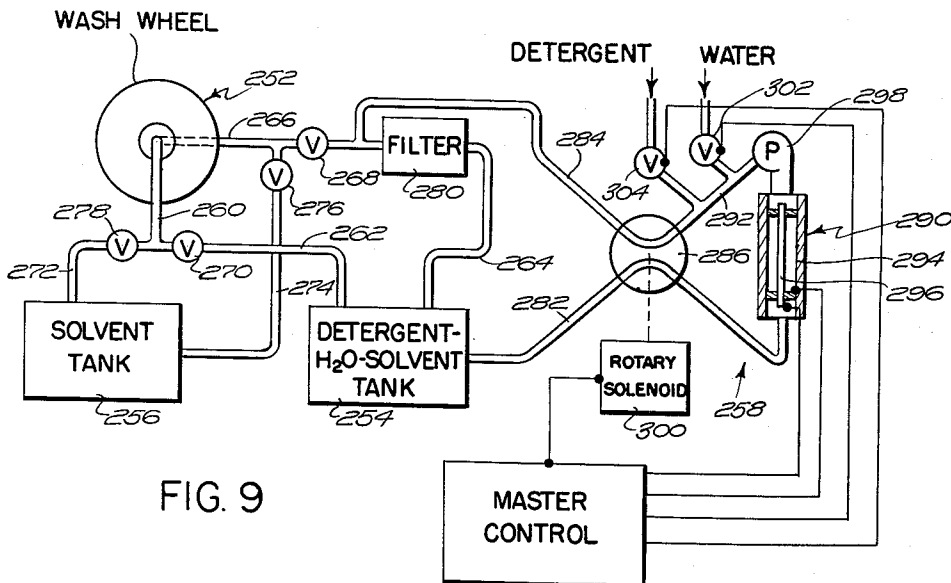
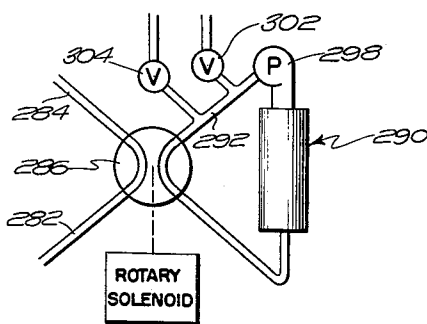
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DRY CLEANING PROCESSES AND DEVICES

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4 Sheets-Sheet 4



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1

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DRY CLEANING PROCESSES AND DEVICES

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6 Claims. (Cl. 324—30)

The present invention relates to dry cleaning and, more particularly, to the cleansing of fabrics with a composition comprising in conventional fashion a dispersion of small quantities of water and a detergent in an organic solvent.

Generally, in a dry cleaning process, a textile article is subjected to a dispersion of water and a detergent, each in relatively low concentration, in an organic solvent, in relatively high concentration. These concentrations must be kept within close tolerances in order that the water, detergent and solvent effectively perform their respective washing functions without damaging the textile articles being cleansed. Although various techniques for controlling water concentration by simple conductivity determinations have been proposed, relatively complex titration sequences are still required in order to determine detergent concentration. The present invention contemplates a novel technique for indicating detergent concentration by determining conductivity.

It is well known that current flow in a fluid is effected by the migration of particles of given charge toward electrodes of opposite charge. Change of electrons at the electrodes establishes a current flow that depends upon the number and types of charged particles present in the fluid, the dimensions of the electrodes, the potential difference between the electrodes, the distance between the electrodes, and the temperature of the fluid. In a dry cleaning fluid of the foregoing type, the charged particles are micelles in the form of detergent droplets more or less enveloped by water molecules. The number of water molecules per detergent droplet depends upon the concentration of water. The conductivity of such a solution has been found to be very responsive to minor variations in water concentration and less responsive to minor variations in detergent concentration. It now has been found that the ratio of detergent to solvent may be determined by conductivity measurements of the water-detergent-solvent fluid sequentially made after adding to the fluid a predetermined relatively large quantity of water. More specifically, it has been found that when a predetermined large quantity of water is added to the original water-detergent-solvent fluid, the conductivity of the fluid increases rapidly to a maximum and thereafter decreases slowly. This maximum conductivity is a function of detergent concentration.

Accordingly, the primary object of the present invention is to provide processes and devices for determining the detergent concentration of a dry cleaning fluid containing minor concentrations of the detergent and water in an organic solvent, which processes and devices involve taking a measured sample of the solution to be examined and adding to the sample a major measured quantity of water, whereby the conductivity of the fluid in the ensuing period of time increases to a maximum, which is functionally related to the detergent concentration.

A specific object of the present invention is to provide in a process for regulating the detergent concentration of a dry cleaning fluid of the foregoing type, the steps of taking a small measured sample of the fluid, adding to the sample a major measured quantity of water, whereby the conductivity of the sample over the ensuing period of time increases to a maximum then decreases, and add-

2

ing detergent to the original fluid in a quantity functionally related to the maximum conductivity.

Other specific objects of the present invention are: to provide simple circuits for measuring and/or controlling the detergent concentration in a fluid of the foregoing type; to provide novel electrode arrangements for applying potentials across samples of the foregoing type; and to provide novel dry cleaning structural systems embodying the present invention.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the processes involving the several steps and the relation and order of one or more of such steps with respect to each of the others, and the devices possessing the construction combination of elements and arrangement of parts, which are exemplified in the following detailed disclosure and the scope of which will be indicated in the appended claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIGURE 1 illustrates a typical curve of conductivity versus water concentration in a dispersion of a detergent in a solvent in given concentrations, the conductivity being measured with the various phases of the solution in equilibrium;

FIG. 2 illustrates a series of typical curves of conductivity versus time for a dispersion of a detergent in a solvent of the foregoing type following the addition thereto of a relatively large quantity of water;

FIG. 3 illustrates the schematic diagram of a circuit for determining the coordinate values of conductivity and time of the curves illustrated in FIG. 2;

FIG. 4 illustrates a novel test cell useful in the processes and devices of the present invention;

FIG. 5 is a perspective view of a component of the test cell of FIG. 4;

FIG. 6 is a schematic diagram of a control circuit embodying the present invention;

FIG. 7 is a schematic diagram of an alternative control circuit embodying the present invention;

FIG. 8 illustrates a dry cleaning system embodying the present invention;

FIG. 9 illustrates an alternative system embodying the present invention; and

FIG. 10 illustrates one of the components of the system of FIG. 9 in a position other than that shown in FIG. 9.

Generally, in a dry cleaning fluid, the ratio by weight of detergent to solvent is termed the charge and the ratio by weight of water to detergent plus solvent may be termed the wetness. Normally, the charge falls within the range of from 1 to 6 percent and the wetness within the range of from .01 to .75 percent. The detergent may be selected from a wide variety of surface-active agents generally characterized by an aliphatic chain either simple or complex having at least one non-polar extremity and at least one polar extremity. In one form, the detergent is a soap, for example, a fatty acid salt such as sodium stearate. In other forms, the detergent is: an organic sulphate or sulfonate, in particular, a sulfonated fatty alcohol such as that produced by the reaction of lauryl alcohol and sulfuric acid; or a non-ionic detergent, for example, an igepal such as that produced by the reaction of lauryl alcohol and ethylene oxide in the presence of sodium hydroxide as a catalyst. The organic solvent, which is selected for its ability to cleanse without harming particular fabrics, may be a volatile aromatic hydrocarbon such as benzene, a chlorinated hydrocarbon such as carbon tetrachloride, trichloroethylene or tetrochloro-

ethane, a keytone such as acetone or an aliphatic hydrocarbon such as terpentine.

As illustrated in FIG. 1, the wetness of a dry cleaning fluid containing small concentrations of water and detergent in an organic solvent is a function of the conductivity of the fluid for a detergent concentration that approximates a predetermined value. When a relatively large predetermined quantity of water is added to such a fluid, e.g., in an amount ranging from approximately 10 to 100 times the weight of water originally present, or ranging from approximately $\frac{1}{25}$ to $\frac{1}{75}$ of the volume of detergent-solvent fluid being wetted, the conductivity of the fluid rapidly increases to a maximum and then slowly decreases in the manner shown in FIG. 2. The maximum conductivity reached has been found to be a function of detergent concentration. The reasons for this phenomenon are believed to be as follows. In a fluid of the foregoing type, detergent-water micelles are the carriers of electrical current. After a large quantity of water is added to the fluid, free water molecules gradually attach themselves to dispersed micelles. The charge on such a micelle increases as a function of the amount of water attached to it. As more water becomes attached, however, the micelle eventually becomes so large that it loses mobility, thereby becoming less able to move in response to this charge. The size and number of the micelles depend upon the detergent concentration which accordingly influences the maximum charge the micelles are capable of carrying.

The circuit of FIG. 3 is used in the following manner to maintain a constant detergent concentration in a tank of dry cleaning fluid. A small sample removed from the tank, for example, is supposed to have the following formulation by weight: sodium stearate—4 parts; water—.1 part; and perchloroethylene—96 parts. First this small sample of the dry cleaning fluid is placed in a cell 20, which includes an external tubular electrode 22 and an internal tubular electrode 24. Across electrodes 22 and 24 are connected in series a variable resistor 26 and a power supply 28. Across electrodes 22 and 24 also is connected a recording voltmeter 30. A relatively large predetermined amount of water, for example 4 parts, is added with rapid stirring to the sample within cell 20 and the varying conductivity of the sample is recorded by voltmeter 30 during the ensuing period. A comparison of the maximum conductivity so recorded with maximum conductivities similarly recorded for a sequence of known calibration samples indicates the amount of detergent that must be added to the tank of dry cleaning fluid in order to maintain the desired predetermined detergent concentration. In practice, the sample in cell 20, thereafter is either discarded or returned to the tank of dry cleaning fluid, which compared with the sample contains a large overall quantity of water that is not appreciably changed in concentration with the addition of the water of the sample.

The test cell of FIG. 4 is designed for use in the circuit of FIG. 3. This test cell, generally designated by 31, comprises a tank in the form of a molded plastic body 32 having an input port 34, an output port 36, and a water injection port 38. The upper extremity of tank 32 is externally threaded to receive the internally threaded depending flange 40 of a cover generally designated by 42. Cover 42, which may be constructed of a molded plastic, comprises three outer depending bosses 44 and three inner depending bosses 46. The lower inner extremities of outer bosses 44 are internally threaded to receive the upper externally threaded periphery of a tubular electrode 48. The lower outer extremities of inner bosses 46 are externally threaded to receive the upper internally threaded periphery of a tubular electrode 50. Mounted above cover 42 is a motor 52 which drives a shaft through a medial opening in cover 42. At a point adjacent the bottom of tank 32, the lower end of shaft 54 mounts a paddle 56. Shaft 54 is medially journaled

at the center of a spider 58, the periphery of which is secured to the internal surface of inner electrode 50. In practice, tank 32 is filled with a dry cleaning fluid sample through port 34. This sample is rapidly mixed by paddle 56 with a predetermined quantity of water injected through port 38. The varying conductivity of this sample is determined by the electrical flow between electrodes 48 and 50. Finally, tank 32 is emptied through port 36.

Each of the control systems of FIGS. 6 and 7 comprises: a Wheatstone bridge having in one of its branches a cell for carrying a detergent-water-organic solvent fluid sample of the foregoing type; a gating means responsive to the output of the Wheatstone bridge; a timing means; and an indicating or servo means for injecting water initially into the sample within the cell, and for injecting detergent finally into the source from which the sample was taken. The operation is such that the final condition of the gating means is dependent upon the maximum conductivity of the sample in the cell within a predetermined period delineated by the timing means, this predetermined period being of sufficient duration to ensure the occurrence of a conductivity peak, which normally occurs from ten to thirty seconds after the addition of the predetermined quantity of water. At the end of this predetermined period, the timing means emits a signal which either (1) is transmitted through the open gate to actuate the indicating or servo means, in which case the maximum conductivity is below a predetermined minimum, or (2) is not transmitted through the closed gate, in which case the maximum conductivity is equal to or slightly greater than the predetermined minimum.

FIG. 6 illustrates a direct current embodiment of such a circuit comprising a Wheatstone bridge generally designated by 60, a gating means generally designated by 62 responsive to the Wheatstone bridge, a timing means generally designated by 64, and a servo means generally designated by 66 responsive to a signal from the timing means when the gating means is open. Wheatstone bridge 60 includes a variable resistor 68, two balancing resistors 70 and 72 and a double electrode cell 74 of the type shown in FIGS. 4 and 5. By virtue of the components now to be described, variable resistor 68 at any given setting determines the conductivity maximum of the sample capable of opening gate 62. As shown input terminals 76 and 78 of Wheatstone bridge 60 are powered by a small direct current voltage applied from a power supply 80. As shown, gate 62 includes a rectifier 82, i.e. a diode or selenium rectifier, which permits current flow between output terminals 84 and 86 in one direction only, and inductor 88 in series with rectifier 82 and two switch elements 90 and 92. It will be recalled that after initiation of the measuring cycle, the conductivity of the sample increases toward a maximum and thereafter decreases. Wheatstone bridge 60 is so designed that during the period of increasing conductivity, the potential at lower terminal 86 is greater than the potential at upper terminal 84. Initially then current flows from terminal 86 through a switch 94, controlled by a cycle starter 95, through a lead 96, inductor 88, rectifier 82 and a lead 98. Thereafter switch element 90 closes in response to the magnetic field set up by inductor 88 and is kept closed by this magnetic field which is maintained by current now flowing from lower terminal 86 through a lead 100, switch element 90, inductor 88, rectifier 82 and lead 98 to upper terminal 84. Cycle starter 95 is actuated by depressing a hold-in switch 102 which applies power from supply 80 through a lead 104, a lead 106, a switch element 108, the heat responsive delay element 110 of a cut-off timer 112, a lead 114, and a lead 116 back to supply 80. Heating element 110 of cut-off timer 112, after conducting for a predetermined period, closes a pair of contacts 118. By closing contacts 118, cut-off timer 112 energizes an inductor 120 by current flow from supply 80 through lead 104, lead 106, lead 122, contacts 118, lead 114 and lead 116 back to supply 80. Inductor 120 operates to close a switch element 124 which

5

maintains current flow through the inductor by leads 126 and 128 which shunt cut-off timer 112 in order to permit switch element 108 to open and heating element 110 to cool to standby condition. Normally, a detergent injector 130 is prevented from supplying detergent to a dry cleaning fluid by an open switch element 132. However, when inductor 120 is energized as above detergent injector 130 is actuated by current flow through a lead 134, a lead 136, switch element 92, a lead 138, switch element 132, now closed, and lead 140. Detergent injector 130 is actuated, however, only if switch element 92 has remained closed, i.e., only if upper terminal 84 of Wheatstone bridge 60 has remained at a lower potential than lower terminal 86 throughout the timing cycle. If at some point in the timing cycle the conductivity of the sample had increased beyond a maximum predetermined by variable resistor 68, the potential difference between upper terminal 84 and lower terminal 86 would have ceased to exist or would have been reversed so that for a moment at least no current would have flowed through inductor 88 by virtue of its series connection to rectifier 82. In consequence, switch elements 90 and 92 would have opened and remained open in response to the sufficiency of the detergent concentration in the test sample within cell 74. In this case, the closing of switch element 132 could have had no effect on detergent injector 130 by virtue of the hiatus at switch element 92. Finally, a switch element 142, closed by inductor 120, signals the cycle starter 95 that the measurement cycle is over, the signal being transmitted by lines 144 and 146.

In FIG. 7, a Wheatstone bridge 148 and a gate 150 are powered by an alternating current supply 152. The foregoing circuits co-operate with a timing network and an indicator or detergent injector of the types shown in FIG. 6.

Wheatstone bridge 148 includes a variable resistor 154, a pair of balancing resistors 156 and 158 and a cell 160, having an inner and an outer tubular electrode, into which the sample of the fluid whose conductivity is to be determined is placed and to which is added the predetermined quantity of water at the start of a measurement cycle. The input terminals 162 and 164 of Wheatstone bridge 148 are powered by alternating current from an input transformer 166. The output terminals 168 and 170 of Wheatstone bridge 148 are connected between ground and the control electrode of the first stage 172 of an amplifier. The output of first stage 172 is capacitively coupled to a second stage 174. The plates of stages 172 and 174 are supplied with direct current by a rectifier including a diode 176 and a filter capacitor 178 connected across a secondary winding of transformer 166. The alternating output of stage 174 is applied to the grid of an electronic switch in the form of a thyratron 180, which alternatively could be an amplification stage of the type designated by 172 and 174. The plate of thyratron 180 is resistively connected to the output of the secondary of transformer 166 so that it is subjected to an alternating current. The cathode of thyratron 180 is connected to ground through a capacitor 182 across which is connected an inductor 184, and a switch element 186 responsive to the inductor. Also responsive to inductor 184 is a switch element 188 constituting a part of the control circuit of the detergent injector.

Initially, the alternating current output of Wheatstone bridge 148 and the alternating current applied to the plate of thyratron 180 so related that when the bridge is unbalanced by a high cell resistance, switch elements 186 and 188 are closed by virtue of current flow in inductor 184. However, when Wheatstone bridge 148 is balanced or overbalanced, thyratron 180 is cut off and switch elements 186 and 188 are opened, inasmuch as thyratron 180 no longer permits current flow through inductor 184. Because now switch element 188 is open, detergent injector cannot be actuated by the cut-off timer.

A modified conventional dry-cleaning system is illus-

6

trated in FIG. 8 as comprising generally a wash-wheel 190, a washing circuit 192, a rinsing circuit 194, a water control system 196 and a detergent control system 198. As shown wheel 190, in conventional fashion, comprises a drum journaled for axial rotation with textile articles and dry cleaning fluid therein. A washing tank 201, containing an appropriate detergent-water-solvent, fluid is connected across wheel 190 by conduits 200, 202, 204, 206, and 207 in such a manner as to circulate the washing fluid through wheel 190 when a pair of valves 208 and 210 are open. A rinsing tank 212 is connected across wheel 190 by conduits 200, 214, 216 and 207 in such a manner as to circulate solvent alone through wheel 190 when a pair of valves 218 and 220 are open. In normal operation when the ingredients of the fluid in tank 200 are at their predetermined levels, after wheel 190 has been loaded with textile articles to be cleansed, valves 208 and 210 are opened to permit solution from cleansing tank 200 to be circulated by a pump (not shown) through wheel 190. A filter 217 in the path of conduit 204 serves to prevent any gross accumulation of impurities in the cleansing fluid. After a predetermined washing period during which wheel 190 continues to rotate with the circulating solution therein, valves 208 and 210 are closed and valves 218 and 220 are opened to permit solvent from rinsing tank 212 to be circulated through wheel 190. After a predetermined rinsing period, valves 218 and 210 are closed to permit removal of the clothes from within wheel 190 and their drying by steam or hot air in conventional fashion.

Connected to washing tank 200 by means of a conduit 222 is a water supply 224. Water is injected into washing tank 200 from water supply 224 in response to the opening and closing of a valve 226, which is actuated by a water monitor that includes a conductivity measuring cell 228 in the path of conduit 206 and an electro-mechanical control system 230. Conductivity measuring cell 228 in conventional fashion includes a casing defining a chamber within which a pair of electrodes are positioned. Control system 230 responds to a signal evoked when the conductivity of the solution within cell 228 reaches a predetermined value to open valve 226 and otherwise to maintain valve 226 closed.

Shunting a portion of line 204 is a detergent control cell 232 of the type shown in FIG. 5. As shown cell 232 is fed through a conduit 234 having a valve 236 and is drained by conduit 238 having a valve 240. Valves 238 and 240 are controlled by a circuit 242 of the types shown in FIGS. 6 and 7. The conductivity measurement is effected across the electrodes within cell 232 in response to maximum conductivity indications in the following manner. In response to a signal from control circuit 242, a valve 244 opens to permit the introduction of water into cell 232 through an inlet 246. Control circuit 242 responds to the maximum conductivity indication received from the electrodes in cell 232 by opening or closing a valve 248 in a detergent inlet line 250 from a detergent supply 252.

FIG. 9 illustrates an alternative system of dry cleaning embodying the present invention. This system, in general, comprises a wash wheel 252, a washing tank 254, a rinsing tank 256, and a water and detergent control system generally designated by 258. Washing tank 254 is connected across wash wheel 252 by conduits 260, 262, 264 and 266 for continuous circulation of the washing fluid through wash wheel 252 when a pair of valves 268 and 270 open. Likewise, rinsing tank 256 is connected across wash wheel 252 by conduits 260, 274 and 266 for continuous circulation of the solvent through wash wheel 252 when a pair of valves 276 and 278 are open. A filter 280 in line 264 serves to prevent any gross accumulation of impurities in tank 254.

Control system 258 is connected across washing fluid tank 254 by shunt conduits 282 and 284. Control system 258 as shown includes a four-way valve 286, which, in stand-by condition as shown in FIG. 9, directs fluid from

7

tank 254 through conduit 282 and a conduit 288 into a cell 290 and back through a conduit 292 to shunt line 284. Cell 290 includes an outer cylinder 294, the inner face of which is coated with a metal, and an inner rod 296 positioned along the axis of cylinder 294, the outer face of rod 296 being coated with a metal. When valve 286 is in stand-by condition, a pump 298, which is interposed between conduit 292 and cell 290, is inoperative.

When a conductivity determination is to be performed, under the direction of a master control circuit 299, valve 286 is pivoted by means of a rotary solenoid 300 through 90 degrees so that the fluid within cell 290 is isolated from the remainder of the system, as shown in FIG. 10. Thereafter water is injected through a valve 302 into conduit 292 in predetermined quantity and rapidly mixed with the fluid within cell 290 by pump 298. The conductivity during the ensuing period is measured by control circuit 299. The maximum conductivity determines the amount of detergent which control circuit 299 may cause to be injected through a valve 304 into the system at the end of the conductivity determination when valve 286 is once again rotated through 90 degrees. Thereafter pump 298 stops to permit the washing fluid to circulate in normal fashion. When valve 286 is in stand-by position, water monitoring may be effected by cell 290 and water injected into the system through valve 302 under the direction of master control circuit 299.

Since certain changes may be made in the foregoing processes and devices, it is to be understood that all matter mentioned in the foregoing description or shown in the accompanying drawings is to be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. A process for determining the detergent concentration of a dry cleaning fluid containing minor concentrations of a detergent and water in an organic solvent, said process comprising the steps of taking a measured sample of said solution, adding to said sample a major measured quantity of water, whereby the conductivity of said sample in the ensuing period of time increases to a maximum that is functionally related to the detergent concentration, passing an electrical current through said sample in order to measure the conductivity of said sample during said ensuing period of time, and indicating said maximum in response to said conductivity as measured.

8

2. The process of claim 1 wherein said major quantity of water is vigorously mechanically mixed with said sample when added thereto.

3. The process of claim 1 wherein associated values of conductivity and time are recorded.

4. The process of claim 1 wherein said solvent is a halogenated hydrocarbon.

5. The process of claim 1 wherein said detergent is a fatty acid salt.

6. A process for determining the detergent concentration of a dry cleaning fluid containing minor concentrations of a detergent and water in an organic solvent, said process comprising the steps of taking a measured sample of said solution, adding to said sample a major measured quantity of water, whereby the conductivity of said fluid of said sample in the ensuing period of time increases to a maximum that is functionally related to the detergent concentration, said fluid of said sample containing from 1 to 6 percent of said detergent, the ratio of said water to said detergent and said solvent ranging from .01 to .75 percent and the ratio of said major quantity of water to said detergent and said solvent ranging from .5 to 5 percent, passing an electrical current through said sample in order to measure the conductivity of said sample during said ensuing period of time, and indicating said maximum in response to said conductivity as measured.

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