Dec. 19, 1961 A. W. LAHTI ET AL 3,013,572

DRY CLEANING DEVICES

Filed May 17, 1957 3 Sheets-Sheet 1

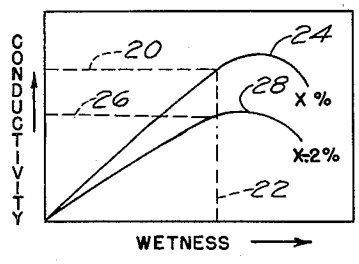

FIG. 1

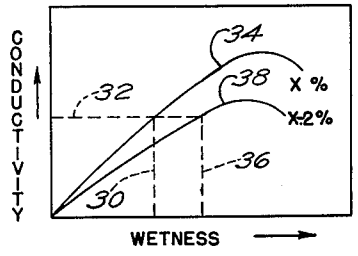

FIG. 2

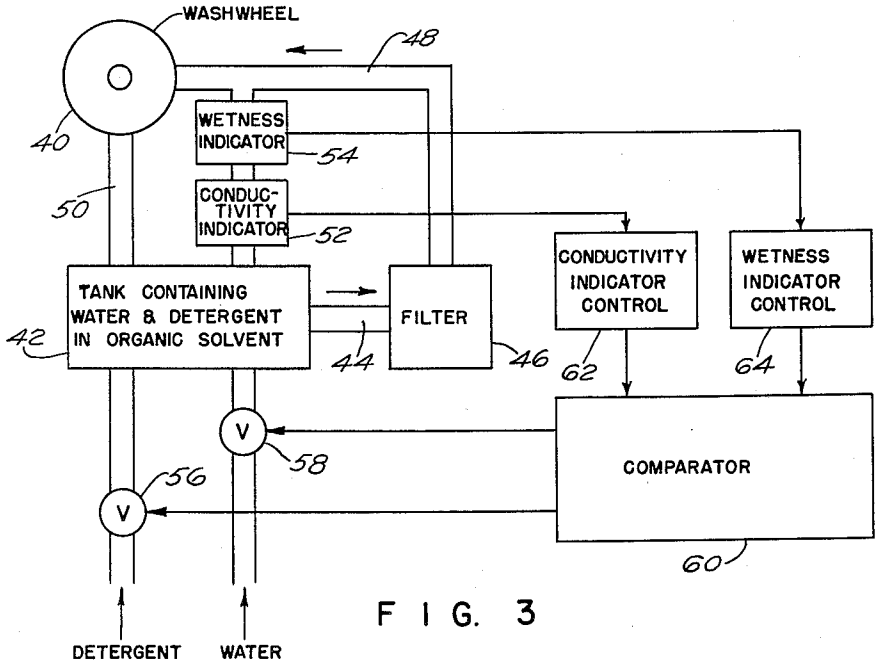

FIG. 3

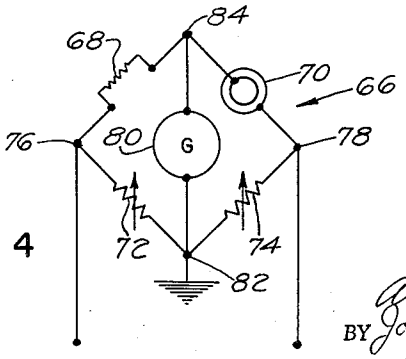

FIG. 4

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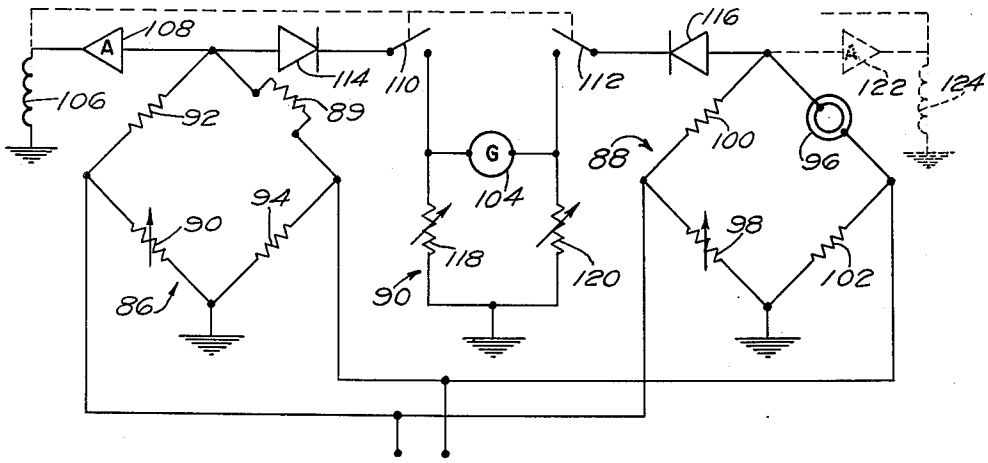

FIG. 5

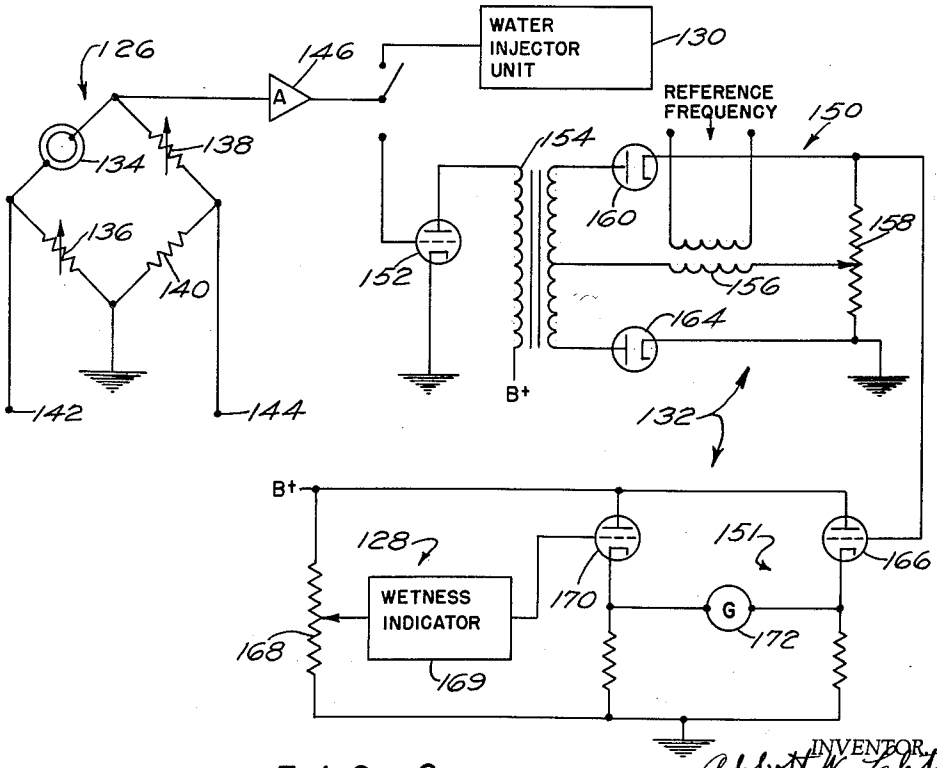

FIG. 6

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DRY CLEANING DEVICES

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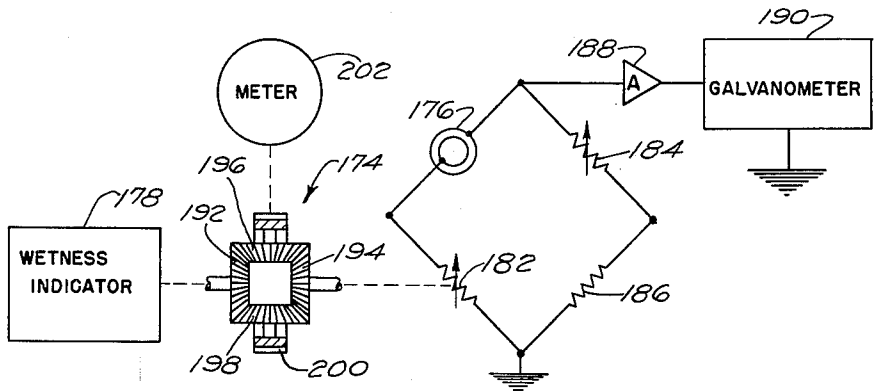

FIG. 7

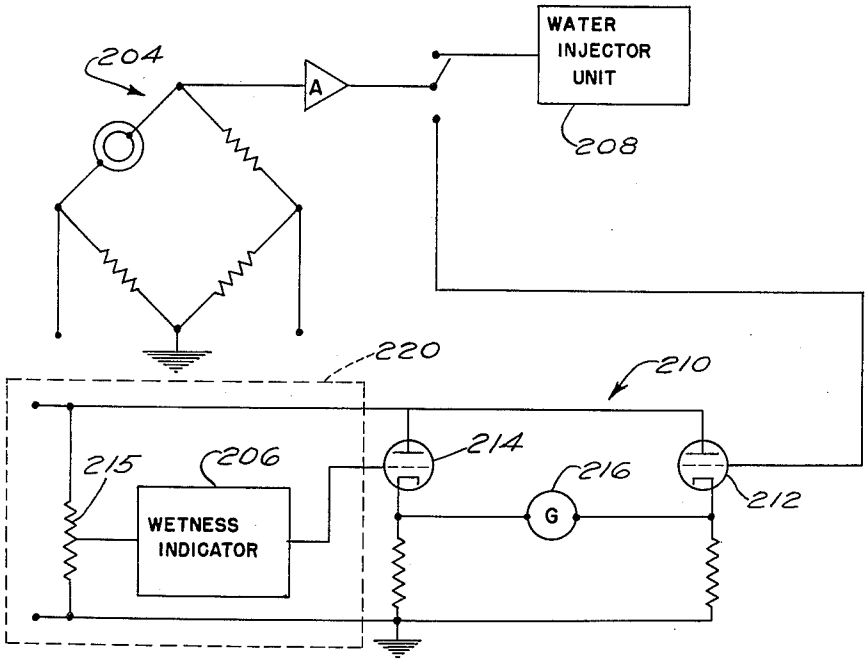

FIG. 8

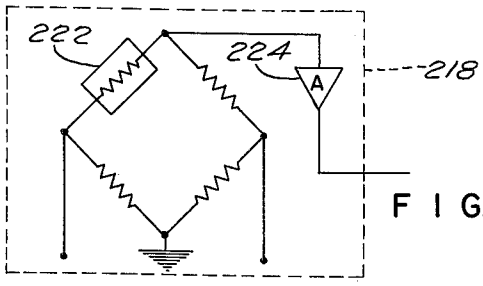

FIG. 9

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3,013,572
DRY CLEANING DEVICES

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Filed May 17, 1957, Ser. No. 659,865
9 Claims. (Cl. 137—93)

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, textile articles are 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 determining water concentration by simple measurement have been proposed, relatively complex titration sequences still are required in order to determine detergent concentration. Generally, in a dry cleaning fluid, the ratio by weight of detergent to solvent is termed the detergent concentration and the ratio by weight of water to detergent plus solvent may be termed the water concentration or wetness. The present invention contemplates a novel technique for indicating detergent concentration simply and accurately.

It is well known that electrical current flow in a fluid is effected by the migration particles of given charge toward electrodes of opposite charge. Exchange 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. Thus, assuming a predetermined organic solvent concentration, the conductivity of such a solution is a function of both water concentration and detergent concentration.

Various devices, which for convenience herein will be termed "direct wetness indicators," exist for determining water concentration in such a solution more or less directly as by mechanically utilizing variations in the length of a strip of animal bone or hair or by electrically utilizing an impedance of particular composition which changes its resistance in response to a variation in wetness.

Such a wetness indicator, in accordance with the present invention, is employed in conjunction with a conductivity indicator to determine detergent concentration under the principle that if two of the three functionally related variables—wetness, conductivity and detergent concentration—are known, the third may be determined. Where, as here, for practical purposes the solvent concentration is predetermined, it is apparent that for a predetermined wetness, as measured by a direct wetness indicator of the foregoing type, the conductivity, as measured by a galvanometer between suitable electrodes, of the solution for a predetermined charge will be of predetermined value. If the wetness remains constant, an increase or decrease in detergent concentration is indicated by an increase or decrease in conductivity. Conversely, if the conductivity remains constant, an increase or decrease in detergent concentration is indicated by a decrease or an increase in wetness. Alternatively, an indication of detergent concentration may be derived by comparing wetness and conductivity, neither being maintained constant. Here, the predetermined change of wetness and conductivity in response to a change in detergent concentration is such as to permit a useful comparison if the wetness indicator and the conductivity indicator track together, as for example, when the change in output of both indicators is linear with respect to the causative change in detergent concentration.

Accordingly, primary objects of the present invention are: 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 comparing the response of a wetness indicator with the response of a conductivity indicator in order to derive an output that is functionally related to the charge; to provide processes and devices of the foregoing type in which the output of either the wetness indicator or the conductivity indicator is kept constant; and to provide processes and devices of the foregoing type in which the output of neither the wetness indicator nor the conductivity indicator is kept constant.

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 present invention, reference should be had to the following detailed description, taken in connection with the accompanying drawings wherein:

FIGURE 1 shows typical curves of conductivity versus wetness in a detergent-water-solvent dispersion for the purpose of illustrating that for a given wetness, the conductivity varies in accordance with detergent concentration;

FIG. 2 shows typical curves of conductivity versus wetness in a detergent-water-solvent dispersion for the purpose of illustrating that for a given conductivity, the wetness varies in accordance with the detergent concentration;

FIG. 3 illustrates a dry cleaning system embodying the present invention;

FIG. 4 illustrates the schematic diagram of a circuit for comparing conductivity and wetness at any particular value of either;

FIG. 5 illustrates a schematic diagram of a circuit for comparing conductivity and wetness, wherein the wetness is held constant by the introduction of water;

FIG. 6 illustrates a schematic diagram of a circuit for comparing conductivity and wetness, wherein the conductivity is held constant by the introduction of water;

FIG. 7 illustrates a schematic diagram of a device for comparing conductivity and wetness, wherein a mechanical comparator is employed;

FIG. 8 illustrates a schematic diagram of an alternative circuit for comparing conductivity and wetness; and

FIG. 9 illustrates a schematic diagram of a modification of the alternative circuit of FIG. 8.

In a dry cleaning fluid, normally, the detergent concentration falls within the range of from 1 to 6% and the wetness within the range of .01 to .75%. 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 sulfate 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 tetrachloroethylene, a ketone such as acetone or an aliphatic hydrocarbon such as terpentine.

As illustrated in FIGS. 1 and 2 wetness of a dry cleaning fluid containing 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. In reference to FIG. 1 it will be observed that conductivity value 20 for a given wetness value 22, when the charge as represented by curve 24 is relatively great, is larger than the conductivity value 26 for the given wetness value 22 when the charge as represented by curve 28 is relatively small. Likewise, in reference to FIG. 2, the wetness value 30 for a given conductivity value 32, when the charge as represented by curve 34 is relatively great, is smaller than the wetness value 36 for the given conductivity value 32 when the charge as represented by curve 38 is relatively small.

In each of the foregoing cases, it will be noted that the conductivity vs. wetness determinations are made upon the initial slopes of the curves in question. This is proper since the water concentrations in a typical dry cleaning system as a practical matter are such as to give rise to values on these initial slopes. The reasons for the shapes of these curves are believed to be as follows. In a fluid of a foregoing type detergent-water micelles are the carriers of electrical current. As 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.

A dry cleaning system embodying the present invention, is illustrated in FIG. 3 as comprising a washing circuit including a washwheel 40 and a cleansing tank 42. Dry cleaning fluid is fed from tank 42 to wash wheel 40 through a conduit 44, a filter 46 and a conduit 48 and is returned to the cleansing tank through a conduit 50. Filter 46 serves to prevent any gross accumulation of impurities in the cleansing fluid. Shunted between conduit 48 and cleansing tank 42, in series, are a conductivity indicator 52 and a direct wetness indicator 54 of the above described types. Communicating with the cleansing tank 42 are a detergent supply controlled by a valve 56 and a water supply controlled by valve 58. Valves 56 and 58 are responsive to a comparator 60 into which a signal from wetness indicator 54 and a signal through conductivity indicator 52 are fed through a wetness indicator control 64 and a conductivity indicator control 62.

In normal operation, when the ingredients of the fluid in tank 42 are at their predetermined concentration levels, after wheel 40 has been loaded with textile articles to be cleansed, the fluid from cleansing tank 42 is circulated by a pump (not shown) through filter 46 and wheel 40. The signal applied by control 62 in response to conductivity indicator 52 is compared in comparator 60 to the signal applied by control 64 in response to wetness indicator 54. In one form, the signal from conductivity indicator control 62 regulates the flow of water through valve 58 in such a way as to maintain the conductivity constant. In another form, the signal from wetness indicator control 64 regulates the flow of water through valve 58 in such a way as to maintain the wetness constant. In a further form, water regulation is not necessary for a determination of detergent concentration. In any case, as shown, comparator 60 regulates the flow of detergent through valve 56 in order to maintain the detergent concentration of the cleansing fluid constant.

FIG. 4 shows a simple control and comparator circuit in which components of a Wheatstone bridge 66 correspond to controls 62 and 64 and comparator 60 of FIG. 3. Wheatstone bridge 66 includes a direct wetness indicator 68, in the form of a resistor that varies its impedence in response to variations in wetness of the cleaning fluid in which it is immersed, a conductivity cell 70 in the form of a pair of electrodes immersed in the cleansing fluid, and a pair of balancing resistors 72 and 74, which may be adjusted to linearize the responses of the wetness indicator and the conductivity indicator for proper tracking. An alternating current is applied to input terminals 76 and 78. A galvanometer 80 is shunted across output terminals 82 and 84. Inasmuch as tracking occurs here practically only in a narrow band of wetness and conductivity indications, this circuit is of primary utility where the detergent concentration does not vary appreciably.

FIG. 5 discloses a wetness indicator control circuit 86, a conductivity indicator control circuit 88 and a comparator circuit 90 responsive thereto. Wetness circuit 86 is in the form of a Wheatstone bridge comprising a resistor 89 that varies in resistance in response to variations in wetness of the cleansing fluid in which it is immersed, an adjusting resistor 90 and a pair of balancing resistors 92 and 94. Conductivity circuit 88 is in the form of a Wheatstone bridge including a conductivity cell 96 of the type described above, a variable resistor 98 and a pair of balancing resistors 100 and 102. An alternating current is applied to the input terminals of bridges 86 and 88. Comparator 90 includes a direct current galvanometer 104 to which signals are applied by wetness circuit 86 and conductivity circuit 88 only when permitted as follows. The output of wetness circuit 86 is applied to a control coil 106 through an amplifier 108. When wetness circuit 86 is balanced, a pair of relays 110 and 112 are closed. In consequence, the outputs of wetness circuit 86 and conductivity circuit 88 are applied through rectifiers 114 and 116 to the opposite terminals of galvanometer 104. Suitable adjustments of the potentials at these terminals may be made by variable resistors 118 and 120. Because comparison between the outputs of wetness circuit 86 and conductivity circuit 88 is made only when the wetness circuit is either balanced or at a predetermined unbalance, i.e. only when the wetness is at a predetermined value, a water injector that is controlled, for example, by the output of amplifier 108, is required to maintain wetness circuit 86 in proper balance.

It will be understood that a circuit similar to the one just described but wherein a predetermined conductivity is maintained will similarly operate. In one such circuit an amplifier 122 and an inductor 124 are serially connected to the output of the conductivity bridge as shown in dotted lines. In this embodiment, of course, inductor 106 and amplifier 108 are eliminated.

FIG. 6 discloses a conductivity indicator control circuit 126, a wetness indicator control 128, a water injector control 130 and a comparator 132.

As shown conductivity circuit 126 includes a conductivity cell 134, variable resistors 136 and 138 for calibrating conductivity and balancing contamination of the cleansing fluid in which the conductivity electrodes are immersed, and a balancing resistor 140. An alternating current is applied to input terminals 142 and 144. The output of bridge 126 is applied through an amplifier 146 first to water injector 130 until the conductivity of the

fluid reaches a predetermined value and then through a sense and magnitude indicator **150** that constitutes part of comparator **132**, the remaining part of which, as shown, is in the form of a vacuum tube voltmeter **151**.

Sense and magnitude indicator **150** utilizes the output of bridge **126** as follows. The output of bridge **126** is applied to the grid of a vacuum tube **152** having the primary winding of a transformer **154** in its plate network. The center tap of the secondary of transformer **154** is supplied with a reference alternating current through a transformer **156**, one end of the secondary of which is connected to the center tap of the secondary of transformer **154** and the other end of the secondary of which is connected to a variable balance resistor **158**. A diode **160** is connected between one end of the secondary of transformer **154** and one end of resistor **158**. A diode **164** is connected between the other end of the secondary of transformer **154** and the other end of resistor **158**. The terminals of resistor **158** acquire a voltage which is zero when the alternating current input to transformer **154** is zero since the alternating current applied to transformer **154**, when rectified by diodes **160** and **164**, produces a zero summation voltage. However when the alternating current input to transformer **154** is other than zero a voltage is produced across resistor **158**, which is positive or negative depending upon the phase relationships of the input voltages. This output voltage across resistor **158** is applied to the grid of a vacuum tube **166**. A potentiometer **168**, whose position is controlled by the mechanical or electrical output of a wetness indicator **169**, applies a voltage to the grid of a vacuum tube **170**. Output cathode voltages of tubes **166** and **170** are compared by a galvanometer **172**.

It will be understood that in an alternative embodiment the output of wetness indicator **169** and the output of conductivity cell **126** may be interchanged. Inasmuch as the output of the wetness indicator is mechanical, a potentiometer may be employed to produce the variable resistance required in bridge **126**.

FIG. 7 discloses a mechanical comparator **174** for effecting a comparison between the output of a conductivity indicator **176** and a wetness indicator **178**. Conductivity indicator **176** is in one branch of a Wheatstone bridge including in its other branches variable resistors **182** and **184** and a balancing resistor **186**. The output of this Wheatstone bridge is applied through an amplifier **188** to a galvanometer **190** that merely indicates bridge balance. Wetness indicator **178** has a mechanical output of the type described above. Comparator **174** is in the form of a differential including gears **192** and **194** which rotate independently about one axis and gears **196** and **198** which rotate independently about a second axis that is fixed with respect to an output gear **200**. As shown gear **194** is connected to variable resistor **182** and gear **192** is connected to the mechanical output of wetness indicator **178**. Output gear **200** is connected to a mechanical meter **202**. A correct reading of detergent concentration on meter **202** may be obtained by either manually or automatically adjusting the various elements until bridge balance is determined by galvanometer **190**.

FIG. 8 discloses a conductivity indicator control circuit **204**, a wetness indicator control **206**, a water injector control **208**, and a comparator **210**. In this instance components **204**, **206**, **208** and **210** generally correspond respectively to components **126**, **128**, **130** and **132** of FIG. 6. In particular, comparator **210** of FIG. 8 is equivalent to sense and magnitude indicator **150** and vacuum tube voltmeter **151** of FIG. 6.

In operation, the alternating current signal derived from conductivity control circuit **204** is applied to the grid of a vacuum tube **212**. The cathode of vacuum tube **212** is connected through a galvanometer **216** to the cathode of a vacuum tube **214**. Alternating current, of the same frequency but preferably of a higher potential than is applied across conductivity control circuit **204**, is applied to the plates of vacuum tubes **212** and **214**. The grid of tube **214**, being connected via a potentiometer **215** across the alternating current source, in conjunction with the grid of tube **212**, will control the cathode currents of tubes **212** and **214** and in consequence the current through galvanometer **216**. Potentiometer **215** will be operated mechanically or manually to correspond to the indication of solution wetness.

FIG. 9 discloses a Wheatstone bridge circuit **218** that, in a modification of the circuit of FIG. 8, replaces the sub-network indicated within dashed lines at **220**. Circuit **218** includes in one of its branches a wetness indicator **222**, variable and balance resistors of the types referred to above, and, preferably also, an output amplifier **224**.

It will be understood in reference to FIGS. 8 and 9 that in an alternative embodiment, the output of wetness indicator **206** or wetness indicator **218** and conductivity indicator **204** may be interchanged.

The present disclosure contemplates that in various embodiments of the illustrated systems, galvanometers **80** of FIG. 4, **104** of FIG. 5, **172** of FIG. 6, **190** of FIG. 7, and **216** of FIG. 8 are supplemented or replaced by control circuitry designed to inject automatically a necessary amount of detergent into tank **42** of FIG. 3. The present invention further contemplates that the disclosed comparison techniques be used to determine other factors than the detergent and water concentration, i.e. fatty acid and other contaminant concentrations. Thus, if wetness is determined by the wetness indicator, conductivity by the conductivity indicator and detergent concentration by chemical titration or the like, comparison of the wetness indicator and conductivity indicator outputs will determine contaminant concentration.

Since certain changes may be made in the above devices and processes without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. A device for determining the detergent concentration of a dry cleaning fluid containing minor concentrations of a detergent and water in an organic solvent, said device comprising first means for measuring and producing an indication of water concentration in said fluid, second means for measuring and producing an indication of the coductivity of said fluid, third meas for maintaining one of said indication of water concentration and said indication of conductivity constant, and fourth means for electrically comparing said indication of water concentration with said indication of conductivity in order to produce an indication of detergent concentration, said first means possessing a physical characteristic directly dependent upon water concentration of said fluid, said second means including electrodes between which electrical current passes through said fluid, said third means accomplishing its function by the introduction of an addition to said fluid.

2. The device of claim 1 wherein said physical characteristic of said first means is geometrical dimension.

3. The device of claim 1 wherein said physical characteristic of said first means is electrical resistance.

4. A device for determining the detergent concentration of a dry cleaning fluid containing minor concentrations of a detergent and water in an organic solvent, said device comprising Wheatstone bridge means including galvanometer means in association with a first branch and a second branch of said Wheatstone bridge means, first detecting means for producing an indication of water concentration in said fluid and second detecting means for producing an indication of the conductivity of said fluid, said galvanometer providing an indication of detergent concentration, said first detecting means being operatively connected into said first branch and possessing an impedance that is directly dependent upon water concentration of said fluid, said second detecting means being

operatively connected into said second branch and including electrodes between which electrical current passes through said fluid.

5. The device of claim 4 wherein said physical characteristic of said first means is geometrical dimension.

6. The device of claim 4 wherein said physical characteristic of said second means is electrical resistance.

7. A device for determining the detergent concentration of a dry cleaning fluid containing minor concentrations of a detergent and water in an organic solvent, said device comprising first Wheatstone bridge means providing an indication of water concentration, second Wheatstone bridge means providing an indication of conductivity, galvanometer means in association with said first Wheatstone bridge means and said second Wheatstone bridge means, first detecting means operatively connected into one branch of said first Wheatstone bridge means, second detecting means operatively connected into one branch of said second Wheatstone bridge means, control means for maintaining one of said indication of water concentration and said indication of conductivity constant, adjust means for varying the balance of said first Wheatstone bridge means and said second Wheatstone bridge means independently, said galvanometer means comparing said indication of water concentration with said indication of conductivity in order to produce an

indication of detergent concentration, said first detecting means possessing a physical characteristic directly dependent upon water concentration of said fluid, said second means including electrodes between which electrical current passes through said fluid.

8. The device of claim 7 wherein said physical characteristic of said first detecting means is geometrical dimension.

9. The device of claim 7 wherein said physical characteristic of said first detecting means is electrical resistance.

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