Dec. 20, 1955 A. G. FREEBORN 2,727,859

APPARATUS FOR THE ELECTRONIC TREATMENT OF LIQUIDS

Filed July 18, 1950 2 Sheets-Sheet 1

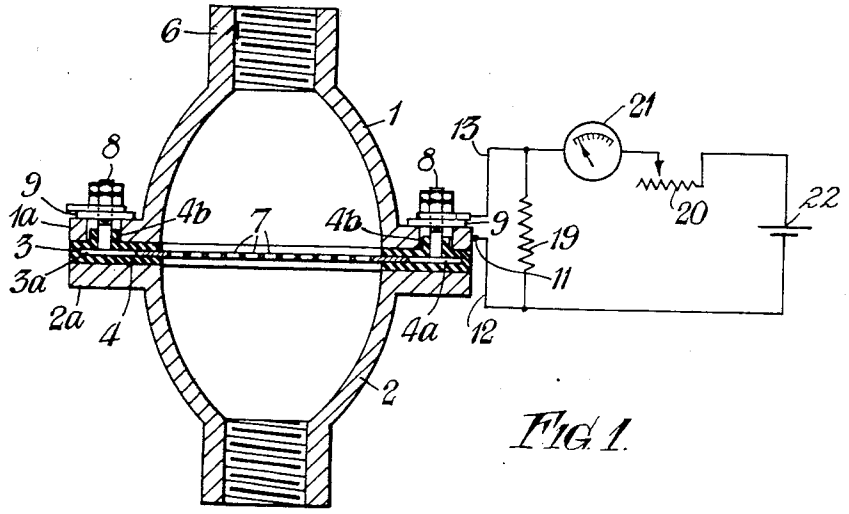


FIG. 1.

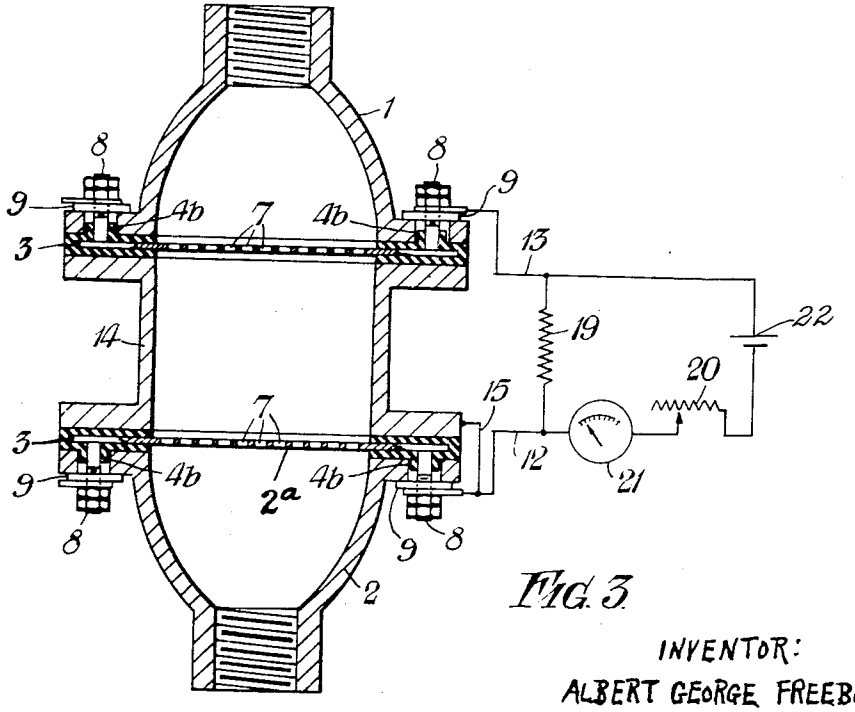


FIG. 3.

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Filed July 18, 1950 2 Sheets-Sheet 2

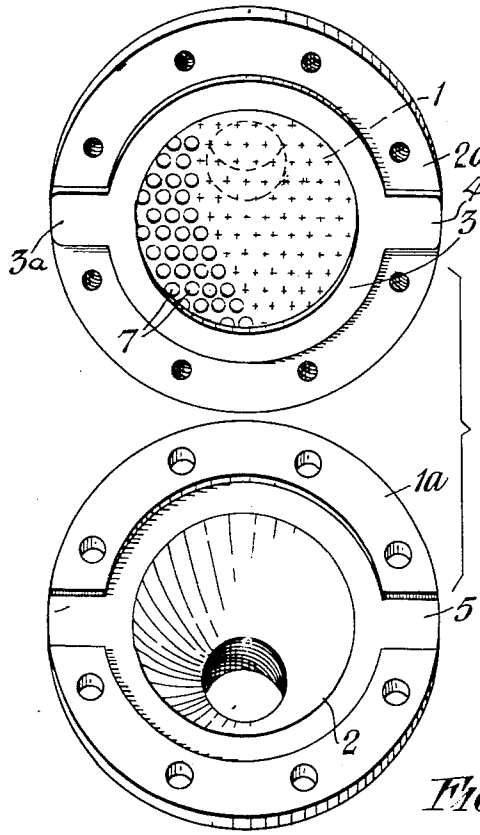
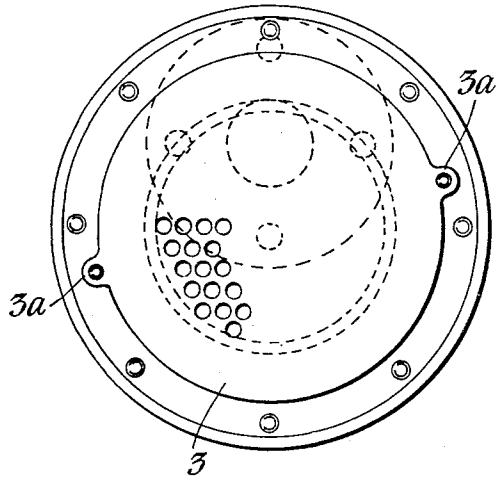


FIG. 2

FIG. 5



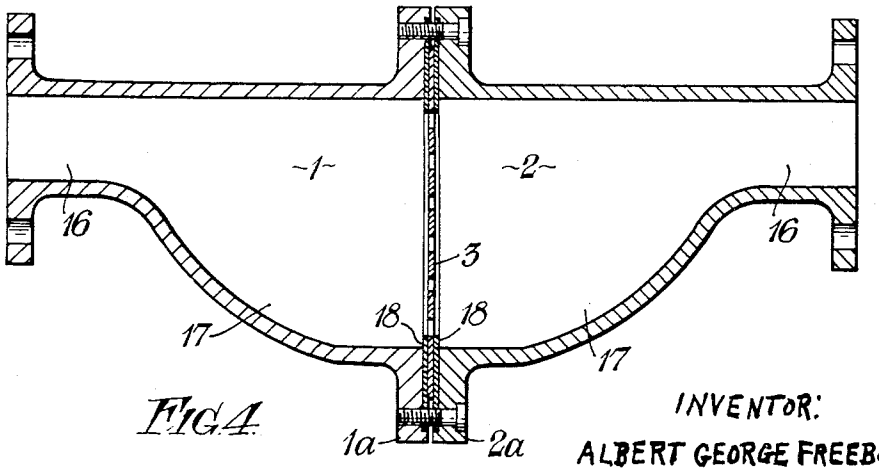


FIG. 4

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APPARATUS FOR THE ELECTRONIC TREATMENT OF LIQUIDS

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Application July 18, 1950, Serial No. 174,517

Claims priority, application Great Britain July 29, 1949

2 Claims. (Cl. 204—305)

This invention relates to improvements in methods and apparatus for subjecting liquids, or liquids with solids in suspension (the term liquid including oils and emulsions and the like) to the effects of an electrical force which necessitates a predetermined electrical potential difference being maintained between two or more electrodes, and where such liquids are brought in contact with these electrodes.

An example of the form of apparatus referred to above is the apparatus described in the present applicant's U. S. Patent No. 2,207,583 for the treatment of hard water to prevent scale formation in boilers, pipes, etc. which would otherwise be formed were the water not so treated. However the present invention is not confined to such a limited field of treatment but can be used for other processes where the apparatus used involves electrodes having a constant potential difference between them for subjecting liquids, emulsions and the like to the action of an electrical force.

In such processes it is usual to have two or more electrodes electrically insulated from each other with terminals for the application of the required electrical force, one or more of said electrodes being immersed in the liquid and one other generally being the outer casing of the apparatus which is also in contact with the liquid, such outer casing having inlet and outlet ports for the liquid to flow through, the only passage for the electrical energy to flow between them being through the liquid being treated, and as the potential difference between said electrodes is generally of a very low order, the only convenient means of obtaining such required potential difference in the past has been to measure or calculate the ohmic resistance through the liquid between the electrodes, and adjust the current flowing between them in accordance with Ohm's law by means of suitable resistance being inserted in series with the source of electrical energy.

In this known method adjustments of the current are necessitated when the specific resistance of the liquid being treated varies. Also when a very low potential difference, e. g. a few millivolts, or a fraction of a volt, between the electrodes is required considerable areas of electrodes are necessary in order to keep the ohmic resistance between them low enough for a measurable amount of current to be needed.

In the majority of cases with the said known apparatus, the apparatus itself can, under some circumstances, form an electrolytic cell, the apparatus involving metallic electrodes in direct connection with an electrolyte (the liquid), and when such a cell has a low internal resistance considerable current can be set up which may vary with the speed with which the liquid is passing over the electrodes, and which current might interfere with the potential required for the process.

The present invention overcomes all of these disadvantages, and objects of the invention are to ensure:

1. That the potential difference between the electrodes remains constant for all practical purposes irrespective

of the specific electric resistance or conductivity of the liquid or changes in such specific resistance without adjustment of the controlling apparatus. That is to say the apparatus will be self-compensating.

2. That the area of electrode required for any given treatment is very much less than with the aforesaid existing apparatus.

3. That the apparatus keeps the self-generated currents down to a minimum.

The method according to the present invention of pre-treating a liquid being fed through conduiting to a consuming stage in order to influence by the action of an E. M. F. of a low order, that is to say a small fraction of one volt, constituents in the liquid susceptible to the influence of said very low E. M. F., consists in subjecting the liquid to the action of a constant electrical force by passing electrical energy through the liquid across electrodes located in intimate physical relationship with the liquid, and maintaining the potential difference across the electrodes constant by connecting them to the source of low E. M. F. and a resistance in parallel with, and relatively small in relation to, the resistance through the liquid between the electrodes, the electrical resistance between the electrodes being relatively high.

Further, the method according to one form of the present invention of pre-treating a liquid being fed through conduiting to a consuming stage in order to neutralise by the action of an E. M. F. of a few millivolts constituents in the liquid susceptible to the influence of said very low E. M. F. without changing the normal function of the liquid, consists in subjecting the liquid to the action of a constant electrical force by passing electrical energy through the liquid across electrodes located in intimate physical relationship with the liquid the electrical resistance between the electrodes being relatively high, and maintaining the potential difference across the electrodes constant by connecting them to the source of very low E. M. F. and a resistance in parallel with, and exceedingly very small in relation to, the resistance through the liquid between the electrodes.

The apparatus of the present invention is broadly characterised by the provision of a shunt resistance of known value across the electrodes of the unit by which are produced relatively high and low resistances in parallel, the difference between these resistances being such that their total resistance will not change appreciably if the internal resistance of the unit or cell varies over quite a large range, such variation being due to variations in the liquid or the speed of the liquid past the electrodes.

In pursuance of the foregoing it should be understood that providing the resistance of the unit and that of the shunted resistance are sufficiently far apart, the resistance of the shunted resistance will for all practical purposes be equal to the resistance of the two in parallel. Thus all that will be necessary to maintain a constant potential difference across the liquid irrespective of considerable change in the specific resistance of the liquid will be to apply across the shunted resistance a sufficient current of electrical energy to maintain the required potential difference across the ends of the shunted resistance.

The invention is further characterised in that the apparatus for subjecting liquids to the action of a very low electrical force, e. g. in the neighbourhood of a small fraction of one volt, comprises a hollow body forming one electrode and shaped for insertion in a pipe line and an internal electrode or electrodes, the said hollow body being constituted by two identical end parts detachably connected together to form a symmetrical hollow body, the internal electrode, or electrodes, being secured detachably in position at the junction plane or planes of the said end parts.

The said apparatus for supporting one internal electrode

can comprise two identical substantially half-ellipsoidal body parts with opposed flanges at their larger diameter ends by which they are bolted together with an interposed disc-like or annular electrode insulated from direct electrical contact with the end parts, the outer ends of said body parts being bossed or flanged for connection to the pipe line, and terminals on the perimeters of the electrode and at least one of the end body parts for connection to the source of low E. M. F.

A single metal plate-like perforated disc can comprise the internal electrode, or an annulus with a plurality of inwardly directed integral or attached limbs or a ring carrying an inwardly directed arm or arms for one or more ball-like metallic electrode elements. If desired a pair or more of the internal electrodes can be provided by providing one or more distance piece sleeves or tubes between them with appropriate insulation.

In carrying one form of the invention into practice, the plant consists of two parts: (1) The unit which may be positioned in a pipe line through which the liquid being treated flows and which may consist of an outer casing, which is one of the aforesaid electrodes, to contain the liquid having inlet and outlet ports for connection to the pipe line and through which the liquid enters and leaves together with one or more electrodes electrically insulated from the outer casing which are immersed in the liquid, and when more than one such electrode is being used they may also be electrically insulated from each other, the outer casing and the immersed electrode all having exterior terminals for the convenient application of the electrical force required; the construction being such that the only path by which electrical energy can flow between the electrodes internally is through the liquid being treated. (2) The source of electrical energy together with the necessary apparatus which controls the flow of electrical energy in accordance with the special requirements of the process.

This invention also calls for apparatus which has two parts: (1) a hollow body or tubular cell body which is adapted to be inserted in a pipe line through which the liquid passes and in which it receives treatment, and (2) the controlling apparatus which applies the electrical energy and controls it.

The casing or shell of the cell can be of cylindrical form with end walls adapted for connection in the pipe line and act as one electrode, for which purpose it would be provided with an external terminal. The internal electrode, however, can be of much simpler construction, and by way of example could consist of a plate extending right across the section of the outer casing but electrically insulated from it by means of rubber gaskets for instance, and having a multiplicity of holes drilled through it through which the liquid can pass, the terminal for this plate being brought outside for the application of the electrical force. The only consideration regarding size of the perforated electrode is that it must be of such area that a sufficient number of holes or orifices can be made in it to pass the requisite amount of liquid. It is also essential that there must be a relatively high electric resistance through the liquid between the electrodes.

The above describes a type of electrode which might be used if it is desirable to break the liquid up into fine streams. If this is not essential this internal electrode can be even simpler still and might consist of a ball centrally situated within the outer casing and supported by a post which passes through the wall of the outer casing through an insulating bush of watertight construction.

This cell of relatively high resistance is shunted either internally or externally with a resistance of known and relatively low resistance which can take the form of a short piece of resistance wire or any other convenient form.

There are then two resistances in parallel, one relatively high (the cell) and one relatively low (the shunting resistance).

Providing the relative difference between these two resistances is considerable the total resistance of the two resistances in parallel will not appreciably change if the internal resistance of the cell varies very considerably.

By way of example drawings are appended hereto illustrating various forms of the apparatus, and wherein:

Figure 1 is a sectional elevation though a simple form of the apparatus e. g. suitable for domestic main supply lines and for like purposes.

Figure 2 is an exploded perspective view of the apparatus shown in Figure 1.

Figure 3 is a sectional elevation showing how the apparatus of Figure 1 can be adapted to receive two or more internal electrodes.

Figure 4 is a sectional elevation of a further embodiment suitable for large capacity work in which the configuration of the outer or tubular electrode is such that it will obviate pockets in which air can collect if the unit is in a horizontal position, and

Figure 5 is an inner end elevation view of one of the body parts of the outer electrode of Figure 4.

Referring to the drawings, in Figures 1 and 2, the unit illustrated has an outer body in itself forming an electrode and constituted by a bronze or other suitable pair of symmetrical substantially half-ellipsoidal hollow parts **1** and **2** with flanges **1***a* and **2***a* respectively between which is gripped the co-operating electrode **3** in the form of a circular plate of Monel metal or other suitable metal or alloy, the electrode 3 being insulated from the electrodes **1** and **2** by rubber gaskets, or, as shown, a single rubber annular gasket **4** moulded about the periphery of the electrode **3**, this electrode and the rubber gasket being formed with diametrically opposed lugs **3***a* and **4***a*, Fig. 2, respectively, the rubber lugs seating in diametrically opposed channels **5** in the flanges **1***a* and **2***a* so that the electrode **3** is fully insulated from the electrode constituting the hollow body part formed by the electrodes **1** and **2**. Hexagonal or other suitable form of hollow bosses **6** are formed on the outer end of the electrodes **1** and **2** for connection to the appropriate pipe line.

The electrode **3** is formed with a plurality of apertures **7** so as to break-up the body of water into a plurality of streams during its passage through the unit, and the number and total effective area of these apertures is such as not to impede the flow of fluid along the conduiting in which the unit is fitted.

One of the lugs **3***a*, or, as shown, both of them, is, or are, adapted to serve as terminal members for which purpose each, or one of them, receives a terminal screw **8**. Actually, one terminal screw is sufficient, but it is convenient to provide two in order that there is normally always afforded a reasonably easy point of connection for a lead, this facilitating testing requiring the temporary connection of a lead to the electrode. Insulation washers **9** are interposed between the nuts **10** and the appropriate flange **1***a* or **2***a*, and on one face each rubber lug **4***a* is formed with a boss **4***b* engaging in an aperture in the appropriate flange **1***a* or **2***a* so as to insulate the terminal stud from the flange.

One of the flanges **1***a* or **2***a* is also fitted with a terminal screw **11** and by means of the selected terminal screw **8** and terminal screw **11** the unit is connected by leads **12** and **13** to the source of very low E. M. F. so that an arrangement similar to an electrolytic cell is provided in which the equivalent of the electrolyte is the liquid passing through the unit, although actually the action taking place in the cell is not the normally accepted electrolyte in which one of the electrodes would acquire a deposit of salts, no such deposit occurring with the present device, although with some liquids e. g. in boilers, and boiler lines, where de-scaling takes place by reason of the action set up by the unit the scale and scale forming constituents will be thrown down as sludge and particles

in the boiler which can be readily removed by the normal process of blowing down.

The end electrodes or body parts **1** and **2** shown in Figures 1, 2 and 3 are symmetrical with respect to each other and each in themselves is of symmetrical configuration, but in the embodiment shown in Figures 4 and 5 whilst the members **1** and **2** are symmetrical with respect to each other each of themselves is of asymmetrical configuration by making their cylindrical outer ends **16** eccentric in relation to their annular flanged inner ends, such outer ends being flanged or otherwise adapted for connection to the appropriate line. The cylindrical outer end of each of the said body parts merges in a substantially flared curvilinear manner into the flange **1***a* or **2***a* so that a biased bulbous portion **17** is provided with each member **1** and **2**. The advantage of this configuration of outer electrode is that the combined bulbous portion **17** can, in the event of the unit being arranged horizontally form the base thereof, and the part cylindrical upper part which is parallel with the axis of the cylindrical end part **16** will enable a free flow of liquid to pass through the unit without pockets being formed therein in which air and gases can collect, this collection of air or gases having been found in the past to cause difficulties in pipe lines.

The electrode **3** in this embodiment is shown as separated by two separate rubber gaskets **18** the perimeters of which are shaped so as to extend over the terminal pin receiving the lug **3***a* of the electrode **3**.

The parts **1** and **2** with the interposed electrode **3**, and likewise the parts **1** and **14** and **14** and **2** of Figure 3 can be secured together by any suitable means, e. g. bolts passed therethrough, or as shown studs passed through co-axial holes in the flanges **1***a* and **2***a* and threaded into one of the set of holes.

The E. M. F. applied to the electrodes is such that the potential difference across the electrode **3** and the electrodes **1** and **2** is of an exceedingly low order, i. e. in the range of from 0.1 to 0.3 millivolt.

An important feature of the present invention is the provision across the leads **12** and **13** of a resistance **19**, so that the whole unit or cell is shunted with a resistance of which is relatively low when compared with the resistance through the fluid in the pipe unit between the electrodes **3** and the outer casing **1** and **2**. This resistance is of an order not higher than 1 ohm.

For example, if the unit or cell is constructed in the manner shown in Figures 1 and 2, with water such as the average water in London which has an electrical resistance of approximately 2,000 ohms per centimeter cube, the cell has an internal resistance of 1,000 ohms and such cell is shunted with a resistance having a value of 1 ohm the total resistance will be .999 ohm. Should the water increase or decrease in resistance fourfold the resultant total resistances will then be .9997 and .996 ohm respectively. Thus the resultant total resistances are all so close to one another that for all practical purposes they are the same. In this case all that would be necessary to ensure that a constant predetermined potential difference is maintained between the anode and cathode of the cell, would be to suitably regulate, e. g. by a variable resistor or potentiometer **20** and a highly sensitive meter **21**, the current of electrical energy, supplied by a suitable source **22**, such as a dry cell, flowing through the total resistance to what would be necessary to cause the required potential difference between the terminals of the total resistance. As an example, assume that the total resistance is 1 ohm and that the required potential difference is 2 millivolts, then a current of 2 milliamps flowing through the total resistance will maintain a steady potential difference of 2 millivolts between the anode and cathode of the cell when vastly differing waters are flowing through the cell. The same principle can be applied to a cell having two or more anodes.

Should flat D. C. electrical energy be adopted, a dry cell would be a convenient source of supply with the necessary series resistance in circuit to adjust the current flow to 2 milliamps. However, A. C. or rectified A. C. can equally well be used with such apparatus, attention being given to impedance should periodicity make this necessary. Should it be desired to use such apparatus with high frequency current particular attention must be given to this latter point.

According to the above example, if the fixed resistance is about 1 ohm and a standard dry cell is used as a means for supplying electric treating energy having a voltage of 1.5 volts, it is necessary to drop this voltage by the variable resistance **21** to the required treating voltage of 2 millivolts. Accordingly, the resistance **21** must have a value considerably larger than the resistance **19** shunted across the treating electrodes. From this it follows further that, in providing a desired treating voltage, the current indicated by the meter **21** or the value of the resistance **20** must be such as to produce a voltage drop equal to said treating voltage across the fixed resistance **19**, substantially independently of the electric resistance of the liquid between the treating electrodes. In other words, the treating voltage can now be adjusted in advance or the meter **21** or variable resistance **20** calibrated in terms of treating voltage, independently of the type of liquid to be treated. This not only greatly simplifies the manufacture and operation of the device, but insures positive and optimum treating conditions at all times and under all circumstances.

Cases in which the process makes it desirable for the fluid to be subjected to the effects of two or more different potentials whilst passing through the cell, or cases in which it is desirable to subject the liquid to two or more different forms of electrical energy such as flat D. C. and high frequency A. C. or pulsating D. C., can easily be arranged by having two or more anodes disposed inside the cathode, electrically insulated from the cathode and from each other and so arranged that the electrical resistance through the liquid is high in each case. The above mentioned shunting resistances and the necessary source of energy being applied as before in each case.

Whilst the foregoing has described the application of this invention to a unit which fits in a pipe line through which the liquid to be treated is flowing, it can equally well be applied to an open trough or any form of apparatus through which liquid can flow, and in addition to its use for the treatment of hard water to prevent scale, it can be used for other processes which call for a liquid to be subjected to the effects of a low E. M. F., for instance, to treat paper pulp in liquid form to give added strength to the resultant paper, to treat vegetable extracts or pulp in liquid form to improve their flavours and keeping qualities to stabilise or break down emulsions etc.

In constructing the cell mentioned above that would be used in a pipe line, the high resistance necessary between the anode or anodes and the cathode can be brought about in various ways. For instance, by sizing and spacing the various electrodes so that the direct passage of the electrical energy through the liquid between the electrodes is in itself sufficiently high for the required purpose, or if more convenient, the internal surface of the cathode which is in contact with the fluid can be partially coated with a high resistance medium, for instance, vitreous enamel.

The cell may be constructed substantially in the manner described with reference to Figure 3, and have its internal surface insulated. It would then have two electrodes of exactly similar construction inside it and immersed in the liquid, insulated from each other and with terminals brought outside. These immersed electrodes which can be identical perforated discs spaced apart by an intermediate or distance piece cylindrical wall section of the cell and insulated by annular insulation layers be-

tween their outer annular marginal parts and flanges on the said intermediate cell wall and two end cell parts, would have to be situated in series with each other relative to the flow of the liquid. One could then be used as the anode and the other as the cathode. As they are in all respects similar there would be no chemical electrical potential difference between them and as they are both subject to the same rate of flow of the same liquid this will not affect them either. One of them could be connected electrically to the outer casing of the cell by a lead 15 if it is necessary to stabilise one pole of the electrical force with the outer casing which may be earthed. Such a cell is illustrated by Figure 3.

In the above connexion, component parts of the cell used for the treatment of liquids have been spoken of as electrodes. They are still to be considered as such even though they may be coated, on the faces of them in contact with the liquid, with an insulating medium such as vitreous enamel, thus, in the case of an electrode 3, leaving only the metal edges of the holes 7 exposed for contact with the water, i. e. obtaining the partial insulating coating for an electrode.

In apparatus such as is generally described above, mention has been made of the current of electrical energy actually flowing from one electrode to another through the fluid. This is because it has been by such means that the most convenient method has been found to maintain the electrode immersed in the liquid or anode at a potential difference relative to the other electrode.

It will be appreciated from the foregoing that the effective surface area of electrodes can be considerably less than with existing apparatus in use, because each electrode only needs that area which the process requires to treat the amount of liquid which the unit is designed to handle, without having to add to this area solely for the purpose of keeping the ohmic resistance between the electrodes low.

The apparatus may include fixed or adjustable means to regulate the rate of liquid flow through one or more of the electrodes so as to establish a uniform flow through all electrodes, or at least when two or more perforated electrodes are employed, through all of them, and e. g. a venturi device or devices fixed or adjustable, can be incorporated in the apparatus for this purpose. Alternatively, or in addition, when using reticulated electrodes such as 3, plugs or other suitable means can be provided for closing any desired number of perforations, and where necessary these plugs can be di-electric members so as to be inert.

I claim:

1. In apparatus for electrically treating liquids containing dissolved ionic constituents comprising a pair of spaced electrodes having applied thereto a predetermined treating voltage of a value substantially below the limit where electrolysis occurs and means for passing a liquid stream to be treated in exposed contact with said electrodes, to condition the dissolved constituents by the electric force acting thereon and to thereby affect their subsequent physical and/or chemical behavior; means for supplying electric energy having a voltage considerably in excess of said treating voltage, a first variable resistance connected in series with said source and said electrodes, and a further fixed resistance having a value equal to a small fraction of said first resistance and shunted across said electrodes, said resistances having a total value to cause the current therethrough from said source to be a considerable multiple of the current between said electrodes required to produce a voltage drop therebetween equal to said treating voltage for a given liquid to be treated, whereby said fixed resistance produces a constant voltage drop equal to said treating voltage and substantially independent of the electric conductivity of said liquid.

2. In apparatus for electrically treating liquids containing dissolved ionic constituents comprising a pair of spaced electrodes having applied thereto a treating voltage of from a few millivolts to fractions of a millivolt and means for passing a liquid stream to be treated in exposed contact with said electrodes, to condition the dissolved constituents by the electric force acting thereon and to thereby affect their subsequent physical and/or chemical behavior; a dry cell for supplying electric energy having a voltage which is considerably in excess of said treating voltage, a first variable resistance connected in series with said cell and said electrodes, and a further fixed resistance of about one ohm which is a value equal to a small fraction of said first resistance and shunted across said electrodes, said resistances having a total value to cause the current therethrough from said source to be a considerable multiple of the current between said electrodes required to produce a voltage drop therebetween equal to said treating voltage for a given liquid to be treated, whereby said fixed resistance produces a constant voltage drop equal to said treating voltage and substantially independent of the electric conductivity of said liquid.

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