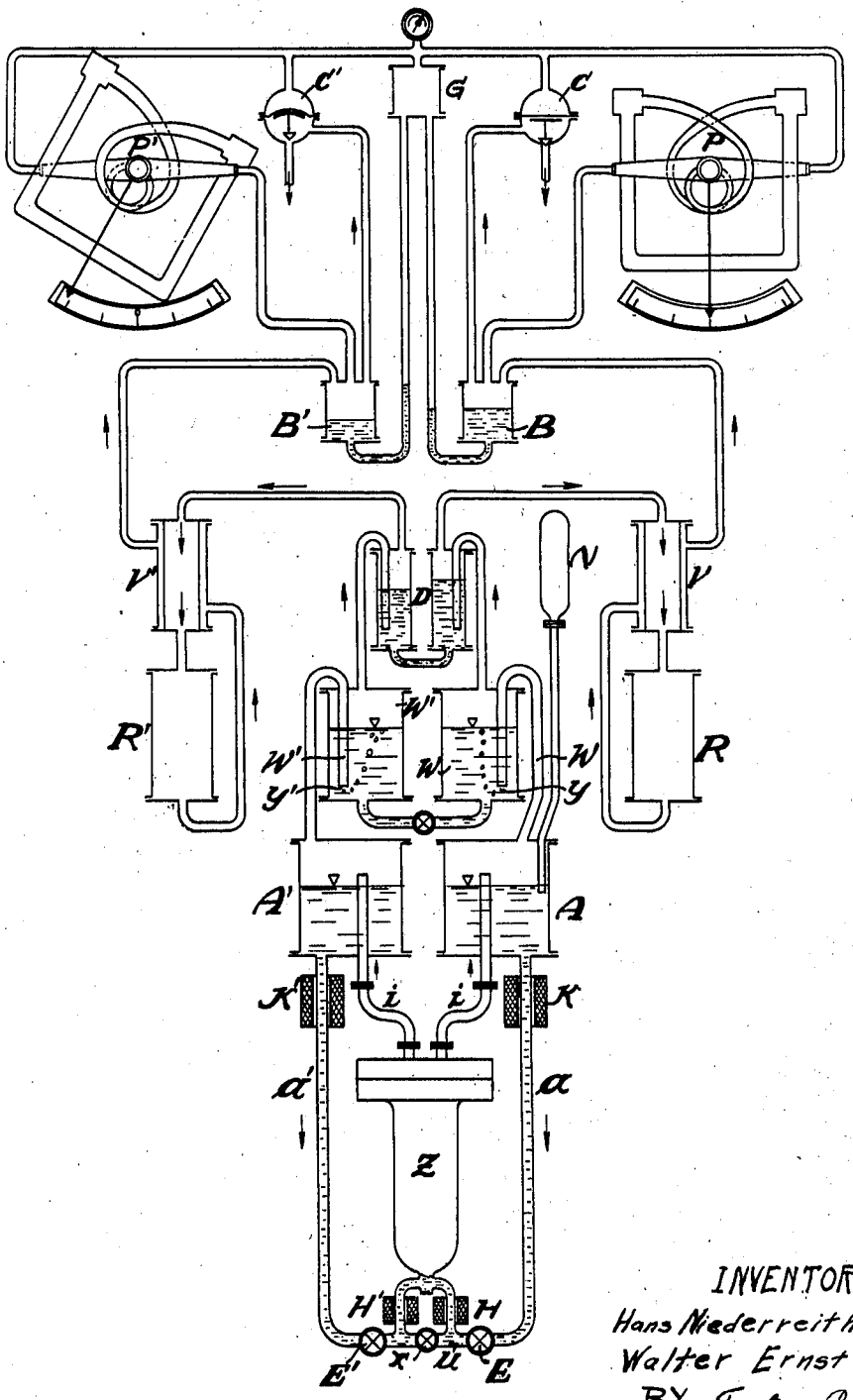
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MEANS FOR REGULATING THE CIRCULATION OF THE ELECTROLYTE IN PRESSURE DECOMPOSERS WITH A SEPARATE CIRCULATION OF THE ANOLYTE AND CATHOLYTE

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## MEANS FOR REGULATING THE CIRCULATION OF THE ELECTROLYTE IN PRESSURE DECOMPOSERS WITH A SEPARATE CIRCULATION OF THE ANOLYTE AND CATHOLYTE

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The invention relates to an improved method of high pressure electrolysis. More particularly it relates to high pressure electrolysis in which a separate circulation of the anolyte and the cathoylte portions is maintained. It is known that any disturbance of the equilibrium between the two circulations of the electrolyte on the anolyte side, on the one hand, and on the catholyte side, on the other hand, may lead to very considerable disturbances in the operation of an electrolyzing plant of this kind, although hitherto no one has made any attempt to effect a systematic adaptation of the two circulations relatively to each other in such a way that the disturbances of equilibrium which arise can be eliminated in a simple and accurate manner by regulation. The object of the present invention is to provide an extraordinarily accurate and sensitive regulation of this kind whereby the equilibrium between the two sides of the electrolyte circulation can be obtained. In doing this the inventors have endeavoured, for reasons of simplicity and economy, to use, as far as possible, means which have already been extensively used heretofore for decomposers of this kind. Accordingly, an arrangement for regulating the circulation of the electrolyte in pressure decomposers with a separate circulation of the anolyte and catholyte will in the first place, comprise, according to this invention, means for effecting the regulation of the circulation by the alternate action of heating and cooling appliances on the circulation pipes.

According to this invention use may also be made, for the purpose of assisting the regulation, of additional throttling devices, which are inserted in the circulating pipes for this purpose. Heating, cooling and throttling devices have already been used previously in electrolyzers, and cooling appliances have also been used in pressure electrolyzers, for the purposes for which such appliances are generally employed, but it is new in pressure electrolyzers with a separate circulation of the anolyte and catholyte to regulate them by heating, cooling or throttling.

In contradistinction to the previous construction of pressure decomposer plants of this kind wherein a mutual adaptation of the two circulations of the electrolyte is, in most cases, not even attempted at all, an extremely fine regulation of the circulations can be obtained by the means indicated by the inventors. This feature, which is of extraordinary value technically, results, however, in disturbances which may react on the circulations of the electrolyte, due to disturbance outside the electrolyzer proper, but in communication therewith. Formerly such disturbances did not appear in the foreground, because the electrolyte circulations themselves were not free from disturbances. When however, the problem of securing the electrolyte circulations against disturbances of equilibrium which arise in the circulations themselves, is solved, according to this invention, additional means for securing the electrolyte circulations against disturbances which may arise from the auxiliary devices in communication with the decomposing plant are very desirable in order that the advantages aimed at may be fully realized. If a decomposing plant built in the usual way be regarded from this standpoint, we find first the means which serves for replenishing with water. For this purpose so-called replenishing bottles have already been used previously and it was universal practice to provide two such replenishing bottles one, on either side of the electrolyzer, i. e., the anode and cathode side. In order, therefore, to adapt this replenishing device to the function assigned to it, the inventors further provide the rule that the replenishing device must be so built in on the catholyte side that it will keep the upper liquid level of the catholyte circulation constant. This mode of arrangement has important advantages for preventing disturbances in equilibrium from the circulation of the electrolyte. The water is used up in the cathode chamber. For this reason, it is advantageous to supply the water to this chamber in particular. This supply is effected with the help of an automatic replenishing device which continuously delivers the water used up, even in the smallest quantities, so

that the level of the liquid in the circulation of the catholyte cannot sink. This must be avoided under all circumstances because even only a small drop would result in disturbance of the equilibrium in the circulation and deterioration in the purity of the gas.

Within the problem of the complete elimination of disturbances in the circulations of the electrolyte, set by the inventors, it is also necessary to so arrange a compensating device inserted between the decomposers and the parts of the apparatus which carry off the gases produced, that reflex actions on the decomposer due to fluctuations of pressure in this part of the plant shall be precluded. The pressure equalizing devices hitherto used by no means suffice for this purpose. According to the present invention this purpose may be achieved by various means.

First, according to the present invention, this equalizing device must consist of one or two series connected equalizers so that any reflex action on the decomposer due to fluctuations of pressure is reduced to a minimum until the regulating device provided for the equalization of the pressure in the gas outlet pipe can come into action. Furthermore, the equalizers are designed to be constructed as equal pressure maintainers in such a way that a constant pressure is maintained at the point where the gas passes from the gas pipe coming from the decomposer into the equalizing vessel.

Finally, according to the present invention, pendulum level meters or similar appliances must be inserted in the gas outlet pipe so as to be acted on by the fluctuations in the level of the liquid in the equal pressure maintainers and to indicate such fluctuations or convert them into regulating impulses.

By these measures it is ensured that although fluctuations in the level of the liquid may occur, they never react on the decomposers.

The measures which may be taken according to the present invention for the purpose of providing protection from reflex actions by fluctuations of pressure in the part of the apparatus which conducts the gases directly from the decomposer are not limited. Thus, again, according to the invention, the usual gas purifying apparatus is intended to be placed in the high pressure portion of the plant immediately following the pressure equalizers. In this way the reflex action of pressure fluctuations in the gas purifying apparatus upon the electrolyte circulations of the decomposer is excluded.

This arrangement affords also certain advantages e. g. a small quantity of catalyst, as the volumes of gas under pressure are smaller and the length of time during which they are in contact with the catalyst is also consequently longer for a given superficial area of catalyst than with the hitherto usual practice of the purifier following the regulating system and before of the bottle battery, in which case the purifier had to work under various pressures, according as the bottle battery possessed more or less pressure. This was considerably less favourable to the proper working of the purifier, as it required a greater consumption of heat and a larger quantity of catalyst.

These purifiers are also intended, according to the present invention, to be specially constructed, being divided into a preheater and the purifier proper, which cooperate in such a way that the sensible heat of the hot, purified gases is utilized to preheat the gases flowing to the purifiers. In this way a considerable economy in heat can be effected. In large plants, the consumption of heat for heating the gases has an important bearing on the temperature produced by the catalyst and the final product. This consumption of heat may, in the arrangement according to the present invention be supplied entirely or in greater part by the heat produced in the purifier by combustion and heating.

The methods employed according to the present invention for preventing the reflex action of fluctuations of pressure in the system for carrying off the gases and in the regulation system on the decomposers and their electrolyte circulations, includes a regulating safety device interposed between the regulating device inserted in the pipe for carrying off the gases and the decomposer, which device automatically converts the pressure above or below atmospheric pressure which arises on the one side (anolyte or catholyte side) into an increase or a reduction in the total pressure of the plant and prevents too great a difference in the two gas pipes, while eliminating any reflex action on the circulations of the electrolyte in the decomposer.

A constructional example of the subject matter of the invention is diagrammatically illustrated in the drawing.

In the constructional example illustrated, a pressure decomposing plant of the kind referred to comprises, first, a vertical, inclined or horizontally arranged decomposing vessel Z, which communicates with the two separating vessels A and $A^1$ by means of circulating pipes $a$ and $a^1$. To it are connected the washers W and $W^1$ for the equalization of small differences of pressure and the mercury equalizing vessels for larger differences of pressure, which may arise from the purifier plants or collecting arrangement. Thence the gases pass into the preliminary purifiers V and $V^1$, which act, at the same time, as condensers, and then to the purifiers R and $R^1$. Then follow the pressure regulators B and $B^1$ in communication with the regulating safety devices C and $C^1$ and a

vessel G at a constant pressure and finally the pendulum level meters P at $P^1$.

When the plant is at work the gas rises from the decomposing vessel into pipes denoted by *i* and passes, mixed with the electrolyte which it has carried with it, into the separating vessels A and $A^1$. Thence the separated electrolyte flows, through the circulating pipes *a* and $a^1$, back to the lower side of the decomposer. These pipes are provided with cooling appliances K and $K^1$, throttling valves E and $E^1$ and the heating appliances H and $H^1$. The electrolyte passes from below into the decomposer and into the cells. The necessary interchange of electrolyte between the two sides may, for example, take place at the lower ends of the returns *a* and $a^1$ through the connection *u*, which may be regulated by means of the valve X. By providing the heating appliance it is possible to secure a circulation of the electrolyte and a temperature favourable to the electric action even when the decomposer has to be brought up to pressure gradually with a current of low strength, after standing idle for a long time, or when, for example, owing to fluctuations in the load, it has to be run for a long time with a current of low strength and therefore, with but small electrolytic heat. When the decomposer is run under a heavy load, so that sufficient or too much heat is produced by the process itself, it is possible by means of the cooling arrangement K, to keep the decomposer at the correct working temperature and at the same time to regulate the circulation to correspond to the more intensive working conditions.

The replenishing of the electrolyte consumed takes place automatically from the replenishing bottles N on the hydrogen side, that is to say, on the side on which the water is actually used up, so that the level of the catholyte in the separating vessel is permanently kept constant.

The gases are passed on to the pressure receptacles W and $W^1$, which act as washers and equalizing vessels, through pipes *w* and $w^1$ which reach down to a point *y*, $y^1$ above the bottom in the receptacles, which are, of course, analogous points in the progression of the gas through the system. By analogous points I mean points equi-distant, along the line of progress, from the points of exit from the electrolyzer. Here the gases are freed from the particles of electrolyte which they have carried with them by being projected upwards through water. At the same time these washers, being connected to each other, can, by way of the pipe which connects them, equalize extremely small fluctuations of pressure in the further gas pipe, so that although the levels inside the washers may change, there is no change in the levels in the separating vessels A and $A^1$ which would cause disturbances in the circulations. As the washers are filled with water, they can only be used for the equalization of slight fluctuations in pressure.

Greater fluctuations in pressure can be taken up by the pressure equalizing apparatus D in which, in the same way as in the washers, mercury is used instead of water, mercury, of course, owing to its greater weight, being able to take up greater fluctuations of pressure. From here the gases pass into the preheaters V and $V^1$ and thence into the purifiers R and $R^1$ in which the small impurities are burned to water by heating them in the presence of catalysts. The gases containing heated steam pass back through the preheater and, on the counterflow principle, give up their heat to the gases flowing to the purifiers. The steam, cooled down by this process, condenses.

From here the gases pass into the regulating safety devices B and $B^1$. These consist of two pressure vessels, which are filled to a certain extent with mercury. This mercury communicates through a pipe with a pressure vessel G, from which a gas under pressure, such as nitrogen for example, at the desired working pressure, presses on the mercury, as also on the other side of the regulating diaphragm in the regulator C, $C^1$ proper. The gases produced come from the preliminary purifier, pass through the upper part of the regulating safety device and thence to the lower part of the regulator. If the pressure of the gas in the decomposer exceeds the pressure of the opposing gas acting on the diaphragm from above, the diaphragm will yield upwardly, the diaphragm valve on the underside of the regulator will open and the gas will be allowed to pass into the collecting pipe. The purpose of the regulating device is to protect the regulator diaphragms from too great differences in pressure. The mercury in the regulating safety device is, on the one hand, under the pressure of the decomposer gases and, on the other hand, under the pressure of the gas in the vessel G (nitrogen for example) and consequently a difference in the level of the surface of the mercury in the vessel of the regulating safety device and in the adjoining pipe indicates the difference of pressure between the two sides of the diaphragm of the regulator. In the drawing, for example, on the right side there is no difference between the gas under pressure from above and the gas in the decomposer from below on the diaphragm of the regulator, because the levels of the liquid in the regulating safety device are at the same height on both sides. On the other hand, on the left hand side of the drawing the decomposer gas has an excess of pressure in comparison with the gas under pressure pressing on the diaphragms of the regulator.

The heights of the columns of mercury in the regulating safety device are such that a

pressure which would damage the diaphragm cannot arise, as at a fixed maximum pressure the columns let gas through either at the top or at the bottom. If, for instance, the gas should accumulate owing to the choking up of the right hand regulator valve and keep on pressing on the diaphragms the columns of the regulating safety device would allow gas to pass through upwards upon a fixed maximum load being reached. The result of this is that the total pressure of the plant rises, without injurious effect on the diaphragms of the regulator and above all without dangerous differences of pressure arising in the gas pipes and thereby causing disturbances in the circulations that would impair the purity of the gas. Another example would be that the plant is only under a slight load and that heavy leaks have taken place on the one side. The regulating safety device therefore allows gas to pass to the leaky side out of the constant pressure chamber G. The resulting reduction of pressure is transmitted to the other side by the blowing off of the other regulator. The pressure in the plant drops automatically without reflex action on the decomposer circulations.

Differences of pressure of this kind in the two gas pipes are indicated, according to the present invention, by the pendulum level meter. This latter is a pivotally mounted communicating pipe which is partially filled with a liquid, such as mercury, for example. In opposition to the movement of the liquid resulting from the different gas pressures and the consequent shifting of its centre of gravity, the centre of gravity of the pipe system is caused to move and a deflection of the indicating apparatus results accordingly. The supply of the gas under pressure takes place through coils of pipe or flexible pipes adapted for high pressure. This very sensitive arrangement may also be used, when motor operated regulators are employed, to regulate automatically the escape of the gases from the regulator in accordance with the deflections of the pendulum level meter.

What we claim is:

1. In combination, a high pressure electrolyzer, a reservoir in communication with the said electrolyzer adapted to supply electrolyte to the said electrolyzer, heating and cooling means adapted to regulate the circulation of the electrolyte and having separate circulation means for anolyte and catholyte, pressure regulating means responsive to pressure differences existing between the gases evolved from the anode and cathode portions of the said electrolyzer, and a high pressure purification and collection system in communication with the said electrolyzer, having additional pressure regulating means disposed therein, responsive to pressure differences existing between the gases originating in the said anode and cathode portions of the said electrolyzer.

2. In combination, a high pressure electrolyzer, a reservoir in communication with the said electrolyzer adapted to supply electrolyte to the said electrolyzer, heating and cooling means adapted to regulate the circulation of the electrolyte and having a separate circulation means for anolyte and catholyte, auxiliary mechanical means co-operating with the said heating and cooling means to promote circulation of the said electrolyte, pressure regulating means responsive to pressure differences existing between the gases evolved from the anode and cathode portions of the said electrolyzer, and a high pressure purification and collection system in communication with the said electrolyzer, having additional pressure regulating means disposed therein responsive to pressure differences exsting between the gases originating in the said anode and cathode portions of the said electrolyzer.

3. In combination, a high pressure electrolyzer, a reservoir in communication with the said electrolyzer, containers interposed between the said reservoir and the said electrolyzer carrying two conduits connected respectively to the anode and cathode portions of the said electrolyzer, heating and cooling means carried by the said two conduits whereby a constant circulation of electrolyte between the cells of the electrolyzer and the said containers is maintained, a high pressure purification and collection system, gas conduits connecting the said electrolyzer and the said high pressure purification and collection system and a pressure regulator interposed between the said electrolyzer and the said purification and collection system adapted to prevent disturbances in the above said circulation of electrolyte due to pressure differences at analogous points in the said gas conduits.

4. The method of generating hydrogen and oxygen under pressure comprising subjecting water to electrolytic decomposition under pressure, passing the evolved gases while in confined streams under pressure through a pressure equalizer comprising a confined liquid adapted to adjust its opposing force in response to the gas stream pressure, the greatest opposing force opposing the greatest gas pressure, washing the gas streams under pressure to remove entrained electrolyte, burning the gas to remove impurities, utilizing the heat produced by the burning of the gas to preheat gases about to be burned, and collecting the gas under pressure.

In testimony whereof we have signed our names to this specification.

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