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(54) **METHOD FOR OPTIMIZING THE YIELD OF ELECTROEXTRACTION OF HEAVY METALS IN AQUEOUS SOLUTION WITH A HIGH SALT CONCENTRATION, AND DEVICE FOR THE IMPLEMENTATION THEREOF**

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(57) **ABSTRACT**

The invention relates to technical conditions of composition and use applied to the existing method and device for extracting heavy metals from an aqueous solution with a high salt concentration, with the single aim of adapting said method to technical, technological and ecological developments that have taken place since the protection thereof, and substantially optimising the results. To this end, the invention of the present patent application adds, to the device of the initial patent, an electronic control means (MC) that can manage three new actions. Disclosed are also modifications in the quality, function, destination and operation of certain elements of the device as well as the addition of a filter at the end of the electroplating operation, the purpose of which is to optimise the quality of the rejected effluent.

FIG 1

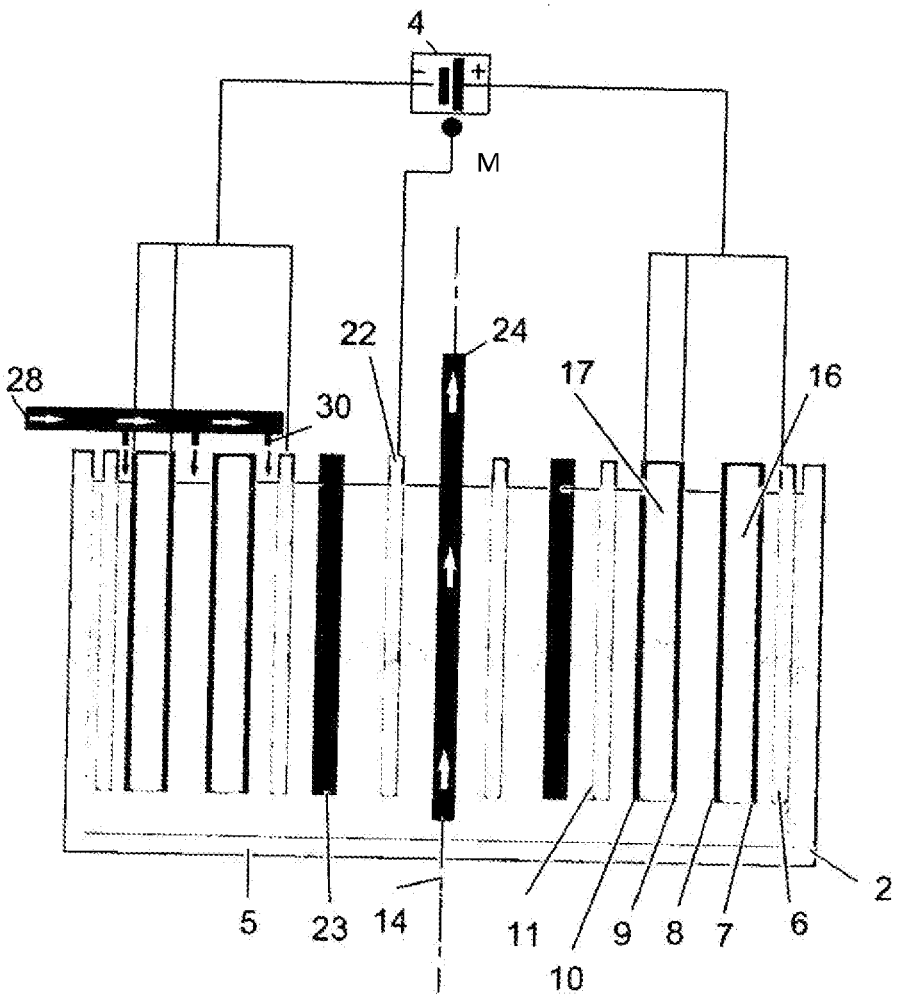


FIG 2

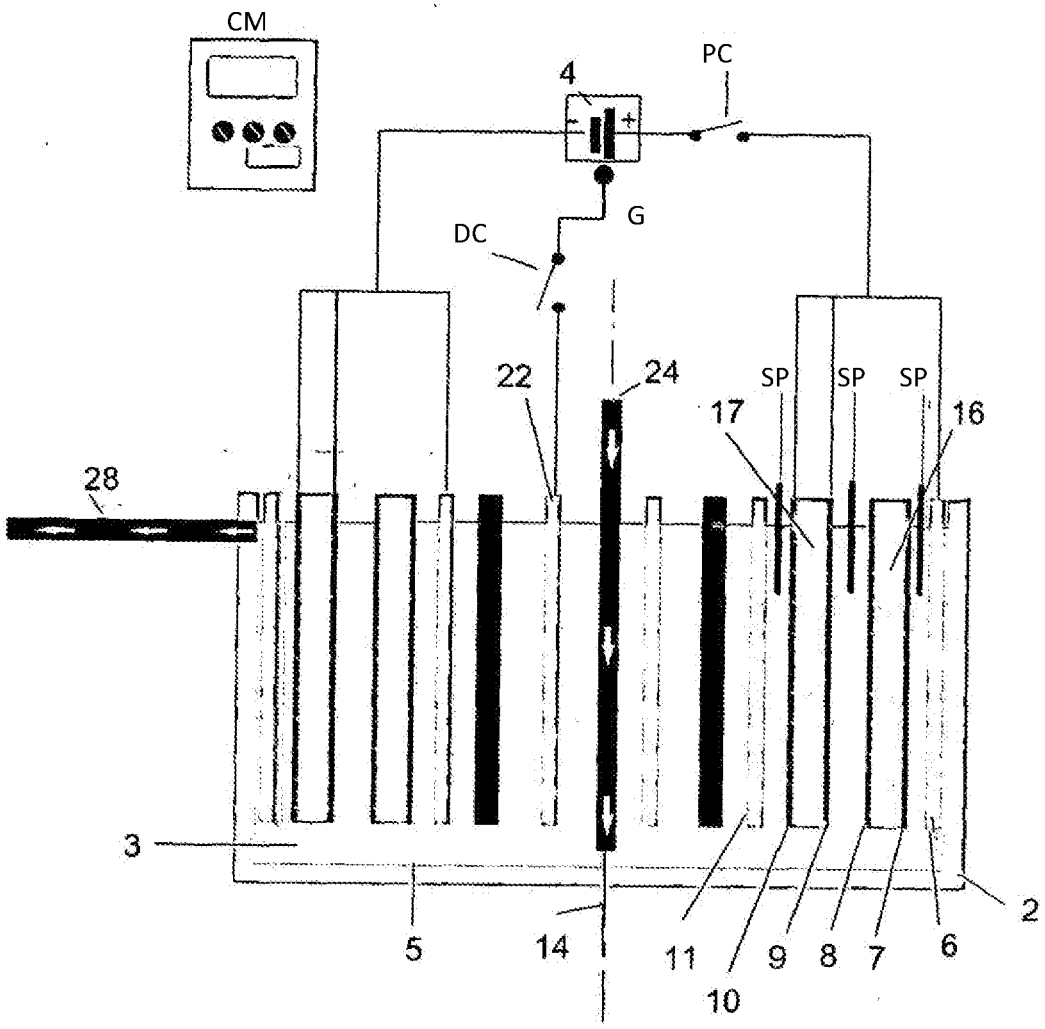
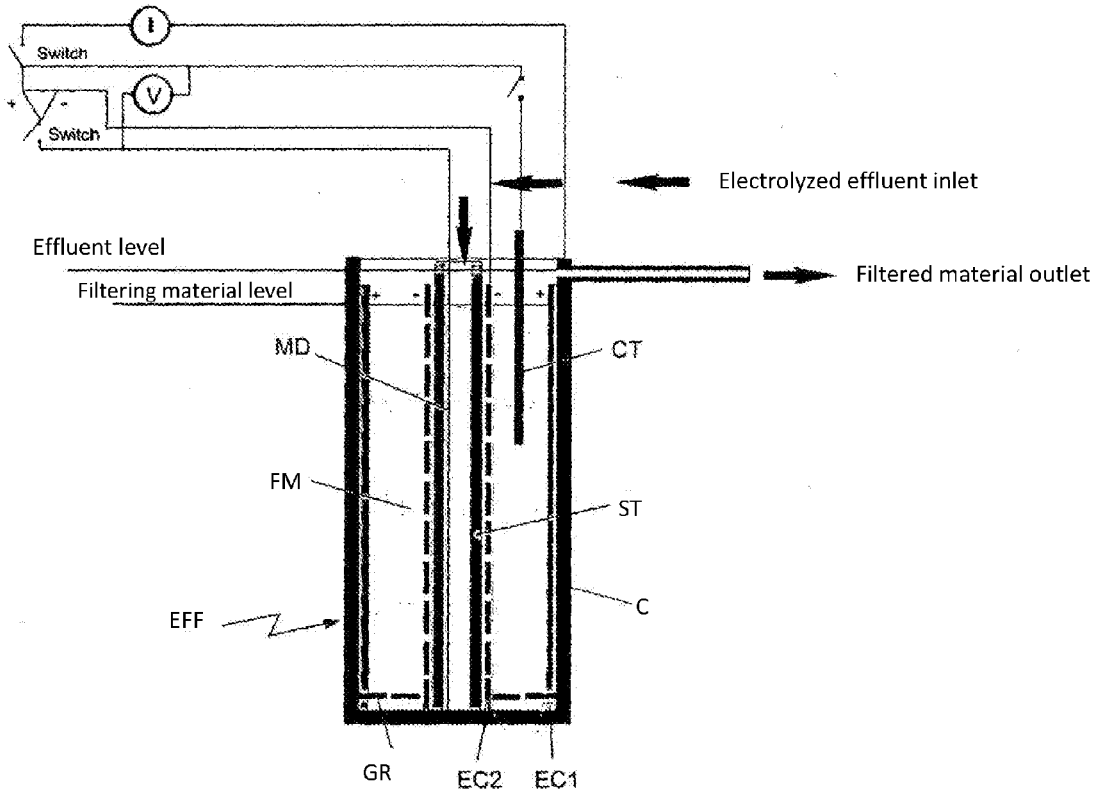


FIG 3


I
Switch
V
Switch
Electrolyzed effluent inlet
Effluent level
Filtering material level
Filtered material outlet
MD
CT
FM
ST
C
EFF
GR
EC2
EC1

METHOD FOR OPTIMIZING THE YIELD OF ELECTROEXTRACTION OF HEAVY METALS IN AQUEOUS SOLUTION WITH A HIGH SALT CONCENTRATION, AND DEVICE FOR THE IMPLEMENTATION THEREOF

[0001] It is known that the isolation of the heavy metals dissolved in an aqueous solution can be obtained by means of electrolysis, a method consisting in immersing into said aqueous solution, two electrodes of which one is designated as "anode" and the other by "cathode", each of them then connected to one or the other of the terminals of an electric current generator, in order to provoke in said aqueous solution the circulation of the positively or negatively charges elements and the concentration on said electrodes of the heavy metals isolated as such.

[0002] The best results of this known method are obtained most often when the aqueous solution has a low salt concentration and a high concentration in metals to be isolated. When this relationship is inverted and the solution to be treated has a high salt concentration and a low concentration in metals to be isolated, the performance of the method is much less and the method is practically inapplicable.

[0003] The author of this invention, aware of these observances provided a first solution to this problem by the filing on Feb. 5, 1995 of the French patent FR 95 05227 published on Aug. 11, 1996 under U.S. Pat. No. 2,733,748, hereinafter referred to as "initial patent".

[0004] This initial French patent filed in 1995 relates to a method and the device intended for the implementation thereof, consisting in capturing the elements that are ionized or in suspension of an effluent radioactive or not on electrodes, by an electrolytic method referred to as "differential electroplating".

[0005] It mainly claims a method of electrolysis and the device for the implementation thereof, characterized by the adding in the aqueous solution with a high salt concentration contained in a tank, of an additional electrode designated as "ground electrode" of the same material and of the same texture as the other electrodes (anode and cathode) and independently connected to a ground of the electric current generator.

[0006] This ground electrode added to the normal electrolysis device, has for effect to limit or annihilate the consequences of the strong salt concentration present in the aqueous solution, which opposes the circulation of the current in said solution and as such alters the effectiveness of the method.

[0007] The immersing of said ground electrode which has only the function of an electrical connection and does not receive heavy metals contrary to the anode and the cathode of the device, makes it possible to obtain the same results as those obtained in the case of a conventional electrolysis, i.e. with a solution with a low salt concentration and this in a similar cycle duration.

[0008] Said patent also claims a method of electrolysis and the device for the implementation thereof, characterized in that an intermittent mixing in a closed circuit of the solution is carried out by means of an actuation element for example a pump, which provides the simultaneous emptying and filling of the tank of the device. This mixing of the solution to be treated is carried out in order to prevent under the effect of the passing of the current the various species present in the solution from organizing themselves in order oppose the fixing of the heavy metals. It makes it possible to preserve the homogeneity of the solution during the operation of electrolysis.

[0009] It also claims the intermittent putting into circulation during the operation of electrolysis of the solution to be treated, between on the one hand the electrolysis tank and on the other hand a filter containing for example clay granules. Driven preferably by a pump this circulation of the solution between the electrolysis tank and the filter makes it possible to filter the solution in order to retain by filtration certain fission products that are difficult to isolate via electrolysis. At the end of the electrolysis, the solution treated and filtered as such returns to a tank and a last finishing filter which refines the filtration in order to obtain an extraction of a maximum of heavy metals before discharge.

[0010] Finally this patent also claims the components of the device, for example the shape, the disposition and the material for constituting the various electrodes, the connection etc.

[0011] The implementation of this method, the developments in technologies and the requirements in terms of ecology have led the inventor to change the method coming from the aforementioned initial patent in such a way as to adapt it to these changes and to as such obtain an optimum quality of the discharged liquid after purification and a conformity with current standards in effect for example in the nuclear, medical, metallurgy, etc. sectors.

[0012] In this objective, the inventor provides in this patent the adding to the device of the initial patent of an electronic control means that can manage three new actions. Disclosed are also modifications in the quality, function, destination and operation of certain elements of the device of the invention as well as the adding of a filter at the end of the electroplating operation, the purpose of which is to optimize the quality of the discharged effluent by fixing the components with a weak electromotive force driven by the residual ionic movements.

[0013] The electronic control means added to the device of the initial patent has for first function the application of successive cut-offs of the electrical power of the device, according to a periodicity determined according to the chemical composition of the solution to be treated.

[0014] This action is of great importance because the temporary stoppage of the supply results in an interaction between the elements in the solution and the electrodes, caused by an exchange between the ions contained in the solution and the electrodes. The consequence is therefore a return to electronic equilibrium that gives back to the electrodes all of their capacity without loss of material deposited before the power cut-off.

[0015] The second function of the electronic control means added to the device of the initial patent consists in decoupling the internal ground electrode provided in the method of the initial U.S. Pat. No. 2,733,748 in order to increase the rapidity of the ionic descaling of the electrodes.

[0016] This action of decoupling the ground electrode has for purpose to disorganize the ionic system in such a way that the free electrons return to the path of their respective electrode and the ions are again deposited where they have to be.

[0017] The third function of the electronic control means added to the device of the initial patent consists in maintaining and regulating during the entire differential electroplating operation, a constant optimum voltage in the solution

to be treated, using a sensor arranged in the solution to be treated and between the electrodes of the device.

[0018] It is known that the resistivity of the whole varies continuously according to the mass that is deposited on the electrodes. The controlling and the maintaining of a constant voltage between the electrodes is therefore an essential factor in the method.

[0019] These particular actions applied to the operation of the device of the initial patent by an added electronic control means, reinforces the effectiveness of the method for extracting heavy metals, in order to adapt it better to the technological developments and new technical and ecological requirements.

[0020] This electronic control means as such allows for all of the controls, adjustments and regulation as well as the transmission of the information required for the proper unfolding of the operations and the memorization of the latter.

[0021] Still with a concern for improving the performance of the device of the initial patent, the device of this patent provides that the material and the texture of the ground electrode of the device be different from the material and from the texture of the electrodes i.e. from the anode and from the cathode.

[0022] The device of this patent also provides that the materials and textures of the electrodes be different. As such the anode and the cathode can be manufactured from materials that are entirely different and determined according to the chemical and radiochemical composition (Radioactive effluents) of the solution to be treated.

[0023] In the characteristics added to the device of the initial patent in order to improve the performance and the yield thereof, the device of this patent provides that the sensors placed between the electrodes, in order to make it possible to control and regulate all throughout the differential electrolysis operation the voltage in the solution being treated, be of a chemically neutral texture such as for example that of a referential glass electrode used for chemical measurements.

[0024] The device of this patent which supplements and modifies the characteristics, composition and operation of the device of the initial patent, provides that the electrodes charged with polluting elements captured during the electrolysis operation be at the end of the operation burned or confined (radioactive elements) according to the type or grade of the polluting effects, with the treated effluents being discharged into the environment or reused industrially in light of their quality.

[0025] The patent of this invention, also provides that the electrodes plunged into the differential electroplating tank, provided in cylindrical and coaxial shape in the initial patent, be of a different form and in particular in the form of a plate. In such a case, the initial principle remains unchanged, with the electrodes being applied on the opposite faces of neutral supports in plates, with the differential ground being placed in an insulating tube in order to prevent any electronic distortion.

[0026] The patent of this invention provides that the device allows for the use in successive alternating cycles or in continuous operation. In this latter case, the supplying of the solution to be treated is carried out by the bottom of the tank and at slow speed and determined according to the chemical composition and the texture of the solution to be treated, with the removal of the treated solution being carried out in the top portion of the tank by a duct provided for this purpose.

[0027] With a concern for obtaining at the end of the operation a discharged effluent that is as purified as possible, this patent provides for the adding or the replacing at the end of the device of an electrofiltration filter intended mainly to fix the residual elements with a weak electromotive force, still present in the solution at the end of the method of differential electroplating.

[0028] Indeed, it was observed that the ionized elements contained in the effluent of which the electromotive force is very weak or zero, pass through the primary filter and the electrolytic treatment bath without being captured or only in a tiny proportion. These elements are then easily fixed on the secondary filters.

[0029] This state seems to be due to the fact that the effluent leaving the electrolysis has not yet reached its ionic stability provoking the formation of colloids that are fixed on the filtering material.

[0030] The electrofiltration filter of this invention has for purpose to exploit this characteristic in order to more easily fix said components with a weak electromotive force, which are driven by the set of weak ionic movements that still exist, amplified by the configuration of said electrofiltration filter.

[0031] Said electroplating filter is mainly comprised of a cylindrical container for example made from a plastic material that is compatible with its operation and its performance. It preferably has dimensions (Height/Diameter) that are compatible with its operation and its optimum performance and has two electrodes plunged into a neutral filtering material, of which one for example the anode, is preferably thrust on the inside peripheral plane of the container and the other for example the cathode is thrust on an axial support tube located at the center of the inner surface of the lower plane of the container.

[0032] The electric current passing through the filtering material is adjusted according to the chemical composition of the solution exiting from the electrolytic treatment container and adapted to the resistivity of the whole knowing that the conductivity of the filtering material varies according to the more or less aqueous liquid that it contains.

[0033] The solution filtered by its passing through the electrofiltration filter of the invention thus has an optimum quality that allows for the discharge thereof into the environment or for example the reuse thereof in another method of manufacturing.

[0034] In a nuclear application, the radioactive elements are practically extracted from the effluent which can then be eliminated into the environment without risk, with the radioactive elements being however confined according to known methods.

[0035] The following description with regards to the annexed drawings as non-limiting examples, will make it possible to understand how the invention can be put into practice.

[0036] FIG. **1** is a median diagrammatical cross-section view of the main element of the device of the initial patent, constituted by an electrolysis tank that is for example cylindrical, provided with electrodes and means of supplying with electrical energy and with solution to be treated.

[0037] FIG. **2** is a diagrammatical cross-section view of the main element of the device of the initial patent modified according to the technical elements claimed by this patent.

[0038] FIG. **3** is a median diagrammatical cross-section view of the electrofiltration filter of this invention.

[0039] This invention follows a patent filed by the same author in May 1995 and published on 8 Nov. 1996 under U.S. Pat. No. 2,733,748, concerning a method for extracting heavy metals from an aqueous solution having a high salt concentration, by means of electrolysis. This patent is designated hereinafter by the mention "initial patent".

[0040] For a better understanding of this patent application, the determining elements of the main claims of said initial patent are repeated hereinbelow in reference with FIG. **1** of this patent.

[0041] The method and the device for extracting heavy metals from an aqueous solution having a high salt concentration object of the initial patent claim an electrolysis tank (**2**) of cylindrical shape and with axis (**14**) containing an aqueous solution (**3**) with a high salt concentration, into which at least one pair of electrodes is plunged. In the diagram FIG. **1** of this patent, three pairs of electrodes are shown for example the anode (**6**) and the cathode (**7**), the anode (**9**) and the cathode (**8**) and the anode (**10**) and the cathode (**11**), powered at the corresponding terminals of an electric generator (**4**) and a ground electrode (**22**) connected preferably to the ground (G) of said generator (**4**). The ground electrode (**22**) is separated from the electrode (**11**) by a polyamide screen (**23**) in order to prevent any electrolytic interaction between these two electrodes.

[0042] The method and the device for extracting heavy metals from an aqueous solution having a high salt concentration object of the initial patent claim a mixing in the closed circuit during the electrolysis cycle, driven by a pump (not shown) carrying out the displacement of the solution (**3**), by emptying the tank (**2**) of the solution (**3**) via the suction channel (**24**) taking the solution in the bottom portion of the tank and near the bottom (**5**) of the latter, in order to simultaneously reintroduce it into the same tank (**2**) and between the electrodes via the channel (**28**) under the action of a pump outside of the tank (**2**). (See FIG. **1**).

[0043] The method and the device for extracting heavy metals from an aqueous solution having a high salt concentration object of the initial patent claim the filtration by intermittence of the treated solution (**3**), during the operation of electrolysis and by means of an independent filter (**32**) (not shown) and annexed to the tank (**2**) comprising a filtering material, for example clay granules.

[0044] The device for extracting heavy metals from an aqueous solution with a high salt concentration object of the initial patent claims a common material and a common texture for the electrodes for example the anodes (**6**) (**9**) **10**), the cathodes (**7**) (**8**) (**11**) and the ground electrode (**22**).

[0045] The device for extracting heavy metals from an aqueous solution with a high salt concentration object of the initial patent claims the characteristics of the shape and of the position of the electrodes (**6**) (**9**) (**10**) (**7**) (**8**) (**11**), namely: that each electrode has a coaxial and generally cylindrical shape and that the device comprises at least one neutral support, in FIG. **1** two neutral supports (**16**) (**17**) of cylindrical shape and of an inert material, having an inner face and an outer face each covered by an electrode, with the electrodes covering the faces of the same support belonging to different pairs of electrodes.

[0046] The device for extracting heavy metals from an aqueous solution with a high salt concentration object of the initial patent, claims for example the presence of at least three pairs of electrodes the anode (**6**) and the cathode (**7**), the anode (**9**) and the cathode (**8**) and the anode (**10**) and the cathode (**11**), and at least two inert supports (**16**) and (**17**), with the electrodes covering the faces of the same support being connected to the same terminal of the electric generator (**4**).

[0047] The device for extracting heavy metals from an aqueous solution with a high salt concentration object of the initial patent, claims the characteristic consisting in that at least one electrode of each pair has a continuous axial opening (not shown) extending from one edge to the other of the electrode for example the electrodes (**8**) and (**10**) and/or the electrodes (**7**) and (**9**).

[0048] Said device for extracting heavy metals from an aqueous solution with a high salt concentration object of the initial patent claims the presence of means for emptying (**24**) the treatment tank (**2**) and means for filling (**28**) said tank (**2**) that communicate in a closed circuit.

[0049] The device for extracting heavy metals from an aqueous solution with a high salt concentration object of the initial patent claims the presence of at least two filters (not shown), a production filter (**32***a*) and a finishing filter (**32***b*) annexed to the tank (**2**) and comprising clay granules.

[0050] This invention relates to the technical conditions of composition and of use, added to the method for extracting heavy metals from an aqueous solution having a high salt concentration object of the initial patent filed by the inventor in 1995 and published on 8 Nov. 1996 under U.S. Pat. No. 2,733,748, with the sole purpose of adapting said method to the technical, technological and ecological developments that have taken place since the filing of said patent and to substantially optimize the results of said method.

[0051] With this objective, the inventor provides in this patent the adding to the device of the initial patent an electronic control means (CM) that can manage three new actions. Disclosed are also modifications in the quality, function, destination and operation of certain elements of the device of the invention as well as the adding of a particular electronic filter at the end of the electroplating operation, of which the purpose is to optimize the quality of the discharged effluent by fixing the components with a weak electromotive force driven by the residual ionic movements. (See FIG. **2**).

[0052] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, has electronic control means (CM) allowing for successive cut-offs of the electrical power of the device (PC), according to durations and a periodicity determined according to the chemical composition of the solution to be treated (**3**) and the texture of the immersed electrodes (**6**) to (**11**).

[0053] This action is of great importance because the temporary stoppage of the supply results in an interaction between the elements in the solution (**3**) and the electrodes (**6**) to (**11**), caused by an exchange between the ions contained in the solution (**3**) and said electrodes. The consequence is therefore a return to electronic equilibrium that gives back to the electrodes (**6**) to (**11**) all of their capacity without loss of material deposited before the power cut-off.

[0054] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, has electronic control means (CM) allow-

ing for decouplings (CM) of the ground electrode (**22**) provided in the method of the initial U.S. Pat. No. 2,733,748 in order to increase the rapidity of the ionic descaling of the electrodes (**6**) to (**11**).

[0055] This decoupling action of the ground electrode (**22**) has for purpose to disorganize the ionic system in such a way that the free electrons return to the path of their respective electrode and the ions are again deposited where they have to be.

[0056] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, has electronic control means (CM) allowing for permanent control and optimum regulation of the voltage in the treated solution (**3**) and during the entire duration of the treatment, by means of sensitive probes (SP) introduced between the pairs of electrodes (**6**)(**7**), (**8**)(**9**), (**10**)(**11**) of the device. These means also allow for all of the functions concerning the control, regulation and communication of information allowing for the proper management of the device. (See FIG. **2**)

[0057] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration involves a ground electrode (**22**) of a material and/or texture that are different from those of the other anode (**6**) (**9**) (**10**) and cathode (**7**) (**8**) (**11**) electrodes. As the ground constituted by the ground electrode (**22**) has to remain unique in the system, all of the other constituents of the device in contact with the liquid (**3**) and for example tank, filters, tubes, pipes, pumps, etc. are in no case conductors of electricity and consequently manufactured from suitable insulating materials. (See FIG. **2**).

[0058] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, involves electrodes, anodes (**6**)(**9**)(**10**) and cathode (**7**)(**8**)(**11**) of materials and texture that are different according to a chemical and radiochemical composition (radioactive effluents) of the liquid (**3**) to be treated. (See FIG. **2**).

[0059] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, involves sensitive probes (SP) with a chemically neutral texture and for example made of glass, in order to allow for the control and the regulation of the voltage in the solution to be treated (**3**), throughout the entire duration of the operation. (See FIG. **2**).

[0060] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration involves the recovery at the end of the cycle, of the confined electrodes (**6**) to (**11**) (radioactive elements) and/or the elimination thereof according to the fixed polluting elements, by means that are adapted to the elements thereof and to the level of the polluting effect thereof (See FIG. **2**).

[0061] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, provides that the electrodes (**6**) to (**11**) plunged into the differential electroplating tank (**2**), provided in cylindrical shape and coaxial in the initial patent, be of a different shape and in particular in the form of a plate. In such a case, the initial principle remains unchanged, with the electrodes being applied on the opposite faces of neutral supports in plates, with the differential ground (**22**) being placed in an insulating tube in order to prevent any electronic distortion.

[0062] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, provides that the device allows for use in alternating successive cycles or as continuous operation. In this latter case, the supply of the solution to be treated is carried out through the bottom (**5**) of the tank (**2**) for example by the duct (**24**) and at slow speed and determined according to the chemical composition and the texture of the solution to be treated (**3**), with the evacuation of the treated solution (**3**) being carried out in the top portion of the tank by a duct (**28**) provided for this purpose. (See FIG. **2**).

[0063] According to a preferred embodiment of the invention, the device for optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, comprises more preferably in the circuit for the circulation of the solution being treated (**3**) and more preferably at the end of the circuit, at least one electrofiltration filter (EFF) intended mainly to fix the residual elements with a weak electromotive force that are still present in the solution (**3**) after the differential electroplating operation. (See FIG. **3**)

[0064] The electrofiltration filter (EFF) is mainly comprised of a cylindrical container (C) for example made from a plastic material that is compatible with its operation and its performance. It is preferably of dimensions (Height/Diameter) that are compatible with its operation and its optimum performance and has two electrodes (EC**1**) and (EC**2**) plunged into a neutral filtering material (FM), of which one for example the anode, (EC**1**) is preferably thrust on the inside peripheral plane of the container (C) and the other for example the cathode (EC**2**) is thrust on an axial support tube (ST) located at the center of the inner surface of the lower plane of the container, which itself is provided at a short distance with a grille (GR). The electric current passing through the filtering material (FM) is regulated according to the chemical composition of the solution (**3**) exiting from the electrolytic treatment container (**2**) and adapted to the resistivity of the whole knowing that the conductivity of the filtering material (FM) varies according to the more or less aqueous liquid that it contains (See FIG. **3**).

[0065] The solution (**3**) filtered by its passing through the electrofiltration filter (EFF) of the invention then has an optimum quality allowing the discharge thereof into the environment or for example the reuse thereof in another method of manufacturing.

[0066] In a nuclear application, the radioactive elements are practically extracted from the effluent (**3**) which can then be eliminated into the environment without risk, with the radioactive elements being however confined according to known methods.

1. A method of optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration, wherein the method comprises:

managing, controlling, and regulating operations linked to the extraction of heavy metals via electrolysis in an aqueous solution with a high salt concentration;

adding one or more sensitive probes (SP) in order to be introduced into the solution to be treated between pairs of electrodes (**6**)(**7**), (**8**)(**9**) and (**10**)(**11**), and

filtering the treated aqueous solution with a high salt concentration using an additional filter (EFF).

2. The method of optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration according to claim **1**, wherein electronic control means (CM) in charge of providing for the management, control and regulation of the operations, control the interruption of the electrical power supply (PC) of the electrolysis device for successive limited durations and a periodicity determined according to the chemical composition of the solution to be treated and the texture of the electrodes used.

3. The method of optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration according to claim **1**, wherein electronic control means (CM) in charge of providing for the management, control and regulation of the operations, control independently of the supply of the electrodes (**6**) to (**11**) of the device, the decoupling of the ground electrode for successive durations and a periodicity determined according to the different factors linked to the method.

4. The method of optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration as claimed in claim **1**, wherein electronic control means (CM) in charge of providing for the management, control and regulation of the operations, control the control and the regulation of the optimum and constant voltage present in solution to be treated, throughout a entire electroplating operation and on information from the sensitive probes (SP) introduced into the solution to be treated, between the pairs of electrodes (**6**)(**7**), (**8**)(**9**) and (**10**)(**11**).

5. The method of optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration as claimed in claim **1**, wherein the electrodes (**6**)(**9**)(**10**) (**7**)(**8**)(**11**) are confined when fixed polluting elements are of a radioactive nature and/or are eliminated by means adapted to fixed polluting elements and to the level of polluting effect thereof.

6. The method of optimizing the yield of the electroextraction of heavy metals in an aqueous solution with a high salt concentration according to claim **1**, wherein the operation can be carried out by alternating successive cycles or continuously, in this latter case, the supply of the solution to be treated is carried out through the bottom of the electrolysis tank and at slow speed and determined according to the chemical composition of the solution to be treated and the texture of the electrodes (**6**) to (**11**) of the device, with the evacuation of the treated solution being carried out in the top portion of the electroplating tank by a duct provided for this purpose.

7. Device for the implementation of the method according to claim **1**, wherein the device comprises:

a) electronic control means (CM) for the management, control and regulation of the operations linked to the extraction of the heavy metals via electrolysis in an aqueous solution with a high salt concentration;

b) immersed electrodes (**6**) to (**11**) constituted of anodes (**6**) (**9**) (**10**) and of cathodes (**7**) (**8**) (**11**);

c) a ground electrode in order to be introduced into the solution to be treated and increase the rapidity of the ionic degreasing of the electrodes (**6**) to (**11**);

d) sensitive probes (SP) in order to be introduced into the solution to be treated between the pairs of electrodes (**6**)(**7**), (**8**)(**9**) and (**10**)(**11**); and

e) at least one electrofiltration filter (EFF) in order to fix the residual elements with a weak electromotive force that are still present in the solution after the differential electroplating operation.

8. The device for the implementation of the method according to claim **7**, wherein the immersed anode electrodes (**6**) (**9**) (**10**) are of a material and texture that are different from those of the immersed cathode electrodes (**7**) (**8**) (**11**), according to the chemical and radiochemical composition of the solution to be treated.

9. The device for the implementation of the method according to claim **7**, wherein the ground electrode introduced into the solution to be treated inside an insulating tube in order to prevent an electronic distortion and connected to the ground (G) of the electric generator, is of a material and texture that are different from those of the other electrodes.

10. The device for the implementation of the method according to claim **7**, wherein the sensitive probes (SP) introduced into the solution to be treated, between the pairs of electrodes (**6**) (**7**), (**8**) (**9**) and (**10**) (**11**), are of a chemically neutral texture and for example made of glass.

11. The device for the implementation of the method according to claim **7**, wherein the electrofiltration filter (EFF) that is independent and associated with the electrolysis tank in order to fix the residual elements with a weak electromotive force that are still present in the solution after the differential electroplating operation, is mainly consisted of a cylindrical container (C) containing a neutral filtering material (FM) wherein are plunged two electrodes (EC), of which one is thrust on the inside peripheral plane of the container (C) and the other is thrust on an axial support tube (ST) located at the center of the inner surface of the lower plane of the container (C), with the electric current passing through the filtering material (FM) being regulated according to the chemical composition of the solution exiting from the electrolytic treatment container and adapted to the resistivity of the whole knowing that the conductivity of the filtering material (FM) varies according to the more or less aqueous liquid that it contains, with the solution filtered by its passing through the electrofiltration filter (EFF) then having an optimum quality allowing for the discharge thereof into the environment or for example the reuse thereof in another method of manufacturing.

12. The device for the implementation of the method according to claim **7**, wherein the immersed anode electrodes (**6**) (**9**) (**10**) are of a material and texture that are different from those of the immersed cathode electrodes (**7**) (**8**) (**11**), according to the chemical and radiochemical composition of the solution to be treated and are constituted in the form of plates, of a composition, material, configuration and arrangement that are compatible with the operation and the performance of the device.

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