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H. C. KREMERS

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ELECTROLYTIC RECTIFIER

Filed July 16, 1926

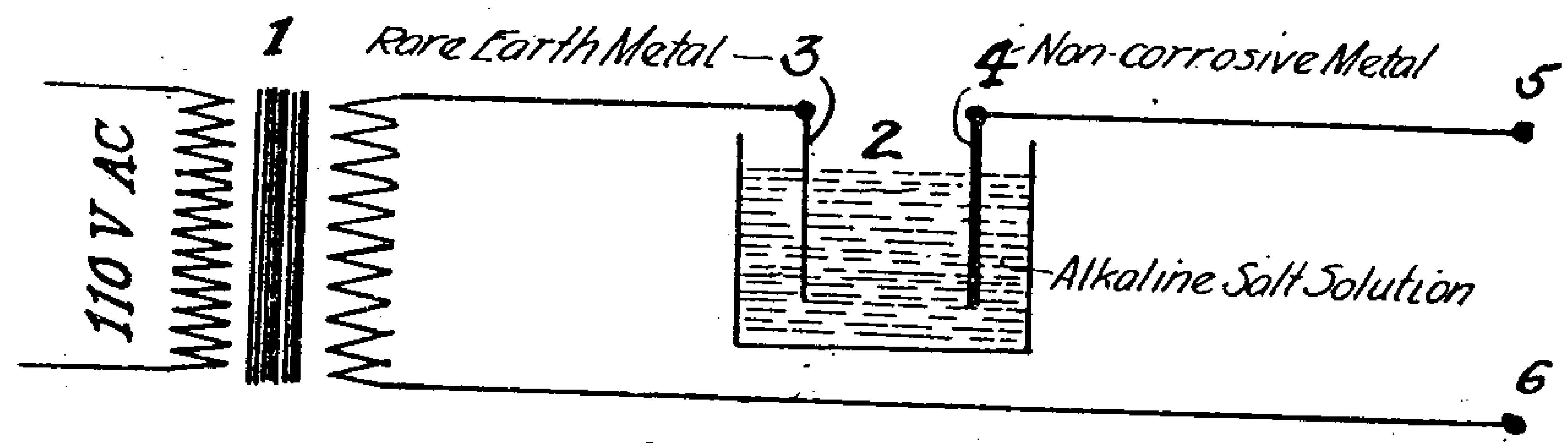

Fig 1

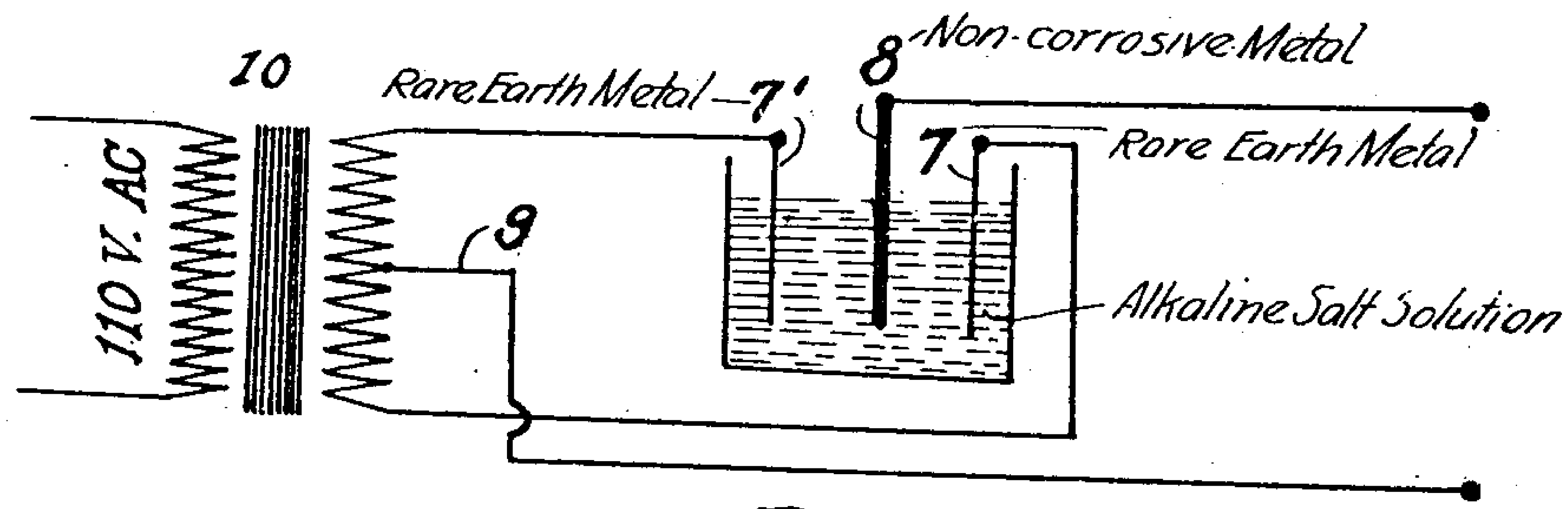

Fig 2

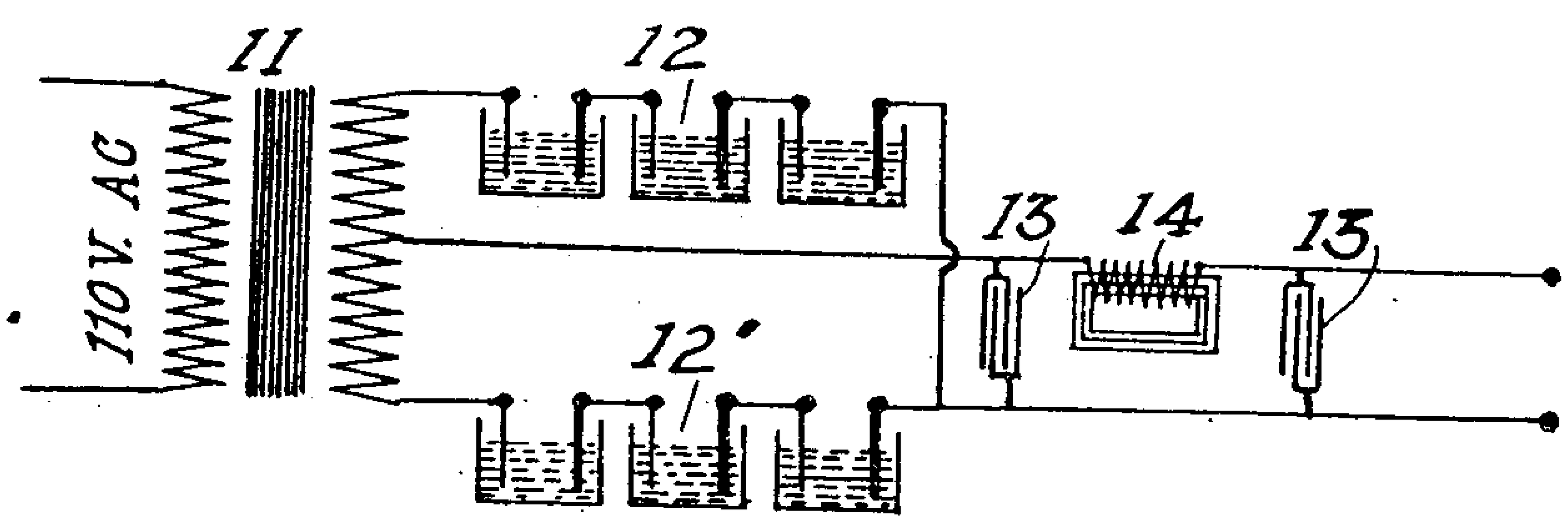

Fig 3

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ELECTROLYTIC RECTIFIER.

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This invention relates to electrolytic cells and more particularly concerns the use of such cells in connection with rectifiers of the electrolytic type.

The rare earth metals, as commonly accepted by the chemical and physical sciences, consist of a group of elements, located in the third periodic group and resembling each other rather closely chemically and physically. The rare earth group consists of the following elements arranged in three groupings; the cerium group, including lanthanum, cerium, praseodymium, neodymium, illinium and samarium; the terbium group, including europium, gadolinium, terbium; and the yttrium group, including dysprosium, holmium, yttrium, erbium, thulium, ytterbium, lutecium and scandium.

In the occurrence of these elements in nature, the cerium group with small amounts of the terbium group and in most cases with lesser amounts of the yttrium group is found in such minerals as monazite sand, cerite, etc. Likewise the yttrium group with small amounts of the terbium group and still lesser amounts of the cerium group is found in minerals such as gadolinite, fergusonite, etc.

Thus there can be obtained without much effort two rather distinct groups of rare earth metals: the cerium group proper with some terbium group material, and the yttrium group proper, also with some terbium group material. With the exception of cerium, the separation and preparation of the individual elements of any one of the three groups mentioned is a very slow and difficult task. Since the elements of the cerium group are so similar in nature, the entire group may be reduced to metal. This metal appears on the market in an alloy known as misch metal (mixed metal). The chemical properties of misch metal are quite similar to that of any one of the individual elements. This commercial misch metal as it appears on the market has usually the following approximate composition: lanthanum—20%, cerium—35%, neodymium—20%, praseodymium—5%, samarium—10%, terbium group—7% and yttrium group—3%. The yttrium group has also been reduced to metal in an experimental way only and called "yttrium mixed metal".

In experimenting with various alloys of the rare earth metals, and particularly misch metal, it has been discovered that if two brightly polished plates of such metal are placed in an electrolytic solution and the two plates connected to the terminals of an electric battery or other source of unidirectional voltage, an instantaneous flow of current occurs. After a few minutes the current is found to drop off to a negligible value, such as a few milli-amperes, the drop in the current being accompanied by, and apparently due to, the formation of a film of oxide on the metal anode, that is, the rare earth metal plate which is connected to the positive battery terminal. If the metal anode is allowed to tarnish or oxidize in air before it is submerged in the electrolyte, the current flow is very small or negligible when the battery is first connected thereto.

It has been further observed that the rare earth metal plate which is used as a cathode, that is, the plate connected to the negative battery terminal, acts as a good conductor of electric current from the electrolyte. Thus, it is seen that the rare earth metals behave as conductors when they function as cathodes and behave as non-conductors when they function as anodes.

The anode used to produce this effect may be composed of any one of the rare earth metals alone, such as cerium, lanthanum, praseodymium or neodymium, or may comprise an alloy of one of these metals or an alloy of misch metal. The electrolyte used may be a solution of sodium or potassium hydroxide, sodium phosphate, borax, boric acid or certain neutral or alkaline salt solutions or mixtures composed of alkalies and salts.

If a cell using a non-corrosive or non-filming electrode or plate such as lead or carbon, a misch metal plate and an electrolyte, (as mentioned above), preferably sodium hydroxide solution, is connected by means of the lead and misch metal plates to an alternating current of a suitable voltage, the current flow in one direction is almost entirely shut off and a direct pulsating current is obtained. In such an arrangement the flow of current is accompanied by an electrolytic action in the cell, with evolution of hydrogen gas at the misch metal and oxygen gas at the lead. The action of the misch metal (or other rare earth metals) is such that electrons are permitted to flow from the misch metal plate to release hydrogen ions but are prevented from passing from oxygen ions into the solution.

It is an object of the present invention to provide an electrolytic rectifier employing as an electrode one of the rare earth metals or an alloy or mixture of several or all of such metals, together with a suitable electrolyte.

It is a further object of this invention to provide an electrolytic rectifier of this type which may be used to convert an alternating current into a unidirectional current which is suitable for charging storage batteries, operating radio apparatus and for other purposes.

It is further contemplated to provide the electrolytic cell employing electrodes of rare earth metal or metals which may be used as a lightning arrester, as an electrolytic condenser or for any other purpose or function to which electrolytic cells are applicable.

In describing the invention in detail, reference will be made to the accompanying drawings, in which

Figure 1 represents, in a diagrammatic and simplified manner, an electrolytic rectifier embodying the present invention;

Figure 2 represents a modified form of electrolytic rectifier designed to rectify the full alternating current wave; and

Figure 3 shows a further modification of the invention employing a multiplicity of electrolytic cells connected in series and provided with means for eliminating undesirable fluctuations in the output current.

The electrolytic cell of the present invention will now be described as used in connection with the rectification of alternating currents, it being understood that this represents only one manner in which this cell may be employed, and that the cell may be used in various other ways. In Fig. 1 of the drawings, a source of alternating current is connected as shown to the primary winding of the transformer 1, the secondary circuit of which includes in series therewith an electrolytic cell 2 comprising a suitable electrolyte as described above, a rare earth metal plate 3 and a plate 4 of carbon lead or other suitable non-corrosive material. The secondary circuit including the cell in series may be connected to the negative terminal 5 and the positive terminal 6 of the storage battery whereby such battery may be charged, or this secondary circuit may be connected to any other device, circuit or apparatus requiring a unidirectional current for its operation. The cell 2 being in series in the secondary circuit allows current to flow in one direction only, thus rectifying one half of the alternating current waves.

By the use of two plates of rare earth metal, shown at 7 and 7′ in Fig. 2, with a single plate 8 of carbon, lead or other suitable material, the full alternating current wave may be rectified. In this arrangement, the plates 7 and 7′ are connected to the opposite terminals of the secondary winding of the transformer 10, the direct current output circuit being connected between the carbon plate 8 and a center tap 9 of the transformer secondary. In this arrangement current may flow from the tap 9 through the external direct current circuit, returning to one or the other of the plates 7 and 7′ through the carbon plate 8 and the electrolyte, the return of the current in the reverse direction being prevented by the action of the rare earth metal electrodes as described above.

In the modification shown in Fig. 3, the secondary winding of a transformer 11 has its terminals connected to two batteries, 12 and 12′ of electrolytic cells of the type described, the individual cells of each battery being connected in series. The return of the direct current output circuit is connected to a center tap of the transformer secondary, and the operation of this arrangement is similar to that of the arrangement shown in Fig. 2. The output circuit of this rectifier may be provided with a suitable filter circuit, such as the condensers 13 and 13′ and the series connected choke coil 14, this filter circuit acting in the well known manner to suppress or choke out variations or ripples in the rectified current. The form and arrangement of the rectifier shown in Fig. 3 is particularly applicable to radio work in which a comparatively high voltage is required in connection with the well known A and B circuits of audion tubes. The use of several cells in series permits the rectification of a comparatively high voltage, as the voltage of the secondary circuit is distributed over several cells in series.

It has been found that various alkaline solutions may be used as the electrolyte in the electrolytic cells of the present invention. One solution which gives very satisfactory results is a 25% solution of sodium hydroxide and water, although various other sodium hydroxide solutions give satisfactory results.

The rectifier constructed in accordance with the present invention has many advantages over the now known types of electrolytic rectifiers. The efficiency of the present rectifier is found to be very much better than the efficiency of the usual aluminum element rectifier, being substantially equal to the efficiency of a rectifier of the electron valve, or tantalum electrode type. In addition, the rectifier of the present invention can be manufactured at a much lower cost than can the rectifiers of the electron valve or tantalum type, the misch metal being readily obtainable at a comparatively low price.

The rectifiers constructed in accordance with the present invention are particularly applicable to use in connection with charging storage batteries, in electro-deposition of metal, and in other electro-chemical reactions, and also in radio work, but these rectifiers are also well adapted for use wherever direct current is required and an alternating current supply is available. The electrolytic cells may also be used in electrolytic lightning arresters of the well known type, two rare earth metal plates or electrodes being submerged in a suitable electrolyte and acting to resist the flow of current until a predetermined high voltage is impressed between the plates.

Although the present invention has been described in connection with certain specific apparatus and devices, it should be understood that the cell of the present invention, and the action between the rare earth metals and the electrolyte therein is capable of general application, and the invention is therefore not limited to the specific embodiments shown. The cells may be provided with any suitable number and arrangement of both rare earth metal and non-filming electrodes, the metal used for the filming electrode may be varied as described above, and the electrolyte used may be any suitable alkaline salt solution. Moreover, the connection between the electrodes and the cells may be varied to suit the desired operation of the device, and many other changes, modifications and combinations may be made without departing from the scope of the invention as defined by the appended claims.

I claim:

1. In an electrolytic cell, a filming electrode of rare earth metal.

2. In an electrolytic cell containing an electrolyte, a filming electrode composed at least in part of rare earth metal.

3. In an electrolytic cell containing an electrolyte of alkaline salt solution, a filming electrode of rare earth metal including cerium.

4. In an electrolytic cell containing an electrolyte and having at least one electrode of non-filming conducting material, a filming electrode of rare earth metal.

5. In an electrolytic cell containing an electrolyte and having at least one electrode of non-filming conducting material, a filming electrode containing cerium.

6. In an electrolytic cell containing an electrode of non-corrosive metal and an electrolyte of alkaline salt solution including sodium hydroxide, a filming electrode composed at least in part of cerium.

7. In an electrolytic cell having an electrode of non-corrosive metal and an electrolyte including sodium hydroxide, a filming electrode comprising a mixture of rare earth metals from the cerium, terbium and yttrium groups.

8. In a rectifier comprising a source of alternating current and an electrolytic cell connected in series therewith, a filming electrode composed at least in part of rare earth metal.

9. In an electrolytic cell having an electrode of lead submerged in an electrolytic solution including sodium hydroxide, a filming electrode composed of rare earth metals including cerium, lanthanum and neodymium.

10. A filming electrode composed of rare earth metal.

11. A filming electrode composed at least in part of cerium.

12. A filming electrode composed of rare earth metals from the cerium, terbium and yttrium groups.

13. A filming electrode composed of rare earth metals including cerium, lanthanum and neodymium.

In testimony whereof I affix my signature.

HARRY C. KREMERS.