June 5, 1934. E. A. HARTY 1,961,825

TELLURIUM ALLOY RECTIFIER

Filed May 10, 1932

Fig. 1.

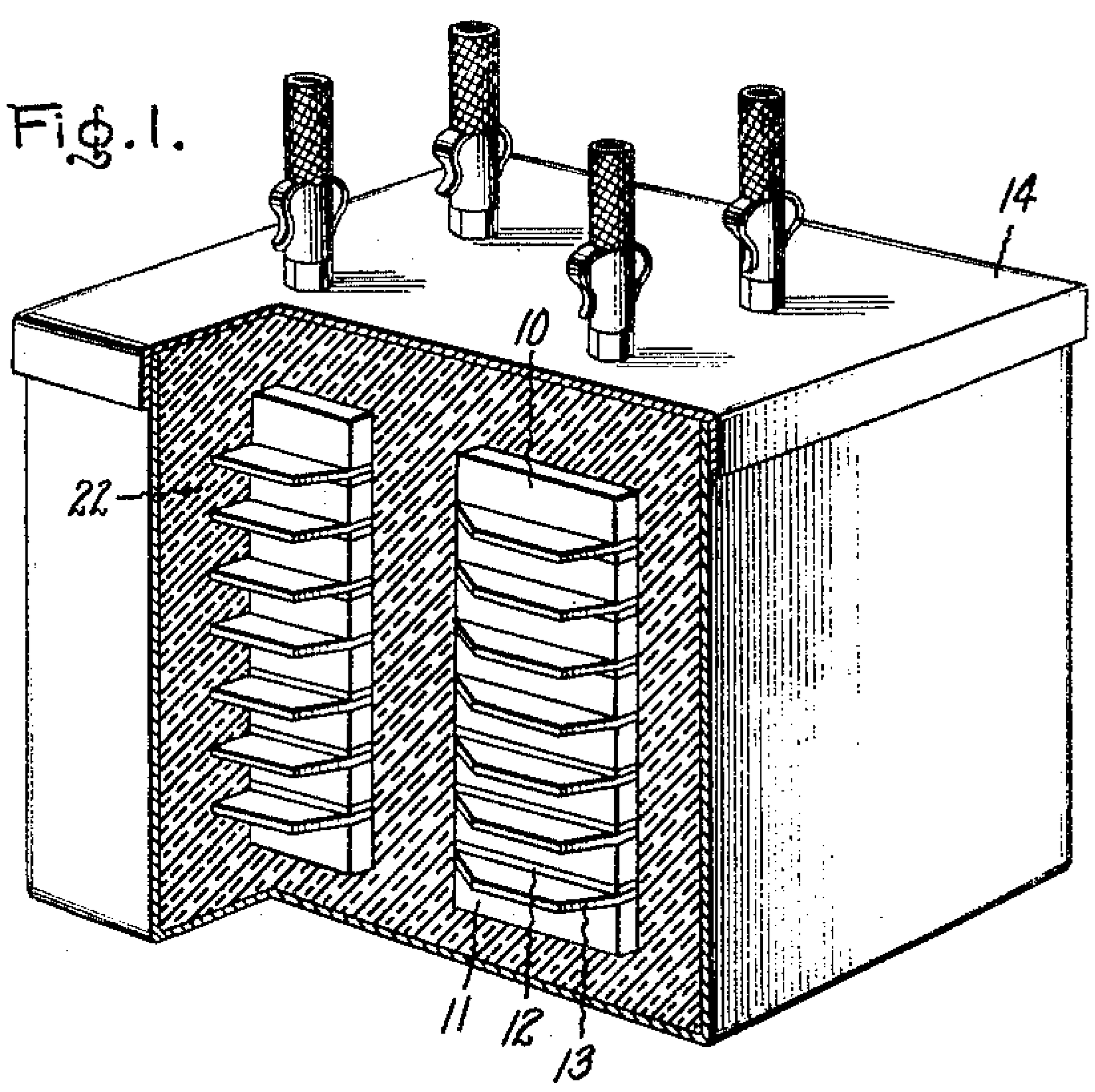


Fig. 2.

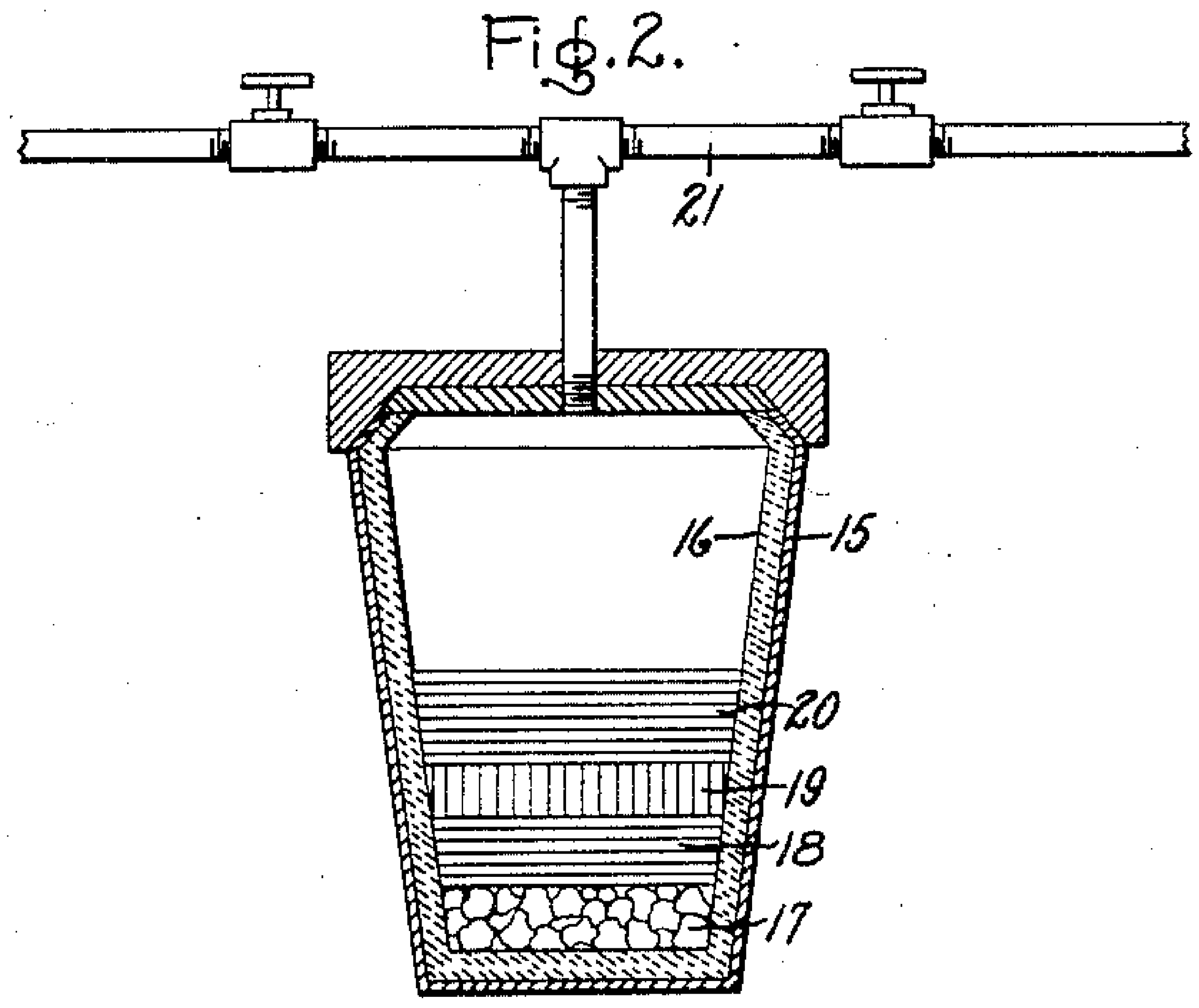
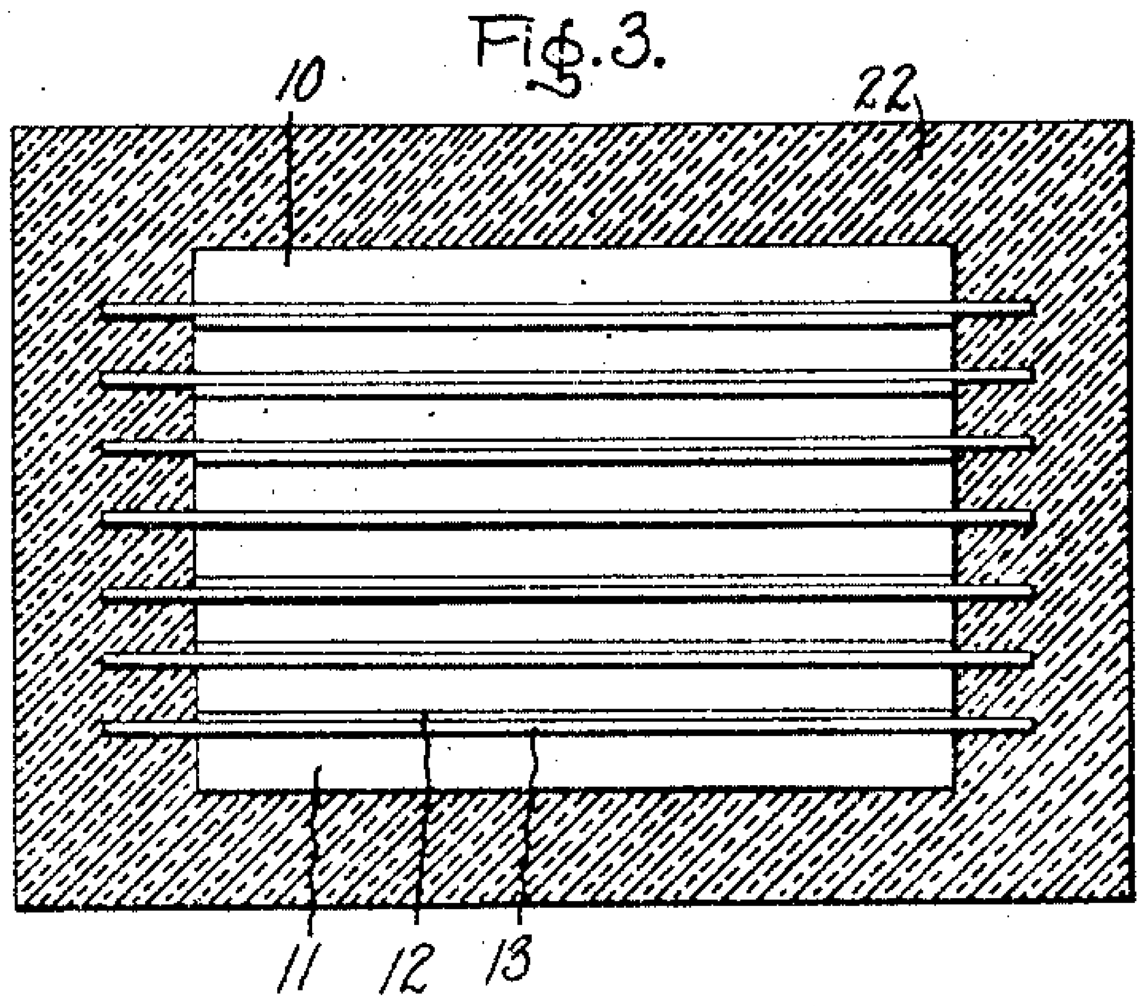


Fig. 3.



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TELLURIUM ALLOY RECTIFIER

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15 Claims. (Cl. 175—366)

My invention relates to alternating current rectifiers of the type which comprises a plurality of conductive members spaced apart by a thin film or spacer of insulating material, and particularly to such rectifiers comprising a plurality of elements composed of tellurium alloy in contact with a plurality of elements composed of another metal, such as magnesium, which has a readily formed and stable oxide.

Rectifiers employing tellurium alloy elements have been disclosed in Letters Patent to Hollnagel and Winckler, No. 1,866,351, filed January 29, 1927, and issued July 5, 1932. It is the object of my present invention to provide an improved method of constructing the active elements of rectifiers of the tellurium type such as disclosed in the above-mentioned patent of Hollnagel and Winckler.

My invention will be better understood from the following description when considered in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Referring to the drawing, Fig. 1 illustrates a rectifier enclosed within a container and embodying tellurium alloy elements constructed in accordance with my invention; Fig. 2 illustrates apparatus utilized in carrying out a process of forming tellurium alloy elements in accordance with my invention; and Fig. 3 illustrates a rectifier similar to that shown in Fig. 1 but having a casing formed of a synthetic resin material.

In Fig. 1 is shown a rectifier unit 10 adapted to be connected to suitable circuits (not shown) and comprising a plurality of elements 11 made of tellurium alloy each in contact with a magnesium sheet 12, the magnesium sheets being in contact with copper sheets or blades 13. The rectifier assembly 10 is mounted within a casing 14 in a manner and for a purpose to be explained more fully hereinafter.

In forming the tellurium alloy elements 11 it has been proposed to use a combination of tellurium, copper, and a small quantity of sodium. When the sodium was introduced into the alloy, however, a more or less violent reaction took place accompanied by sputtering of the alloy. I have developed a method of treatment of the tellurium alloy materials whereby the violence of the reaction is minimized.

For the preparation of the alloy, in accordance with my invention I employ the apparatus shown in Fig. 2 wherein 15 represents a metal autoclave lined with refractory material 16, or an autoclave having placed therein an enamelled crucible with cover. The sodium 17 is placed in the bottom of the crucible or lined autoclave, then a layer of broken tellurium metal 18 is placed on the sodium, the copper 19 is added, and the remaining tellurium 20 is placed on top of the copper. The autoclave is then sealed and by means of suitable piping 21 the air is evacuated and nitrogen under a pressure of 5 to 10 lbs. per square inch is introduced. The autoclave is then heated and maintained at a temperature of 600° C. for a time sufficient to insure that its interior reaches that temperature.

The purpose of placing the material in the autoclave is to prevent sputtering of the alloy which takes place as soon as the sodium and tellurium melt, the combining of these elements being accompanied in the autoclave by a somewhat violent explosion. The nitrogen is employed to prevent losing any sodium, which might combine with oxygen present in air; the nitrogen further acts as a cushion to reduce the violence of the explosion. As soon as the interior of the autoclave has reached 600° C., all of the elements placed therein are in a molten condition and no more sputtering occurs. The heat is then turned off, the nitrogen is exhausted, and the autoclave is opened. In order to open the autoclave it is necessary to allow air to flow into the vessel. Otherwise it will be difficult or impossible to open the vessel because of the vacuum which will be present. The piping system illustrated in Fig. 2 permits the ready introduction of air into the vessel for the above purpose. After the autoclave is opened a quartz stirring rod is used to stir up the melt to ensure that a thoroughly mixed alloy will be obtained. No heat is applied to the mixture after the autoclave is opened. When the temperature of the melt reaches 450° C. it is poured into a suitable preheated die which permits the casting of flat plates of tellurium alloy, for example plates ⅛″ x 1″ x 1″.

After preparing the cast alloy plates it is necessary to grind the plates in order to make them sufficiently flat. The grinding operation is performed preferably by means of a suction holder in which several of the alloy plates are ground at a time against a rotating flat plate on which #1 or #2 sandpaper is glued.

The magnesium plates 12 of rectangular shape, for example 1″ x 1½″ and .015″ thick, are punched out by means of a suitable die and are pressed in order to present a flat surface. Grease is removed from the surface of the magnesium plate by washing the plates in alcohol and drying with tissue paper, and glaze and oxide are removed by rubbing the plates on #0 sandpaper.

The electrochemical formation of rectifier elements or cells each comprising a tellurium alloy plate 11 and a magnesium plate 12 consists in first wetting the surface of the magnesium with distilled water to obtain a uniform film. The tellurium alloy plate, which was previously ground flat as above described, is then placed on the wetted magnesium surface, care being taken that no relative motion takes place between the plates. This combination element or cell constituted by a single tellurium alloy plate 11 in contact with a single magnesium plate 12 is placed in a holder under a pressure of the order of 5 pounds and an alternating current of about 4 amps. at from 5 to 8 volts is caused to pass through it. This process causes a film to appear between the tellurium alloy and the magnesium, the film having very marked rectifying properties. At the start of the operation the alloy and the magnesium react and a black film appears. However, the heat of the current dries up the water and a welding action then takes place. This welding action starts at the center of the plates and travels around the united surfaces of the plates until after about an hour the welding effect is visible around the edges. This action has a tendency to weld the tellurium alloy and magnesium together so that a single rectifying unit is obtained, or single rectifier cell, which may be utilized in any desired rectifier combination. For example rectifier units so formed may be used under the severe conditions of battery charging in which the voltage impressed upon the rectifier when its anode is negative, being equal to the sum of the line voltage and the battery voltage.

Tellurium alloy elements for rectifier use have comprised heretofore a large proportion of tellurium, for example 93 parts, and a relatively small proportion of copper, for example 7 parts, the copper being added to compensate for the high resistance of the tellurium when used alone. I have found, however, that the rectifying action of the tellurium alloy elements is markedly improved by forming the alloy of tellurium, copper and silver. Thus a rectifier comprising, in accordance with my invention, alloy elements having substantially 97½ parts tellurium, 2 parts copper and 2½ parts silver shows in operation a considerable decrease in cell drop and leakage current over the rectifiers hereinbefore described having tellurium and copper alloy elements. In some instances I have found it desirable to form the alloy of substantially 97½ parts tellurium, 2 parts copper, 2½ parts silver, and ½ part sodium.

In developing the tellurium alloy rectifier it was observed that rectifier elements not on load and unheated had a tendency to absorb moisture from the atmosphere and that the film present between the tellurium alloy and the magnesium elements became powdered. It was found that moisture creeping between the rectifier plates caused the powdering trouble. To avoid this difficulty it has been suggested to seal up the edges of the rectifier elements by means of varnishes, for example varnishes formed of phenolic compounds. The direct current characteristics of the tellurium rectifier cells indicated, however, an increased cell drop and leakage with time, whether the edges of the cells were sealed with varnish, as suggested, or were left unsealed.

In order to avoid the above difficulty due to absorbed moisture between the tellurium alloy plate and the magnesium plate, in accordance with my invention I place the rectifier unit 10 in a container 14 and seal the cells formed by the rectifier elements 11, 12 by filling the container with a suitable compound 22. The rectifier is connected across a battery in such a way as to cause the leakage current to flow thereby heating the rectifier elements, and the hot compound is poured into the container while the current is flowing through the rectifier.

A sealing compound to be satisfactory for the purpose of protecting the tellurium alloy and magnesium rectifier cell from the effects of moisture must have the following properties:—it must be stable and not decompose chemically at the operating temperature of the rectifier, 50° to 60° C.; it must be hard or pasty at this operating temperature; it must not contain free acid, such as hydrochloric acid, having a tendency to attack the magnesium element.

The effectiveness of this method of sealing the rectifier elements against powdering of the film between the tellurium alloy and the magnesium by moisture is such that after 2000 hours exposure to moist atmosphere no change occurs in the direct current characteristics of the rectifier. Rectifiers in their unsealed state can not be operated intermittently since as above explained they absorb moisture during the idle periods and cease to rectify. Unsealed units when run continuously are hot and, therefore, under usual favorable atmospheric conditions cannot absorb sufficient moisture to damage them, but under unusual conditions, such as operating the unsealed units in a damp cellar, these unsealed units absorb moisture even while heated by the current, and stop rectifying. However, rectifier units sealed, in accordance with my invention, in a casing filled with compound as shown in Fig. 1, and operated under the above extreme conditions of dampness show no changes whatever.

In Fig. 3, instead of mounting the rectifier units 10 comprising the tellurium alloy plates 11, magnesium plates 12 and copper sheets 13 in a metal or other container filled with sealing compound as shown in Fig. 2, the rectifier unit is molded, in accordance with my invention, in a synthetic resin compound 22 preferably of the type comprising phenol-aldehyde condensation products. The synthetic resin compound seals the rectifier elements from the deteriorating effects of moisture, and on hardening forms in itself a casing for the rectifier unit or units. Thus is produced a compact unitary rectifier structure which may include connection means such as prongs (not shown) molded into the resin and similar to those of a vacuum tube, the rectifier structure then being capable of being plugged into a suitable outlet or socket as on the transformer of a loudspeaker or the like.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a rectifier, a tellurium alloy element comprising a relatively large proportion of tellurium, a relatively small proportion of copper, and a relatively small proportion of silver.

2. In a rectifier, a tellurium alloy element comprising tellurium, copper, silver, and a relatively small portion of sodium.

3. In a rectifier, a tellurium alloy element comprising substantially 97½ parts of tellurium, 2 parts of copper, and 2½ parts of silver.

4. In a rectifier, a tellurium alloy element comprising substantially 97½ parts of tellurium, 2 parts of copper, 2½ parts of silver and ½ part of sodium.

5. The process of manufacturing a tellurium alloy element for an alternating current rectifier, said alloy including copper and a relatively small portion of sodium, which comprises melting the constituents of said alloy in an atmosphere of nitrogen.

6. The process of manufacturing a tellurium alloy element for an alternating current rectifier, said alloy including a relatively small portion of sodium, which comprises heating the constituents of said alloy in an atmosphere of nitrogen to a temperature of the order of 600° C.

7. The process of manufacturing an alternating current rectifier element including tellurium and sodium which comprises heating said tellurium and sodium in an atmosphere of nitrogen.

8. The process of manufacturing an alternating current rectifier element including tellurium, copper, and sodium which comprises heating said tellurium, copper and sodium in an atmosphere of nitrogen.

9. The process of manufacturing an alternating current rectifier element including tellurium, copper and sodium which comprises heating said metals in an atmosphere of nitrogen to a temperature of the order of 600° C.

10. The process of manufacturing an alternating current rectifier element including tellurium and sodium which comprises placing said sodium in the bottom of an autoclave, placing said tellurium above said sodium, evacuating the air from said autoclave, introducing nitrogen into the interior of said autoclave, and heating said autoclave long enough to produce a temperature in the interior thereof of the order of 600° C.

11. The process of manufacturing an alternating current rectifier element including tellurium, copper and sodium which comprises placing said sodium in the bottom of an autoclave, placing a portion of said tellurium on said sodium, placing said copper on said portion of the tellurium, placing the rest of the tellurium on said copper, evacuating the air from said autoclave, introducing nitrogen at a pressure of the order of 5 to 10 pounds per square inch into the interior of said autoclave, and heating said autoclave long enough to produce a temperature in the interior thereof of the order of 600° C.

12. A rectifier unit comprising a plurality of elements of the tellurium-copper alloy type, said alloy including a portion of silver, each of said elements being in contact with an element composed of another metal forming a film between said alloy and said other metal, means to protect said film from the effects of absorbed moisture including a casing containing said element and a compound within said casing to seal the contacting edges of said element.

13. A rectifier unit comprising a plurality of elements of the tellurium-copper alloy type, said alloy including a portion of silver, each of said elements being in contact with an element composed of another metal forming a film between said alloy and said other metal, means to protect said film from the effects of absorbed moisture including a mass of synthetic resin of the type comprising phenol-aldehyde condensation products in which said elements are molded.

14. The method of protecting the film between tellurium alloy elements and magnesium elements of a rectifier from the effects of moisture which comprises passing a heating electric current between said elements, and embedding said elements in a sealing compound while said current is flowing.

15. The method of preventing the powdering of the film between tellurium-alloy elements and magnesium elements of a rectifier due to the effects of moisture, which comprises causing leakage current to flow between said elements to heat said element, and pouring hot sealing compound about said elements while said elements are heated by said leakage current.

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