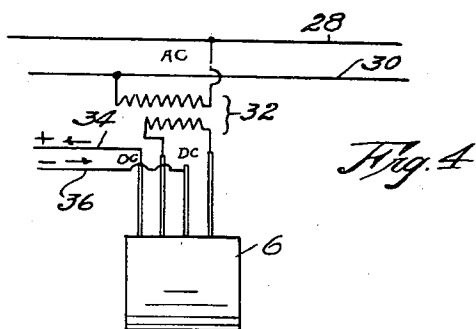
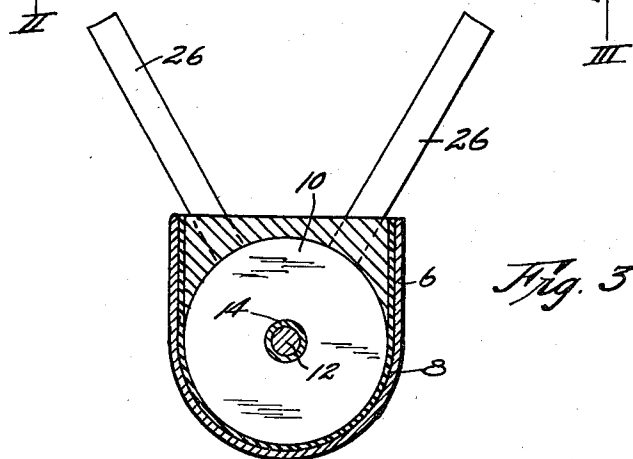
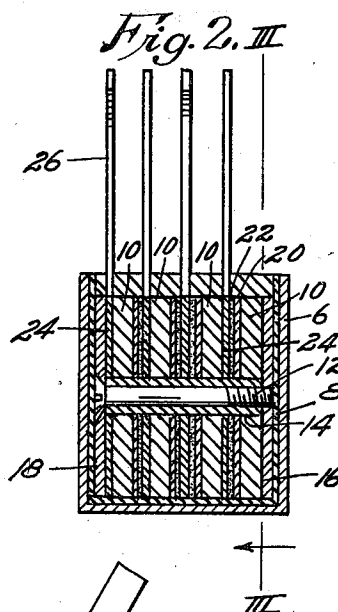
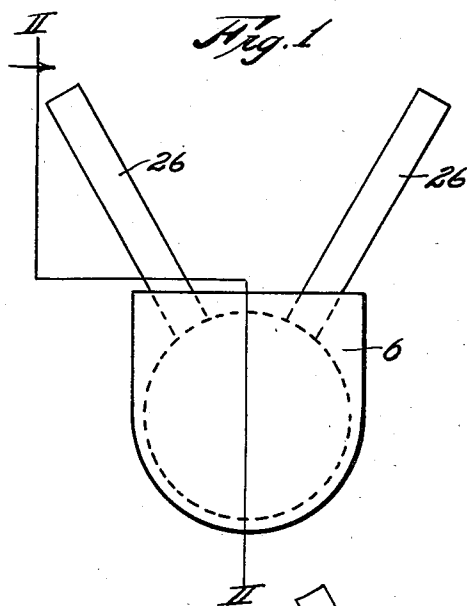


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UNIDIRECTIONAL CURRENT CARRYING DEVICE AND
PROCESS OF PRODUCING THE SAME
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UNIDIRECTIONAL CURRENT-CARRYING
DEVICE AND PROCESS OF PRODUCING
THE SAME

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7 Claims. (Cl. 175—363)

This invention relates to unidirectional current-carrying devices and the method of manufacturing the same, and particularly the method of forming the electrode elements for the unit, and the primary object of the invention is to provide such a device, known in the trade as a rectifier, which will have structural characteristics contributing to the high efficiency and extreme durability, lasting throughout a long period of time and through wide ranges of load, frequencies and temperatures.

A yet further object of the present invention is the provision of a rectifier of the aforementioned character that is adaptable for service requiring electrical characteristics that are stable and which respond effectively to currents of high frequency without being broken down or otherwise damaged by overloads.

It is an established fact that the unidirectional property of rectifiers forming the subject matter of this invention depends entirely upon the physical nature of the junction between the compound layer and the copper, or similar material, upon the surface of which the said compound is formed. When used as a rectifier, the current passes through the junctions and the resistance to said current is increased or decreased, according to the direction of flow.

One of the important aims of this invention, therefore, is to provide a rectifier wherein this aforesaid function is created in a particular manner through the employment of specific steps, all as will be more fully hereinafter set down in the specification, referring to the accompanying drawing, wherein:

Figure 1 is an end elevation of a rectifier made to embody this invention.

Fig. 2 is a vertical, sectional view through the same, taken on line II—II of Fig. 1.

Fig. 3 is a vertical, cross section through the rectifier taken along line III—III of Fig. 2, and,

Fig. 4 is a wiring diagram showing the manner in which a rectifying unit embodying this invention is connected for actual use.

In following the method contemplated, there should be utilized certain equipment in the nature of a furnace which will be constructed so that the necessary high temperature might be attained with a minimum of current consumption. A predetermined number of the electrode blanks may constitute a charge for this furnace and the furnace chamber should be so made that the charge of blanks practically fill the same. Suitable insulation must be provided to preclude excessive heat radiation, for, as will be more fully set down

later, the temperature in the furnace chamber should rise and fall and be controlled so that the operator will have definite knowledge as to the action throughout the entire time. The furnace must have means for circulating a current of pre-heated air about the charge of blanks as they are being treated therein.

The quenching baths used and hereafter mentioned and claimed should be first a heavy hydrocarbon oil such as ordinary heavy automotive lubricating mineral oil that is maintained at a temperature of at least 70 degrees C., and secondly, a relatively light hydrocarbon such as kerosene, which is not heated above atmospheric or room temperature.

The method of forming the electrode elements has, as a necessary first step, the selection of satisfactory metal, which should be a sheet copper stock containing impurities of silver, iron, nickel, lead or tin, totaling in aggregate to not over one-tenth of one percent by weight of the said metal. The thickness of the stock used should be chosen so that it is at least an amount equal to ten percent of the diameter of the finished electrode element so as to minimize deformation at the temperatures employed in the forming of the compound.

As before mentioned, the blanks are introduced into the furnace in charges of a predetermined number, but first should be flattened and cleaned. The introduction into the furnace may be made by supporting the blanks on racks made of material which will resist oxidation at the temperature of the furnace.

The furnace is first heated to a temperature of substantially 1060 degrees C.; the charge of blanks is introduced without pre-heating and at their normal or atmospheric temperature. The relatively cold blanks, upon introduction into the furnace, will absorb a sufficient amount of heat to cause the furnace temperature to drop to 1000 degrees C. As heat is applied to the blanks in the furnace to slowly raise the temperature toward the starting point, a current of pre-heated air is caused to slowly circulate around the blanks to prevent voids or any static condition and to establish the means for forming cupric oxide and cuprous oxide, as well as the oxides of the contained silver, iron, nickel, lead and/or tin. All of said compounds continue to form as the temperature rises in the furnace and, as is well known in the art, when 1040 degrees C. is reached, the cupric compound begins to decompose into the cuprous compound and oxygen. Above this point of 1040 degrees C. the cupric compound proceeds

to decompose into the cuprous compound and oxygen and the surface of the compound coating presents a distinctly glazed appearance indicating that the compound is in a molten or semi-molten state.

From seven to ten minutes' time is required to raise the temperature of the charge and the furnace together back to the starting point of 1060 degrees C. After this length of time, and after the said high temperature is again reached, the charge of blanks are removed from the furnace and another charge of cold blanks introduced to start the operation over again. Through such action it is apparent that the furnace may be used continuously and will be held within its operating range without the loss of time between charges.

As the next step respecting the method of forming the electrode elements, the treated blanks are allowed to cool in the air to just below the reducing temperature, or to a temperature of about 600° degrees C. It is advisable at this point to quench the plates in a non-oxidizing bath of heavy hydrocarbon in the nature of a mineral oil which has been heated to a temperature near its boiling point. This bath of hydrocarbon should have a temperature of at least 70 degrees C. When the plates have reached the temperature of the oil bath, the blanks must be removed and further cooled to room temperature in a relatively light hydrocarbon oil in the nature of kerosene and thereafter thoroughly cleaned to make ready for the next step.

To complete the conditioning of the electrode elements for assembly in a rectifying unit, one side of the electrode element should be completely freed of the compound formed thereon as just mentioned. The other side is merely smoothed so that the compound is flat. In treating the oxide coating, it should be ground or rubbed upon an absolutely plane surface of a slab of moderately hard graphite so that a good coating of this graphite adheres to the surface of the compound after the same is flattened. Obviously, a good contacting surface is thereby obtained. It is necessary that these elements be ground to a perfectly flat condition prior to assembly.

One form of a rectifying unit embodying the electrode elements made as just mentioned is exemplified in the accompanying drawing and comprises a case 6, that may be drawn from any suitable metal so that it will receive the parts of the unit. A lining 8 of insulating material is placed within case 6 and then the electrode elements 10 made as herein set down are threaded on a supporting bolt 12 which has a tubular sleeve 14 of insulating material passed thereover. In order to draw the electrode elements and the terminals tightly together, pressure plates 16 and 18 are employed to co-operate with bolt 12 in forming the completed unit. These pressure plates are drawn tightly together merely by tightening bolt 12 prior to the introduction of the unit into case 6.

As the method disclosed, each of the electrodes 10 has a compound 20 on one surface thereof, with a light coating 22 of graphite overlying the same and immediately adjacent to the adjoining terminal plate 24. These terminal plates 24 each have an outwardly extending arm 26 formed thereon so that the unit might be positioned in the electrical circuit.

It is a further important feature in making up a rectifying unit that these terminal plates

24 be of hard metal such as spring tempered brass that has been heavily nickel plated and polished. Pressure plates 16 and 18 should also be made of heavy steel, hardened and ground to a flat condition. The nickel plated surfaces of the pressure plates 24 lie directly against the graphite-coated compound layer that is formed on the electrode elements 10, and thus when pressure is exerted as contemplated, no distortion will take place that would be detrimental to the efficiency of the rectifier.

After the various aforementioned parts of the rectifier unit are introduced into case 6, the entire device should be coated with a good grade of lacquer or varnish to preclude destructive action of the elements.

A typical manner of positioning a rectifying unit in a circuit is illustrated in Fig. 4, wherein the A. C. supply lines 28 and 30 are in connection with a step-down transformer 32. The rectifying unit is connected across the low tension side of transformer 32 by wires which join two of the contact plates 24 through the medium of arms 26. As indicated in Fig. 2, the arms 26 that are used are the alternating current input terminals of the unit. The other arms are connected to any instrument or other device with which the unit is to be associated and the direct current passing out through wires 34 and 36 travels in the direction of the arrows and is of a positive and negative character in wires 34 and 36, as illustrated.

Rectifying units made as set down hereinabove have been found in actual use to afford advantages over other so-called "copper oxide rectifiers" in that they have a greater stability over a much longer period of time; positively permanent characteristics through the entire range or ordinary climatic temperatures and for a long period of time. The nature of the couples that are made as a result of the present method permits a more rapid exchange of copper ions and the ability to withstand great current overloads without injury is an inherent feature. The employment of a hard, unyielding and highly polished metal contact plate obtains an electrical connection that is exceptionally efficient and manifestly more permanent than metal foils which have heretofore been employed by manufacturers of such rectifying units.

The compound formed on the surface of the electrode elements is extremely hard, free of fractures, and is undoubtedly composed of cuprous oxide, copper and the oxides of the metal present in the copper itself. The compound, therefore, is in the nature of an alloy and tests indicate such is the case because the fusing point is lower than that of either the well known copper or cuprous oxide.

The conclusion must be reached that because of this fact and the structural features set down herein, the rectifying unit is of a superior character and unique to the extent that it becomes highly desirable wherever a good, durable and long life unit is necessary.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. The method of forming electrode elements for rectifiers of the kind described, which comprises heating a copper plate in a furnace having a temperature of 1060 degrees C. until a coating of oxygen compound is formed thereon; cooling the plate to the reducing temperature of substantially 600 degrees C.; thereafter quenching

the plate in a bath of heavy mineral oil having a temperature of at least 70 degrees C.; and thereafter cooling the plate to room temperature in a bath of relatively light mineral oil.

5 2. The method of forming electrode elements for rectifiers of the kind described, which comprises charging a furnace having a temperature of substantially 1060 degrees C. with a number of copper plates sufficient to immediately reduce
10 the temperature of the oven to substantially 1000 degrees C.; slowly raising the temperature of the oven and plates until a coating of cuprous oxide is formed on the plates and until the starting temperature has been reached; allowing the
15 plates to cool in the air to a temperature just below the reducing temperature; thereafter quenching the plates in a hydrocarbon bath maintained at its boiling point; and thereafter further cooling the plates to room temperature
20 in a bath of relatively light hydrocarbon.

3. The method of forming electrode elements for rectifiers of the kind described, which comprises heating a copper plate having substantially one-tenth of one percent by weight of silver, iron, nickel, lead and/or tin therein to a temperature high enough to form a coating on the said plate in the nature of cuprous oxide and the oxides of the said silver, iron, nickel, lead and tin, said coating having a fusing point lower
30 than pure copper or cuprous oxide; thereafter cooling the plate in a bath of hydrocarbon having a temperature of at least 70 degrees C.; and thereafter cooling the plate to atmospheric temperature in a bath of relatively light hydrocarbon.
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4. The method of forming electrode elements for rectifiers of the kind described, which comprises heating a copper plate at a temperature of 1060 degrees C. until a coating of oxygen compound is formed thereon; allowing the coated element to cool to substantially the reducing temperature, thereafter further cooling the said element in a hot bath of mineral oil having a

temperature of 70 degrees C.; finally cooling the said coated element in a relatively light mineral oil bath at room temperature; and then grinding the elements to a perfectly flat condition prior to use.

5. In a rectifying unit of the kind described, an electrode element comprising a copper plate having a coating of an oxygen compound of copper formed on one face thereof whereby to form a rectifying junction at the adjoining surfaces; and a relatively hard, flat highly polished nickel-plated contact plate in engagement with the surface of the said coating of oxygen compound, said oxygen compound being ground to flatness to engage said flat contact plate.
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6. In a rectifying unit of the kind described, an electrode element comprising a copper plate having a coating of an oxygen compound of copper formed on one face thereof whereby to form a rectifying junction at the adjoining surfaces; a coating of graphite overlying the coating of the oxygen compound; and a highly polished, nickel plated, rigid contact plate in engagement with the surface of said coating of oxygen compound, said coating of oxygen compound being ground flat to engage the said contact plate.
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7. In a rectifying unit of the kind described, an electrode element comprising a copper plate having not over one-tenth of one percent by weight of silver, iron, nickel, lead and/or tin and having a coating thereon of a compound composed of cuprous oxide, and oxides of the said contained silver, iron, nickel, lead and tin to form an alloy having a fusing point lower than that of either the copper or cuprous oxide; a coating of graphite overlying the coating of compound; and a highly polished, nickel plated, rigid contact plate in engagement with the surface of said coating of compound, said coating of oxygen compound being ground flat to engage the said contact plate.
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