March 18, 1930. S. RUBEN 1,751,460

ASYMMETRIC ELECTRIC COUPLE

Filed Nov. 16, 1925

Fig. 1

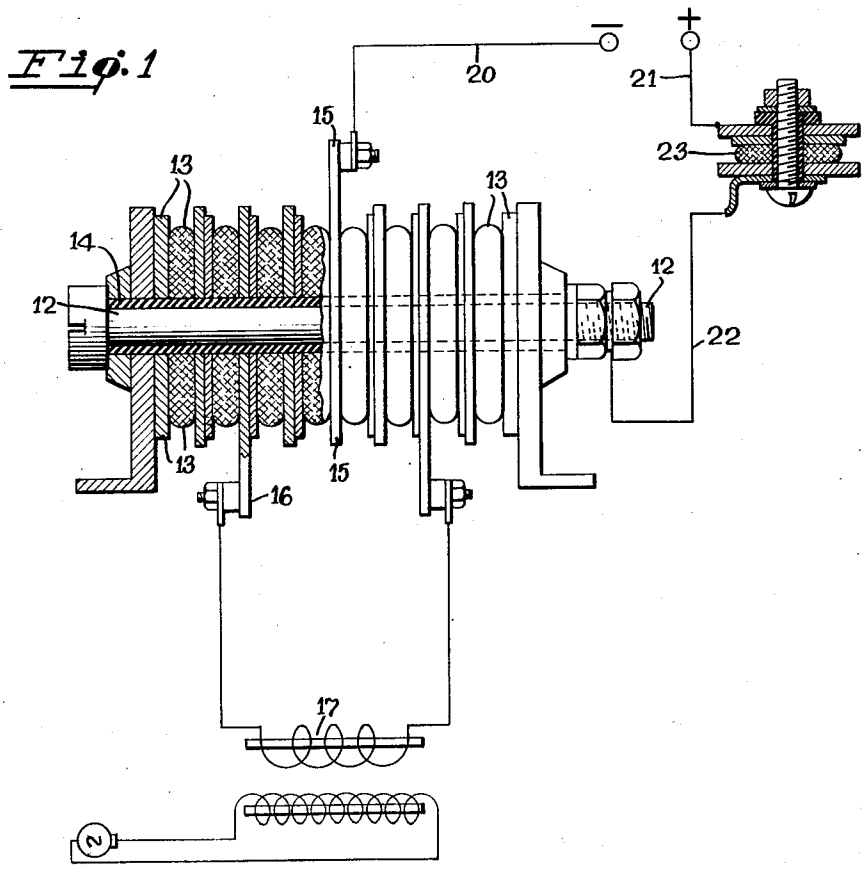
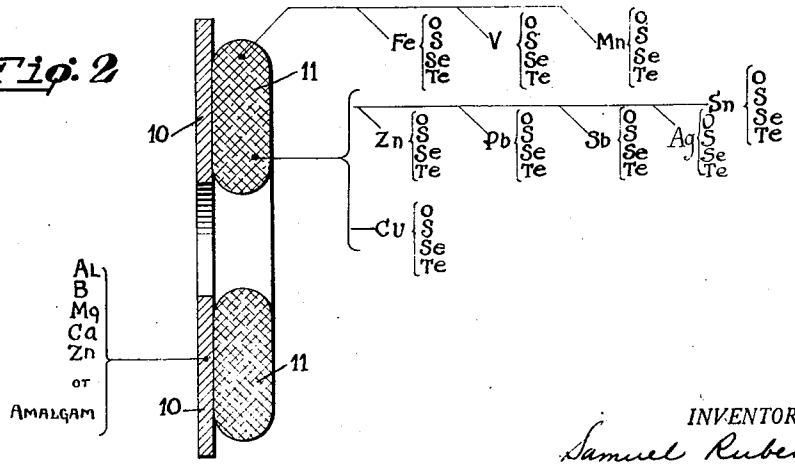


Fig. 2



INVENTOR.
Samuel Ruben
BY
Mayer Warfield & Watson
ATTORNEYS.

Patented Mar. 18, 1930 1,751,460

UNITED STATES PATENT OFFICE

SAMUEL RUBEN, OF BROOKLYN, NEW YORK, ASSIGNOR TO RUBEN RECTIFIER CORPORATION, OF ENGLEWOOD, NEW JERSEY, A CORPORATION OF DELAWARE

ASYMMETRIC ELECTRIC COUPLE

Application filed November 16, 1925. Serial No. 69,215.

This invention relates to asymmetric electric couples and more particularly to electric couples adapted to be used in alternating current rectifying devices and the like, which are of the dry surface contact variety.

Rectifiers of this type are characterized by the use of a body of electro-positive material, employed as one electrode element, disposed in electrical contact with a body of electro-negative material employed as the other electrode element. Such rectifiers depend for their operation upon the resistance and current blocking characteristics of the film which forms as the result of electro-chemical action at the junction of said electrode elements. Rectifiers of this character, known to the prior art, have been low in efficiency and limited in their application to small currents, becoming unstable after short periods of use.

The present invention accordingly has for its object, generally, to provide a device of the character specified which is efficient, economical and readily manufactured. More specifically its object is to provide a construction and arrangement of electrode elements in the electric couple which will yield a sustained rectifying effect for relatively large currents over relatively long periods of time.

This application is a continuation in part of my co-pending applications, Serial No. 739,188, filed September 22nd, 1924, now Patent No. 1,649,741; Serial No. 750,539, filed November 18th, 1924, now Patent No. 1,649,742; Serial No. 754,956, filed December 10th, 1924; Serial No. 155, filed January 2nd, 1925, now Patent No. 1,649,743; Serial No. 13,143, filed March 5th, 1925, now Patent No. 1,649,744; Serial No. 14,657, filed March 11th, 1925; Serial No. 23,582 filed April 16, 1925, now Patent No. 1,678,824; Serial No. 38,780, filed June 22nd, 1925; and Serial No. 51,524. filed August 20th, 1925.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction combinations of elements, and arrangement of parts, which will be exemplified in the constructions hereinafter set forth and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Figure 1 is a view showing diagrammatically asymmetric electric couples provided in accordance with the invention and adapted to be operated as a rectifying device; while

Fig. 2 shows schematically an elemental asymmetric electric couple of the dry surface variety devised in accordance with the invention.

Referring now to the drawing and particularly to Fig. 2, 10 denotes an electro-positive electrode element in disk form which may be made of any suitable electro-positive metal or compound. The electro-negative electrode element is also of a disk-like or washer-shaped form, and is shown at 11 in direct contact with the electro-positive element.

In the practice of the invention, the electro-negative electrode element here provided is specially formed so as to have inherently the desired reacting properties in the process of forming and maintaining the inverse current blocking film at the junction with the electro-positive electrode element without the use of an interposed resistance layer. By these properties, forming currents customarily employed in the so-called "aging" processes may be dispensed with.

This effect is accomplished by providing a metallic base which is compounded chemically with strongly electro-negative chemical elements that are adapted to provide the rectifying and current blocking properties. The electro-negative chemical elements which are to be thus compounded with the metallic base, comprise, generally, the elements of the so-called oxygen family in the sixth group in the periodic series of chemical elements. Specifically, the chemical elements of this family which may be so used are oxygen, sulphur, selenium and tellurium. In general the latter are preferable as they are more highly conducting than the former.

The metallic base of the electro-negative

electrode element is preferably of cupric origin since such metal base readily forms chemical compounds with the elements of the sixth group. In order that the electro-negative element when made from a cupric base shall not be brittle and shall be readily machinable and otherwise have a sufficient flexibility when under pressure to make a contact at substantially all points with the electro-positive element, it is preferable that the metallic base of the electro-negative element shall not be a pure cupric derivative but a compound metallic body containing copper, for example, a brass, bronze, or other alloy of copper with another metallic element capable of imparting the desired characteristics. The metallic elements which have been found suitable for thus alloying with copper are zinc, silver, lead, tin and antimony. These metallic elements likewise readily combine with the elements of the sixth group substantially in the same manner as does copper alone. Consequently, when these metals are alloyed with copper they provide a metallic base which has the metallic characteristics desired for the electro-negative element. Particularly favorable characteristics have been obtained with brass mixtures in which a substantial percentage of alloyed material is added to the copper, for example, a mixture of 85% copper and 15% zinc.

Such brass body is with advantage amalgamated or given a surface coating of mercury before being treated to form compounds with the chemical elements of the sixth group, since the compounds formed are thereby more homogeneously cemented to the brass body and are less likely to chip off.

Any suitable method may be practiced in effecting the chemical reaction incident to the formation of compound of the brass body with the chemical elements of the sixth group; for example, to form sulphides, one substantially in accord with that taught in my copending application Serial No. 739,199, filed September 22, 1924, may be followed, in which the metallic base is exposed in a non-oxidizing atmosphere of sulphur and heated to a temperature of from 150° to 500° C.

Electro-negative elements which are compounds of selenides or tellurides have particularly good inherent reaction characteristics for film formation. To form these compounds the temperatures at which the chemical reaction occurs must be higher than for sulphides. Also, a slight admixture of sulphides reduces the brittleness generally characteristic of such compounds. The preferred method of producing a composite sulphur-selenium compound for the electro-negative electrode element consists in exposing one or more brass bodies in a non-oxidizing atmosphere in a reaction chamber containing a mixture of vapors of sulphur and selenium in substantially the proportions of 1:5 to 6 parts by weight; the reaction chamber being heated to a temperature substantially in the neighborhood of 800° C.

After the selenide bodies have thus been produced and cooled, and before assembly or machining, they are with advantage again relatively highly heated in the reacting atmosphere and cooled, as by so doing occluded gases remaining in the selenide compound from the reaction chamber are driven off with consequent improvement in the rectifying characteristics of the resulting asymmetric couple.

Electro-negative electrode elements having such characteristics may, however, be attained without alloying simply by mechanically mixing with a metallic derivative of cupric origin other metallic derivatives, all preferably in pulverulent form. Small crystals may also be used. Such derivatives are also in the form of chemical compounds of the elements of the sixth group, and may be made from relatively basic metals, for example, from any one of the metals enumerated above, or from manganese, lead, vanadium or iron. In such cases the powdered or crystalline material would be mixed thoroughly together to attain even distribution, and by means of suitable applications of heat and pressure formed into slugs or ingots to provide the metal-like body desired for an electro-negative element. Where crystalline material is used, the pressure should be such as to force the crystals into face-to-face relation, whereby a relatively compact body results.

The relative amounts of materials to be either alloyed or mixed together to form an electro-negative element should be such as to give a resulting body having a contact drop of potential greater than that of pure cupric sulphide.

The resulting electro-negative body, after its heat treatment, is preferably finished by grinding or otherwise machining so as to have a flat smooth surface, and will have a higher specific resistance than that of pure cupric sulphide; when in use such element will not require a facing or intermediate resistance layer in order to produce a rectifying effect.

As an electro-positive electrode element, a metallic base is selected which is relatively highly electro-positive to the elements of the sixth group of the electro-negative element; since, as a general rule, the greater the divergence in the electrochemical scale between the constituents used for the electro-positive and for the electro-negative elements, respectively, the more effective will be the rectifying effect achieved. The chemical elements comprising the lighter metals of the second and third periodic groups in general provide

suitable metallic bases for the electropositive element 10. The preferable elements are, for example, calcium, magnesium and zinc, together with boron and aluminum, or the amalgams of any thereof, i. e. alloys with mercury. The amalgams in such cases may be provided in any suitable manner; for example, by treating in a saturated solution of mercuric chloride, as set forth in my copending application Serial No. 750,939, filed November 18, 1924.

The disk-like electro-positive electrode elements shown at 10 may be manufactured from sheets of the last named metals, the disks being coated with mercury where an alloy is desired. In order to vary independently of the electro-negative element, the contact resistance at the abutting surfaces of the electrode elements, the surface of the electropositive elements may also be oxidized; for example, a thin uniform coating of oxide may be provided which is formed as taught in my copending application Serial No. 754,956, filed December 10, 1924.

Where the electro-negative electrode element comprises mixture or compounds with selenium or tellurium, magnesium or an amalgam thereof is preferred as materials for the electro-positive electrode element, since such give particularly favorable rectifying effects in an asymmetric couple of this invention.

The rectifying effect to be had from the asymmetric couple thus provided depends not only upon the specific resistance at the contact surface between the electropositive and electro-negative electrode elements (which resistance results specifically from the character of the said elements) but also, as taught in my copending application Serial No. 38,780 filed June 22, 1925, upon a second factor, namely the pressure uniting these elements.

The pressure to be here employed is such as to overcome the dynamic repulsion arising from the electrostatic forces operating at the contacting surfaces of the adjacent electropositive and electro-negative elements, and may be provided in any suitable manner, for example, mechanically by means of a bolt passed through the aligned disk-elements and insulated therefrom. An assemblage of couples retained in this manner is shown in Fig. 1 where 12 denotes a bolt which is passed through a plurality of aligned asymmetric couples 13 that are arranged in series in two groups inverted with respect to each other; the bolt 12 is insulated from these couples by means of a sleeve of insulation shown at 14. Interposed between the inverted groups of asymmetric couples is a common electrode 15. This electrode is preferably disposed in contact with an electronegative electrode element of each group so that this electrode serves as a negative terminal, as indicated, for the circuit traversed by the rectified current.

Substantially midway of the series of asymmetric couples in each group is interposed an electrode 16; the electrodes so interposed are adapted to be connected across the terminals of a suitable source of alternating current, for example, the alternating current transformer shown at 17.

The arrangement of asymmetric couples in the rectifying device is adapted for full wave rectification, since the outer end of each group of asymmetric couples is adapted to serve as a positive terminal, but, for simplicity of illustration, the circuit comprising the conductors 20, 21 and 22 is shown as connected to but one positive terminal so as to be traversed by only one-half of the alternating current wave received by the rectifying device. In series with the conductors 21 and 22 which connect with the positive terminal of the rectifying device shown in service, is connected a cut-out device shown generally at 23. This cut-out device may be of any convenient type, but is preferably one having unilateral conductivity and may be an asymmetric couple of the same type as used in the rectifying device itself. As shown, the cut-out 23 comprises but a single couple. It will, of course, be understood that any number of couples may be here used in series when it is desired to provide an inverse current-blocking element with a greater margin of safety than may be had from the use of single couple in order to insure the cutting out of all inverse flow of current that might otherwise tend to take place where the input voltage for a storage battery or like device, being charged in the circuit traversed by the rectified current, becomes accidently reduced or ceases.

By the present invention it will be seen that an asymmetric couple is provided giving a rectifying effect which is not liable to the deteriorating influences hertofore prevailing, inasmuch as the electronegative element itself contains the proper constituents to react in the formation and in maintenance of the inverse current-blocking film and resistance characteristics adapted to produce the rectifying effect desired without the so-called "aging" heretofore generally necessary. Inasmuch as the electro-negative element has a certain degree of flexibility, it can accommodate itself to operating stresses whereby proper contact between the electropositive and electro-negative elements is at all times insured. Since the elements are united mechanically under adequate pressure the intense forces of electro-static repulsion which hertofore operated to destroy proper contact and consequently the rectifying effect are rendered harmless. The necessary contact drop of potential is also provided in this arrangement since the resulting material in

the electro-negative element has a higher inherent resistance than is offered by the metallic base of such electrode.

By this invention also it will be seen that a rectifier is provided in which there is no hydrolytic reaction, since there is no occluded water in any part of the electro-positive or electro-negative elements. Consequently these elements are not liable to disintegration from any internal causes or local currents and are therefore adapted for regular and dependable service over long periods of time. It is also capable of withstanding high temperatures in service without liability of attack from the atmospheric elements.

Once the asymmetric couples are properly assembled and the proper pressure applied, there is no further critical relationship between the parts that need to be considered in order to maintain operating conditions. The asymmetric couple of this invention is consequently adapted to give steady rectified current under substantially all operating conditions of service. Also it will be seen that the asymmetric couples here provided have in large degree a capacitance effect so that the series of rectifying elements disposed as shown in Fig. 1 operate like a condenser to insure an initial and even distribution of the potential drop over the rectifying device so that as soon as the source of alternating current is imposed across the receiving terminals illustrated at 16, an immediate flow results in the output circuit.

Since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electro-positive electrode element chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing a compound of a chemical element from the oxygen family in the sixth periodic group and resistance modifying material of a character adapted to impart self forming and self maintaining characteristics to the inverse current-blocking film which forms at the junction, and means for retaining said electrode elements operatively in contact under pressure.

2. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing a compound of a chemical element from the oxygen family in the sixth periodic group with a metal from the empirical class containing iron, vanadium, manganese, zinc, lead, antimony, tin, and copper, and resistance modifying material of a character adapted to impart self-forming and self-maintaining characteristics to the inverse current-blocking film which forms at the junction, and means for retaining said electrode elements operatively in contact under pressure.

3. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing a compound of a chemical element from the oxygen family in the sixth periodic group with metallic copper and resistance modifying material of a character adapted to impart self-forming and self-maintaining characteristics to the inverse current-blocking film which forms at the junction, and means for retaining said electrode elements operatively in contact under pressure.

4. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing a compound of a chemical element from the oxygen family in the sixth periodic group with metallic copper and a resistance increasing metal chosen from the empirical class containing zinc, silver, lead, tin and antimony whereby the inverse current-blocking film electrochemically formed at the junction has self-forming and self-maintaining characteristics, and means for retaining said electrode elements operatively in contact under pressure.

5. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing a compound of a chemical element from the oxygen family in the sixth periodic group with copper alloyed with a resistance increasing metal of a character adapted to impart self-forming and self-maintaining characteristics to the inverse current-blocking film which forms at the junction, and means for retaining said electrode elements operatively in contact under pressure.

6. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element

chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing a compound of a chemical element from the oxygen family in the sixth periodic group with an alloy of copper in which the alloyed material is chosen from the empirical class containing zinc, silver, lead, tin and antimony, and means for retaining said electrode elements operatively in contact under pressure.

7. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing a compound of a chemical element from the oxygen family in the sixth periodic group with an alloy of copper and zinc in which copper preponderates, and means for retaining said electrode elements operatively in contact under pressure.

8. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing the chemical element selenium, compounded with copper in a manner whereby when subjected to normal operating voltages is inherently reacting and produces a rectifying film at the junction of said electrode elements and means for retaining said electrode elements operatively in contact under pressure.

9. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element chosen from the class of lighter chemical elements of the second and third periodic groups, an electronegative electrode element of a body containing a compound of sulphur and selenium taken substantially in a ratio not greater than 1 to 5 with a metal including copper, and means for retaining said electrode elements operatively in contact under pressure.

10. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element of a metal from the class of the lighter chemical elements of the second and third periodic groups and an electronegative electrode element formed of a metallic base containing copper alloyed with a resistance increasing metal, said alloy being compounded with the chemical elements sulphur and selenium taken in substantially a ratio not greater than 1 to 5, whereby said electronegative electrode element has inherently reaction properties adapted for the formation and maintenance of an inverse current blocking film at the junction of said electrode elements, said couple having means for maintaining the elements thereof united under pressure.

11. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element of a metal from the class of the lighter chemical elements of the second and third periodic groups and an electronegative electrode element formed of an alloy of the metals copper and zinc compounded with a chemical element of the sixth periodic group beginning with the letter "S" whereby said electronegative electrode element has inherently reaction properties adapted for the formation and maintenance of an inverse current blocking film at the junction of said electrode elements, said couple having means for maintaining the elements thereof united under pressure.

12. In dry surface contact rectifying devices and the like, an asymmetric couple comprising an electropositive electrode element of a metal from the class of the lighter chemical elements of the second and third periodic group and an electronegative electrode element formed of material having a metallic base of copper compounded with the chemical elements sulphur and selenium taken substantially in a ratio not greater than 1 to 5 whereby said electronegative electrode element has inherently reaction properties adapted for the formation and maintenance of an inverse current blocking film at the junction of said electrode elements, said couple having means for maintaining the elements thereof united under pressure.

In testimony whereof I affix my signature.

SAMUEL RUBEN.