Dec. 14, 1954 I. GOLDMAN ET AL 2,697,188

SELENIUM RECTIFIER

Filed March 16, 1949

2 Sheets-Sheet 1

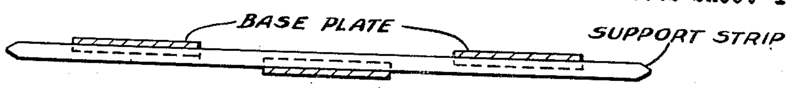

FIG. 1

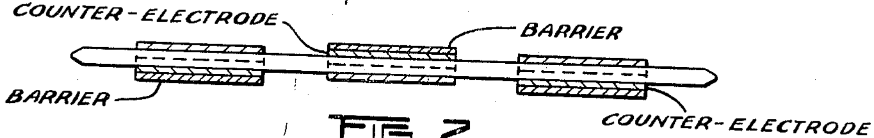

FIG. 2

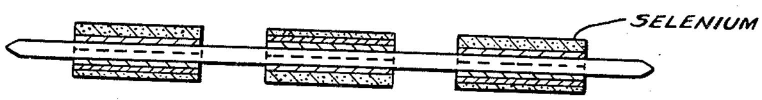

FIG. 3

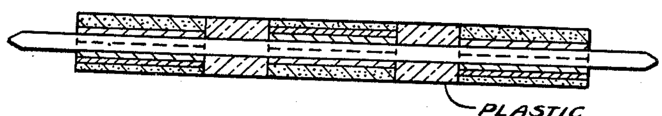

FIG. 4

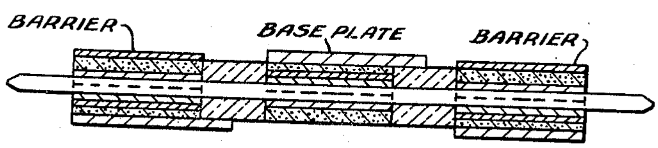

FIG. 5

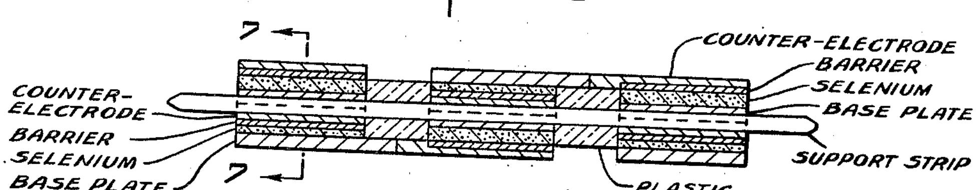

FIG. 6

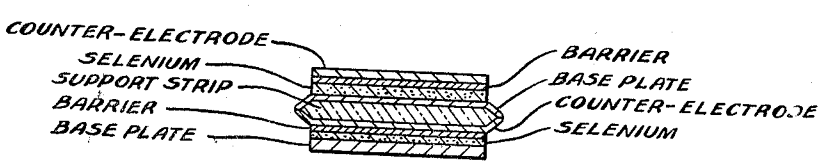

FIG. 7

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2 Sheets-Sheet 2

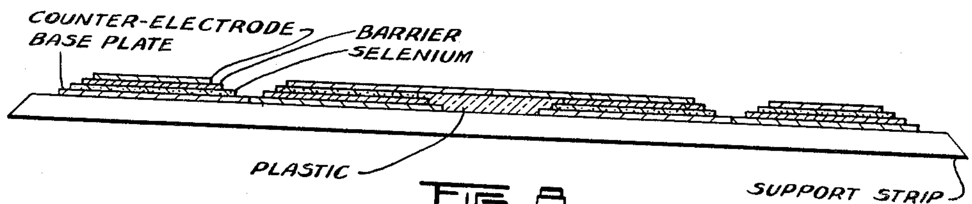

FIG. 8

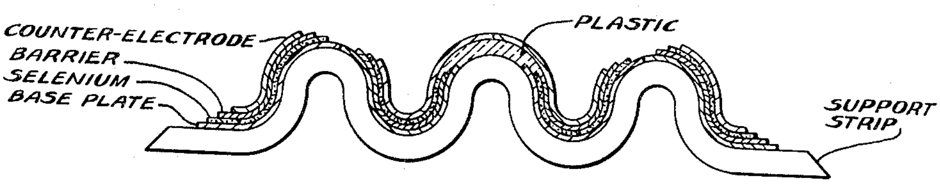

FIG. 9

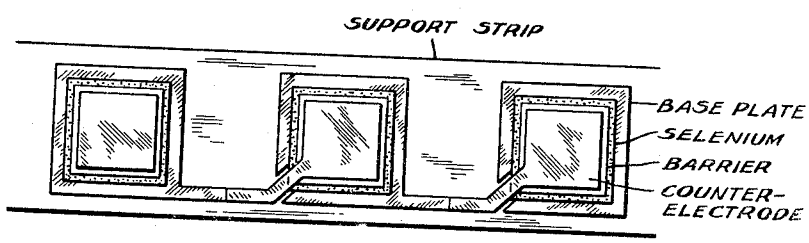

FIG. 10

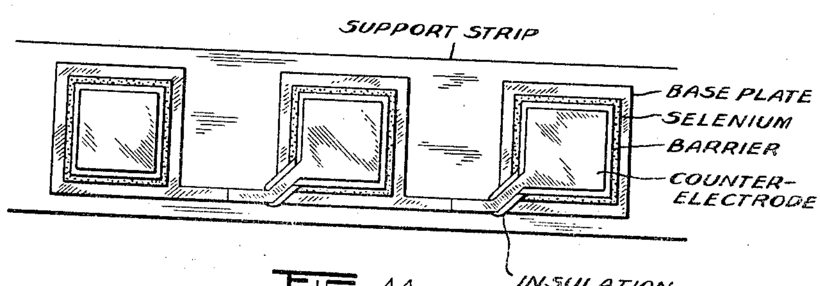

FIG. 11

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SELENIUM RECTIFIER

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3 Claims. (Cl. 317—234)

This invention relates to dry or contact rectifiers and the method of making them; more particularly it relates to rectifiers of the selenium type.

The selenium rectifiers of the prior art have for the most part consisted of a base plate which is continuous except for a central hole. This plate usually consists of a suitably etched, sand-blasted or otherwise roughened panel of aluminum or one of its alloys or of iron, the panel being coated with a suitable coating layer of nickel or bismuth which is in turn coated with selenium; this latter layer having been treated to transform the selenium to a crystalline allotrope which material is coated with a counterelectrode and finally "electroformed" to develop proper electrical characteristics. In theory the nickel or bismuth coating is believed to produce a lowered forward resistance possibly because of the formation at the nickel or bismuth-selenium interface of a nickel or bismuth selenide which may be soluble in either the nickel or bismuth or both. However, despite the possible formation of the nickel selenium compound the adhesion of the selenium to the nickel or bismuth is principally mechanical and unless the continuous substrate has been roughened as by sand-blasting, etching or other means prior to nickel or bismuth coating, the selenium does not adhere properly and tends to flake off when the selenium coated plate is subjected even to slight mechanical deformation.

Furthermore, the prior art method of manufacture is quite complicated requiring a large amount of space and equipment. In accordance with prior art methods, it is first necessary to clean the continuous substrate whether it be made of steel or aluminum or alloys of aluminum. Subsequent to this cleaning operation it is necessary to roughen the surface by either mechanical or chemical means. Following this step, it is necessary to apply a thin film of nickel or bismuth on the roughened surface whereupon a selenium coating is deposited on one or both surfaces of the nickel or bismuth coated substrate by any one of several methods as for example, evaporation, electro-deposition, or pressing a selenium powder. This step is then followed by heat treating operation which transforms the amorphous selenium to its so called crystalline metallic allotrope. The product thereby produced is then ready for the formation of the blocking layer as by oxidizing or otherwise treating the selenium surface with a liquid chemical reagent or ozone or some other means. After this step, it is necessary to apply the counterelectrode for instance, by spraying with a low melting solder, whereupon electro-forming is resorted to to develop suitable electrical characteristics. All of these foregoing steps are necessary for the formation of an individual plate. In order to obtain a rectifier of the desired type it is necessary to assemble several plates into a stack and coat the stack with lacquer or paint. This whole process as described is both lengthy and complicated and does not readily lend itself to continuous manufacturing methods.

The object of this invention is to provide a selenium rectifier of superior design employing fewer parts and lending itself to simpler manufacturing techniques than are currently used.

A further object of this invention is to provide a selenium rectifier which will permit greater current output and which incorporates by virtue of its novel design inherent flexibility as to internal electrical arrangement permitting manufacture in various circuit types such as bridge, series and parallel.

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In accordance with this invention it has been found that these objects and other advantages can be obtained by applying onto a non-electrical conducting material such as plastic, or ceramic, films of the elements comprising the rectifier, namely the base plate, selenium, a barrier layer forming material, spacing material, counterelectrode and protective lacquer.

In the accompanying drawings which illustrate preferred embodiments of this invention, Figs. 1 through 6 show side views partly in section of a form of the rectifier of this invention in its various stages of construction.

Fig. 7 is a section through line 7—7 of Fig. 6.

Fig. 8 is a side view partly in section of a modified structure of the rectifier of this invention.

Fig. 9 is a side view of another modified structure of this invention.

Fig. 10 is a plan view of another modified structure of this invention.

Fig. 11 is a plan view of a modified version of the structure of Fig. 10.

In the preparation of rectifiers in accordance with preferred practice of this invention, a strip of non-electrically conducting material such as plastic or ceramic is first roughened as by sand-blasting to provide a clean, rough surface exhibiting secure adhesion to any metal deposited thereon. When the strip of non-electrically conducting material has been properly roughened, it is ready for the deposition of the first or base plate material as indicated in Figs. 1–7 of the drawings. This film of base plate material may be deposited upon the strip in many ways. However in accordance with a preferred embodiment of this invention, the base plate material can be deposited upon the desired areas of strip material by a spray operation utilizing a proper masking device. When making a rectifier of the design illustrated in Figs. 1 through 7 of the drawings, this masking device is so constructed that it will permit over-spray of the base metal onto the side of the plastic strip as shown in Fig. 1. In making the rectifier of this type the strip is turned over and the same masking device is used on the reverse side of the supporting strip in a similar manner. The counterelectrode material is sprayed onto the plastic or non-electrical conducting surface again permitting overspray so that an adequate electrical contact will result between the two metals along their point of juncture as indicated in Fig. 2. The structure so formed is now in part ready for the deposition of a layer of selenium. However, since a barrier layer must be formed on the selenium surface which is preferably positioned between the selenium and the counterelectrode material it is preferable to take steps at this time to insure the formation of such a surface. This may be accomplished in many ways known to the art. A specific example of which consists in applying an organic lacquer containing peroxide between the counterelectrode and the selenium. Therefore an organic lacquer containing peroxide may be sprayed onto those surfaces which consist of the counterelectrode material. After coating the counterelectrode portion, the selenium may then be deposited in any known manner including the preferred manner of spraying. When a spray technique is used, another masking device is employed which will block off all of the present uncoated plastic surfaces so that selenium can be sprayed onto all of the exposed metal surfaces as indicated in Fig. 3. Following the application of the selenium, it now becomes necessary to form an artificial barrier layer on the selenium surface deposited on the base plate material. This may be accomplished as described above with the use of an organic lacquer containing peroxide. In accordance with preferred practice, the assembly is now masked so that all of the selenium coated surfaces are covered by another masking device and a plastic composition is sprayed to build up a layer equal in thickness to the composite layer of metal plus selenium. See Fig. 4. Subsequent to this and by utilizing still another masking device base plate material is sprayed on top of the selenium surfaces which have beneath them counter-electrodes. A distinctive feature of the masking device which is used at this point is that it permits overspraying of the counterelectrode material onto the plastic spacing composition. See Fig. 5. A composite article is then ready for the last spraying operation which is conducted with the use of a masking device similar to that used in the preceding step with the exception that now those selenium layers which have beneath them counterelectrode material are now sprayed with material of base plate composition. This masking arrangement also has the distinctive feature of allowing an over-spray of the base plate material onto the plastic spacing composition to permit the making of adequate electrical contact at the juncture between the sprayed counterelectrode and the sprayed base plate materials. A completed six plate strip is shown in Figs. 6 and 7. As a final step, lacquer may be sprayed over the whole unit without the use of a masking device in order to add corrosion resistance to the assembly. However, prior to the lacquering, it is preferable to anneal the selenium to form the metallic conductive modification. This step however, may be performed immediately after the application of the selenium and prior to further processing. Prior to the lacquering it is also preferable to electroform the completed unit. The electro-forming operation being carried out on the strip as a unit, or on the individual plates or groups of plates as desired.

There are many advantages which can be claimed for the strip rectifiers manufactured in accordance with the preceding description. For example, it is very simple to manufacture. It requires no assembly. The process lends itself to continuous processing of the strip and subsequent cutting into units of the desired number of plates. The number of plates per unit being determined by the desired output per strip. Furthermore, it permits flexibility of design in that by other changes in the masking devices parallel, series or bridge type rectifier strips may be produced. Furthermore, the strip type rectifier design will permit of greater heat dissipation and thereby allow the rectifier to be operated at a higher output than is possible with the stacked rectifiers.

Another advantage of this type of rectifier design is that it leads to over-all manufacturing economies in that fewer parts are required for assembly. The equipment required for manufacture is simplified and standardized and the process can be completely automatic requiring the attention of only supervisory and maintenance personnel.

In considering the process here and above described, it should of course be understood that the base plate material may be made of any material which has a high work function. Materials of this type which are known and have been used in the prior art include bismuth, nickel, cadmium, cobalt, manganese, iron, chromium and alloys of bismuth, cadmium, lead and tin. The counterelectrode material should be one which has a lower work function than the base metal chosen. For this purpose, use is frequently made of cadmium, tin and alloys of cadmium, tin, bismuth and lead. The bismuth only being useable at those times when the base metal is not bismuth.

In those cases in which the spray technique is used as described for the preferred embodiment of the invention, the base plate metal and counterelectrode metal should preferably be sprayable at temperatures sufficiently low to prevent injury to the selenium when sprayed thereon. Of course when methods other than spraying are are used this temperature characteristic is not of as critical importance.

As has been implied, heretofore, the selenium may of course, be applied in many different ways, as for example, by spraying or pressing. However, if the spraying technique is used, the conditions of spraying, e. g., distance of gun from work, temperature, etc., will depend upon the type of spray mechanism used (powder, wire or molten metal). The lower the temperature is kept, the more easy it will be to avoid vaporization of the selenium.

The plastic coating over the counterelectrode may also serve another function in that it can act as an insulator to prevent shorts between the counterelectrode material and the base plate material if any cracks or fissures appear in the selenium.

It is of course, understandable that other modifications can be made without departing from the spirit of this invention. For example, a sprayed strip rectifier of the type disclosed may also be made on one side of a non-electrical conducting strip so that the unsprayed or uncoated side may be fastened directly to an electrically conducting surface such as a metal radio chassis. A structure of this type is shown in Fig. 8 of the drawing. The plastic supporting strip there shown is coated on one side with successive coatings of base plate material, counterelectrode material, barrier layer forming material and insulating material. Furthermore it should be understood that the sprayed rectifier can be made on a supporting strip of "a plastic or the like which is shaped other than flat for improved structural strength." For example, it might be desirable to make use of a corrugated supporting strip as shown in Fig. 9. This, besides giving improved structural strength would also give a greater surface area for rectification.

Fig. 10 shows still another version or modification of this design. In this case, the base metal or base plate material is sprayed directly onto the supporting material in all cases with the selenium coating lying between it and a counterelectrode positioned directly there-above so that in each unit the counterelectrode is positioned farthest away from the supporting plate and contact being made between it and the base plate of the next unit.

Fig. 11 shows another modification of the strip rectifier shown in Fig. 10. It differs from that shown in Fig. 10 only in providing a separate overspray of insulating material to permit the counterelectrode to extend beyond the edge of the individual rectifier element and thus be in position for contact with the base metal of the preceding rectifier element.

In working with strip rectifiers of this type it has further been found that the density of the selenium coating has a decided effect on the results obtained. For example, it has been found that when a sprayed selenium surface is further processed by pressing the surface with a hot roller or platen for as little as ten to twenty seconds and thereby densifying it, the average value of forward current can be increased by as much as a multiple of 2. It is of course, obvious that rectifiers of the construction described herein readily lend themselves to use in the so-called printed circuits.

As can readily be seen from the above description, the rectifier of this invention readily lends itself to the manufacture of an all-sprayed strip rectifier and thus can readily be made by a continuous process. When using a continuous process it is naturally advantageous to start with a flexible supporting strip material. Fortunately, the process is conveniently applicable to the use of a continuous strip of flexible material such as fiber glass which may have for its first step in the process an immersion in a "B" stage phenolic resin. Polymerization of the resin and consequent stiffening of the fiber glass strip can be made to take place at some subsequent stage in the manufacture of the rectifier. From the above, it is therefore readily apparent that the rectifiers of this invention can be made with either a rigid or a flexible strip material in its early processing stages. In some instances, flexible material may be preferred particularly if the process is to be a truly continuous one.

While the above description and the drawings submitted herewith disclose preferred and practical embodiments of the rectifiers of this invention, it will be understood by those skilled in the art that the specific details of construction and arrangement of parts as shown and described are by way of illustration and are not to be construed as limiting the scope of the invention.

What is claimed is:

1. A current rectifier comprising a plurality of rectifying units superimposed on the surface of a non-conductive material having a corrugated cross section, each of said rectifying units comprising a film of base plate material immediately adjacent said non-conductive material, selenium films adjacent to said base plate material and superimposed thereon, and a counterelectrode adjacent each selenium film and superimposed thereon.

2. A current rectifier comprising a plurality of inversely positioned rectifying units superimposed on both surfaces of a non-conductive material, said rectifying units comprising superimposed sprayed materials of base plate material, selenium and counterelectrode.

3. A current rectifier comprising a plurality of inversely positioned rectifying units in electrical contact with one another superimposed on both surfaces of a non-conductive material, said rectifying units comprising superimposed sprayed films of rectifying elements,

said electrical contact being made over the edge of said non-conductive material.

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