Nov. 20, 1934. N. C. PEARCY 1,981,245

SPACE CURRENT DEVICE

Original Filed Feb. 20, 1924

Fig. 1.

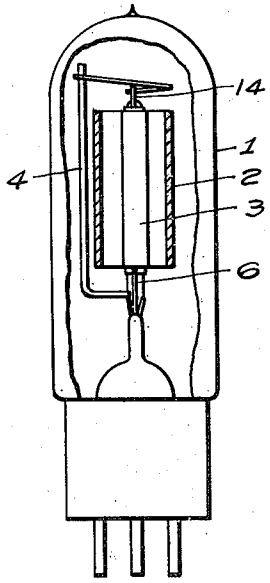


Fig. 2.

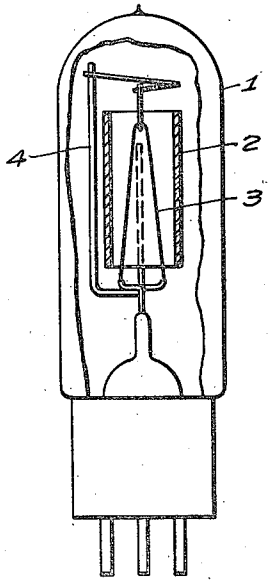


Fig. 3.

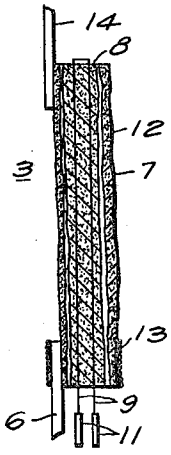


Fig. 5.

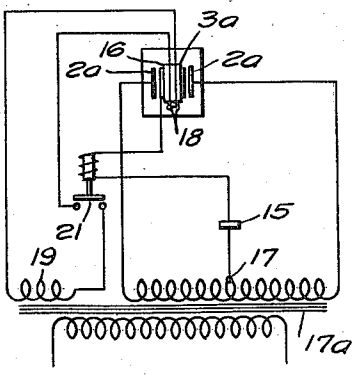
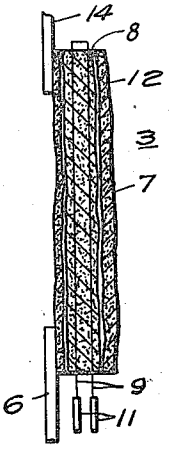


Fig. 4.



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Patented Nov. 20, 1934 1,981,245

UNITED STATES PATENT OFFICE

1,981,245

SPACE-CURRENT DEVICE

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Original application February 20, 1924, Serial No. 694,028. Divided and this application July 24, 1934, Serial No. 736,697

2 Claims. (Cl. 250—27.5)

This application is a division of my copending application Serial Number 551,411, filed July 17, 1931, for Space-current devices which is in turn a division of Serial Number 694,028, filed February 20, 1924.

My invention relates to space-current devices and it has particular relation to devices of the above designated character utilizing indirectly heated cathodes for gas filled rectifiers.

One object of my invention is to provide a space-current device having an improved cathode capable of maintaining a large electron emission and which is capable of withstanding the positive-ion bombardment met with in commercial gas-filled rectifiers.

Another object of my invention is to provide a gas filled rectifier that may be efficiently used in connection with large rectified currents.

According to my invention, I provide a gas filled rectifier having a cathode which is either directly or indirectly heated and employs as an electron-emitting element a fused mass of nickel and thermionically active oxides, such as barium oxide, strontium oxide and calcium oxide. I thus obtain an electron-emitting element which has very high emissivity and maintains about the same characteristics for a very long time, far exceeding the life and the performance of the ordinary tungsten electrodes.

My invention is particularly well adapted for use in connection with thermionic tubes of the type described in the copending application of H. M. Freeman and W. G. Wade, Serial No. 611,263, filed January 8, 1923 and assigned to the Westinghouse Electric and Manufacturing Company.

Other objects of my invention consist in the provision of new methods of making an improved space-current device and thermionic cathodes of the above designated character. With the foregoing and other objects in view, my invention consists in the details of structure and methods of construction described hereinafter and illustrated in the accompanying drawing, wherein

Figure 1 is a view in elevation of a rectifier according to my invention with a portion of the front wall broken away to show the inner structure.

Fig. 2 is a similar view illustrating a modification of my invention.

Fig. 3 is a sectional view of a thermionic cathode employed in the space-current device shown in Fig. 1.

Fig. 4 is a view, similar to Fig. 3, showing a modified cathode structure.

Fig. 5 is a diagrammatic view of a rectifier system embodying my invention.

By way of illustration, I have shown my cathode applied to a rectifier, although it is susceptible of other uses, as in three-electrode tubes. Referring to Fig. 1, a rectifier comprises an evacuated envelope 1 having mounted therein an anode 2 and a cathode structure 3 which is supported in a familiar manner by a rod 4 and a terminal strap 6 of metal constituting the electric connection to the cathode. The envelope is preferably filled with a small quantity of inert gas such as argon or mercury vapor for securing an atmosphere of molecules capable of carrying a discharge between the cathode and the anode at relatively low pressures, as is well known in the art.

The principal feature of my invention is the construction of the cathode 3, one modification of which is shown in Fig. 3 and which comprises a cylindrical member 8 of a refractory insulating material, such as zircon or porcelain, having a heating element 9, of U shape, extending through longitudinally disposed perforations therein. The heating element is supplied with two terminal wires 11, one of which may be connected to the terminal strip 6 leading to the cathode surface. Surrounding the cylindrical member 8 and in close contact therewith is a sleeve 12 comprising a fused mass of metal and oxides of the alkaline earth metals, the sleeve constituting the electron-emitting element 7 of the cathode.

In making the sleeve, I prefer to use nickel on account of its relatively low melting point and since it gives very good performance. As electron-emitting oxides, I employ the oxides of barium, strontium and calcium which are fused or sintered with finely divided nickel particles to form a homogeneous mass and which are firmly held to the nickel, assuring a long life and producing a cathode capable of standing the positive-ion bombardment and maintaining substantially constant performance throughout the life of the rectifier. The cathode just described is much superior to a cathode structure wherein the high electron emissivity is obtained by dipping a metallic surface in a proper solution for obtaining an oxide coat, since the coat which is obtained by such dipping is destroyed, after a relatively short time, by the bombardment of the positive ions and the tube becomes inoperative after a very short period of operation. Another advantage of my improved cathode is that its construction is much cheaper and consumes only a fraction of the time

necessary to make an oxide coated electrode by the dipping process.

One of the novel steps of making an improved cathode according to my invention involves the intimate mixture of the finely pulverized compounds of the alkaline earth metals, and also the employment of finely pulverized nickel. To obtain the finely divided nickel I take nickel oxide and heat the same in an atmosphere of hydrogen at approximately 600° C. until the oxide is reduced to metal. To obtain the intimate mixture of compounds of the alkaline earth metals used in my improved method of making the cathode, I dissolve a mixture a barium nitrate, strontium nitrate and calcium nitrate in water and precipitate the carbonates of the above-named metals from the solution so obtained, by adding a solution of ammonium carbonate. The precipitate thus obtained, when filtered, washed and dried, constitutes a very intimate mixture of the carbonates of the three metals.

The above-described method of obtaining a pulverized mixture of the compounds of the three metals consists, in general, in dissolving soluble salts of the metals which are to be mixed in a suitable solvent and precipitating from the solution insoluble salts of the metals. In a practical instance, I have used the following proportions:

	Per cent
Barium nitrate	40
Strontium nitrate	26.67
Calcium nitrate	33.33

I regard the above-described step of mixing the ingredients constituting the electron-emitting element of the improved cathode as instrumental in securing the performance of the same and desire that the same be regarded as a distinct feature of my invention.

The nickel particles and the carbonates of the alkaline earth metals are mixed together and moistened with a suitable binder such as water or an acid, such as acetic acid, for example, which reacts with a portion of the carbonates and forms a soluble salt of the alkaline earth metals. I thus obtain a plastic mass which is extruded through a suitable die into the desired shape. I may form rods or slabs, or in case of a cathode employed in a rectifier as shown in Fig. 1, I form a cylindrical sleeve which fits over the cylindrical refractory element 8.

The extruded body is dried and then heated in an atmosphere of hydrogen to a temperature sufficient to sinter the materials constituting the same. In a practical instance where I use the proportions of the ingredients named above, I bring the heated mass to a temperature of approximately 1000° C.

After removing the sintered body thus obtained from the furnace, the same is ready to be assembled in the space-current device, the carbonates of the alkaline earth metals forming with the nickel, a homogeneous, mechanically strong mass. The carbonates may be reduced to oxides either during the sintering process or at any time afterwards, preferably when treating the tube on the pump in a well-known manner, after the same has been completely assembled.

According to another method, I may form the plastic mass of the nickel particles and the carbonates of the alkaline earth metals into a sleeve surrounding the heater member 3 and introduce the composite body thus obtained into the furnace for carrying out the sintering process as described hereinbefore.

The connection of the electric lead or strip 6 to the cathode may be made either by securing the strip to the cylinder 12 by any mechanical means such as a wire 13 wound around the cylinder or by welding the strap directly to the surface of the cylinder, or by a combination of both methods. The cylinder 12 is secured at its upper end to the holding rod 4, by a strip 14 similar to strip 6 or by any other suitable means.

Rectifiers and tubes made with cathodes obtained in the manner described hereinabove operate very successfully and give larger currents at lower voltages than are possible with any other cathode construction of which I am aware. In particular I am able to operate such cathodes in rectifiers without maintaining a current in the filamentary heater 9, as the current therethrough may be turned off as soon as the current flow through the rectifier is initiated, the bombardment of the positive ions being sufficient to maintain the cathode at a temperature where the same is in an electron-emitting state.

An operative unit of the last described character is shown in Fig. 5. A double-wave rectifier is provided with an improved cathode 3*a* made according to my invention and two anodes 2*a* leading to a supply transformer 17*a*. A direct-current load device 15 is connected between the active coat 16 of the cathode and the middle terminal 17 of the transformer 17*a*. The heating filament 18 of the cathode is supplied from an auxiliary transformer winding 19 through a switch 21 which is electromagnetically controlled by the current flowing to the direct current load. The switch is closed when the load current is below a certain value and opened when the current exceeds that value at which the positive-ion bombardment maintains the cathode in an electron emitting state.

While a somewhat similar operation of rectifiers has been described heretofore, I am not aware of any practical construction utilizing a cathode which embodied the oxides of the alkaline earth metals and which was capable of producing a rectifier carrying a large amount of current at the low pressures utilized in my devices. For instance, the electron emission which is obtained by means of my improved cathode is many times larger than the electron emission possible when the cathode consists of a metal bead such as tungsten.

In Fig. 4, is shown a modification of my invention, the refractory cylinder 8 being coated with nickel or other metal previous to the assembly in the electron-emitting sleeve 12, the whole body being assembled when hot so that the nickel coat is plastic and forms an intimate connection between the sleeve 12 and the refractory member 8, facilitating the flow of heat from the heater member to the sleeve and expediting the step of initiating the operation of the rectifier.

I have found that the plastic mass of the nickel and alkaline earth metals may be extruded through a suitable die to form a filament similar to that used in carbon filament lamps. Since the oxides of the rare earth metals are of relatively high resistance and are intermingled with the fine metal particles, a filament so obtained is of relatively high resistance and consumes little current while giving a relatively large electron emission. A filament of this character, when used in a gas-filled tube, is better able to withstand the bombardment of the gas molecules than an ordinary coated filament, and the life of such filament is much longer than can be obtained with

other constructions. A tube made according to the last named method is shown in Fig. 2.

A distinct advantage of the filaments and cathodes made according to my invention is that the same are operated at relatively low temperatures and they are less subject to destruction than cathodes operated at high temperatures.

The directly heated cathodes of the prior art had a disadvantage that is obviated by my indirectly heated cathode construction. In general, these cathodes of the prior art have a long wire for large cathode area with the result that one part of the wire is more negative than another part. In fact, one end of the long cathode could be regarded as negative and the other end positive at any particular instant. The discharge will concentrate on the negative end with the result that there will very likely be "hot spots" on that end with the consequent damage to the cathode. In my indirectly heated cathode construction, the electron emitting cathode is all one potential so that there is no concentration of the discharge but on the contrary, the high thermal and electrical conductivity of the sintered coating tends to evenly distribute the discharge over the cathode surface.

My invention also provides a practical construction for larger currents than have hitherto been practicable with the gas rectifier, having directly heated cathodes. Large currents require a large cathode surface and a high temperature. With the directly heated cathodes of the prior art, these requirements meant a small diameter wire in order to provide the high temperature and an extremely long one to provide the large surface. However, the practical difficulties of supporting such a long wire and maintaining the slender wire under bombardment have limited the size of the prior gas filled rectifiers.

Another difficulty is that large currents under very small voltage pressure are very unstable and difficult to regulate in a long wire subject to a discharge.

With my construction of an indirectly heated cathode, however, the electron emitting surface and the connections thereto can be designed most efficiently for the discharge or rectified current and the heater circuit can be designed for the most efficient supply of heat. If a small diameter heater wire is used, it is protected from the discharge by the refractory insulating material. The size of this refraction core makes the electron emitting surface surrounding it inherently large.

I do not desire to be limited to the precise process and details of construction described hereinbefore, but I desire that the appended claims shall be given the broadest construction consistent with the prior art.

I claim as my invention:

1. An electrode of the class described comprising a solidified coherent mixture of finely divided base metal and an alkali or alkaline earth metal oxide fused on the surface.

2. An electrode of the class described comprising a mixture of finely divided base metal and finely divided alkali or alkaline earth metal solidified into a coherent mass and fused on the surface.

NOAH C. PEARCY.