I. LANGMUIR.

FILM CONDUCTOR AND THE METHOD OF MAKING THE SAME.

APPLICATION FILED JUNE 6, 1914. RENEWED MAY 1, 1917.

1,273,628. Patented July 23, 1918.

Fig. 1.

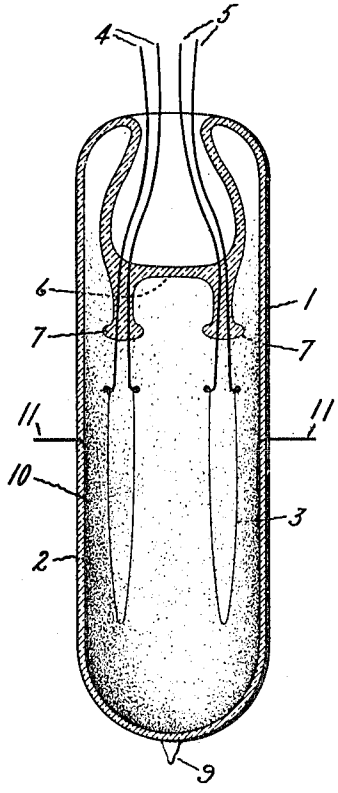
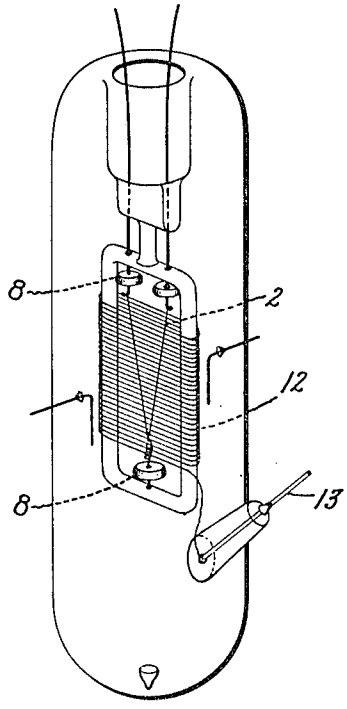


Fig. 2.



Witnesses:

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UNITED STATES PATENT OFFICE.

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FILM CONDUCTOR AND THE METHOD OF MAKING THE SAME.

1,273,628. Specification of Letters Patent. Patented July 23, 1918.

Application filed June 6, 1914, Serial No. 843,569. Renewed May 1, 1917. Serial No. 165,796.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Film Conductors and the Methods of Making the Same, of which the following is a specification.

The present invention comprises gas-free metal films formed in a vacuum too high to permit a disruptive electrical discharge and suitable particularly as electrodes for electrical devices, particularly devices requiring a very high vacuum in which gas-free electrodes are necessary.

Adherent films of metal have been heretofore formed by cathodic disintegration but in this case there must necessarily be present a gas at a pressure above one micron of mercury and for practical purposes the pressure should be from 20 to 30 microns. Under these conditions the metal film is less strongly adherent and consists of discrete particles as described in detail in *Zeit. fur Elektrochemie*, vol. 18, (1912), pages 373—419—837. During the deposition of a film by cathodic disintegration gas appears to be fixed on the metal so that the film will subsequently give up gas and hence could not be used in a device intended to operate with pure electron discharge in which the pressure must be below one micron.

Figure 1 of the accompanying drawing illustrates a simple form of electron discharge device containing a vaporizable conductor for preparing a film anode and Fig. 2 is a modification in which the vaporized metal is furnished by the cathode.

As disclosed and claimed by me in my Patent No. 1,237,210, issued August 14, 1917, an extremely high vacuum may be produced by incandescing a refractory metal conductor, such as tungsten in a partial vacuum to a temperature elevated enough to actively vaporize the refractory metal. This vaporized metal is deposited on the walls of the evacuated container as a hard strongly adherent film which even when so thin as to be transparent is a good electrical conductor and capable of carrying relatively heavy currents.

Referring to Fig. 1 the envelop 1, consisting of glass, quartz, or similar non-conducting material, is provided with two vaporizable conductors 2, 3, consisting of tungsten, tantalum or molybdenum and provided, respectively, with leading-in conductors 4, 5 sealed into a stem 6 in the usual manner. One of these filaments 2, 3 may be used for the cathode of the completed apparatus and the other may be vaporized by heating it to intensive incandescence by passage of current. The particles of vaporized metal travel outward in all directions in straight lines. In order to avoid the formation of a continuous conducting film over the entire inner surface of the container and in electrical contact with the cathode provision should be made for intercepting the vaporized metal near the cathode so as to "cast shadows" on the envelop wall which will be free from deposited metal. This may be done by shaping the stem 6 so that it will in part bulge outwardly, also by providing knobs or rings on the leading-in wires as shown at 7, Fig. 1, or 8, Fig. 2.

The container is first exhausted to a good vacuum as may be obtained by means of a pump by chemical exhaust or other means, the envelop being heated during pumping to remove water vapor. The preliminary exhaust should reduce the pressure to one micron (0.001 m. m.) or less. The completion of the vacuum may be carried out by the active vaporization of a tungsten conductor in a side chamber by heating it electrically to about 2700 to 2900° C., preferably in the presence of a small amount of anhydrous pentoxid of phosphorus. The envelop is then sealed off, as indicated at 9, and one of the refractory conductors, for example, the filament 3 is heated to about 2700° to 2900° C. by passage of current, thereby depositing the desired gas-free film as indicated at 10. Contact is made to the film 10 of vaporized metal by sealed-in wires 11, two being provided to insure a good contact. This film is gas-free and so hard and coherent that even when no more than 10^{-6} m. m. in thickness it can only with the greatest difficulty be scratched off the glass with a knife.

The device shown in Fig. 1 may be used as a rectifier when the cathode 2 is maintained incandescent, and the film of deposited metal is used as the anode. Similar devices of this nature may be used as relays by providing a discharge controlling grid 12, Fig. 2 connected to a leading-in conductor 13. In the device shown in Fig. 2 no separate

conductor for producing the anode film has been provided, as the cathode 2 may itself serve to provide the vaporized metal without serious damage when an extra heavy filament has been provided to serve as cathode.

The films produced in this manner may be easily made about 10^{-5} to 10^{-6} c. m. in thickness and in apparatus such as described will readily receive currents of about 100 milliamperes or more.

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

1. As an article of manufacture, a solid body and an adherent, gas-free film of metal produced by the vaporization of said metal in a vacuum having a residual gas pressure below about one-thousandth of a millimeter of mercury.

2. An electrical discharge apparatus having an anode consisting of a gas-free film of metal produced by vaporization in a vacuum in which the residual gas is at a pressure too low to permit a disruptive discharge therein.

3. An electrical discharge apparatus having an envelop of non-conducting material and a gas-free layer of metal thereon produced by vaporization of said metal in a vacuum having a residual gas pressure below about one-thousandth of a millimeter of mercury.

4. The method of producing a gas-free, adherent metallic film upon a solid body which consists in exposing said body to metal vapor in a vacuum having a residual gas pressure below one-thousandth of a millimeter of mercury.

5. The method of depositing gas-free conductive films upon insulating surfaces which consists in heating a highly refractory metal to a temperature near its melting point in vacuum too high to permit of the passage of a disruptive discharge and exposing the surface upon which a film is desired to said vapors.

6. An electrical discharge device comprising the combination of a glass envelop, an incandescing cathode, and an anode consisting of a dense, coherent film of tungsten deposited on the wall of said envelop by vaporization in a vacuum too high to permit a disruptive electrical discharge at high voltages.

7. The method of depositing a gas-free conductive film of refractory metal upon non-conducting surfaces which consists in incandescing a refractory metal conductor at the vaporizing temperature of the metal constituting said conductor in a vacuum so high that electrical discharges may be produced therein without positive ionization.

8. An article of manufacture comprising an envelope of non-conducting material and a layer of metal thereon produced by the vaporization of said metal in a vacuum having a residual gas pressure below about 1/1000 of a millimeter of mercury, said metal being sufficiently hard and coherent to resist abrasion.

9. The method which consists in vaporizing metal in a vacuum having a residual gas pressure below 1/1000 of a millimeter of mercury, and receiving said vaporized metal upon a solid body, thereby producing a coherent, gas-free deposit of metal.

In witness whereof I have hereunto set my hand this 5th day of June, 1914.

IRVING LANGMUIR.

Witnesses:

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