Feb. 17, 1942. E. HOFMAN 2,273,488

METHOD OF SEALING ELECTRICAL CONDUCTORS TO QUARTZ

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Fig. 1



Fig. 2



Fig. 4

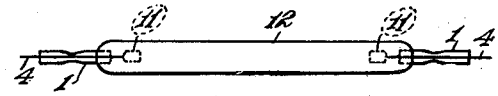


Fig. 5

Fig. 3

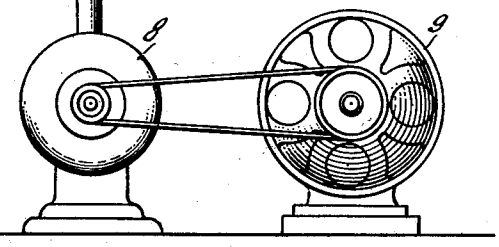




Fig. 6

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METHOD OF SEALING ELECTRICAL CONDUCTORS TO QUARTZ

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7 Claims. (Cl. 49—81)

This invention relates to a method of sealing an electrical conductor in a quartz envelope to form a tube capable of producing very high frequency rays in the ultra-violet band or even higher. In the construction of a high-frequency tube for this purpose, it is very important that an air-tight seal be secured between the electrical conductor and the quartz envelope.

It is very hard to make an air-tight seal directly between the conductor and quartz because of the great difference in the coefficient of expansion and contraction brought about by the heating and cooling required in making the seals. In the past it has been the usual practice, so far as I am aware, to make several intermediate-stage seals between a conductor and different grades of glass, gradually bringing the glass up to the quartz strata; for example, a pure, clean tungsten wire is fused to a grade of glass having a coefficient of expansion near that of tungsten, and to this glass is fused a second grade of glass having a coefficient of expansion a little nearer that of quartz, and then these steps are repeated until the final glass will seal to the quartz. This is what is ordinarily called a "graded seal," as is well known to those skilled in the art. Other forms of seals have been used, but so far as I am aware, no one prior to my invention, to be herein described, has ever made a seal directly between quartz and a metal conductor, and, particularly, I do not know of anyone having formed this type of a seal with the aid of a vacuum which has a distinctive advantage as will be hereinafter pointed out. I have known, in some cases, as many as seven different grades of glass being used between the conductor and the final quartz envelope.

It is therefore, one of the objects of my invention to eliminate all of these intermediate seals and make an air-tight seal directly between the conductor and the quartz. By attaining this object, it will be seen that the cost of constructing a tube of this character is materially reduced.

Another object of my invention is to provide a method or process of making such a seal whereby any leak can be readily detected and corrected before the tube is offered for use, thereby eliminating waste and expense which will be caused by a leaky seal.

After long study and many tests, I have found that a metallic conductor, such as molybdenum or tungsten, having a melting point materially greater than the melting point of quartz, may be used, provided the conductor is made in a certain shape at the portion where the seal is to be made, and also provided that this portion of the conductor is first treated in a manner as will be presently described.

After much study and effort, I have found that if the conductor, such as molybdenum or tungsten, is round and of a size which may be used, it is very hard, if not well-nigh impossible, to make a seal directly between the quartz envelope, and such a round conductor. I have also discovered that if that portion of the conductor, where the seal is to be made, is made very thin and flat, the thickness being on the order of .001", and properly treated, I can make a perfect seal by the method herein illustrated and described.

My invention will be better understood by reference to the annexed drawing, wherein:

Figure 1 shows a conductor placed inside a quartz tube or envelope ready for sealing.

Figure 2 is a view of the device shown in Figure 1, turned 90 degrees.

Figure 3 shows the device of Figures 1 and 2 attached to a vacuum pump for exhausting the envelope or tube.

Figure 4 shows the finished seal with an electrode terminal attached to the conductor.

Figure 5 shows, somewhat diagrammatically, a completed tube with my sealed conductors applied at both ends thereof.

Figure 6 is a view on the line 6—6 of Figure 4.

In Figure 1 I have shown a quartz envelope or tube 1 closed at the end 2 and open at the end 3. Inside the tube is placed a conductor 4, such as molybdenum or tungsten, a portion 5 of which is reduced in thickness down to approximately .001". As a commercial way of making the conductor, I use a ribbon stock for the portion 5, approximately .001" thick and approximately $\frac{1}{16}$" wide, and spot-weld a short section of this at its ends to another ribbon conductor 4 which may be thicker and wider; for example, the portions 4 at opposite ends of the spot-weld portion or section 5 may be on the order of $\frac{1}{8}$" wide and $\frac{1}{32}$" thick.

Before inserting the conductor, formed as shown in Figures 1 and 2, into the tube or envelope 1, at least the conductor portion 5, to which the seal is to be made, is treated in any satisfactory manner as by dipping the conductor in a solution of uranium (powdered uranium glass may be used) dissolved in hydrofluoric and hydrochloric acids. I have obtained best results by using a proportion of 70% of the former and 30% of the latter, although this range is not critical and may be varied to quite an extent. Dipping or treating the conductor portion 5 in this manner produces a cleaning action and adds to the conductor what appears to me to be a flux of such a nature that the melted quartz will strongly adhere thereto. This action is enhanced probably due to the fact that uranium has a melting point close to quartz on the upper side, so the small amount of it which adheres to the

conductor portion 5 during the dip, is melted between the quartz and the conductor.

After the conductor has been thus treated, it is placed in the envelope or tube 1 and this is connected through a suitable joint member 6 with an exhaust manifold 7 connected to a pump 8 driven by a motor 9. At the time the exhaust apparatus is started, heat is applied through suitable heating means such as an oxy-acetylene burner arrangement 10, which will start the melting operation on the quartz tube around the portion 5 of the conductor. As the quartz softens under the influence of the heat and a vacuum is established by the pump mechanism, the pressure of the air externally of the tube will cause the same to collapse and squeeze the quartz material around the treated ribbon section 5, and will become securely welded or joined thereto.

Due to the thinness of this section as compared with the thickness of the envelope or tube 1, there is not enough contraction of the small section of metal to impair the joint.

To test the seal made in the manner described, after it is completed, the end 2 of the tube is removed and if there is the slightest leak at the seal, this will be registered on the vacuum apparatus, the instruments for registration not being indicated in the drawing. After the seal has been completed, a terminal 11 is connected to the conductor end 4 in any satisfactory manner as by spot-welding at the point indicated. The device shown in Figure 4 is then ready to be applied to a tube 12 by inserting the terminal end 11 thereinto and burning the ends of the tube 12, which is of quartz, to the end of the respective quartz tube 1, thereby completing a tube as shown in Figure 5.

In the showing of Figures 3 and 4, the depression in the tube 1 of the seal has been exaggerated in order to show the effect more clearly.

What I claim is:

1. The method of forming an air-tight seal between a ribbon conductor of metal selected from the group consisting of molybdenum and tungsten and having a melting point materially above the melting point of quartz, and a quartz envelope, which consists in first treating the conductor with a solution of uranium, hydrofluoric and hydrochloric acids, inserting the treated conductor into a quartz envelope closed at one end, applying a vacuum to the open end of the envelope and also applying heat to the envelope at a portion where the seal is desired, thereby allowing pressure of the air to squeeze the heated quartz portion securely around the wire.

2. The method of forming an air-tight seal between a molybdenum conductor, and a quartz envelope which consists in first treating the conductor with a solution of uranium, hydrofluoric and hydrochloric acids, inserting the treated conductor into a quartz envelope closed at one end, applying a vacuum to the open end of the envelope and also applying heat to the envelope at a portion where the seal is desired, thereby allowing pressure of the air to squeeze the heated quartz portion securely around the wire.

3. The method of forming an air-tight seal between a tungsten conductor and a quartz envelope which consists in first treating the conductor with a solution of uranium, hydrofluoric and hydrochloric acids, inserting the treated conductor into a quartz envelope closed at one end, applying a vacuum to the open end of the envelope and also applying heat to the envelope at a portion where the seal is desired, thereby allowing pressure of the air to squeeze the heated quartz portion securely around the wire.

4. The method of making an air-tight seal between an electrical conductor selected from the group consisting of molybdenum and tungsten and having a melting point materially greater than quartz, and a quartz envelope which consists in forming one portion of the conductor about three-eighths of an inch long to a thickness of one-thousandth of an inch, and a width of approximately one-sixteenth of an inch, treating at least this part of the conductor with a solution of uranium, hydrofluoric and hydrochloric acids in the approximate proportion of 70% of the first and 30% of the second acid, inserting the treated conductor into a quartz envelope closed at one end, applying a vacuum to the open end of the envelope and also applying heat to the envelope at a portion where the seal is desired, thereby allowing pressure of the air to squeeze the heated quartz portion securely around the wire.

5. The method of making an air-tight seal between an electrical conductor selected from the group consisting of molybdenum and tungsten and having a melting point materially greater than that of quartz, and a quartz envelope which consists in treating at least a short, thin portion of the conductor approximately one-thousandth of an inch thick with a solution of uranium, hydrofluoric and hydrochloric acids of relative proportions which will put said thin portion in a condition so melted quartz will closely and firmly adhere thereto, inserting the conductor with the thin portion into a quartz envelope closed at one end, applying a vacuum to the open end of the envelope and also applying heat to the envelope at the portion surrounding the thin part of the conductor, thereby allowing pressure of the air to squeeze the heated quartz portion securely around the said thin portion.

6. The method of making an air-tight seal between an electrical conductor selected from the group consisting of molybdenum and tungsten and having a melting point materially greater than that of quartz, and a quartz envelope which consists in treating at least a short, very thin portion of the conductor with a solution of uranium, hydrofluoric and hydrochloric acids, inserting the conductor with the thin portion into a quartz envelope closed at one end, applying a vacuum to the open end of the envelope and also applying heat to the envelope at the portion surrounding the thin part of the conductor, thereby allowing pressure of the air to squeeze the heated quartz portion securely around said thin portion.

7. The method of forming an air-tight seal between a conductor selected from the group consisting of molybdenum and tungsten and having a melting point materially higher than quartz, and a quartz envelope which consists in forming in the conductor a short, very thin, flat portion, treating at least the thin portion of the conductor with a solution of uranium, hydrofluoric and hydrochloric acids proportioned so the thin portion is conditioned so that melted quartz will stick firmly thereto, inserting the conductor with the thin, treated portion within an envelope, heating the envelope around the thin portion of the conductor and causing the envelope to contract around said thin portion.

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