

Nov. 24, 1925.

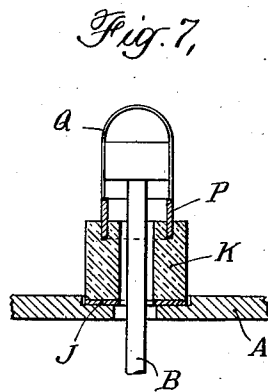
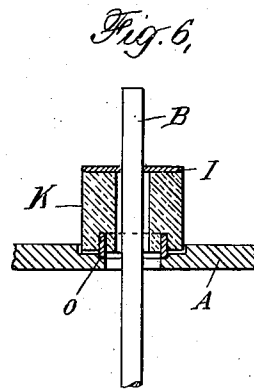
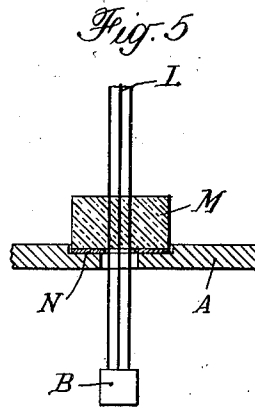
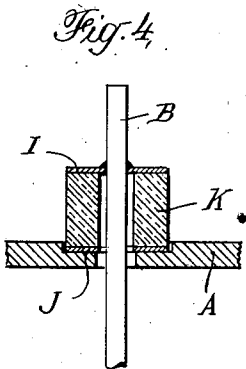
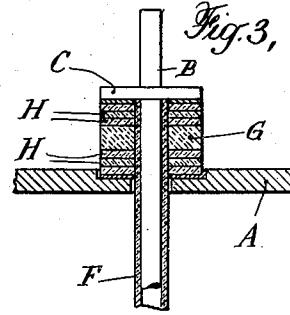
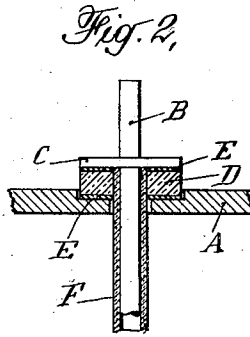
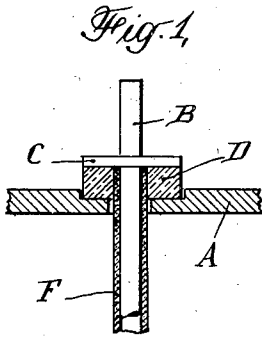
1,562,533

E. WEINTRAUB

SEALED JOINT

Filed Feb. 15, 1923

2 Sheets-Sheet 1



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1,562,533

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2 Sheets-Sheet 2

Fig. 8,

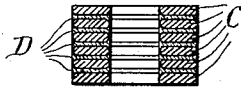


Fig. 9,

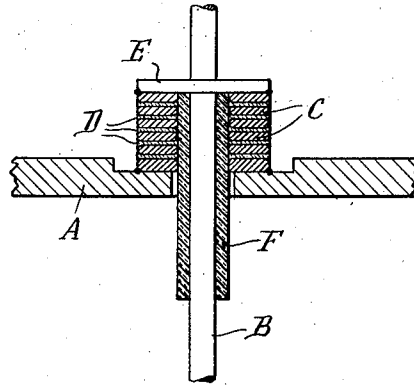


Fig. 10,

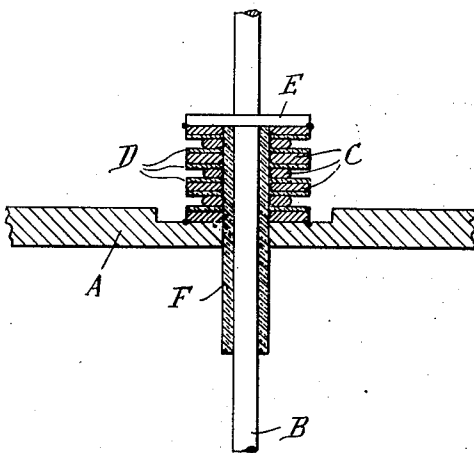
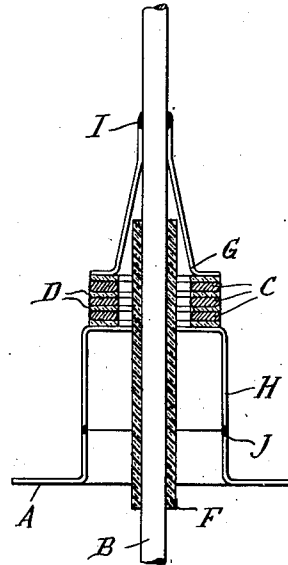


Fig. 11.



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SEALED JOINT.

Application filed February 15, 1923. Serial No. 619,173.

To all whom it may concern:

Be it known that I, EZECHIEL WEINTRAUB, a citizen of the United States, residing at Neuilly-sur-Seine, France, have invented certain new and useful Improvements in Sealed Joints; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to sealed joints and more particularly sealed joints adapted to be employed in evacuated vessels in the electrical arts, as for example, in mercury vapor rectifiers, three-electrode vacuum tubes, and other vacuum apparatus having enclosed metallic members extending from the exterior to the interior of an evacuated vessel.

The primary object of the invention is the provision of a joint of the character referred to which is perfectly air-tight and which at the same time is a good electrical insulator.

Another object is to provide a joint having the desirable properties previously mentioned and which is capable of rapidly conducting and dissipating heat, thereby insuring to a large extent against ruptures in or near the joint which might otherwise occur, due to excessive heat.

Still another object is the provision of a joint of this character, which is adapted to function as a high voltage insulator, characterized in that it is possessed of a high degree of mechanical strength.

Among the known methods for making joints for the purposes herein referred to, those most generally used today involve a simple mechanical clamping together of the parts to be joined with the interposition of a more or less plastic gasket such as asbestos, leather, etc., to which is sometimes added a mercury seal. Joints of this kind are delicate, their mounting and dismounting is complicated, and perfect tightness is insured only with difficulty.

The present invention provides a joint construction (as well as a method for producing the same) which is absolutely perfect from the point of view of tightness, is readily mounted and taken apart, and admits of any degree of insulation desired.

The principal feature of the method involved in this invention consists, in that between the metallic parts to be joined there is

interposed a layer of suitable substance such as glass, quartz, vitric enamels, etc., which assume before fusion a softened condition in which they readily adhere to the metal and whose respective coefficients of expansion are close to those of the metallic parts to be joined together. The parts joined by this method form a perfect assemblage, being practically, if not literally, all of one piece. If the metallic parts between which a joint is to be made have quite similar coefficients of expansion, a single interposed element or layer made of a material which coefficient of expansion is about the same may be sufficient, but if, on the other hand, the parts to be joined have unequal coefficients of expansion, or if the joint must have certain properties (for instance, in high voltage insulators) which require the intercalation therein of elements suitable for the purpose having still another coefficient of expansion, the joint may include a pile-up of interposed elements usually in the form of plates, whose coefficients of expansion vary progressively (by amounts small enough to avoid danger of disruption or dislocation) between that of the metals to be joined together and that of the special interposed element or elements.

According to another aspect of the invention, a joint is provided having the characteristics of high insulation and mechanical strength, as well as being a perfect vacuum seal. A joint of this type is particularly advantageous for use in vacuum apparatus intended for operation on high tensions.

The utility of the present invention is not limited to the electrical arts. The joints herein described, modified, perhaps, to suit the particular problem in hand, are well adapted for use in vacuum bottles and for use in conjunction with vacuum pumps. In fact, it is thought many other uses for such joints will occur as occasions arise.

As specific examples, two steel plates may be joined according to the present method by enameling each with one of the usual steel enamels, placing the enameled surfaces in contact, heating the parts in a furnace to a temperature between 400° and 600° C. and subjecting them to a pressure sufficient to cause them to coalesce. The pressure may go up to a few kilograms per square centimetre. The temperature and pressure will

vary with the nature of the enamel used, but should always be selected so as to cause perfect coalescence of the two enamel layers, without causing excessive excretion of the enamel from between the two surfaces.

The same process is applicable for joining copper, steel alloys and other metals—an appropriate enamel having a corresponding coefficient of expansion being selected in each instance. In the cases where it is desired to join tungsten or molybdenum parts the surfaces to be joined are covered with a layer of refractory glass such as "Pyrex", which has a coefficient of expansion close to that of tungsten. The parts may be joined in the manner described above, but the temperature applied is of course higher than in the case of the softer enamels, being from 600 to 800° C.

Instead of heating the parts in a furnace they can be heated by induction with high frequency currents.

In cases where the two metallic surfaces must be insulated from each other in a vacuum-tight manner for higher voltages, the insulation provided for by the coalescing of the two enamel layers may not be sufficient, as the thickness of a good enamel that can be produced on steel is not much in excess of 1 mm. or 1½ mm. If a glass or enamel plate of a nature similar to that of the enamel on the plates is interposed between the enameled plates and subjected to pressure and temperature as above, it is possible to increase the thickness of the enamel layer by a few millimetres, without causing undue fragility.

A better construction than that just described from the standpoint of combined high insulation and mechanical strength, may be obtained by an arrangement comprising a plurality of superposed plates or rings with thin interposed layers of appropriate enamel. The number of such plates or rings employed in any particular case depends upon the voltage which it is desired to withstand. The total effective insulation of a joint of this kind is equivalent to the sum of the effective insulation of the several layers of enamel. In a structure such as just described the metal plates or rings, as the case may be, add greatly to the mechanical strength of the joint as compared with a joint of the kind previously mentioned, wherein the insulating medium of glass or other vitric substance is of considerable thickness and correspondingly more fragile, particularly with respect to compression stresses.

A further advantage inherent in a joint such as that last described arises from its relatively high thermic conductivity along a plane parallel to the surface of the plates or rings—the metal being a good heat conductor. This factor is particularly impor-

tant where the joint is employed in apparatus in which high temperatures have to be considered.

In the case of very high voltages there may be danger of surface leakage. To avoid this the plates or rings may be staggered or made of progressively diminishing diameter or other expedients resorted to for avoiding having the edges of the adjacent plates coincide. Another expedient which may be resorted to for avoiding surface leakage is to cover the exterior or interior surfaces of the assembled joint with a suitable insulating material in addition to the enamel. For a more detailed description of various embodiments of the invention, reference will now be made to the accompanying drawing, in which

Fig. 1 is a fragmentary sectional view of a device including an evacuated vessel in which an electrode is inserted;

Fig. 2 illustrates a slight modification of that embodiment of the invention shown in Fig. 1;

Fig. 3 is an alternative form of joint, wherein the insulating properties are considerably enhanced;

Figs. 4, 5, 6 and 7 are further alternative embodiments, each having its own particular utility; and

Figs. 8, 9, 10 and 11 show four embodiments which are particularly characterized by the properties of combined high insulation, mechanical strength and efficiency in dissipating heat.

In Fig. 1 there is illustrated a simple case wherein the electrode B and the vessel A are assumed to be made of steel. The electrode is provided with a steel collar C integral therewith. A cylinder D, made of glass or other suitable vitric substance whose coefficient of expansion is near that of steel, is mounted between the vessel A and the collar C. In effecting joinder of parts here shown they are all heated to a temperature sufficient to soften the glass and mechanical pressure is exerted upon the collar C, thereby bringing about perfect adherence, on the one hand, between itself and the cylinder D, and on the other, between the cylinder D and the vessel A. During the operation it is preferable to surround the cylinder by a refractory mold (or a metallic mold lined with a refractory material such as graphite, etc.) in order to avoid deformation of the glass cylinder.

Prior to this welding operation the collar C and the vessel A may be enameled on the surfaces which are to come into contact with the glass cylinder. This modification is indicated in Fig. 2, wherein E refers to the enamel layer which is first applied to the metal surfaces. The layer of enamel E must of course be chosen so that its coefficient of expansion is near that of steel or

whatever metal the parts may happen to be made of. The intermediate cylinder D may moreover be omitted and the metallic parts welded directly through the medium of the layers of enamel by simple pressure at the softening temperature of the latter, provided the joint sufficiently answers the requirements in addition to that of vacuum tightness, which might be imposed. This would be the case where only a moderately efficacious electrical insulator is required. The resulting joint is of extremely simple and strong construction and its tightness is perfect.

If a certain electrical insulation is to be obtained, the height of the cylinder D may be made sufficient to enable the latter to resist the voltage applied, but it should be noted that the glasses, whose coefficients of expansion are about equal to that of steel, are only slightly refractory, and the insulating qualities are not of the best. In addition to this, owing to their chemical composition, they give rise to cathodic strains, which may be detrimental in electric apparatus where cathodic emission comes into play.

The last-mentioned difficulty may be readily eliminated by the use of a tube F made of high class insulating material such as porcelain, fused silica, etc. surrounding the electrode. The tube F is in immediate contact with the surface of the glass cylinder, which is directed toward the interior of the vessel.

The insulating properties of the joint may be considerably improved by means of the arrangement shown in Fig. 3. The parts are joined together in this case through the medium of a cylinder G made of a good insulating material, as for instance, porcelain and dimensioned in proportion to the applied voltage. Between this cylinder G, which insures the required insulation, and the collar C of the electrode on the one hand, and between the cylinder G and the vessel A on the other hand, glass discs H are inserted, the successive coefficients of expansion of which vary gradually from that of porcelain to that of steel (assuming both the electrode and the vessel to be made of steel). The number of discs is such that the difference in expansion between two welded elements remains too small to give rise to any dislocation of the structure whatever.

Any insulating substance other than porcelain may of course be used for the cylinder G, for instance, fused silica or a refractory glass such as the one known under the trade name "Pyrex." The selection to be made between the various insulating substances will depend upon the particular voltage applied, upon the number of pieces to be joined together, and also upon the more or less high degree of complexity to

which any solution of the joint problem would lead. With fused silica as the insulator G and the parts to be joined made of steel, it will be necessary to provide several discs of glass between the fused silica and each of the metal parts respectively. A porcelain with a coefficient of expansion sufficiently high is available whereby only one glass disc is required for affecting the weld. If the parts to be joined are made of tungsten or molybdenum, certain ferro-nickel alloys or of any other substance having a coefficient of expansion of the same order of magnitude are dealt with, they may be welded directly to a single lump of a refractory glass such as "Pyrex," having high insulating qualities. Assembling the elements is accomplished as in the previous instances by exerting pressure at the softening temperature of the glass, the joints of the interposed elements being made one after the other, starting with those which require the highest temperature.

The arrangement shown in Fig. 3 is particularly adapted for those cases where the parts to be welded have unequal coefficients of expansion. The piled-up glass discs have such coefficients of expansion as to vary progressively between the coefficients of expansion of the metallic parts to be joined.

In the structure of Fig. 4, the collar I is welded to the electrode B (which latter may be made of any metal desired) and is made of a metal or alloy having a coefficient of expansion approximately the same as that of a high insulating refractory glass. A plate J made of the same metal or alloy as the collar I is welded to the metallic vessel A. The cylinder K is made of a high insulating refractory glass or equivalent substance, having approximately the same coefficient of expansion as the collar I and plate J. Tungsten or molybdenum are suitable metals for the collar I and plate J, with which may be used for the cylinder K a refractory glass having a coefficient of expansion approximately equal to $(3 \text{ to } 4) \times 10^{-6}$, as for instance, "Pyrex" glass. Ferro-nickel alloys having appropriate composition may also be used for the parts I and J. With ferro-nickel alloys ranging from 30 to 44% nickel there may be obtained a whole series of coefficients of expansion ranging from zero to 5×10^{-6} , which series includes the coefficients of expansion of the refractory and high insulating glasses up to fused silica.

In the example of Fig. 5, the electrode B, which may be made of steel, is welded to rods L, made of tungsten or molybdenum, the latter being sealed into a mass of high insulating refractory glass M, the latter being welded according to the method hereinbefore described to a plate of tungsten or molybdenum N, which latter is in turn welded to the metallic vessel A. This ar-

arrangement is of particular advantage in those cases where the electrode does not have to conduct high amperage currents and hence where efficient cooling thereof need not be considered.

In Fig. 6 is shown a modification of the arrangement shown in Fig. 4, the plate J being replaced by a cylinder O.

In Fig. 7 the plate I of Fig. 4 is replaced by a cylinder P welded or secured in any other manner to the steel electrode B through the medium of a metal hood Q, which may be used as a cooling device.

In Figs. 8, 9, 10 and 11 are shown four embodiments of the invention which, while being particularly adapted for use as high voltage insulators, are characterized by a high degree of mechanical strength and as excellent heat conductors by virtue of which property they are especially adapted for use in apparatus where high temperatures are developed. In each of these four last-mentioned structures the joint consists of several superposed enamel plates, the number being sufficiently great so that the sum of the thickness of the successive enamel layers provides sufficient insulating capacity for the voltage applied. Each of the enamel layers is sufficiently thin so that the mass formed by the piled-up plates is not fragile.

Fig. 8 illustrates a joint per se, without any associate apparatus. The metallic plates entering into the make-up of the joint are naturally given a shape appropriate to the purpose. In the examples chosen they are supposed to be built up from steel rings C (shown in cross section in the figures) which are welded together by layers of enamel D, having a thickness of .5 to 1.0 mm. As a rule a gentle pressure will be sufficient to effect the jointing operation at the softening temperature of the enamel. The weight of the piled-up metallic plates may moreover suffice to give the necessary pressure while the latter must at all times be smaller than that pressure at which part of the enamel would be squeezed out from between the metallic plates, thereby reducing by an undue amount the thickness of the layers of enamel after the welding operation.

Instead of the enameled iron or steel plates C, pieces made of other metals or alloys covered with enamels or appropriate glass may be used, for instance, copper ferro-nickel plates coated with crystal glass or other similar glasses, or tungsten plates coated with refractory glasses having a small coefficient of expansion, such as the one known under the trade name "Pyrex," etc. Frequently it might be advantageous to use metals or alloys in conjunction with enamels or high refractory glasses having small coefficients of expansion but being me-

chanically less fragile and better electric insulators; the resulting built-up structures are better able to resist temperature changes or unequal temperature distribution.

The welding of the plates may be carried out to advantage in the electric furnace, the insulation of the built-up structure being controlled during the operation by any suitable means. In the embodiment shown in Fig. 9, the mass constituting the joint structure made in accordance with Fig. 8 is mounted between the wall A and a metallic collar E, carried by the rod B. The metallic plates at the ends of the built-up mass are welded by autogenous welding or are brazed, or secured by any other equivalent means to the collar E and the wall A. An insulating sleeve F slidably mounted on the rod B provides the insulation between this rod and the edges of the hole left in the wall A and also the inner edges of the metallic plates C forming part of the built-up joint.

It may be desirable in some instances to make the metallic plates of the built-up joint structure of various diameters so as to increase the distance over which any surface discharge is compelled to travel, thereby avoiding such discharges. Fig. 10 shows an arrangement of this character wherein it will be seen that the alternate plates C are of different diameter. The same object may be accomplished in some cases by merely coating the outer surface of the structure with an insulating enamel, without providing plates of different diameters.

In the arrangement of the joint there must be taken into consideration the conditions arising from the welding of the extreme metallic plates of the joint to the parts A and B, which are required to be joined together in order to avoid the danger of formation of cracks in the joint as the result of the heat liberated in this welding operation. An arrangement such as the one shown in Fig. 11 may be adopted, in which the outermost parts G and H of the built-up structure are given such a shape and dimension that the points I and J where they are to be welded to the vessel A and electrode B respectively, are sufficiently remote from the enamel or glass layers D.

Joints constructed in accordance with the embodiments of the invention shown in Figs. 8, 9, 10 and 11 are not only of value where high insulation is required, but they are also useful in numerous instances where a good thermo insulator is desired, as for instance, the joints between the outer and inner jackets of metallic thermos bottles, diffusion pumps, etc. For these latter purposes the thermo insulation afforded by the enamel or glass layers of the present joint meets all the requirements.

The particular embodiments of the invention shown in the drawings are given

only by way of example and are not to be construed as limiting the invention in any respect.

I claim:

5 1. An electrical device comprising an evacuated vessel, an electrode extending from the exterior to the interior of said vessel, and an airtight joint interposed between said electrode and said vessel, said
10 joint comprising a pair of metallic members having substantially parallel adjacent surfaces, and a layer of fusible nonconducting vitric material having a coefficient of expansion substantially equal to that of the
15 metallic members, said layer being interposed between and adhering to said surfaces.

2. An electrical device comprising an evacuated vessel, an electrode element within said vessel, said electrode element terminating at the exterior of said vessel and an airtight, non-conducting joint between said electrode and said vessel, said joint comprising a plurality of metallic members
25 joined together by means of non-conducting vitric material, such as glass, the vitric material adhering to the metal with which it is in contact, the coefficients of expansion of the adjoining metallic members and vitric material being of approximately the same
30 value, the differences if any in each instance being so small, that excessive contraction or expansion strains due thereto cannot develop.

3. An electrical device comprising an evacuated vessel, an electrode element within said vessel, said electrode element terminating at the exterior of said vessel and an airtight, non-conducting joint supporting said electrode and interposed between said
40 electrode and said vessel, said joint comprising a pile-up consisting of alternate layers of metal discs and non-conducting vitric material, said discs being welded together by said vitric material, the coefficients of expansion of said metal discs being, in each instance, approximately the same as the vitric material adhering thereto.

4. The method of producing an airtight electrically insulated joint between two metallic members by means of a vitric material having a coefficient of expansion differing materially from those of the metallic members which consists in securing to each of said metallic members a metallic part having
55 a coefficient of expansion substantially equal to that of the vitric material, applying the vitric material to the exposed surface of at least one of said metallic parts, subjecting said vitric material to a softening temperature and pressing said parts together with the softened vitric material interposed therebetween, sufficient pressure being applied to cause the two metallic parts
60 to adhere one to the other.

In testimony whereof I affix my signature.

EZECHIEL WEINTRAUB.