Oct. 13, 1936. H. SCOTT 2,057,452

GLASS-TO-METAL SEAL

Filed Jan. 31, 1934

Fig. 1.

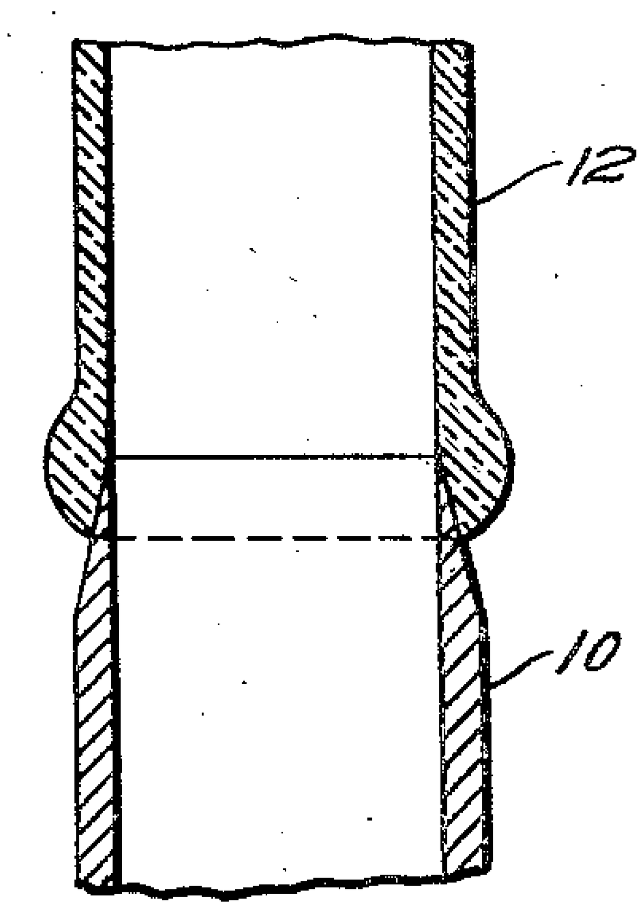


Fig. 2.

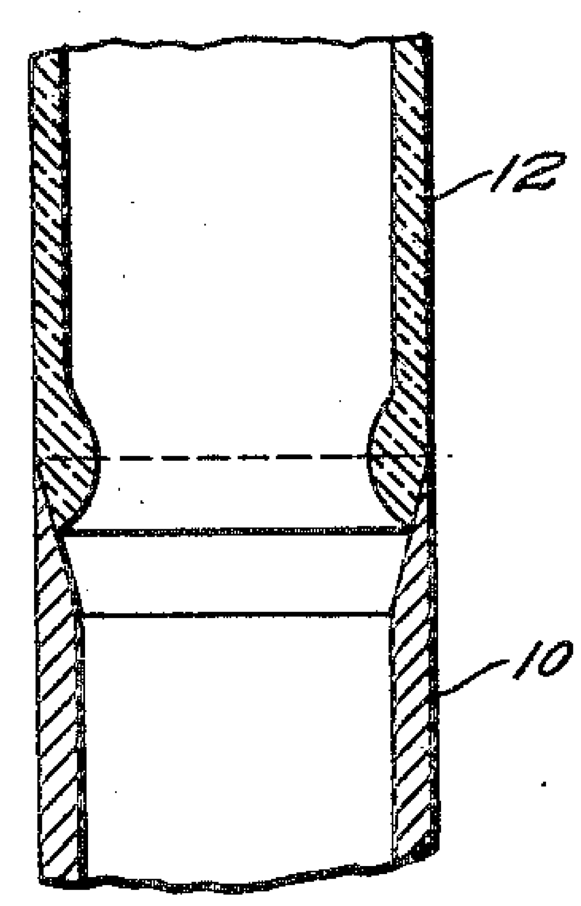
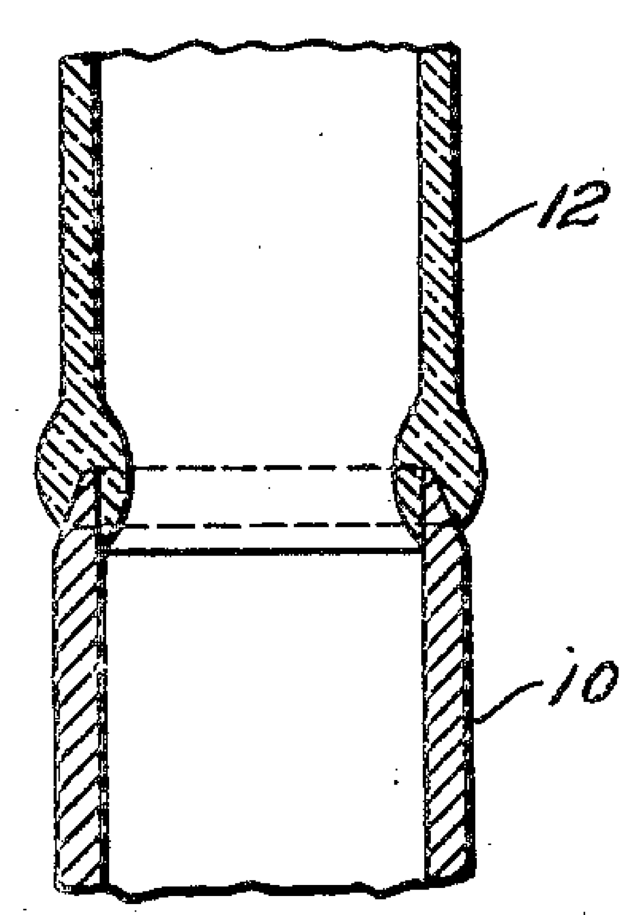


Fig. 3.



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GLASS-TO-METAL SEAL

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3 Claims. (Cl. 49—92)

My invention relates to glass to metal seals and it has particular relation to improvements in the design of seals between relatively large glass and metal sections.

Vacuum tight joints of this general character are now extensively required in the construction of many electrical devices, particularly radio transmitting, rectifier, X-ray and other electronic tubes. In the making of such seals between commercial grades of glass, particularly those of the so-called hard compositions now widely used, and metals having properties suitable for proper fusion with the glass and also for service as a member or element of the electronic tube or other device, difficulty has been experienced in keeping the stress concentrations below the glass fracturing value.

This difficulty is especially serious because the metals heretofore widely used in sealing applications, notably copper, certain compounds and compositions of copper, tungsten, and molybdenum, are unsuitable for gaseous conduction devices in the construction of which metal tube or cup structures must be sealed into the glass. Thus the copper and its compounds form joints which have low resistance to thermal shock and which additionally are attacked when mercury is contained within the device. Likewise, tungsten and molybdenum are unduly expensive and incapable of formation into structural parts other than simple wire leads.

I have found that certain iron-base alloys, made up approximately one-half of iron and the remainder nickel, cobalt, chromium, manganese and other components of steel are capable of sealing directly into hard glasses having an expansivity less than 5×10^{-6} per degree C. and a high silicon content. Such glasses are those known in the trade as G-702-P and G-705-AJ. These alloys are low in cost, easily fabricated, rolled or otherwise formed into convenient shapes, are readily "wet" by the glass to form a satisfactory union therewith, and are not attacked by mercury vapor.

When, however, tubular seals of diameters of the order of several inches are made between hard glass and the referred to alloys, the before-mentioned difficulties of stress concentration and glass breakage are still found to be present, if the usual or conventional mechanical designs are used in the joints. The general purpose of the present invention is to provide improved designs for seals of the character under consideration which overcome this disadvantage and which possess additional advantages to be particularized hereinafter.

One object of my invention, therefore, is to provide tubular seals between glass and metals which reduce to a minimum the stress concentrations in the joined materials.

Another object of my invention is to provide a tubular glass to metal seal which is capable of withstanding the severe thermal shocks which result from sudden or abrupt changes in temperatures.

A further object of my invention is to provide a seal design of the above character which is particularly applicable to junctions between hard glass and tubular sections of metals which have inflection temperatures lower than the strain point of the glass.

My invention itself, together with additional objects and advantages thereof, will best be understood through the following description of specific embodiments when taken in connection with the accompanying drawing in which:

Figures 1 and 2 are sectional views of tubular seals constructed in accordance with one embodiment of my invention, and

Fig. 3 is a similar sectional view of a seal constructed in accordance with a second embodiment of my invention.

In the preparation of tubular joints between iron-base alloys and soft glass, no particular difficulty is met because the alloy may be so chosen as to have practically identical expansion characteristics as does the glass. When, however, a hard glass is joined to an appropriate iron base alloy, which basically may be made up of nickel and cobalt with at least 40% of iron or may contain at least 22% of chromium, the correspondence in expansion is less perfect so that stresses may remain in the glass even after the annealing treatment customarily applied in the making of the seal.

This is because of the fact that the hard glasses have a strain point, defined as the lowest temperature at which stresses can be completely released or very nearly so in a relatively long given period such as eighteen hours, which is usually above 450° C. The iron-base alloys may be prepared to have a mean expansivity, over the temperature range of zero degreees C. to their inflection temperature, equal to that of the glass over the same temperature range. The inflection temperature, which is defined as that above which the expansivity of the alloy increases rapidly, is, however, under the conditions stated, lower than the strain point of the glass. Consequently a joint cannot be produced which is completely free from stresses at atmospheric temperature even after the customary annealing at the strain point for eighteen hours or longer.

I have found that this condition is particularly pronounced in the case of tubular seals having diameters of the order of several inches. Whereas a solid rod of the iron base alloy can be satisfactorily sealed into hard glass having a coefficient of expansion of 3.6×10^{-6} per degree C. and a strain point of 467° C., a tube joint of the same components similarly annealed is found practically always to crack if design precautions are not taken to avoid stress concentrations.

In the case of a properly chosen tube two inches in diameter and tapered in the usual or conventional manner at the end joined to the glass, cracks were found to develop with either a fine or a blunt taper when the glass was applied both on the inside and the outside periphery of the tube in a continuous layer. It was observed that the crack starts at the knife edge and all indications are that it is due to exceedingly high concentration of stress at this point.

In accordance with my invention I have eliminated this stress concentration in two ways. The first, typified by the showings of Figs. 1 and 2, is by restricting the attachment of the glass either to the outside or the inside of the iron base alloy tube which is given a considerable or relatively gradual taper at the joined end. The second of these methods, typified by the showing of Fig. 3, is to round the edge of the tube, that is, to turn a considerable radius on it of the general order of 0.020 of an inch and apply the glass to both the inside and outside surfaces.

In each of the several figures of the drawing the tubular section of metal is represented generally at 10 while the mating section of glass to which the metal is to be joined is shown generally at 12. For purposes of the present discussion it may be assumed that the glass is of a so-called hard grade and that the metal is an iron-base alloy of the type heretofore described in detail.

By employing the designs of the three illustrated constructions I have succcessfully joined the commercially available hard grades of glass with properly chosen iron-base alloy tube and cup structures which, in certain test joints which were made to demonstrate the effectiveness of the designs, had an inside diameter of two inches and a wall ⅛″ in thickness. In all cases the seals were annealed at 400° C. for about eighteen hours and were then cooled in air at room temperature. In none of the instances involving a proper combination of materials and treatment did cracks develop.

Furthermore, joints constructed in accordance with my invention are found to possess exceedingly high resistance to thermal shock and are therefore most satisfactory in gaseous conduction and other electronic tube devices.

Nor are the beneficial results restricted to seals between glass and an iron base alloy having an inflection temperature lower than the strain point of the glass, for in cases in which the alloy has a higher strain point than does the glass sealed into the improved designs of my invention afford high resistance to thermal shock and provide certain other advantages of a type previously considered.

Although I have shown and described certain specific embodiments of my invention I am fully aware that many modifications thereof are possible. My invention therefore is not to be restricted except insofar as is necessitated by the prior art and by the scope of the appended claims.

I claim as my invention:

1. A joint or seal between a tubular section of glass and a mating section of an iron-base alloy having an inflection temperature lower than the strain point of the glass characterized in that the glass is attached to both the inside and the outside surfaces of the alloy section and in that the end of said alloy section is rounded to a contour of blunt shape having no sharp edges.

2. A joint or seal between a tubular section of an alloy containing nickel and cobalt with at least 40% of iron and a mating section of glass characterized in that the glass is attached to both the inside and the outside surfaces of the alloy section and in that the end of said alloy section is rounded to a contour of blunt shape having no sharp edges.

3. A joint or seal between a tubular section of an iron-base alloy containing at least 22% of chromium and a mating section of glass characterized in that the glass is attached to both the inside and the outside surfaces of the alloy section and in that the end of said alloy section is rounded to a contour of blunt shape having no sharp edges.

HOWARD SCOTT.