April 3, 1956 P. E. GATES 2,740,186

GAS TUBE ASSEMBLING METHOD

Filed July 17, 1951

2 Sheets-Sheet 1

PRIOR ART

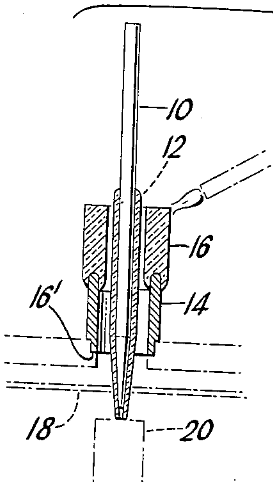

Fig. 1

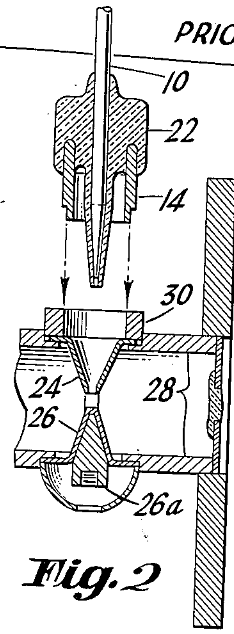

Fig. 2

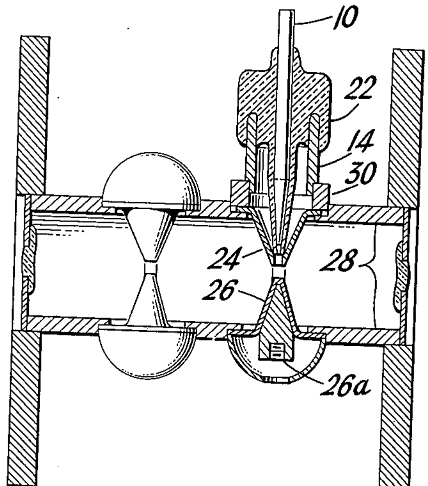

Fig. 3

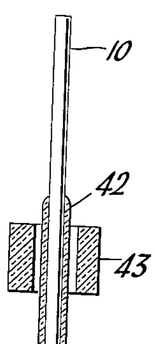

Fig. 4

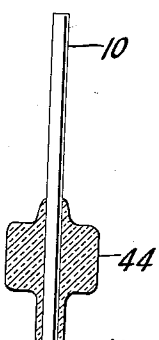

Fig. 5

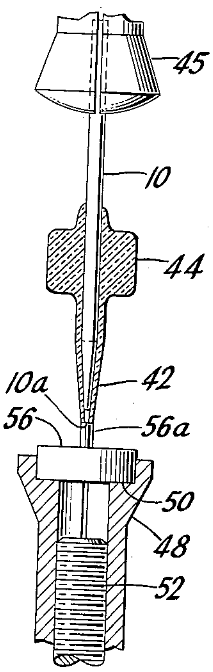

Fig. 6a

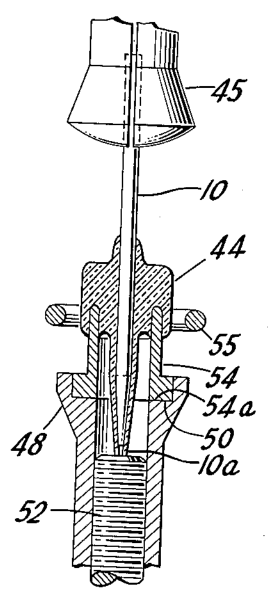

Fig. 6

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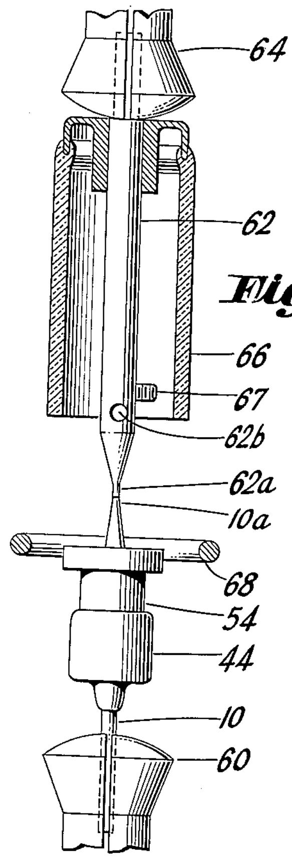


Fig. 7

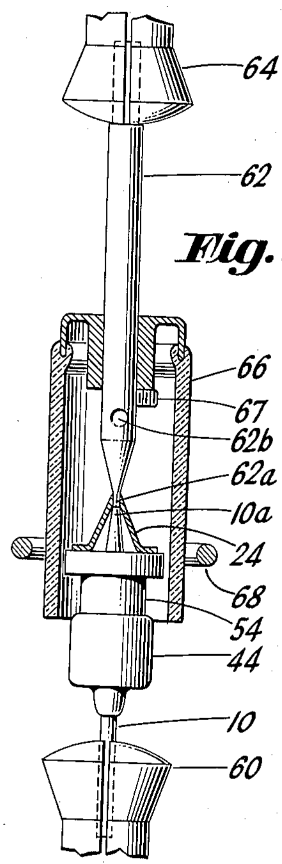


Fig. 8

Fig. 9

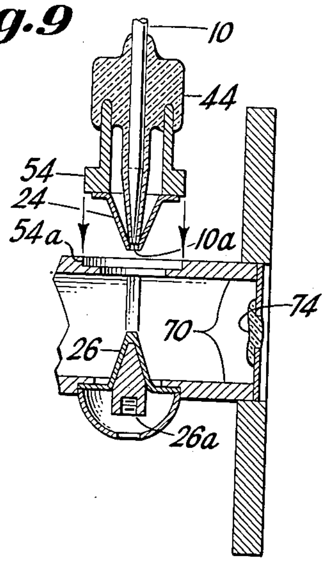
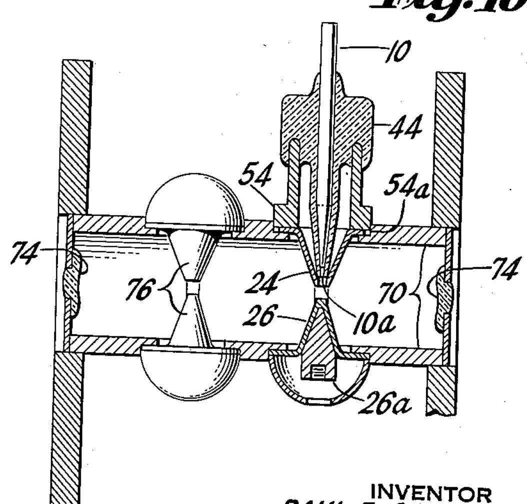


Fig. 10



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1

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GAS TUBE ASSEMBLING METHOD

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1 Claim. (Cl. 29—25.13)

The present invention relates to assemblies of electrodes in gas filled electric discharge tubes used in microwave systems, and to methods of making such assemblies.

This invention will be understood from its application to a particular type of gaseous discharge device described in detail below, as a matter of convenience, but variations of the particular configurations and applications to other types of tubes will be readily apparent to those skilled in the art. In these tubes, it is currently required that a glow discharge be established between two electrodes, where the volume of ionized gas and the intensity of the ionization must be accurately controlled and should be as nearly alike as possible from each tube to the next. Transmitter-receiver (TR) and attenuator tubes as well as some forms of anti-transmit-receiver (ATR) tubes are types of gaseous discharge tubes in which the problem arises. In these tubes, a waveguide passage is often defined by a metal portion of the tube envelope. The ionization controls the transmission of microwave energy in this transmission path. In the case of TR and ATR tubes, the ionization that is to be established as a weakly ionized discharge between the electrodes in question, is to facilitate the intense ionized discharge or break-down across the transmission path when high level microwave energy is impressed on the device.

Certain forms of these tubes have heretofore included a glass sheathed wire or rod, extending concentrically within a hollow cone to an opening at the end of the cone, where both the inner electrode and the cone are exposed to the gas filling within the transmission path. By applying a voltage of suitable magnitude between this inner electrode and the cone, a gaseous electric discharge is established.

In order that the control may be effected uniformly from each tube to the next, it has been found critically important that the concentricity of the inner electrode within the cone be maintained and that the end of the electrode be uninformly spaced from the opening in the cone. An object of the present invention resides in the provision of a method of assuring the desired uniformity of orientation of the electrode with respect to the open ended outer electrode. For convenience the conventional terminology will be used hereinafter in which the inner electrode is termed the "keep-alive" electrode or simply the "keep-alive" and the outer-electrode that is usually conical in form is termed a "gap electrode." The gap electrode conventionally is assembled opposite a similar (but solid) gap electrode in the device so as to impose the ionized discharge on the microwave transmission, in the case of attenuator tubes; and in the case of TR and ATR tubes, the gap electrodes produce breakdown at high-level energy moments, in which case the keep-alive electrode furnishes a desired initial ionization level for fast responses to the high-level energy condition. The nature of the invention and its various features of novelty will be understood from the following detailed description of an illustrative embodiment thereof in contrast to a conventional prior art construction and procedure shown in the accompanying drawings. In the drawings:

2

Figures 1 to 3 illustrate, in fragmentary cross-sectional views, a typical prior art practice in the assembling of tubes of this class; and Figures 4 to 8 inclusive illustrate, in progressive stages, an improved procedure for assembling the keep-alive and gap electrode. Figure 9 shows a completed gap electrode and keep-alive assemlby together with a portion of the envelope of a gas tube to which the electrode assembly is to be inserted, and Figure 10 shows a complete TR tube containing the assembly of Figure 9. All of the views are enlarged.

Referring now to Figures 1 and 2, a center rod **10** of reduced cross-section at its lower end is sheathed or "beaded" with glass **12** in a preliminary operation; and also in a preliminary operation, collar **14** is sealed to a short length of glass tube **16**. These are oriented in a fixture having a seat **16'** for receiving collar **14** and a radial jaw clamp **18** and stop **20** for receiving and orienting the beaded rod **10, 12**. The orientation of a glass beaded lead by means of clamp **18** is difficult, partly because of the variation in thickness of the glass beading and partly because of the cumulative tolerances in the dimensions of the various parts. Glass portions **12** and **16** are fused together by gas heat in a seal **22** as shown in Figure 2, as one complete sub-assembly.

Another sub-assembly is formed as shown in Figure 2 of a pair of gap electrodes **24** and **26** in opposed walls **28** of a rectangular length of metal waveguide which also forms the envelope wall containing ionizable gas. As shown in Figure 2, the keep-alive sub-assembly is to be inserted concentrically within the hollow gap electrode **24**. In an effort to insure this result, a ring **30** is inserted carefully into a circular recess in wall **28** of the waveguide, after cone **24** is itself carefully centered in this recess, and both are brazed in place. When sleeve **14** is seated in ring **30** and soldered or brazed, the concentricity of rod **10** in cone **24** and the axial spacing of the lower end of rod **10** from the opening in cone **24** are theoretically achieved. However, because of the numerous tolerances which may be cumulative in effect, a serious error and lack of uniformity are likely to be produced. This is demonstrated as a fact through numerous costly X-ray photographs, the only physical inspection feasible. The following description relates to an illustrative embodiment of the present invention for avoiding such non-uniformity.

The accuracy required is of the order of .001 inch. The spacing of the tip of a keep-alive electrode from the inside wall of the gap electrode may be no more than .003 inch and the endwise spacing between the keep-alive electrode and the opening in the cone may be no more than .040 inch. The cone angle in this assembly may be 18 degrees, measured between the axis and a straight-line element of the cone.

As shown in Figures 4 and 5, the first steps in preparation of the desired electrode assembly are first, the beading of the keep-alive rod **10** with a glass sheath **42**, followed by heat sealing of a short glass tube **43** to form a glass button **44** on glass sheath **42**, with the aid of fixtures and beading apparatus. The tip of rod **10** is shown terminating within bead **42**, a detail accomplished chemically. Rod **10** is next gripped by collet **45** (Fig. 6) so as to extend accurately and axially from that collet, and the rod and collet are vertically slidable in a bearing (not shown) so as to be manually raised and thereafter lowered of their own weight, and restrained during the descent. A second collet **4** is in axial alignment with collet **45** and the lower collet **48** has a recess **50** formed in the collet jaws. A stop **52** is provided within the bore in collet **48**, accurately located a pre-determined distance from the bottom of recess **50**. A shouldered collar or metal sleeve **54** is received within collet 48 and is centered thereby without allowing for any spacing or tolerance between the exterior of that sleeve and the interior of collet 48. By means of a suitable heating device, advantageously, a single *r-f* coil 55 concentrically about button 44 and collar 54, a seal is formed to unit collar 54 in assembly to beaded rod 10, rigidly and hermetically. In this operation one critical dimension is definitely established, namely, the spacing between the tip 10*a* of keep-alive electrode and the bottom 54*a* of collar 54.

It is desirable that tip 10*a* be centered within collar 54, within reasonable limits, and for this reason the straightness of rod 10 is assured by inspection at the outset and the axial alignment of tip 10*a* with respect to chuck 48 is checked occasionally by replacing collet 54 in chuck 48 with a dummy plug 56 as shown in Figure 6*a*, this plug having portion 56*a* that should be aligned with tip 10*a* of the keep-alive before assembly to collet 54.

Apparatus shown in Figure 7 is for assembling the keep-alive to the cone in a separate operation, before either of these electrodes is assembled to the metal envelope or wave-guide. In this operation the accurate concentricity of the cone about the keep-alive is uniformly assured. Further, the rejection of defective assemblies is easily made possible by visual inspection and at a stage of the manufacture where the electrode assembly is comparatively inexpensive. The fabrication of one gap electrode and the keep-alive as a separate assembly, later to be assembled opposite another gap electrode in the waveguide, represents an important feature of this invention.

The accuracy of this positioning was heretofore known, when made according to Figures 1 and 2, only after actually completing a tube. Inspection was by actual operation and by X-ray examination. In the event of inaccuracy the whole costly product then had to be discarded, or at best reclaimed in an expensive procedure.

A pin 62 having tip 62*a* is accurately opposed to the tip 10*a* of the keep-alive, pin 62 being vertically reciprocable with an axially slidable collet 64. In the event of any eccentricity of pin 62 in relationship to keep-alive 10, one or the other of these is carefully adjusted with the aid of an optical magnifier. Pin 62 is next raised to a position of clearance. Thereafter, cone 24 is deposited on collar 54 and pin 62 is lowered carefully to contact with tip 10*a*, at the same time adjusting the cone laterally so as to receive the tip 62*a*. Concentricity of cone 64 about keep-alive 10 is consequently assured to a high degree of accuracy.

Shroud 66 is next lowered about the assembly of electrodes 10 and 24, limited in its descent by screw 67 and forming gas is passed through a passage down pin 62 through opening 62*b* to flow about gap electrode 24.

Brazing heat is then developed by induction coil 68 to unite electrode 24 and sleeve 54. The accurate keep-alive and gap electrode assembly as shown in Figure 9 is complete upon cooling.

In the fabrication of the discharge gap structure, there remains only the sealing of collar 54 in the recess 54*a* in the waveguide body (Fig. 9), effected by soldering or brazing, and conventional adjustment of the opposed gap electrode 26. This is accomplished with a threaded tool inserted into portion 26*a*, by manipulating the tool to force the cone into proper adjustment.

It will thus be seen that the keep-alive and the hollow electrode 24 are assembled as a unit in a preparatory series of operations followed by a separate operation of uniting this assembly to the waveguide which constitutes a part of the envelope wall. The keep-alive electrode is oriented with respect to the hollow gap electrode 24 in two principal operations, the first of which (Fig. 6) establishes the endwise spacing between the tip of the keep-alive electrode and the end of the hollow gap electrode, and the second of which (Fig. 8) insures the concentricity of the two. This separation of the endwise and concentric dimensional characteristics is effected, utilizing collar 54, so as to achieve economically and directly, and at an early stage in the manufacture, what previously was accomplished indirectly and at final stage of tube manufacture.

In Figure 10 a completed TR tube is shown incorporating the assembly of the hollow gap electrode and the keep-alive. In contrast to the assembly in Figure 1 where collar 14 and ring 30 are separate parts, the form in Fig. 10 involves unitary collar 54. The unitary collar represents an improvement in that the possibility of a leaky seal (between portions 14 and 30) is avoided and cumulative error due to tolerances of the parts is also eliminated. Mechanical inspection of the relationship between cone 24 and the tip 10*a* of the keep-alive electrode is greatly simplified. By inspecting the electrode assembly before it is inserted into the metal waveguide body, X-ray inspection becomes unnecessary. The loss involved in rejecting an entire assembly such as that in Figure 1 because of inaccurate cone and keep-alive assemblies is eliminated.

Proper electrical performances can be reliably expected from the electrode assembly in Fig. 10 when the tube is completed. The tube when complete has windows 74 sealed across the ends of rectangular waveguide portion 70 and is filled with a mixture of an ionizable gas and a quenching gas at low pressure. In operation, a glow discharge is established between the keep-alive and the hollow cone to speed the intense discharge between cone 24 and cone 26 when high intensity energy is impressed upon one of the windows 74. Break-down reliably occurs between the cones which produces a change in the transmission characteristic of the waveguide and reflects the high intensity energy. During the low level signaling conditions, the waveguide transmits the signal into one of the windows and out of the other, and under such conditions in the TR tube described, the ionized gas in the region of the keep-alive produces a minimum of effect on the signal, that is, there is a minimum of interaction between the low level transmission and the keep-alive. Cones 76 which do not have a keep-alive electrode, also participate in the formation of an effective break-down during high level energy conditions.

The foregoing illustrative description relates to a significant improvement in the construction of a costly type of tube and represents an important gain both in uniformity of product and in manufacturing efficiency. The broader aspects of the invention are applicable to other forms of tubes employing electrode assemblies of this character as mentioned above, and accordingly the appended claim should be accorded that latitude of interpretation that is consistent with the spirit and scope of the invention.

What is claimed is:

The method of making a microwave transmission-control tube, including the steps of assembling a keep-alive electrode concentrically within a hollow open-ended electrode and with predetermined spacing between an end of the keep-alive electrode and the open end of the hollow electrode, uniting a further gap electrode to the envelope of a tube, and uniting the assembly of the hollow electrode and the keep-alive electrode to the envelope of the discharge tube opposite the further electrode which with said hollow electrode defines a break-down discharge gap.

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