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TRAVELING-WAVE TUBE ASSEMBLY

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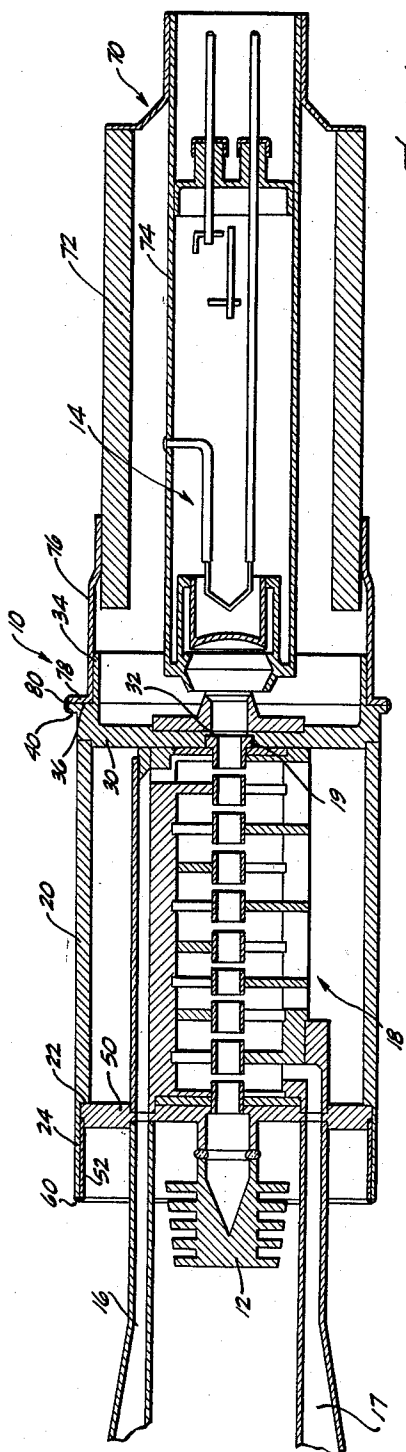


FIG. 1.

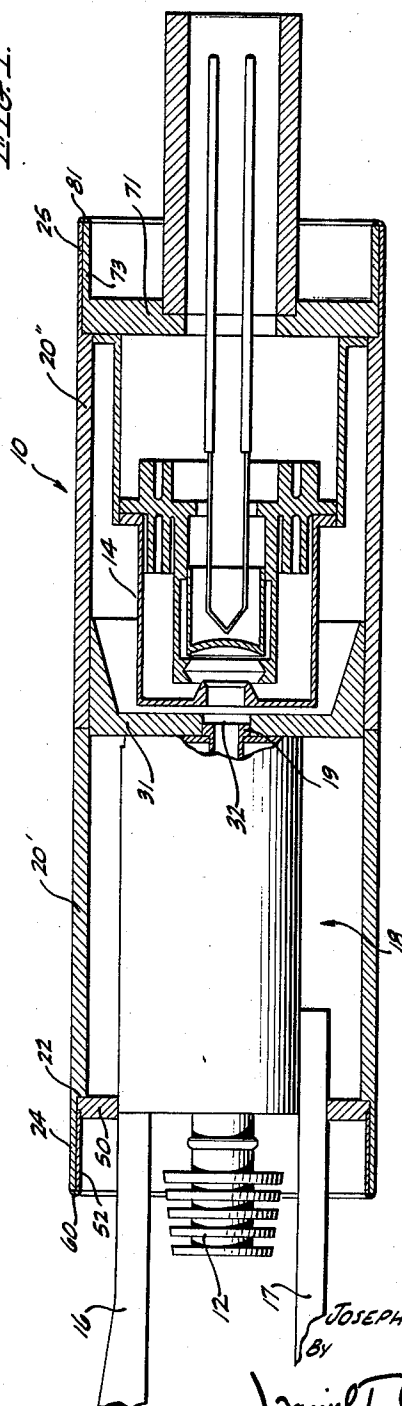


FIG. 2.

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TRAVELING-WAVE TUBE ASSEMBLY

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6 Claims. (Cl. 315—3.5)

This invention relates generally to electron discharge devices and particularly to an improved traveling-wave tube which may be readily dismantled and re-assembled.

Traveling-wave tubes normally comprise a number of major components such as one or more electron guns, a slow-wave structure and an electron collector, a transmission line coupling means and an envelope enclosing and supporting these components. Usually these component parts are manufactured as sub-assemblies and then joined to the envelope by a permanent hermetic seal. A serious problem relating to the final assembly of these component parts is the satisfactory provision of a very critical alignment of the electron gun and slow-wave structure. These parts in turn must be precisely aligned with an external focusing magnet in order to assure that the electron stream reaches the collector electrode without impinging upon the slow-wave structure. Such impingement of the electron stream would cause a serious deterioration in tube performance and would in a very short period destroy a slow-wave structure. Therefore, when such traveling-wave tubes are initially manufactured they are aligned very carefully and ordinarily permanently sealed together.

In the normal operation of a traveling-wave tube, the end of the tube's life is often due to loss of cathode emission, burn-out of heater, gas evolution, or breakage due to accident or mishandling. This usually would require the actual replacement of only one minor element. However, because of the serious problem of realigning the traveling-wave tube once it has been taken apart, it normally has been the practice in the past to discard the entire tube, including the expensive slow-wave structure, wave-guide couplings, and the anode elements of the electron gun. Heretofore, attempts to avoid a permanent seal have been made without practical success. A typical technique, for example, has been to attach heavy end pieces, separately supporting the electron gun and the slow-wave structure, to the envelope. This method, however, has for the most part proved unsatisfactory, both in that the hermetic seal is imperfect and in that additional weight is thereby added to the tube making it less practical and mobile for airborne applications.

It is, therefore, an object of the present invention to provide an improved electron tube which may readily and practically be dismantled and re-assembled.

It is another object of the present invention to provide a traveling-wave tube having an assembly of structure such that internal components subject to deterioration with age may be easily replaced without discarding the entire tube.

It is a further object of the present invention to provide a comparatively lightweight traveling-wave tube which may be dismantled for maintenance and inspection purposes without discarding the tube and without requiring extensive skilled labor.

It is still another object of the present invention to provide a traveling-wave tube which by replacement or interchange of internal components may be converted as dic-

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tated by current demands from one type of tube to another.

In one example of the present invention these and other objects are achieved by providing an outer aligning envelope and, at each end, an arrangement including aligning shoulders and an extended sealing lip means. The electron gun may be plugged into one end and, once inserted, is automatically precisely aligned axially with the aligning envelope. Similarly, the slow-wave structure assembly, which includes input and output waveguide sections as well as the collector electrode, is inserted into the opposite end. Once inserted, the slow-wave structure is also automatically precisely aligned co-axially with the axis of the outer aligning envelope. In one embodiment, the end of the slow-wave structure inserted furthest into the aligning envelope is held in axial alignment by additional aligning surfaces which are in fixed relation to the aligning envelope. Once the two main sub-assemblies are inserted into the aligning envelope, all three members are automatically precisely aligned. Both the electron gun and the slow-wave structure assembly are also provided with a peripheral sealing lip matching with an associated lip of the aligning envelope. A vacuum seal is then provided by a peripheral sealing, as by a light weld, along the periphery of the matching sealing lips at each end of the aligning envelope. The tube may then by conventional means be degassed and evacuated.

The sealing lips are made slightly extended in a manner to provide an amount of expendable metal. By this arrangement the tube may be disassembled and then re-assembled. For example, the electron gun may be removed by removing the peripheral weld about the sealing lips and simply unplugging that subassembly. The amount of heat required for the light weld is sufficiently small as to not destroy or in any way affect the aligning surfaces and retentive shoulders so that a repaired or replacement electron gun may be readily reinserted and resealed by another light peripheral weld.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawing, in which like reference numerals refer to like parts and in which:

Fig. 1 is a longitudinal sectional side view of a traveling-wave tube in accordance with the invention; and

Fig. 2 is a longitudinal sectional side view, somewhat simplified, of a second traveling-wave tube in accordance with the invention.

In accordance with the invention, referring now to Fig. 1, a demountable structure may be provided for use with an electron tube, such as a traveling-wave tube 10. Arranged with the traveling-wave tube 10 are the principal operating units, including the collector 12, the electron gun 14, input and output waveguides 16 and 17 and a slow-wave structure 18. It will be understood the details of the traveling-wave tube 10 have been simplified for clarity and that the drawing is not to scale.

The traveling-wave tube 10 is provided with a cylindrical aligning envelope or housing 20 having a collector end at the lefthand side (as viewed in the figure) and an electron gun end at the righthand side (also as viewed in the figure). The cylindrical aligning envelope 20 includes, at the collector end, an inner alignment shoulder 22. The envelope 20 is concentric with the longitudinal axis of the traveling-wave tube 10 and the inner alignment shoulder 22 is in a plane transverse to this longitudinal axis. The aligning envelope 20 includes a thin-walled sealing ring 24 at the extreme lefthand or collector end. The relationship between the inner diameter of the envelope 20 and

the greater inner diameter of the sealing ring 24 thus defines the inner alignment shoulder 22. The thin-walled sealing ring 24 may be, as shown, a part of the unitary cylindrical envelope 20, or it may be separate from but affixed to the aligning envelope 20. The inner circumference of the thin-walled sealing ring 24 defines an alignment surface for elements of the traveling-wave tube 10 which are to be inserted and held in that end.

At the electron gun end of the cylindrical envelope 20 is a collar member 30. The collar 30 lies substantially transverse to the longitudinal axis of the tube 10 and is hermetically affixed to the righthand end of the envelope 20. The collar 30 defines an inner aligning aperture 32 about the path of the electron stream in the traveling-wave tube 10. The collar 30 includes an end ring 34 integral therewith. The end ring 34 is concentric with the longitudinal axis of the traveling-wave tube 10 and includes an outer alignment shoulder 36 and an outer alignment surface. The collar 30 also includes a thin sealing flange 40 extended outwardly from the collar 30. Together with the outer alignment surface, the sealing flange 40 defines the outer alignment shoulder 36.

A transverse plate, hereafter called the collector end plate 50, is mounted across the lefthand end of the cylindrical aligning envelope 20. The outer circumference of the collector end plate 50 is in engagement with the inner alignment shoulder 22 of the envelope 20. A thin-walled sealing ring 52 for the end plate 50 is concentric with the longitudinal axis of the traveling-wave tube 10 and is affixed to the end plate 50 at relieved portions of its circumference. The outer surface of the sealing ring 52 registers slidably with the inner surface of the sealing ring 24 of the cylindrical aligning envelope 20 and assumes a position defined by the alignment surface on the thin-walled sealing ring 24. The two sealing rings 24, 52 may be chosen to be coextensive for any desired length along the longitudinal axis of the tube 10, for purposes to be described below. It is to be noticed, however, that the alignment surface on the sealing ring 24 and the inner alignment shoulder 22 of the cylindrical envelope 20 precisely define the position of the collector end plate 50 when inserted in the collector end of the cylindrical aligning envelope 20. Therefore, the input and output waveguides, 16 and 17 respectively, and the slow-wave structure 18, which are mounted in appropriate receiving apertures in the collector end plate 50, are likewise precisely positioned. It will be understood that the collector end plate 50 may be appropriately arranged to receive and retain the principal traveling-wave tube 10 structures, including the collector 12, the input and output waveguides 16 and 17 and the slow-wave structure 18. Additionally, the collector end plate 50 may also be employed to hold an exhausting tube (not shown) for evacuating the envelope 20.

Note also that when the slow-wave structure 18 is fully inserted, the furthest inserted end registers with the edges of the inner aligning aperture 32 of the collar 30. The slow-wave structure 18 may have a hub-like end 19, as shown, to engage the collar 30 for accurate seating and positioning by the inner aligning aperture 32.

The matching lips which are thus defined by the thin-walled sealing ring 24 and the sealing ring 52 of the collector end plate 50 may be joined together, as by a first light welding bead 60. This first light welding bead 60 provides an effective hermetic seal for the collector end region of the traveling-wave tube 10. Helic welding is a preferable process for making the light welding beads without undue heat being applied to the component parts being welded.

At the electron gun end of the traveling-wave tube 10 is mounted an electron gun support assembly 70. The electron gun support assembly 70 is in a general manner concentric about the longitudinal axis of the traveling-wave tube 10, and includes an outer tube structure 72 and an inner tube structure 74 affixed and hermetically sealed

thereto. The inner tube structure 74 is employed for supporting the electron gun 14, including the cathode, filament, getter, connectors and other structures usually associated therewith. The aligning portion of the electron gun support assembly 70 includes an annulus 76 fixed to the outer tube structure 72. The inner circumference of the annulus 76 registers slidably with the outer alignment surface of the collar 30. The fitting between the inner circumference of the annulus 76 and the outer alignment surface adjacent the alignment shoulder 36 is such as to permit the support assembly 70 to be slidably mounted on, but to be precisely positioned by, the collar 30. The annulus 76 terminates on the side closest to the envelope 20 in a base flange 78 which registers with the outer alignment shoulder 36 of the collar 30. The base flange 78 is in engagement with the outer thin sealing flange 40 of the collar 30. The radial length, from the center of the traveling-wave tube 10, over which the base flange 78 and the thin sealing flange 40 are coextensive may be varied as desired. It is, however, desirable to provide sufficient material in this direction for several successive welds, as is described in detail below. A second light welding bead 80 joins the matching lips of the base flange 78 of the electron gun and assembly 70 and the thin sealing flange 40 of the collar 30. The second light welding bead 80, therefore, provides a hermetic seal at the electron gun end of the traveling-wave tube 10.

The structure shown in Fig. 1 is of an assembled traveling-wave tube 10. It is desired that the principal operating parts in this structure (slow-wave structure 18, collector 12, electron gun 14, etc.) be extremely precisely aligned. Such objectives are in fact met by the alignment relationships and structures provided.

At the collector end, for example, the entire structure supported in the collector end plate 50 is mounted within the apertures in the end plate 50 and may be inserted into the aligning envelope 20 as one unit. The sealing ring 52 on the end plate 50 fits within the sealing ring 24 of the aligning envelope 20, the limit of insertion of the end plate 50 being precisely established by the inner alignment shoulder 22 of the aligning envelope 20. Movement of the end plate 50 normal to the longitudinal axis of the tube 10 is prevented by the registering surfaces of the sealing rings 24, 52. Thus, the collector end plate 50 and the attached collar, input and output waveguides 16 and 17 and the slow-wave structure 18 are precisely aligned with respect to each other and the envelope 20. Further, the hub 19 on the furthest inserted end of the slow-wave structure 18 registers with the inner aligning aperture 32 in the inner collar 30. Thus, the slow-wave structure 18 is additionally restrained from movement. Such restriction is often desirable because of appreciable forces acting upon such slow-wave structures 18.

The electron gun 14 is similarly precisely aligned with respect to the longitudinal axis of the traveling-wave tube 10. The support assembly 70 is arranged to hold the electron gun 14 in a fixed relation with respect to the annulus 76 and the base flange 78 of the support assembly 70. Therefore, when the annulus 76 is fitted over the alignment surface on the end ring 34 of the collar 30, the electron gun 14 assumes definite relationships along and concentric with the longitudinal axis of the tube 10. Movement of the assembly 70 and the electron gun 14 parallel to the longitudinal axis is limited by the engagement of the base flange 78 with the outer alignment shoulder 36 of the collar 30. Thus, it may be seen that all the principal operating parts have precise relationships with respect to each other and to the longitudinal axis of the tube 10, through the use of the aligning envelope 20 and the attendant structure.

Further features of this invention provide the extremely valuable capability of dismantling and re-assembling the tube 10. The first light welding bead 60 at the collector end and the second light welding bead 80 at the electron

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gun end may be removed, as by a grinding, cutting or arcing process. With the light welding beads 60, 80 employed and with the relatively thin-walled sealing rings 24, 52 or flanges 40, 78 employed, the heat generated in this removal process is not sufficient to distort or otherwise affect the remaining members of the traveling-wave tube structure. After such disposal of the welding beads 60, 80, therefore, either or both of the end assemblies may be removed from the aligning envelop 20 to enable work to be performed on the parts involved. Thereafter, the part may be reinserted in the same precise alignment originally maintained. The tube may then be re-evacuated and another welding bead 60 or 80 applied to the part previously removed. The value of having a coextensive length of material available for subsequent removals and welds will now be apparent. For example, a considerable length of material may be provided at the sealing rings 24, 52 at the collector end if it is desired to experiment with a number of different types of slow-wave structures 18, or to recheck the same slow-wave structure 18 a number of times. In either event, the tube may be readily disassembled and the internal parts handled without requiring skilled labor, extensive measurements or an entirely new structure.

The arrangement in Fig. 2 is a second exemplification of the invention which may be employed if desired. In Fig. 2, some parts like those shown in Fig. 1 are illustrated in simplified form for clarity. The basic arrangement of the collector 12 of the electron gun 14, the input and output waveguide 16 and 17 and the slow-wave structure 18 is like that shown in Fig. 1. The arrangement of the collector end plate 50 and the rings 24, 52 at the collector end is like that shown in Fig. 1 and the description will not be repeated in detail here. In this arrangement, however, the aligning envelope 20 and the electron gun end are disposed in a different combination. The aligning envelope, as shown in Fig. 2, may consist of a collector end half 20' and an electron gun half 20'' which are affixed together at the center of the tube 10. Instead of the collar 30 of Fig. 1 there is a collar 31 entirely within the envelope halves 20' and 20''. This collar 31 includes an inner aligning aperture 32 used with the hub 19 of the slow-wave structure 18 in the same manner as that shown in Fig. 1.

Alignment of the electron gun structure 14 with respect to the outer aligning envelope 20'' is achieved by the use of an electron gun end plate 71 and an electron gun sealing ring 73 in conjunction with a sealing ring 25 at the extremity of the electron gun half 20'' of the envelope. The matching lips of the sealing rings 25, 73 are joined by a light welding bead 81.

The arrangement at the electron gun end may be seen to be similar to that at the collector end, and a detailed description will not be given. The traveling-wave tube 10 of Fig. 2 may be dismantled and precisely re-aligned by removal of either or both the end ring sections 24, 52 or 25, 73, and precisely re-assembled with new or changed structures. The matching lips on the ring combinations may thereafter again be hermetically sealed after re-evacuation.

It is to be noted that in both Fig. 1 and Fig. 2 the arrangement of the entire structure is such that all operating parts may be dismantled. For example, the input and output waveguides 16 and 17 respectively both extend from the collector end of the structure, so that no dismantling of the slow-wave structure 18 or the waveguides 16 or 17 is needed. It should further be evident that all structures are referenced with respect to the envelope 20. The outer surface of the envelope 20 may therefore be used as an alignment surface for aligning the entire traveling-wave structure, for example, with an external focusing magnet or solenoid (not shown).

Thus, there has been disclosed an electron tube housing, such as a traveling-wave tube housing, comprising a cylindrical main body member having an end ring at

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each end and different ring members each mating with a different one of the end rings. The terminal portions of the ring combinations may be joined together to provide a hermetic seal. The rings are of sufficient length, however, to permit the joined segments to be removed. Thereby the tube may be dismantled for repair or interchanging of parts. The ring combinations are of sufficient length to provide a surplus of material which will permit re-fusing of the then remaining terminal portions of these rings. This feature provides a tube which is practically adaptable to tube maintenance; which is of comparative light weight; and which may be rebuilt to serve as a high-powered tube, a backward-wave oscillator, or an amplifier, by replacement of internal components.

What is claimed is:

1. A rebuildable traveling-wave tube housing comprising: a hollow cylindrical member having a main body portion; a first sealing ring of greater inner diameter than the inner diameter of said main body portion and concentric therewith, said first sealing ring being fixedly coupled to one end of said main body portion and defining therewith an inner circumferential alignment shoulder; an end plate abutting against said inner circumferential alignment shoulder; a second sealing ring coupled to said end plate in registry with the inner circumference of said first sealing ring, said sealing rings being coextensive in the direction of the longitudinal axis of said cylindrical member; means hermetically joining the terminal portions of said sealing rings; collar means fixedly coupled to a second end of said main body portion, said collar means including an axially extending outer circumferential alignment ring concentric with said cylindrical member and a radially extending circumferential sealing flange normal thereto and providing therewith an outer circumferential alignment shoulder; a support assembly closing the second end of said main body portion, said support assembly including an annulus concentric with said main body portion and in registry with the alignment ring of said collar, said annulus terminating in a circumferential flange abutting against sealing flanges of said collar, said flanges being coextensive for a predetermined length in a direction normal to the longitudinal axis of said cylindrical member; and means hermetically joining the terminal portions of said flanges.

2. An electron tube and housing comprising: a travelling-wave tube, an elongated slow-wave structure, an elongated cylindrical member disposed coaxially with said slow-wave structure and having at least one end ring integral with an end of said cylindrical member, said end ring having an outer diameter substantially equal to that of said cylindrical member and having a greater inner diameter than the inner diameter of the remainder of said cylindrical member thereby to provide an inner alignment shoulder at the juncture between said end ring and said cylindrical member, a ring member positioned within said end ring, said ring member having substantially the same length as said end ring and being concentric with and engaging said end ring, a circular base member supporting elongated, operative elements of said traveling-wave tube secured to an end of said ring member and engaging said alignment shoulder, concentric collar means supported within said cylindrical member about said operative elements near their end opposite said base member to maintain in reproducible manner said operative elements automatically in accurate, predetermined relationship with said elongated cylindrical member, and removable, rebuildable means sealing the terminal portion of said end ring to the terminal portion of said ring member, whereby the ring member may be removed from said end ring by removing the sealed portion of said end ring and said ring member and whereby said ring member may be re-sealed to said end ring by sealing the then remaining terminal

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portions of said end ring to the then remaining terminal portions of said ring member.

3. A rebuildable traveling-wave tube comprising: a collector, an elongated slow-wave structure, an electron gun, an input waveguide, an output waveguide, a cylindrical housing enclosing said collector, slow-wave structure and electron gun, said housing comprising: a hollow elongated cylindrical member, first and second circumferential means coupled to said cylindrical member at the different ends thereof and each defining an axial reference shoulder and a circumferential alignment surface, a collector ring member concentric with and disposed in a first end of said elongated cylindrical member, said ring member including a collector end plate member secured thereto and engaging the reference shoulder associated therewith for supporting said collector and said elongated slow-wave structure, thereby to align the collector and slow-wave structure with the cylindrical housing, collar means concentrically supported within said cylindrical housing for removably and rebuildably supporting said slow-wave structure in axial alignment with said cylinder housing, an electron gun ring member concentric with and disposed in the second end of said elongated cylindrical member, said electron gun ring member having an electron gun ring end plate secured to said ring member and in contact with the reference shoulder associated therewith, means sealing the terminal portions of said collector ring member and said electron gun ring member to their respective ends of said hollow elongated cylindrical member, whereby said traveling-wave tube may be dismantled and rebuilt by removing and resealing the sealed terminal portions.

4. A rebuildable traveling-wave tube comprising: an electron gun, a collector, a slow-wave structure positioned intermediate said electron gun and said collector with one end of said slow-wave structure secured to said collector, a hollow elongated cylindrical member disposed about said slow-wave structure and portions of the electron gun and the collector and having first and second end rings integral with the main body portion and disposed on opposite ends thereof and being of greater inner diameter than the inner diameter of the adjacent main body portion thereby to provide first and second inner alignment shoulders at the junctures between said end rings and the ends of said main body portion, an electron gun ring member positioned within said first end ring and concentric therewith, and registering with the inner walls of said first end ring, said electron gun ring member also including an electron gun end plate engaging said first alignment shoulder thereby to align an electron gun supported by said electron gun end plate along the axis of the traveling-wave tube and also with the main body portion of said hollow elongated member, a collector ring member positioned within said second end ring and concentric therewith and registering with the inner walls of said second end ring, said collector ring member including a collector end plate secured to said collector ring member and engaging said second alignment shoulder thereby to align a collector supported by said collector end plate with the electron gun, said collector base member having a collector aperture, an input waveguide aperture and an output waveguide aperture, first and second means welding the terminal portions of said electron gun ring member and said collector ring member to the terminal portions of said first and second end rings respectively, an internal collar having a central aperture and engaging the inner surface of the main body portion of said hollow elongated member, said collar being positioned intermediate the slow-wave structure and the electron gun and receiving, at the aperture thereof, a portion of the slow-wave structure, and input and output waveguides passing through their respective apertures in the collector base member for introducing and extracting an electromagnetic signal from the slow-wave structure, whereby the welded portions of said terminal portions

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of said first and second end rings and said electron gun and collector ring members may be removed for internal maintenance of the traveling-wave tube and whereby the then remaining portions of said terminal portion of said first and second end rings and said electron gun and collector ring members may be rewelded.

5. A rebuildable traveling-wave tube comprising: an electron gun; a collector; a slow-wave structure positioned intermediate said electron gun and said collector; input and output waveguides coupled to said slow-wave structure and extending past said collector; a cylindrical envelope disposed about said slow-wave structure, said envelope including a relatively thin collector end ring integral with the main body portion of said envelope and disposed at the collector end thereof, said collector end ring being of greater inner diameter than the adjacent diameter of the main body portion, thereby to provide an inner alignment and an inner alignment shoulder at said collector end; a collector base end plate hermetically retaining said collector, slow-wave structure and waveguides and positioned within said collector end ring transverse to the longitudinal axis of said envelope, said end plate abutting against the alignment shoulder of said envelope; a collector sealing end ring coupled to said collector end plate and concentric therewith, said collector end ring registering at its outer circumference with the inner circumference of the alignment surface on the end ring portion of said envelope, thereby to provide a coextensive sealing portion along the longitudinal axis of said envelope; a collar having a central aligning aperture for receiving a portion of said slow-wave structure, said collar being mounted transverse to said envelope at the electron gun end thereof, said collar including a ring portion defining an outer alignment surface concentric with said envelope and a relatively thin sealing flange normal to the longitudinal axis of said envelope and defining an alignment shoulder with the alignment surface of the ring of said collar; an electron gun support assembly, including coupled outer and internal tubes for supporting said electron gun, said electron gun support assembly including at the said outer tube an annulus concentric with said envelope, the inner circumference of said annulus registering with the outer alignment surface defined by the ring of said collar, said electron gun support assembly being terminated in a relatively thin circumferential base flange in engagement with said sealing flange portion of said collar, said base flange and said sealing flange being coextensive for a predetermined radius in a direction normal to the longitudinal axis of said envelope; and welding beads joining and sealing the matching lips defined by the terminations of the registering sealing rings at the collector end and the terminations of the registering sealing flanges at the electron gun end.

6. An electron tube and housing comprising: a traveling-wave tube, an elongated slow-wave structure, an elongated cylindrical member disposed coaxially with said slow-wave structure and having at least one end ring integral with a first end of said cylindrical member, said end ring having an outer diameter substantially equal to that of said cylindrical member and having a greater inner diameter than the inner diameter of the main body portion of said cylindrical member thereby to provide an inner alignment shoulder at the juncture between said end ring and said cylindrical member, a ring member positioned within said end ring, said ring member having substantially the same length as said end ring and being concentric with and engaging said end ring, a circular base member supporting elongated, operative elements of said traveling-wave tube and secured to an end of said ring member and engaging said alignment shoulder, concentric collar means supported within said cylindrical member about said operative elements near their end opposite said base member to maintain in reproducible manner said operative elements automatically in accurate, predetermined relationship with said elongated cylindrical member, re-

movable, rebuildable means sealing the terminal portion of said end ring to the terminal portion of said ring member; whereby the ring member may be removed from said end ring by removing the sealed portion of said end ring and said ring member and whereby said ring member may be re-sealed to said end ring by sealing the then remaining terminal portions of said end ring to the then remaining terminal portions of said ring member, and second removable, rebuildable means at the second end of said cylindrical member for supporting others of said operative elements in accurate axial alignment with said cylindrical member, said second means including a pair of relatively thin terminally removably and rebuildably

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joined peripheral members which are at least partially coextensive and in engagement and which when rebuildably joined reproduce said accurate axial alignment.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,935,641

May 3, 1960

Joseph J. Caldwell, Jr.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 65, for "hermatic" read -- hermetic --;
column 5, line 55, for "dismantaled" read -- dismantled --;
column 7, line 22, for "cylinder" read -- cylindrical --.

Signed and sealed this 11th day of October 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents