Aug. 31, 1965 W. J. KEARNS 3,204,140

HOT CATHODE ELECTRON TUBE

Filed July 10, 1961 2 Sheets-Sheet 1

FIG. 1.

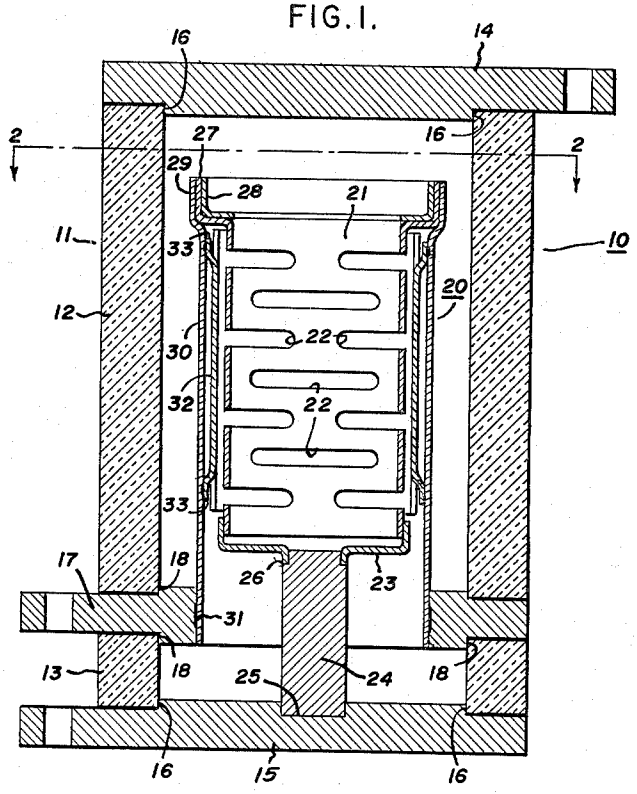
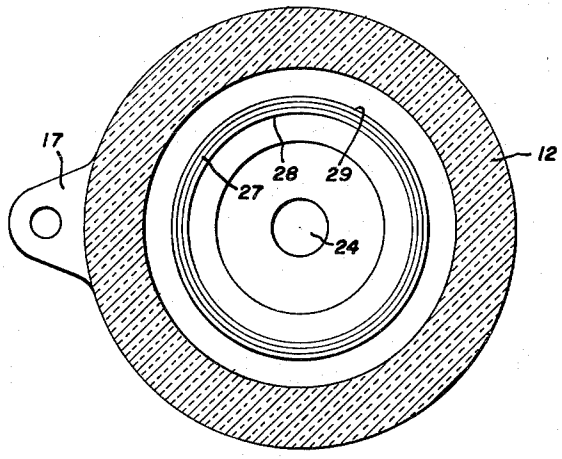


FIG. 2.



INVENTOR:
WILLIAM J. KEARNS,
BY Philip J. Schlamp
HIS ATTORNEY.

Aug. 31, 1965 W. J. KEARNS 3,204,140

HOT CATHODE ELECTRON TUBE

Filed July 10, 1961 2 Sheets-Sheet 2

FIG.3.

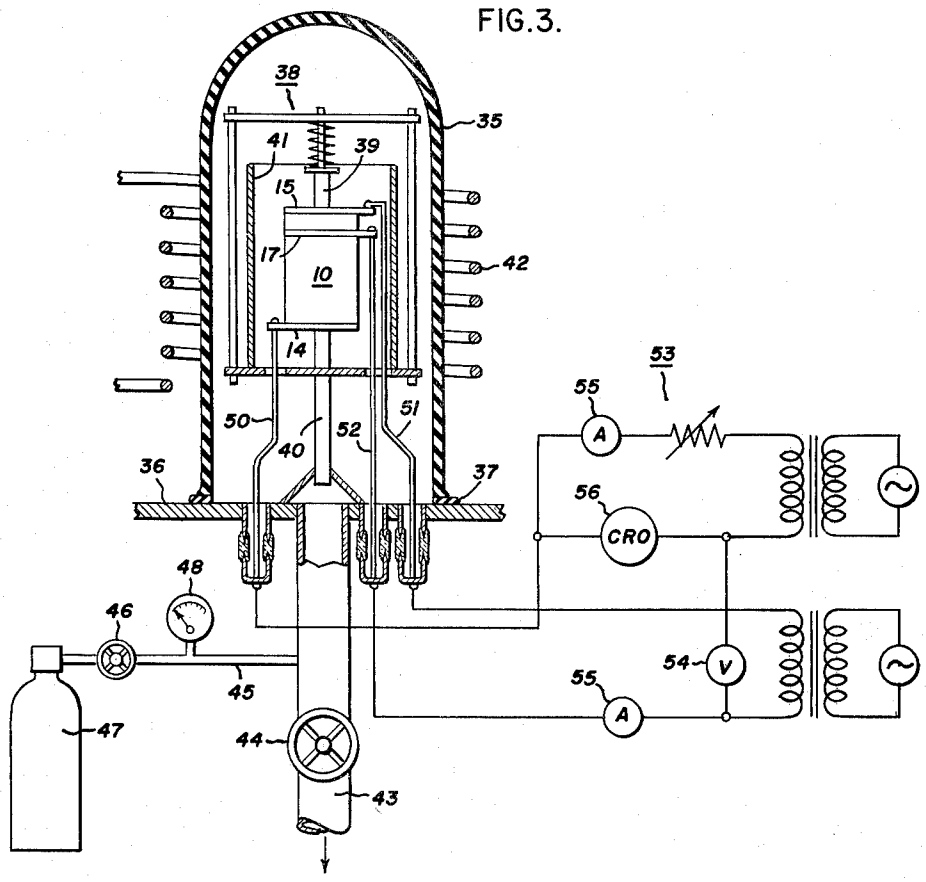
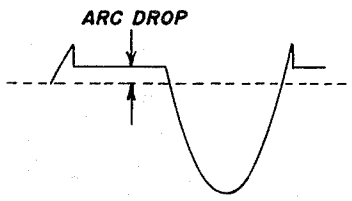


FIG.3a.



INVENTOR:
WILLIAM J. KEARNS,
BY Philip R. Schlamp
HIS ATTORNEY.

United States Patent Office 3,204,140 Patented Aug. 31, 1965

3,204,140

HOT CATHODE ELECTRON TUBE

William J. Kearns, Scotia, N.Y., assignor to General Electric Company, a corporation of New York

Filed July 10, 1961, Ser. No. 123,023
10 Claims. (Cl. 313—239)

My invention relates to gaseous electric discharge devices in the form of hot cathode electron tubes and pertains more particlularly to a new and improved ceramic and metal thermionic cathode gas diode and to a new and improved method for manufacturing such a device.

In many circuit applications, such, for example, as power generator control circuits, it is desirous to employ a gaseous rectifier diode. Additionally, it is often desirous to employ such circuits in equipment, such as high speed vehicles, wherein the circuits, including the diodes, are normally subjected to substantial mechanical shock and vibration as well as wide circumambient temperature ranges including substantially high temperatures. In such applications it is desirable that the diode be adapted for withstanding, over an extended operating tube life, the normally encountered conditions of shock and vibration. Additonally, it is desirable that the device be adapted for operation over the whole of the normal ambient temperature range with stable electrical characteristics including a substantially low forward potential drop, and a substantially constant tube potential drop during each conducting cycle and for all values of tube current. It is also desirable that the diodes be adapted for operating with constant filament power over the entire normal ambient temperature range, thus, obviating the need for filament derating.

My invention contemplates the provision of tube structure and a method of manufacturing a ceramic and metal thermionic cathode gaseous diode whereby the above-discussed desiderata are obtained. More specifically, my invention contemplates the provision of an improved ceramic and metal thermionic cathode gaseous diode which is particularly adapted for withstanding substantial mechanical shock and vibration. Additionally, the improved diode contemplates tube structure and a manufacturing method effective for providing a device adapted for operating with the above-discussed desired electrical operating characteristics over the whole of a circumambient temperature range of from about —65° to about 400° C.

Accordingly, a primary object of my invention is to provide a new and improved ceramic and metal thermionic cathode gaseous rectifier device.

Another object of my invention is to provide a new and improved ceramic and metal gaseous electric discharge device adapted for substantially uniform electrical operating characteristics over a substantially wide normal operating temperature range including relatively high temperatures.

Another object of my invention is to provide a new and improved ceramic and metal gaseous electric discharge device adapted for operating with substantially uniform electrical operating characteristics at relatively high circumambient temperatures and without the need for filament derating.

Another object of my invention is to provide a new and improved method of manufacturing a ceramic and metal gaseous electric discharge device in a manner which affords desired operating electrical characteristics of the device over a substantially wide circumambient temperature range and for substantially all operating current values.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of my invention I provide a ceramic and metal gaseous electric discharge device including an envelope comprising a pair of cylindrical ceramic insulators, a highly refractory metal washer-like member butt-sealed between the opposed ends of the insulators and a highly refractory metal disk-like member butt-sealed to the outer end of each insulator to complete the envelope. The disk-like member at one end of the envelope comprises an anode while the disk-like member at the other end and the washer-like member constitute contacts of a directly-heated generally cylindrical nickelate cathode. The cathode is coaxially supported in the envelope with the lower end of the cathode electrically secured to a support rod concentrically mounted on the lower disk-like member. The upper end of the cathode is electrically connected to a surrounding cylindrical refractory metal shield which is concentric and electrically secured to an inner rim portion of the washer-like member. Mounted between the shield and cathode in coaxial and spaced relation thereto is a second shield. In manufacturing my improved diode I arrange the several elements in a stacked array interposing between each ceramic and metal part of the envelope a thin washer-like element of a sealing material which can be any metal or alloy which forms with the metallic parts a low melting eutectic effective for wetting the ceramic. The stacked array of envelope parts is held together with relatively small longitudinally directed forces and is heated in an atmosphere of a noble gas or gases with which the device is ultimately to be charged. Then and before sealing of the envelope wall parts is effected, the cathode is energized to an activating temperature following which the device is operated as though sealed. When operability is indicated the cathode is de-energized and the previously furnished noble gas atmosphere is exhausted. Thereafter the stacked array is reheated in a second atmosphere of the same gas or gases and at a pressure which is in a predetermined multiple of the pressure at which the device is to be operated normally. Additionally, reheating effects operation of the sealing material and thus completes the envelope and effects the entrapment in the tube of the gas with which it is to operate normally.

For a better understanding of my invention reference may be had to the accompanying drawing wherein:

FIGURE 1 is an enlarged elevated sectional view of a ceramic metal gaseous electric discharge device constructed according to one embodiment of my invention;

FIGURE 2 is a transverse sectional view taken along the lines 2—2 in FIGURE 1 and looking in the direction of the arrows;

FIGURE 3 illustrates schematically a form of apparatus which may be utilized effectively in carrying out the various steps comprising my improved method of manufacturing a gaseous electric discharge device; and

FIGURE 3*a* is a diagram of an oscilloscopic trace indicating operability of a device constructed according to my invention.

Referring to FIGURE 1, there is illustrated a ceramic and metal gaseous electric discharge device comprising an embodiment of my invention and generally designated **10**. The device **10** includes a ceramic and metal envelope **11** which comprises coaxially arranged upper and lower cylindrical ceramic insulators or wall sections **12** and **13**, respectively, and upper and lower metal end caps or disk-like members **14** and **15**, respectively. As illustrated in FIG. 1 and as one preferred form of this invention sections **12** and **13** are of substantially different lengths with a longer section **12** and a shorter section **13**. The axial length of section **12** is a plural number of

lengths of section 13. Each of the caps 14 and 15 includes on its inner side an annular shoulder 16 which is dimensioned to extend into the corresponding end of the respective ceramic wall sections. This arrangement serves to facilitate stacking of the tube envelope parts and to insure concentricity thereof. Also included in the envelope structure is an annular contact and electric support member 17 which is interposed between the opposed ends of the insulators 12 and 13 and closely adjacent cathode cap 15. Each side of the member 17 is formed to include a shoulder 18 for extending into the opposed ends of the ceramic insulators 12 and 13. This feature, also, is adapted for both facilitating stacking of the parts during manufacture of the tube and insuring concentricity of the parts in the finished envelope.

The metal members 14, 15 and 17 are preferably formed of titanium. However, the present invention is operative if zirconium replaces the titanium in whole or in part. The insulators 12 and 13 are formed of a suitable ceramic which is adapted for matching the thermal coefficients of expansion of titanium and which facilitates bonding thereto and subsequent use of the device at varying temperatures without adversely affecting the ceramic or the bonds between the ceramic and metal members. A group of ceramics found to be suitable are generally known in the art and are available under the denomination Forsterites. One such Forsterite is disclosed and claimed in U.S. Patent No. 2,912,340 of A. G. Pincus issued November 10, 1959, and assigned to the same assignee as the present invention. Another ceramic which is particularly suitable for use in constructing the present device is the Forsterite-Spinel disclosed and claimed in copending U.S. application Serial No. 831,510 of R. H. Bristow filed August 4, 1959, now U.S. Patent 3,060,040, and assigned to the same assignee as the present invention.

The ceramic and metal members are suitably joined by butt-seals to complete the envelope structure 11 by metallic bonds which can be formed by the method disclosed and claimed in U.S. Patent No. 2,857,663 of J. E. Beggs issued October 28, 1958, and also assigned to the same assignee as the present invention. It is to be understood that other sealing techniques are equally applicable, such, for example, as any of the several generally known methods requiring premetalizing of the ceramic and the use therewith of a solder material to effect a joint between the ceramic metalized surfaces and a metal member. However, the bonding material employed preferably should be characterized by low permeability and a low evaporation rate. Thus, for example, solders containing silver would be undesirable because of oxygen permeation especially at elevated temperatures and the bonding material employed is silver-free. Gold-containing solders would be of marginal utility because of their high evaporation rate during the sealing process which would tend to cause deposition of conductive material on the insulator walls and thereby detract from the insulative capability thereof.

In the complete envelope 11 the upper member 14 serves as a planar anode electrode, the lower member 13 serves both as a cathode support element and a cathode contact member. The washer-like member 17 also serves the dual functions of cathode support and cathode contact.

The cathode structure generally designated 20 is generally tubular in construction and is of the directly heated type. Specifically, the cathode structure 20 comprises an emissive sleeve 21 formed to include a plurality of staggered transverse slots 22 for providing a tortuous long resistance path between the longitudinally spaced ends thereof. The lower end of the sleeve 21 is secured, as by spot-welding, in a shallow cup-like conductive member 23 which is similarly secured on the upper end of a conductive stud 24 brazed concentrically in a bottomed shallow bore 25 inner surface of the cathode contact

member 15. The stud 24 extends through annular contact member 17 and includes a shoulder 26 at the upper end and the inner rim of the member 23 is dimensioned for resting snugly thereon. Thus, the lower end of the cathode sleeve 21 is supported rigidly and concentrically in the envelope 11 and spaced from annular member 17 in a direction toward anode cap 14 and at the same time in a manner to provide electrical connection to the lower end of the emissive sleeve.

The upper end of the sleeve 21 is flared at 27 and receives in nesting fashion an annular member 28. Additionally, the flared end 27 of the cathode sleeve is disposed in nesting fashion also in a flared end 29 of a tubular outer shield member 30 formed of a highly refractory metal such as molybdenum or tungsten. By suitable means, such as by spot-welding, the flared ends of the cathode sleeve, the member 28 and the outer shield are conductively and rigidly secured together.

The lower end of the outer shield 30 is disposed in and is spot-welded directly to an inner cylindrical surface 31 formed in the member 17 and so as to be concentric with the tube envelope and the various described elements contained therein. Shield 30 is further defined as being in upstanding relationship with respect to the annular member 17 and extending into the longer section 12 adjacent anode 14. In the just-described cathode and shield structure the cathode is of the directly heated type and the cathode heating or energizing circuit is completed therethrough by passing between and including the end cathode contact member 15, stud 24, member 23, cathode sleeve 21, outer shield 30 and the annular contact member 17. Thus, the members 15 and 17 constitute the external heater contact surfaces of the device.

The staggered slots 22, in the sleeve 21, as mentioned above, serve to elongate the resistance path through the sleeve and thus to enhance the heating of the sleeve. Additionally, I have found that the sleeve 21 can advantageously be formed of nickelate which is a common term for barium-nickel alloys which are widely used in the art for hot-cathode power rectifiers. The nickelate cathode is employed due to its normal high operating temperature. Thus, the tube envelope temperature can become substantially elevated without adversely affecting the operation of the cathode. Therefore, filament derating, or lowering of filament heating power at high ambient temperatures is not required.

In order to increase the thermal efficiency of the described device, there is provided a second shield element 32 disposed between the cathode sleeve 26 and the outer shield 30. The shield 32 is also tubular and is advantageously formed of a highly refractory metal such as molybdenum or tungsten. The second shield 32 is supported on the inner wall surface of the outer shield in spaced relation to both the outer shield and the cathode sleeve. As seen in FIGURE 1, the shield 32 can be formed with tabs 33 protruding laterally outwardly from the upper and lower ends which tabs can be spot-welded to the outer shield 30. As also seen in FIGURE 1, the inner shield proper is disposed coaxially in the structure in parallel spaced relation to both the cathode sleeve 21 and the outer shield 30. This structure serves to enhance the thermal efficiency of the cathode and to isolate thermally the cathode from the envelope structure.

In manufacturing my improved device, I preassemble the cathode and shield structure and spot-weld the shield structure to the inner surface of the member 17 and the members 28 and 32 in the end of the cathode sleeve in the manner shown in FIGURE 1. Then I stack the various described envelope contact and wall sections in the order of parts illustrated in FIGURE 1 but in a position inverted from that illustrated in FIGURE 1 and with the lower end of the rod 24 positioned in the shallow concentric bore 25 along with a quantity of appropriate brazing material. Additionally, in the stacked array the above-mentioned sealing material is interposed between the

members **14**, **15** and **17** and the adjacent end surfaces of the ceramic sections **12** and **13**. Then I place the stacked array in the exhaust apparatus illustrated in FIGURE 3.

The apparatus of FIGURE 3 with which the method aspects of my invention can be practiced comprises an insulative bell jar **35** sealed to a working bench top **36** by a suitable gasket **37**. The bell jar **35** is positioned over and encloses a suitable fixture generally designated **38** which includes opposed rods **39** and **40** adapted for engaging opposed ends of the stacked array of tube parts in the manner shown. The upper rod **39** is spring-urged downward and, thus, the fixture is adapted for urging various tube parts longitudinally together. Additionally, the fixture **38** supports a metallic susceptor, or heat concentrator, **41** which fits about the stacked tube parts when the latter are positioned and urged together between the rods **39** and **40**.

An inductive heating coil **42** supplies energy to couple the susceptor **41** to heat the reaction area. A conduit **43** sealed in the working table part **37** beneath the bell jar **35** is connected to a valve **44** to a suitable exhaust system not shown. Connected to the conduit **43** on the bell jar side of the valve **44** is a line **45** including a valve **36** and connected to a source **47** of stable noble gas such as helium, argon, neon, krypton, xenon or mixtures thereof at a suitable adjustable pressure. A pressure gage **48** is employed in the line **45** for enabling predetermined controlled pressure of the gas admitted into the bell jar **35**. Preferably xenon is employed as the noble gas.

In the illustrated apparatus are provided leads for effecting electrical connections to the various contact elements **14**, **15** and **17** in the tube envelope assembly. Specifically, the apparatus includes an anode lead **50** insulatively sealed through the working table top **36** and adapted for being connected to the anode contact **14** of the tube assembly in the bell jar. Additionally, the apparatus includes a pair of heater circuit leads **51** and **52** similarly sealed through the working table top and adapted for being secured to the disk-like cathode contact **15** and the annular contact member **17** in the manner illustrated in FIGURE 3. Exteriorly of the bell jar the filament leads **51** and **52** are connected across a suitable adjustable power supply and test circuit generally designated **53** and including a voltmeter **54** and ammeters **55**. The cathode and anode leads are also suitably connected exteriorly of the bell jar across the test circuit portion of the circuit **53** and which includes a cathode ray oscilloscope generally designated **56**.

In manufacturing the described tube utilizing the above-described apparatus, the bell jar first is exhausted to approximately 10^{-6} mm. Hg with the stacked array of tube parts disposed therein. Then the filament, or cathode circuit, is energized to heat the cathode for outgassing and preactivating same while the valve **44** is open and evacuation of the bell jar continues. Concurrently the tube parts are heated to a temperature of approximately 700° C.–900° C. for approximately 15 to 20 minutes to outgas same.

Subsequently valve **44** is closed and valve **46** is opened to admit gas to the bell jar from the supply **47** and until a bell jar pressure of approximately 100 microns is reached. Thereafter, anode potential is applied by means of the circuit **53** and the trace of the arc drop across the device, or between the cathode and anode is observed. Illustrated in FIGURE 3*a* is an oscilloscope trace considered to be satisfactory. Observation of such a trace is indicative of a suitably operable tube and after it has been observed the bell jar can be re-evacuated by opening the valve **44**. During this exhaust step the filament power is disconnected.

Then the device can be loaded to a desired gas pressure and sealed according to any one of the methods and procedures disclosed and claimed in U.S. Patent No. 2,957,741 of J. M. Lafferty issued October 25, 1960, and assigned to the same assignee as the present invention. I prefer, however, to employ the following procedure: Following operation of the unsealed tube in the above-described manner to determine operability, the bell jar is reloaded with gas by first closing the valve **44** and then opening the valve **46**. Thus, the bell jar and contained stacked, but as yet unsealed tube assembly is elevated in pressure with the desired noble gas or mixture thereof to a desired pressure of, for example, 450 microns. Then the temperature is raised to a point at which ceramic-to-metal seals form, which temperature may, for example, be approximately 1050° C., and the temperature is reduced upon observation of seal formation. The seal is then allowed to cool to room temperature.

According to the Lafferty method of forming noble gas filled electric discharge devices by heating to form metal ceramic seals in an atmosphere with which the device is to be charged, the gas pressure is adjusted so that upon cooling the pressure within the device is at the desired operating pressure. This requires the Charles' law be taken into account. The pressure with the bell jar at the time the seals are formed is a predetermined multiple of the desired operating pressure equal to the ratio of the absolute temperature at the time the seals are made to the absolute temperature at which the device is to operate. These same considerations apply to the present invention.

Thus, for example, in forming the device illustrated which operates normally at pressures of the order of 100 microns, ceramic-to-metal seals are formed within the bell jar **35** of FIGURE 3 while the pressure of an inert gas or suitable mixture thereof is maintained at approximately 4.5 times the operating pressure, or approximately 450 microns. Upon cooling to room temperature it is found that the pressure within the device is approximately equal to 100 microns.

In forming the gaseous discharge device in accordance with the above-described method, outgassing is carried out at conventional temperatures and times, as, for example, 700°–900° C. for 15 to 20 minutes. The temperature at which the ceramic-to-metal seals are formed depends upon the sealing material utilized. The said assembly must be heated to a temperature at least as high as the eutectic temperature of the system formed by titanium and the sealing material. These temperatures vary from 870° C. when copper is used to 1200° C. when platinum is used. The temperature must not be raised too high or be maintained too long, or the sealing material may evaporate onto the surface of the ceramic body and adversely affect its insulating characteristics. In practice the high sealing temperatures are maintained only until the sealing material is observed to melt, alloy, and flow over the ceramic body. As a practical matter this generally is achieved by limiting the sealing temperature to no higher than 100° C. above the eutectic temperature and maintaining this temperature for one to five minutes.

While I have shown and described a specific embodiment of my invention and a particular arrangement of steps for carrying out my arrangement, I do not desire my invention to be limited to the particular forms shown and described, and I intend by the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A ceramic and metal gaseous discharge device adapted for operating at a normally high ambient temperature range comprising an envelope including a pair of coaxial ceramic insulators, a pair of metal end caps sealed across the outer ends of said insulators, one of said end caps comprising an anode and the other a cathode contact, an annular contact member sealed between said insulators and including an inner rim portion disposed in said envelope, a tubular metallic shield sup-

ported and directly attached to said rim portion of said annular contact member and extending concentrically in said envelope, a directly-heated nickelate cathode disposed in said shield, and said cathode having one end supported by and electrically connected to said annular contact member and the other end supported by and electrically connected to said end cap comprising a cathode contact.

2. A ceramic and metal gaseous discharge device comprising an envelope including a pair of coaxial ceramic insulators of different length, a pair of disk-like contact members sealed across the outer ends of said insulators, one of said disk-like members comprising an anode and the other a cathode contact, an annular contact member sealed between said insulators adjacent said cathode contact and including an inner rim portion disposed in said envelope, a tubular metallic shield directly supported by said inner rim portion of said annular member and extending concentrically in said envelope to a point adjacent said anode, a cathode sleeve extending concentrically in said shield, said cathode sleeve having one end directly electrically connected to and supported by the end of said shield adjacent said anode and the other end supported by and electrically connected to said cathode contact.

3. A ceramic and metal gaseous discharge device according to claim 2, wherein said ceramic insulators and contact members are joined hermetically by silver-free metallic bonds.

4. A ceramic and metal gaseous discharge device according to claim 2 wherein a second shield member is supported in concentric and spaced relation between the first-mentioned shield and said cathode sleeve.

5. A ceramic and metal gaseous discharge device comprising an envelope including a pair of coaxial ceramic insulators of substantially different lengths, a pair of disk-like contact members sealed across the outer ends of said insulators, one of said disk-like members comprising a planar anode and the other a cathode contact, an annular contact member sealed between said insulators and closely adjacent said cathode contact and including an inner rim portion disposed in said envelope, a tubular refractory metal shield directly supported on said inner rim portion of said annular contact member and extending concentrically in said envelope toward said anode, a directly-heated cathode sleeve extending concentrically in said envelope toward said anode, said directly-heated cathode sleeve also extending concentrically in said shield, said sleeve having one end circumferentially electrically connected to the end of said shield adjacent said anode, whereby said cathode sleeve is rigidly supported at one end by said shield and said shield serves as an electrical connection to said annular contact member, and said cathode sleeve having the other end electrically connected to and supported by said cathode contact.

6. A ceramic and metal gaseous discharge device comprising an envelope including a pair of coaxial ceramic insulators of substantially different lengths, a pair of disk-like contact members sealed across the outer ends of the insulators, one of said disk-like members comprising a planar anode and the other a cathode contact, an annular contact member sealed between said insulators closely adjacent said cathode contact and including an inner rim section disposed in said envelope, a tubular refractory metal shield directly supported on said inner rim portion of said annular contact member and extending concentrically in said envelope toward said anode, a directly-heated cathode sleeve extending concentrically in said shield, said sleeve having one end circumferentially electrically connected to the end of said shield adjacent said anode, whereby said cathode sleeve is rigidly supported at one end by said shield and said shield serves as an electrical connection to said annular contact member, and a conductive stud concentrically secured to the inner surface of said cathode contact and to the other end of said cathode sleeve for rigidly supporting said other end of said sleeve and providing an electrical connection to said cathode contact.

7. A ceramic and metal gaseous discharge device comprising an envelope including a pair of coaxial cylindrical ceramic insulators of substantially different lengths, a pair of disk-like contact members secured across the outer ends of said insulators, one of said disk-like members comprising a planar anode and the other a cathode contact, an annular contact member sealed between the insulators closely adjacent to said cathode contact and including an inner rim portion disposed in said envelope, a tubular metal shield directly supported on said inner rim portion of said annular member and extending concentrically in said envelope toward said anode element, the end of said shield adjacent said anode member including a flare, a directly-heated cathode sleeve extending concentrically in said shield, said sleeve having a flared end nesting in and circumferentially electrically secured to the flare in said shield, the remaining portion of said sleeve extending in spaced relation to said shield and said sleeve having the other end thereof electrically connected to and supported by said cathode contact.

8. A ceramic and metal gaseous discharge device comprising an envelope including a pair of coaxial cylindrical ceramic insulators of substantially different lengths, a pair of disk-like contact members sealed across the outer ends of said insulators, one of said disk-like members comprising a planar anode and the other a cathode contact, an annular contact member sealed between said insulators closely adjacent said cathode contact and including an inner rim portion disposed in said envelope, a tubular refractory metal shield having one end directly supported on said inner rim portion of said annular contact member and extending concentrically in said envelope into the longer of said ceramic insulators and toward said anode member, the end of said shield adjacent said anode member including a flare, a directly heated cathode sleeve extending concentrically in said shield, said sleeve having a flared end nesting and circumferentially electrically secured to the flare in said shield and the remaining portion of said sleeve extending in spaced relation to said shield, said cathode sleeve having the other end disposed in and electrically connected to the rim of a cup-like conductive member, and said cup-like member being concentric and conductively supported on a conductive stud extending through said annular contact member and electrically connected to said cathode contact.

9. A ceramic and metal gaseous discharge device comprising an envelope including a pair of coaxial cylindrical ceramic insulators of substantially different lengths, a pair of disk-like contact members secured across the outer ends of said insulators, one of said disk-like members sealed across the outer end of the longer of said coaxial insulators and comprising a planar anode, the other disk sealed across the outer end of the other of said ceramic insulators and comprising a cathode contact, an annular contact member sealed between said insulators closely adjacent said cathode contact and including an inner rim portion disposed in said envelope, a tubular refractory metal shield having one end directly supported on said inner rim portion of said annular contact member and extending concentrically in upstanding relationship in said envelope in said longer section toward said anode, a directly-heated cathode sleeve extending concentrically in said shield, said sleeve having one end circumferentially electrically connected to the end of said shield adjacent said anode, whereby said cathode sleeve is rigidly supported at one end by said shield and said shield serves as an electrical connection to said annular contact member, said cathode sleeve having the other end axially spaced from said annular contact and electrically connected to and supported by said cathode contact, and a second refractory metal shield carried by said first-mentioned shield and supported thereby in spaced relation

between said first-mentioned shield and said cathode sleeve.

10. A ceramic and metal gaseous discharge device comprising an envelope including a pair of coaxial cylindrical ceramic insulators of substantially different lengths, one of said insulators being of a length which is a plural number of the length of the other of said insulators, a pair of disk-like contact members sealed across the outer ends of said insulators, one of said disk-like members sealed across the outer end of the longer of said insulators comprising a planar anode, the other disk sealed across the outer end of said shorter ceramic insulator being a cathode contact, an annular contact member sealed between said insulators closely adjacent said cathode contact and including an inner rim portion disposed concentrically in said envelope, a tubular refractory metal shield having one end directly supported on said inner rim portion of said annular contact member and extending concentrically in said envelope in upstanding relationship in the longer section of said ceramic insulators to a point closely adjacent said anode, a nickelate directly-heated cathode sleeve including staggeredly arranged transversely extending slots increasing the electrical resistance path between the ends of said sleeve, said sleeve extending concentrically in said shield and having one end circumferentially electrically connected to the end of said shield adjacent said anode, whereby said cathode sleeve is rigidly supported by said shield, said shield

serves to avoid sputtering of conductive material on said ceramic insulators and also serves as an electrical connection to said annular contact member for said cathode, a stud member directly supported by and electrically connected to said cathode and extending through said annular contact member, a cup-like member directly supported by and electrically connected to the free end of said stud, said cup-like member receiving in direct contact relationship therewith the other end of said cathode sleeve, and a second refractory metal shield carried by said first-mentioned shield and supported thereby in spaced relation between said first-mentioned shield and said cathode sleeve.

References Cited by the Examiner

UNITED STATES PATENTS

2,489,938	11/49	Smith	313—38
2,508,979	5/50	Van Gessel	29—25.13
2,632,231	3/53	Brown	29—25.13
2,647,218	7/53	Sorg et al.	313—247
2,879,428	3/59	Williams	313—247
3,023,341	2/62	Kendall et al.	313—250

JOHN W. HUCKERT, *Primary Examiner.*

GEORGE N. WESTBY, DAVID J. GALVIN, *Examiners.*