

May 24, 1932.

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1,859,522

ELECTRON TUBE

Filed March 12, 1930

2 Sheets-Sheet 1

Fig. 1.

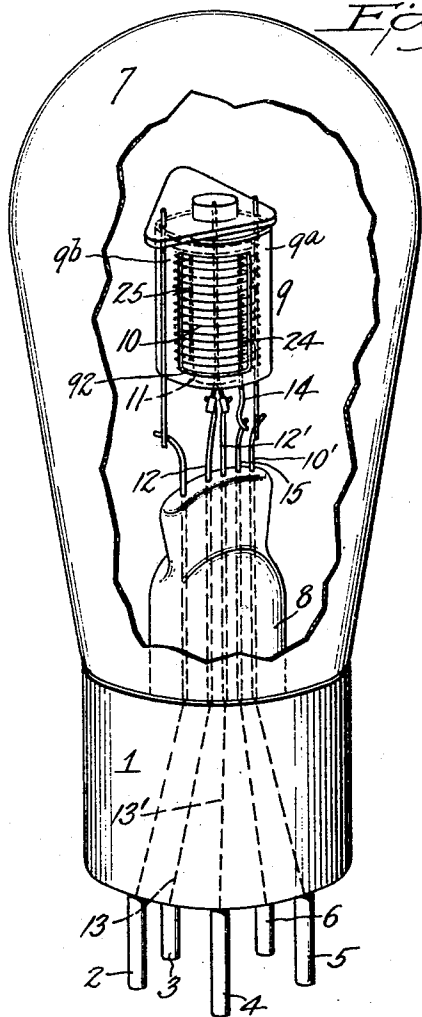


Fig. 2.

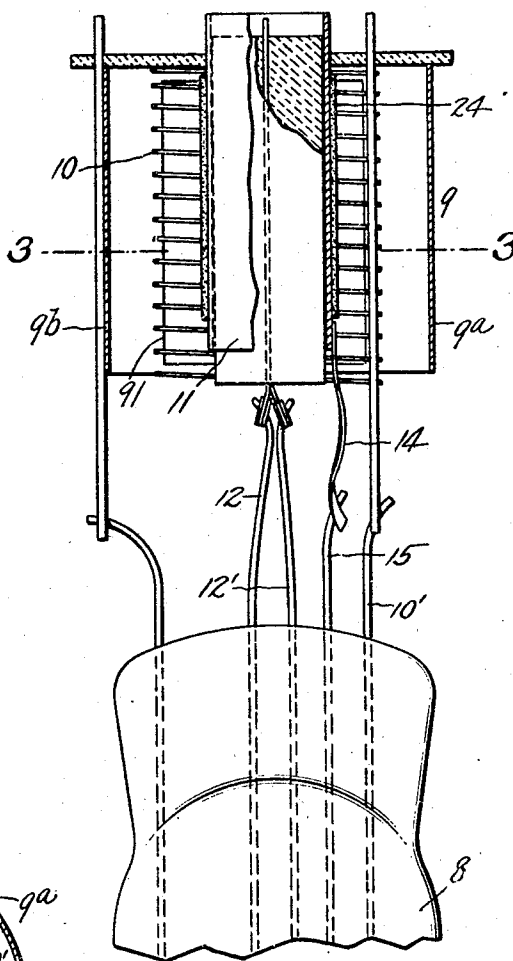
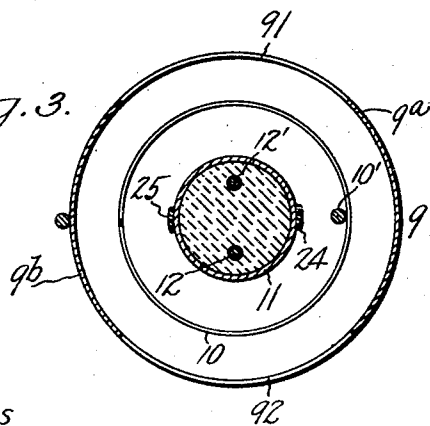


Fig. 3.



WITNESS

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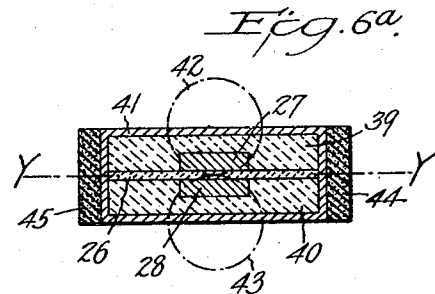
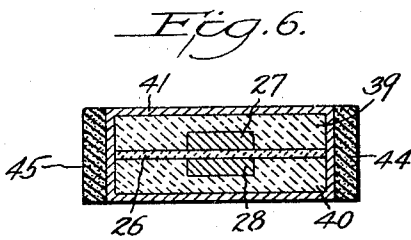
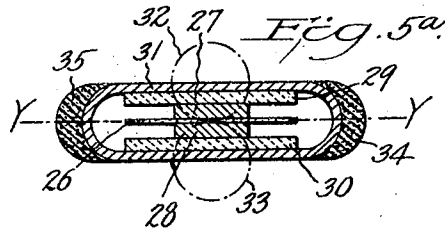
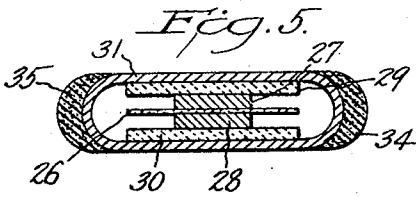
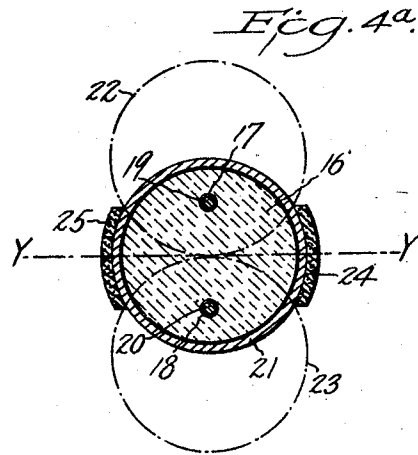
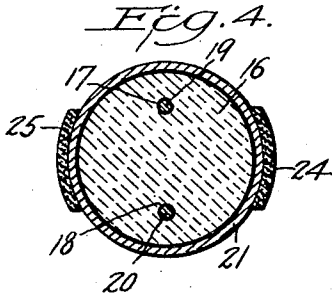
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2 Sheets-Sheet 2



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ELECTRON TUBE

Application filed March 12, 1930. Serial No. 435,046.

This invention relates to space discharge devices of thermionic type and particularly to the type in which the cathode is a unipotential cathode. This structure usually embodies a conductive thimble indirectly heated, chiefly by radiation and conduction from a heater element energized by alternating current.

This application is in part a continuation of my application Serial Number 431,121, filed February 25, 1930. The primary object of my invention is to minimize or substantially eliminate hum introduced into the output circuit of the tube by fluctuating temperatures, voltages or currents within the heater element when the same is energized by alternating current.

I have discovered that in this type of tube, having an indirectly heated cathode, one of the chief sources of hum in the output of the tube is due to the magnetic field of the heater current. Other features contributing to hum are the leakage of heater current through the insulating material into the cathode, and voltage effects across segments of the heater element itself, as well as voltage effects between the heater element and the cathode thimble. Tubes of present-day manufacture utilize a straight or helically coiled wire extending through the cathode thimble with or without an intervening insulator to prevent contact with the cathode thimble, or a "hair-pin" type heater with straight parallel legs extending through a cylindrical insulator having two holes longitudinally throughout and parallel to its axis.

The heater wire in this latter type is round and the separation between the two sides or legs of the hair-pin is about $\frac{1}{3}$ the diameter of the cylindrical insulator, which fits snugly into the cathode thimble.

The separation of the heater legs in such a type of cathode produces a considerable magnetic field, incompletely neutralized, which reaches out into the electron stream near the cathode surface and there causes a change of direction in the flow of the electrons to the plate periodically with the rise and fall of the magnetic field following the alternation of the heating current flow. This change in

the magnetic field at the surface of the cathode is the primary element varying the length of travel of an electron from its source or origin to the plate or anode of the tube. This variation in length of path over which the electrons travel causes hum in the current flowing in the output circuit of such a tube.

An analysis of this structure shows that the distance from one of the legs to the cathode surface is about equal to the separation between the heater legs so that near the plane bisecting the two legs of the hair-pin there is considerable unneutralized field on the cathode surface. In a surface portion on the cathode substantially parallel to this plane there is substantial neutralization between the magnetic fields produced by the individual legs of the hair-pin.

I have developed combinations of three fundamental features to be described hereinafter for minimizing the fluctuations in the magnetic field at the surface of the cathode. The first is the feature of maintaining the centers of the legs of the heater element as close together as possible, thereby producing more nearly perfect neutralization between the magnetic fields thereof, the second is the location of the emissive surface along points on the cathode thimble wherein the most complete neutralization of the magnetic fields from the two legs of the heater element is obtained, and the third is to so construct the anode that none of the electrons which, by chance, have been subjected to a stronger magnetic field of the heater reach the anode, and therefore play no part in the space current of the tube.

Referring to the drawings, in which like reference characters have been used throughout insofar as possible,

Fig. 1 diagrammatically illustrates a complete electron tube of my improved form.

Fig. 2 shows the tube of Fig. 1 partly in section to disclose the relationship of the cathode connection and the connections to the heater element in relationship to the grid and plate leads.

Fig. 3 diagrammatically illustrates a cross-section of the tube of Fig. 1 on the line 3—3.

Fig. 4 is a cross section of a cathode of my improved form;

Fig. 4A graphically illustrates the hum output of an electron tube with change of position of electron emissive material upon the surface of a cathode of the type shown in Fig. 4;

Fig. 5 is a cross section of a modified form of my invention;

Fig. 5A graphically illustrates the hum output of an electron tube with change of position of electron emissive material upon the surface of a cathode of the type of Fig. 5;

Fig. 6 is a modification of the type of cathode shown in Fig. 5;

Fig. 6A graphically illustrates the hum output of an electron tube with change of position of electron emissive material upon the surface of a cathode of the type shown in Fig. 6.

Referring to Figs. 1 and 2, 1 designates a base having five prongs designated 2 to 6 respectively, such as employed in the standard base of heater type tubes of present-day manufacture. This base carries a glass envelope 7 preferably evacuated and within which there is a stem 8. Upon this stem 8 there is rigidly mounted an anode 9 either cylindrical or oblong in cross-section surrounding a grid 10 and a cathode 11.

The grid 10 is of the usual cylindrical or oblong form, as shown. The anode however has cut-away portions as shown at 91 and 92.

The cathode is preferably one of the types disclosed and claimed in my copending application hereinbefore referred to and is provided with two heater connections 12 and 12' securely mounted within the stem 8 and in continuation of lead-in wires 13 and 13' which in turn are connected to the socket pins 3 and 4 respectively. The cathode thimble is provided with a connection 14 sealed through the stem 8 and in continuation of a lead-in wire 15 which in turn is connected to prong 5.

In these figures it will be noted that the cathode lead-in 15 is disposed between the lead-ins 12 and 12' to the heater element on one side and the lead-in 10' to the grid on the other side. This feature is to eliminate insofar as possible any induction in the lead-in wire to the grid of the tube. This is accomplished since the cathode lead-in is usually grounded and acts as a shield between these elements.

The cathode thimble itself may either be cylindrical, nearly elliptical or rectangular as shown in Figs. 4, 5 and 6, details of the description of which follow hereinafter.

In such a cathode structure the heater element is so arranged within the cathode thimble that the bend of the hair-pin does not protrude from the upper end of the cathode thimble, and I have found that a safe distance below the end of the cathode thimble for the bend of the hair-pin is approximately .06

inch, as an example of one of the tubes I have constructed in accordance with the features of my invention. The heater wires themselves at the bottom of the thimble should be as short as possible and connected to rugged supporting members of large heat carrying capacity so that substantially no emission occurs from the heater element terminal protruding from the cathode thimble as shown in detail in Fig. 1.

In Fig. 4 I have shown a cross section of one form of my improved heater element in which numeral 16 refers to a cylindrical insulating element of isolantite fused quartz, magnesium oxide, or like insulating materials having adequate insulating properties at the required high temperature, and having two cylindrical holes 17 and 18 through which the legs 19 and 20 of the heater element are passed. The insulating member 16 is of a type commonly used in slow heater cathode types of tubes available on the market at the present day, and in which the holes 17 and 18 are spaced at a distance of approximately 0.02 inches. Surrounding the insulating member 16, I have provided a cathode thimble 21 of nickel, approximately 0.001 inches thick and about 0.05 inch diameter.

In examining the electrical constants of a cathode of this structure, I have determined that the fluctuating components present in the plate circuit of a tube having a cathode of such a structure is due to effects of the magnetic field upon small portions of electron emissive material distributed about the surface of the cathode thimble 21.

In Fig. 4A, I have graphically developed as curves 22 and 23 in polar coordinates the hum in equivalent volts developed in the plate circuit of a tube having a cathode of this character as a small amount of electron emissive material is progressively moved around the cathode. An analysis of curves 22 and 23 clearly illustrates that near the plane YY of the cathode the electron emissive material lies in a region of substantially no fluctuating magnetic field. However, it will also be noticed that as the electron emissive material is moved away from the axis YY to other parts of the cathode surface, it enters regions of increasing magnetic flux with maxima being reached when the electron emissive material lies near a plane bisecting both legs 19 and 20 of the hair-pin heater. This is due to the differing distances between the emissive material and the two heater legs 19 and 20. Therefore as one simple form of my invention I propose to coat the cathode thimble 21 shown in Fig. 4 only with strips of electron emissive material as indicated at 24 and 25. It will be noted herein that I have located the electron emissive material at those portions of the cathode wherein the hum curves

22 and 23 of Fig. 4A do not depart appreciably from the zero polar ordinate of hum.

In Fig. 5 I have shown a cathode built up of a central thin sheet of insulating material 26 of mica or like heat resisting material, an insulator at high temperatures, upon opposite sides of which are placed flat ribbons 27 and 28 of tungsten or molybdenum wire about 0.001 inches thick and 0.020 inches wide, forming the legs of the heater element. Upon the outer sides of the heater legs 27 and 28 I have provided insulating strips of mica 29 and 30, or like insulating material. Upon the outside of these insulating strips 29 and 30, there is placed an oblong cathode thimble 31 sufficiently thick to maintain the insulating elements 26, 29 and 30 and the heater ribbons 27 and 28 in a fixed rigid condition at all temperatures. An investigation of the hum developed within the plate circuit of a vacuum tube employing a cathode of this character is shown in Fig. 5A, wherein the curves 32 and 33 illustrate the hum as the electron emissive material is moved around over the surface of the cathode thimble 31. Likewise in this structure it will be seen that near the plane YY there is substantially no fluctuating magnetic field due to alternating current energization of the heater element. In this structure therefore, I employ the electron emissive material at the narrow ends of the oblong shape as shown at 34 and 35, thus placing the material as far remote from any magnetic influence as possible.

The graphs in this figure and those of Figs. 6A are upon a scale enlarged by many times the scale of that of Fig. 4A in order to render the effect visible on a drawing of this size. In the actual structures built the maximum magnetic field developed by the structure of Figs. 5 and 6 was substantially one fiftieth of that of the structure of Fig. 4.

Referring to Fig. 5A it will be noted that should any emissive material be spilled or creep over the surface of the cathode 31 during the manufacture or use of the tube, there will be no appreciable hum developed in the output circuit of the tube due to the more complete neutralization of the magnetic fields of the two legs 27 and 28 of the ribbon-shaped heater. This neutralization is accomplished because the centers of the elements 27 and 28 are extremely close together, and when the distance between the centers of these elements is compared to the distance therefrom of any electron emissive material, one might state that the electron emissive material in each of the Figures 4 and 5 is equidistant from the legs of the heater element.

In Fig. 6 I have shown a modified form of the structure shown in Fig. 5, in which the insulating elements 29 and 30 of Fig. 5 have been replaced by grooved isolantite or like

material members 39 and 40, the grooves of which closely surround the legs 27 and 28 of the ribbon-like heater element. Around this entire structure, there is placed a rectangular cathode thimble 41.

In Fig. 6A, I have shown the effect of electron emissive material at various points over the cathode structure shown in Fig. 6. By comparison it will be seen that the hum characteristics of this structure are practically identical with those illustrated in Fig. 5A with reference to the structure shown in Fig. 5. I therefore coat the narrow sides only of the rectangular structure as shown at 44 and 45 with electron emissive material.

In the present invention I propose to use an anode the surface of which consists partly of neutral portions, that is, portions which do not carry a positive charge and, therefore, are ineffective in attracting electrons or not receptive to electrons, and partly of electron-receptive portions. An embodiment of this principle is illustrated in Figs. 1 to 3, and the details of construction of this anode will be best understood from Fig. 3. The portions 9a and 9b consist of metal sheet and represent the electron-receptive portions, while 91 and 92 indicate cut-away segments of the anode cylinder corresponding to neutral portions thereof.

As will be further noted I show in the assembling of Fig. 3 the partly cut-away anode cooperating with one of my partially coated cathodes as described in my co-pending application Ser. No. 431,121. This cathode is appreciably electron-emissive only in the coated portions 24, 25, whereas the uncoated segments 11 of the cathode cylinder are substantially non-electron-emissive. The operation of this assembling may, therefore, be described as follows. The two legs 12 and 12' of the heater element, when energized with alternating current, are surrounded by a fluctuating electro-magnetic field of their own, which field is substantially neutralized in zones adjacent the plane passing symmetrically between the two heater legs. This field spreads out radially through the cathode thimble and reaches out to the anode surface and it may be said to be composed of four sector-shaped solenoids two of which are bisected by said plane and two of which are bisected by a plane passing through the centers of both heater legs. According to what has been said before the average magnetic flux density in the first two sectors is much lower than the average flux density in the last two sectors.

In order to reduce hum in the output circuit of the tube, as caused by electro-magnetic disturbances from the current in the heater element, to a minimum I, therefore, place the electron-emissive portions 24, 25 of the cathode and also the electron-receptive portions 9a, 9b of the anode in the flux solenoids of

relatively low average magnetic flux density.

Though I prefer an arrangement of this kind, it will be understood that I can get a similar, but less complete effect, if I combine
 5 an all-around coated cathode having surface portions of higher and lower magnetic disturbances with an apertured anode of this invention. In this case I so orient the cathode
 10 that its surface portions of lower disturbance or more completely neutralized electro-magnetic field lie within flux solenoids subtending electron-receptive portions of the anode. If
 15 so oriented, electrons emitted from portions of higher magnetic field disturbances will, for the most part, fall back on the cathode especially when checked by a grid electrode of negative charge, since the neutral portions of
 20 the anode which do not exert any attraction at all on electrons lie in the same flux solenoid and the effective portions of the anode are too far removed to have a considerable influence
 on these more highly disturbed electrons. Cathode constructions especially suitable for this kind of cooperation with an apertured
 25 anode have been described in my co-pending application Ser. No. 432,286, filed on March 1, 1930.

The cathode shown in the assembling of Fig. 3 is of the type illustrated in Fig. 4, but,
 30 evidently, I can use in such an assembling with the same results any of the cathodes shown in Figs. 5 and 6. In order to obtain like or similar effects as to hum suppression it will in all such assemblings only be necessary
 35 to so orient the apertured anode with respect to the partially coated cathode that the cut-away areas of the anode and the non-electron-emissive surface portions of the cathode
 40 lie substantially parallel to the plane passing symmetrically between the legs of the heater element, or, in other words, those anode and cathode areas must be likewise disposed relative to said plane.

As an example of a tube of this construction I employed a cathode heater of the type
 45 illustrated in Fig. 5 oriented with respect to the anode in the manner described with reference to Fig. 3, the anode being cylindrical of a diameter of about .250 inches, having
 50 openings 91 and 92 therein of about 90 degrees each and the grid 10 of a diameter of .175 inches with the result that I produced a tube having the general amplifying characteristics
 55 of a 227 type of tube as commercially available and in which it was impossible to measure any hum in the plate circuit thereof when coupled to a cathode ray oscillograph through a battery energized amplifier having an amplification constant of 750.

While I have shown three different cathodes especially suitable for co-operation with an apertured anode of this invention and have
 60 given dimensions for particular examples of tubes embodying my invention, I do not wish to be limited by such specific embodiments,

but rather by the scope of the appended claims.

Having thus described my invention, what I claim is:

1. In an electron tube, the combination of a cathode thimble, a hair-pin heater element
 70 within said thimble being insulated therefrom and extending substantially co-axially therewith, an anode surrounding said thimble and spaced therefrom, said anode being
 75 cut away in an area substantially parallel to a plane passing symmetrically between the legs of said heater element, and an electron emissive coating upon said cathode thimble at
 80 points of substantially equal magnetic field strength of each of the legs of said heater element.

2. In an electron tube, the combination of a cathode thimble, a hair-pin heater element
 85 within said thimble being insulated therefrom and extending substantially co-axially therewith, an anode surrounding said thimble and spaced therefrom, said anode being cut
 away in an area substantially parallel to a plane passing symmetrically between the legs
 90 of said heater element, and an electron emissive substance upon the exterior of said thimble, said thimble surface being free of electron emissive material in an area likewise disposed
 95 relative to said plane as said cut-away area.

3. In an electron tube, the combination of a cathode thimble, an inverted V-shaped heater
 100 element formed of a flat ribbon, the legs of which are closely disposed to each other within said thimble and insulated therefrom, an anode surrounding said thimble and spaced
 apart therefrom, said anode being cut away in an area substantially parallel to a plane
 105 passing symmetrically between the legs of said heater element, and an electron emissive material upon the surface of said thimble, said thimble surface being substantially free
 from electron emissive material in an area
 110 likewise disposed relative to said plane as said cut-away area.

4. In an electron discharge device including a cathode having an electron-emissive
 115 thimble heated by a separate electric heater element which element extends interiorly of said thimble and substantially coaxially therewith and is linked with an electro-magnetic field of its own composed of a plurality
 120 of well-defined magnetic flux solenoids of lower and higher average flux density spreading radially through said thimble, the combination therewith of an anode having electron-receptive and neutral portions, said electron-receptive
 125 portions being situated in said flux solenoids of lower density and said neutral portions being situated in said flux solenoids of higher density.

5. In an electron discharge device including a cathode having a substantially non-electron-emissive thimble heated by a separate

rate electric heater element which element extends interiorly of said thimble substantially co-axially therewith and is linked with an electro-magnetic field of its own composed of a plurality of well-defined magnetic flux solenoids of lower and higher average flux density spreading radially through said thimble, the combination therewith of an electron-emissive substance substantially on surface portions only of said thimble lying in said solenoids of lower density, and of an anode having electron-receptive and neutral portions, said electron-receptive portions being situated substantially in said flux solenoids of lower density, said neutral portions being situated substantially in said flux solenoids of higher density.

6. In an electron discharge device including a cathode having an electron-emissive substantially cylindrical thimble heated by a separate electric heater element of inverted U-shape the two legs of which heater element extend interiorly of said thimble in close proximity to each other substantially co-axially therewith and are linked with a resultant electro-magnetic field of their own composed of two diametrically opposed flux solenoids each of a sector-shaped cross-section symmetrically disposed relative to a plane passing symmetrically between said two heater legs and both solenoids of relatively low value of average flux density and of two diametrically opposed flux solenoids each of a sector-shaped cross-section symmetrically disposed relative to a plane passing through both centers of said heater legs and both solenoids of relatively high value of average flux density, the combination therewith of an anode having electron-receptive and cut-away segments, said lower-density flux sectors subtending said electron-receptive segments, and said higher-density flux sectors subtending said cut-away segments.

7. In an electron discharge device including a cathode having a substantially cylindrical thimble with electron-emissive and substantially non-electron emissive segmental surface portions thereon heated by a separate electric heater element of inverted U-shape the two legs of which heater element extend interiorly of said thimble in close proximity to each other substantially co-axially therewith and are linked with a resultant electro-magnet field of their own composed of two diametrically opposed flux solenoids each of a sector-shaped cross-section symmetrically disposed relative to a plane passing symmetrically between said two heater legs and both solenoids of relatively low value of average flux density and of two diametrically opposed flux solenoids each of a sector-shaped cross-section symmetrically disposed relative to a plane passing through both centers of said heater legs and both solenoids of relatively high value of average flux density, the combination therewith of an anode having electron-receptive and cut-away segments, said lower-density flux sectors subtending said electron-receptive segments, and said higher-density flux sectors subtending said cut-away segments.

In testimony whereof I affix my signature:
BENJAMIN F. MIESSNER.