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ULTRAHIGH-FREQUENCY GENERATOR AND ELECTRON TUBE

Original Filed April 8, 1949 3 Sheets--Sheet 1

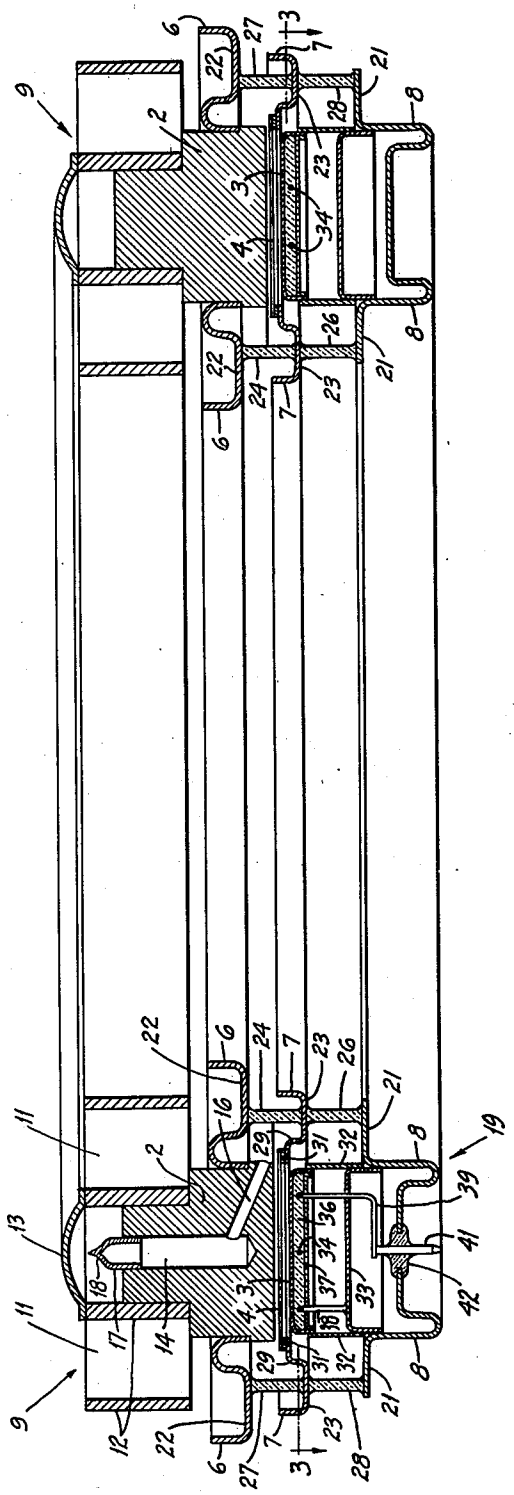


Fig. 1

INVENTORS
WILLIAM W. EITEL
JACK A. Mc CULLOUGH
HAROLD E. SORG
BY Harold E. Sorg
ATTORNEY

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Original Filed April 8, 1949 3 Sheets-Sheet 2

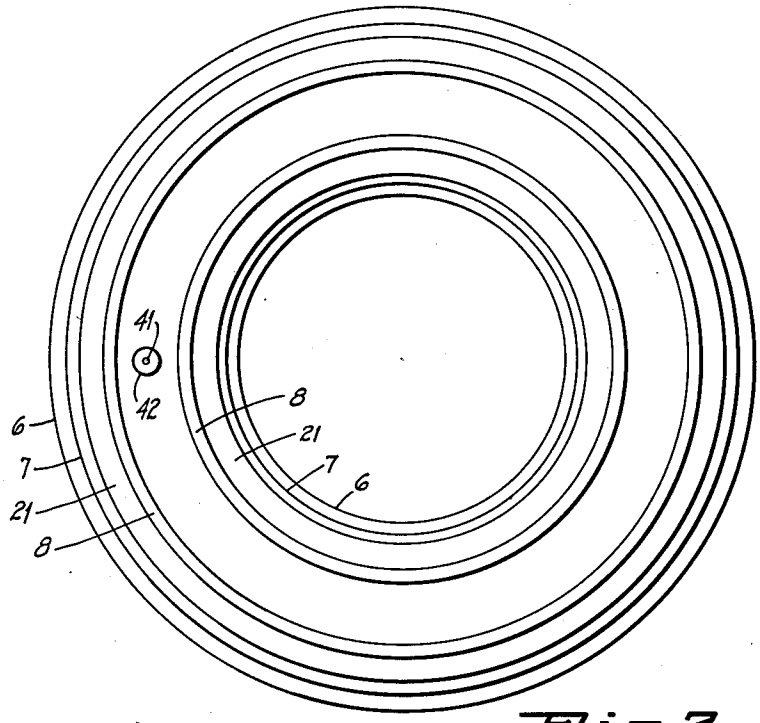


Fig. 2

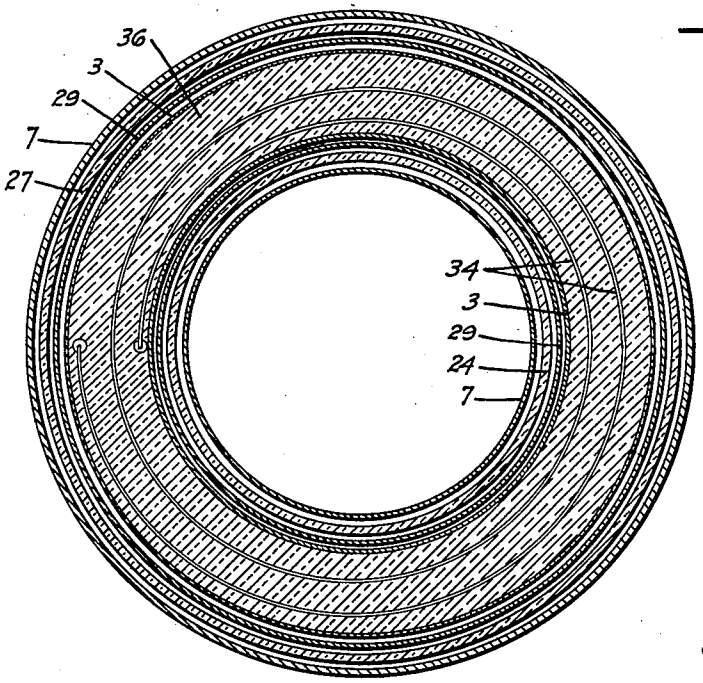


Fig. 3

INVENTORS
WILLIAM W. EITEL
JACK A. McCULLOUGH
HAROLD E. SORG
BY Harold E. Sorg
ATTORNEY

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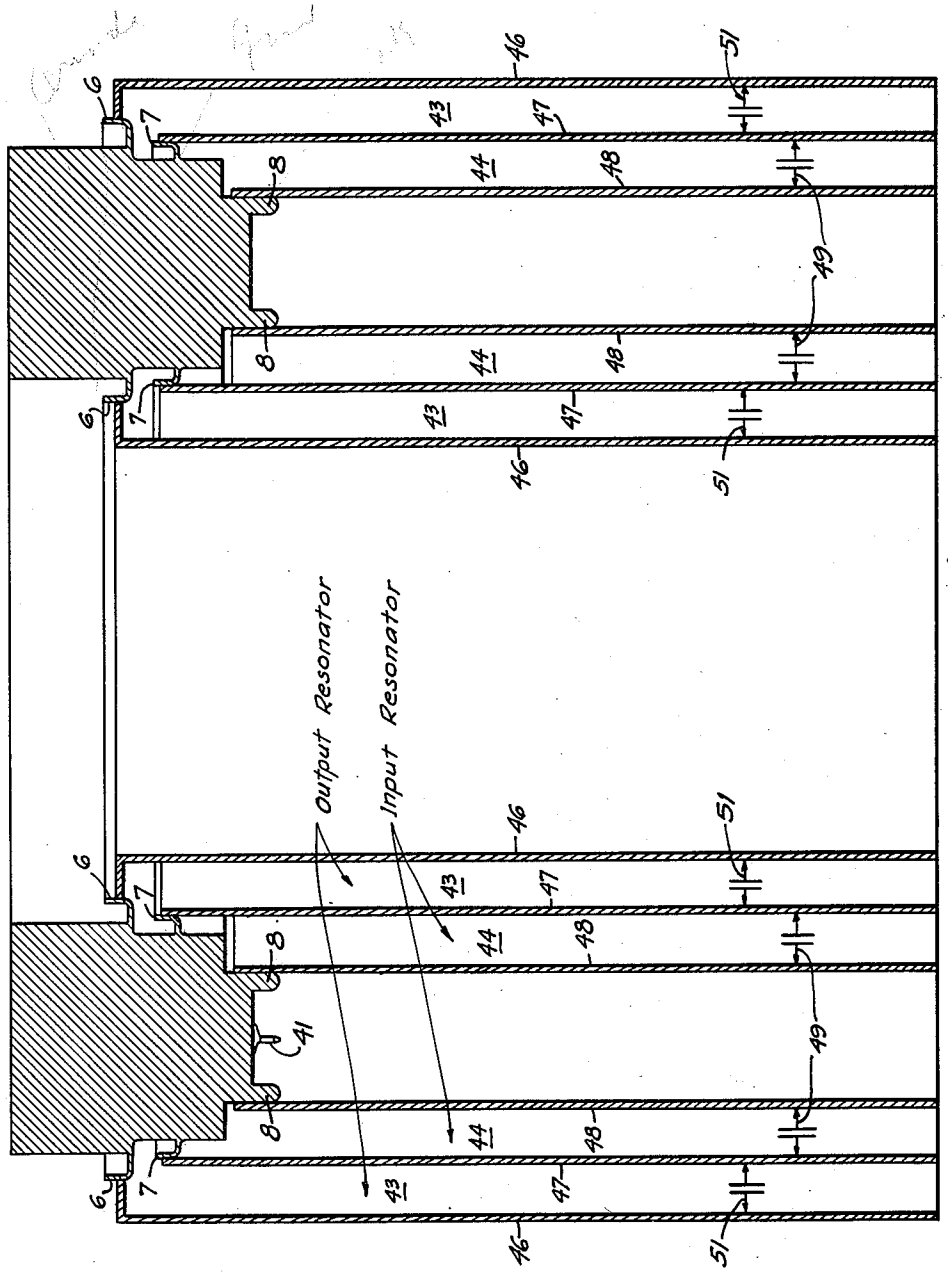


Fig 4

INVENTORS
WILLIAM W. EITEL
JACK A. Mc CULLOUGH
HAROLD E. SORG
BY Harold Elsy
ATTORNEY

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UNITED STATES PATENT OFFICE

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ULTRAHIGH-FREQUENCY GENERATOR AND ELECTRON TUBE

William W. Eitel, Woodside, Jack A. McCullough, Millbrae, and Harold E. Sorg, Redwood City, Calif., assignors to Eitel-McCullough, Inc., San Bruno, Calif., a corporation of California

Original application April 8, 1949, Serial No. 86,232, now Patent No. 2,573,190, dated October 30, 1951. Divided and this application June 19, 1951, Serial No. 232,294

2 Claims. (Cl. 250—36)

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This is a division of our copending application, Serial No. 86,232, filed April 8, 1949, and now U. S. Patent No. 2,573,190.

Our invention relates to a radio-frequency generator including an improved electron tube and associated circuitry for operation at ultra-high frequencies.

Tubes of the negative grid type, either triodes or tetrodes, have in the past been made in tubular shapes, this conventional design having grown out of the old lamp industry. These tubes have served a good purpose at the lower frequencies, and, if more power output was desired it was only necessary to make the tube larger to take care of the additional heat dissipation because the lower frequencies did not place dimensional limitations on the tube. This increase in the tube size is not possible at the higher frequencies, however, and therefore a high frequency tube of the conventional type is seriously limited as to its power output capabilities.

The broad object of our invention is to provide a radio-frequency generator embodying an improved tube of annular shape which satisfies the dimensional limitations imposed by the higher frequencies and yet has sufficient heat dissipation capabilities to give a relatively large power output.

Another object is to provide an annular cavity-type resonator for operation in conjunction with the annular tube, which cavity circuitry is suited for use as an amplifier or an oscillator at the ultra-high frequencies.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of our invention. It is to be understood that we do not limit ourselves to this disclosure of species of our invention, as we may adopt variant embodiments thereof within the scope of the claims.

Referring to the drawings:

Figure 1 is a vertical sectional view of a triode embodying the improvements of our invention; and

Figure 2 is a bottom view of the same.

Figure 3 is a horizontal sectional view taken in a plane indicated by the line 3—3 of Figure 1.

Figure 4 is a diagrammatic sectional view showing a radio-frequency generator incorporating the tube of our invention.

In terms of broad inclusion our improved radio-frequency generator comprises an electron tube having an annular envelope, a plurality of ring-shaped electrodes including an anode and grid and cathode, the opposing surfaces of the electrodes preferably lying in planes transverse to the tube axis, and terminals for the electrodes concentric with the axis. The envelope preferably has concentric inner and outer side walls

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with the anode supported at one end and the cathode at the opposite end, and with the flat ring-shaped grid supported by terminal rings interposed in the side walls. The improved circuitry embodied in our radio-frequency generator comprises a resonator having annular cavities concentric with the axis of the annular tube, the conductors defining the cavities being coaxial with the electrode terminals on the tube. The ring-shaped electrodes of the annular tube are thus coupled across the ends of the annular cavities so that the width and not the circumferential length of the electrodes becomes the important dimensional factor determining the upper frequency limit. A tube with relatively large electrode areas and consequently large power output capabilities is therefore provided, while at the same time satisfying the dimensions necessary for efficient operation at the ultra-high frequencies.

In greater detail, and referring first to Figures 1, 2 and 3 of the drawings, the triode version of our improved high frequency tube comprises an annular or doughnut-shaped envelope, having concentric inner and outer side walls providing an evacuated closure for a plurality of ring-shaped electrodes including an anode 2, cathode 3 and control grid 4. In order to allow close spacings between the electrodes and to provide other advantages in the annular tube structure, the electrodes are preferably of the planar type having opposed surfaces lying in parallel planes transverse to the tube axis. These electrodes have terminals on the envelope, preferably including a pair of anode terminals 6, a pair of grid terminals 7 and a pair of cathode terminals 8, which electrode terminals are also ring-shaped and concentric with the tube axis. In the interest of illustrating the structure most clearly the tube of Figure 1 is shown with fairly wide electrodes. In actual practice for high frequency operation the effective electrode width measured across the section of the ring-shaped electrodes would be considerably less than that shown, say about 3/8 inch for a U. H. F. tube. The overall diameter of the tube may be of any desirable size, depending upon the total active electrode area required for the power output desired.

Ring-shaped anode 2 is preferably of the external anode type and forms the upper part of the tube envelope, supported between the side walls. This circular anode may be machined from any suitable metal, preferably copper for good heat conduction, and has an inner portion terminating at a flat face providing the active surface of the anode and an outer portion projecting from the upper end of the envelope carrying a cooler 9. For a forced air cooled tube, as illustrated, the cooler preferably comprises two circular cooler sections secured to opposite

sides of the anode, each section comprising radial fins 11 held by retaining sleeves 12. A ring-shaped cap 13 across the sections completes the cooler structure. If desired suitable jackets may be used on the anode for water cooling.

At one point in the circle defined by the anode a vertical passage 14 is provided communicating with the interior of the envelope through a transverse passage 16. A metal exhaust tubulation 17 is secured in the outer end of passage 14 which tubulation, after evacuation of the envelope, is pinched off at tip 18. In the completed tube this tubulation is housed and protected by the cooler structure.

The lower end of the envelope opposite the anode comprises a circular metal header 19 shaped to form the downwardly extending cathode terminals 8 and the radial sealing flanges 21, the bottom wall of the header being preferably made reentrant for added regidity. The pair of concentric ring-shaped cathode terminals 8 are thus formed as an integral part of the header. Anode terminals 6 have integrally formed circular sealing flanges 22 which have lips brazed to the anode, the flanges 22 being located above the sealing flanges 21 of the header 19. Grid terminal rings 7 likewise have integrally formed sealing flanges 23 located between the flanges 21 and 22.

The inner side wall of the envelope comprises a pair of cylindrical insulating sections, including an upper section 24 sealed between flanges 22 and 23 and a lower section 26 sealed between flanges 21 and 23. In a like manner the outer side wall comprises a pair of cylindrical insulating sections, including an upper section 27 sealed between the flanges 21 and 23 and a lower section 28 sealed between the flanges 21 and 23. The envelope sections may be of a vitreous material such as glass sealed along their edges to the metal flanges by ordinary glass-to-metal sealing techniques using flames to fuse the glass at the sealing areas. If desired ceramic may be employed for the envelope sections, using conventional ceramic-to-metal bonding techniques.

As shown in Figure 1 the flat ring-shaped grid 4 is supported along both of its circular edges by the inwardly extending flanges 29 which are formed integrally with the grid terminal rings 7. The ring-shaped grid may be fabricated in any suitable manner, as by wires bonded or woven together and stretched across a pair of retaining rings 31 which are in turn secured to the flanges 29. Instead of being fabricated from wire or mesh the grid may be made of a perforated sheet metal ring. In any case, several advantages are gained by the ring-like shape and mounting arrangement of the grid in our tube because the grid, although of large total effective area, is amply held by supports which extend along the entire length of its inner and outer peripheral edges. Since the grid is inherently narrow compared to its circumferential length, the active part of the grid has the necessary support and rigidity to insure accurate maintenance of the close spacings between it and the adjacent electrodes. This is very important in high frequency tubes where any change in the already close electrode spacings results in a wide shift of the operating frequency.

Much trouble has been occasioned by such grid movement in the conventional tubular type tubes because of the oil-canning or diaphragm-like movement of the disk-shaped grids involved in such tubes. The ring shape of our grid together with the support along both peripheral edges provides a great improvement in that respect as well as providing a grid of much larger effective electrode area. Still another advantage is that our grid, being circular and narrow, is ideally shaped and supported for maximum heat removal from the effective grid area, which means greater heat dissipation capabilities of the grid and hence more power output from the tube. This will be apparent when it is realized that heat from the grid can flow radially in both directions out through the adjacent grid terminal rings. It should also be understood that electrode widths in the tube shown in Figure 1 are much greater than would be the case in an actual tube, the larger widths shown being for purposes of illustrating the structure more clearly. In an actual tube for ultra-high frequency operation the electrode widths for example may be not over 3/8 inch or less. A ring-shaped grid of that narrow width and supported along both edges, regardless of its circumferential length, obviously is very rigid and has good heat dissipation properties. These advantages with respect to the grid in our improved tube are emphasized because grid dissipation and grid stability are usually the limiting factors in the high frequency operation of transmitting tubes.

The cathode 3 preferably comprises a cupped or channel shaped ring, say of nickel, with a flat upper face carrying a thermionic electron emitting material such as the conventional barium-strontium oxide coating. This cathode ring is supported by a pair of skirts or ring-like flanges 32, preferably of thin sheet metal to thermally isolate the cathode. Flanges 32 are in turn preferably supported on another channel-shaped ring 33 which is fitted between the cathode terminal portions 8 of the header 19. Ring 33 also functions as a heat baffle to conserve heat within the cathode structure.

The cathode is heated indirectly, preferably by a pancake heater coil 34 embedded in an insulating layer 36 disposed between the cathode ring and a backing plate 37 fitted between the flanges so that the cathode and its heater may be fabricated as a unit prior to assembly in the tube. One end 38 of the heater coil is brought out and connected to the cathode structure as at the baffle plate 33, and the other end 39 is connected to a lead 41 projecting out of the envelope between cathode terminals 8 and sealed in place by a glass bead 42. Heater current for the cathode may thus be applied by making external connections to a cathode terminal and the lead 41.

Figure 4 illustrates diagrammatically an improved R. F. generator embodying the annular tube, the view being in vertical section and the tube being in sectional outline to show the terminal connections. It will be noted that the generator comprises annular cavity resonators associated with the annular tube, which circuitry is ideally suited for ultra-high frequency operation. The generator shown comprises an annular output resonator 43 and anuular input resonator 44 made up of pairs of coaxial metal conductors 46, 47 and 48, the conductors 46 being connected to anode terminls 6, conductors 47 being connected to grid terminals 7, and conductors 48 being connected to cathode terminals 8. The annular cavities and annular tube are thus all concentric about the central axis of the tube, which is possible because the electrode terminals and cavity conductors are all coaxial.

It is seen from the above that each annular resonator comprises a pair of concentric cavity

sections, namely, the output resonator comprises a pair of cavity sections 43 and the input resonator comprises a pair of cavity sections 44. It is also seen that the entire resonator structure is made up of six concentric cylindrical conductors, a first pair 46 of these conductors being innermost and outermost, a second pair 47 lying between the first pair, and a third pair 48 lying between the second pair. By this arrangement the spaces between the first and second pairs of conductors form the pair of concentric cavity sections 43 of the output resonator and the spaces between the second and third pairs of conductors form the pair of concentric cavity sections 44 of the input resonator.

The input and output resonators may be tuned by annular plungers 49 and 51 for adjusting the axial length of the cavities, and which may have built-in blocking condensers as illustrated for isolating the D. C. plate and grid bias voltages. These tuning plungers are slidably mounted in the cavity sections of both the input and output resonators. The D. C. connections are not shown since such will be obvious to those skilled in the art, it being understood that one of the heater connections may be brought up through the space between the cathode conductors 48 and connected to the lead 41. Any conventional means (not shown) such as probes or loops may be provided for coupling R. F. power into and out of the resonators, which in the case of an amplifier would involve feeding the driving power into the input resonator 44 and taking power out of the output resonator 43. In the case of an oscillator, suitable feedback loops or probes would be arranged to feed energy from the output resonator back to the input resonator, as will be readily understood.

It will be noted that annular or ring-shaped electrodes of the tube are bridged across the ends of the annular cavities so that the critical electrode dimension with respect to frequency is the width and not the length of the electrodes. That is a very important factor in our improved R. F. generator because it makes possible the generation of very large orders of R. F. power in the upper frequency ranges. This advantage stems directly from the improved tube and circuit relationship, wherein the ring-shaped electrodes are coupled across the ends of the annular cavities. Thus in the amplifier version of the generator shown in Figure 4, which is a common-grid type of triode operation, the cathode and grid are coupled across the end of the annular input cavity 44 and the anode and grid are coupled across the annular output cavity 43, the annular cavities and ring-shaped electrodes all being concentric with the central axis of the annular tube.

The particular advantage of our annular type planar electrode tube and associated circuitry, whether constructed as a triode or as a tetrode, is that large electrode area and electrode supporting mass is provided to handle large currents in the tube and take care of the heat dissipation necessary for high power operation, yet close electrode spacings are attainable and the width across a given section of the tube may be kept small to provide good efficient operation in the ultra-high frequency range. This matter of suitability for high frequency operation will be apparent from inspection of Figure 4, where it is seen that the annular or ring-shaped electrodes are connected across the ends of the annular resonant cavities. Thus the width and not the length of the electrodes is the important dimensional factor determining the upper frequency limit in our improved annular tube and circuitry. Since the electrode width may be kept to a small dimension in our tube, it is possible to provide efficient operation in the upper U. H. F. region, say above 2000 mc. Furthermore, since the circumferential length of the electrodes does not limit the frequency in our R. F. generator it is clear that the overall diameter of the tube may be increased indefinitely to provide the needed electrode areas, depending upon the output power required. We have thus provided an R. F. generator, using a single negative grid type of tube, for generating very large orders of power in the upper frequency ranges. If desired the electrodes may be of different shapes than that shown, such as electrodes of arcuate or dome-shape in cross section. The planar type electrodes are preferred, however, because of the simplicity of construction and the ease of establishing close electrode spacings.

We claim:

1. A radio-frequency generator having input and output cavity resonators comprising six concentric cylindrical conductors, a first pair of said conductors being innermost and outermost, a second pair lying between the first pair and a third pair lying between the second pair, the spaces between the first and second pairs of conductors forming a pair of concentric cavity sections of the output resonator and the spaces between the second and third pairs of conductors forming a pair of concentric cavity sections of the input resonator, and an annular electron tube coaxial with the conductors and having ring-shaped electrodes including a cathode and grid and anode, the ring-shaped anode being electrically connected to ends of the first pair of conductors, the ring-shaped grid being electrically connected to ends of the second pair of conductors and the ring-shaped cathode being electrically connected to ends of the third pair of conductors.

2. A radio-frequency generator having input and output cavity resonators comprising six concentric cylindrical conductors, a first pair of said conductors being innermost and outermost, a second pair lying between the first pair and a third pair lying between the second pair, the spaces between the first and second pairs of conductors forming a pair of concentric cavity sections of the output resonator and the spaces between the second and third pairs of conductors forming a pair of concentric cavity sections of the input resonator, and an annular electron tube coaxial with the conductors and having ring-shaped electrodes including a cathode and grid and anode, the ring-shaped anode being electrically connected to ends of the first pair of conductors, the ring-shaped grid being electrically connected to ends of the second pair of conductors the ring-shaped cathode being electrically connected to ends of the third pair of conductors, and tuning plungers slidably mounted in the cavity sections between said conductors.

WILLIAM W. EITEL.
JACK A. McCULLOUGH.
HAROLD E. SORG.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,298,949	Litton	Oct. 13, 1942
2,408,927	Gurewitsch	Oct. 8, 1946
2,416,565	Beggs	Feb. 25, 1947
2,419,536	Chevigny	Apr. 29, 1947
2,519,420	Varian	Aug. 22, 1950