June 9, 1953 D. H. PREIST ET AL 2,641,657

RADIO-FREQUENCY TRANSMISSION DEVICE

Filed April 18, 1949 2 Sheets-Sheet 1

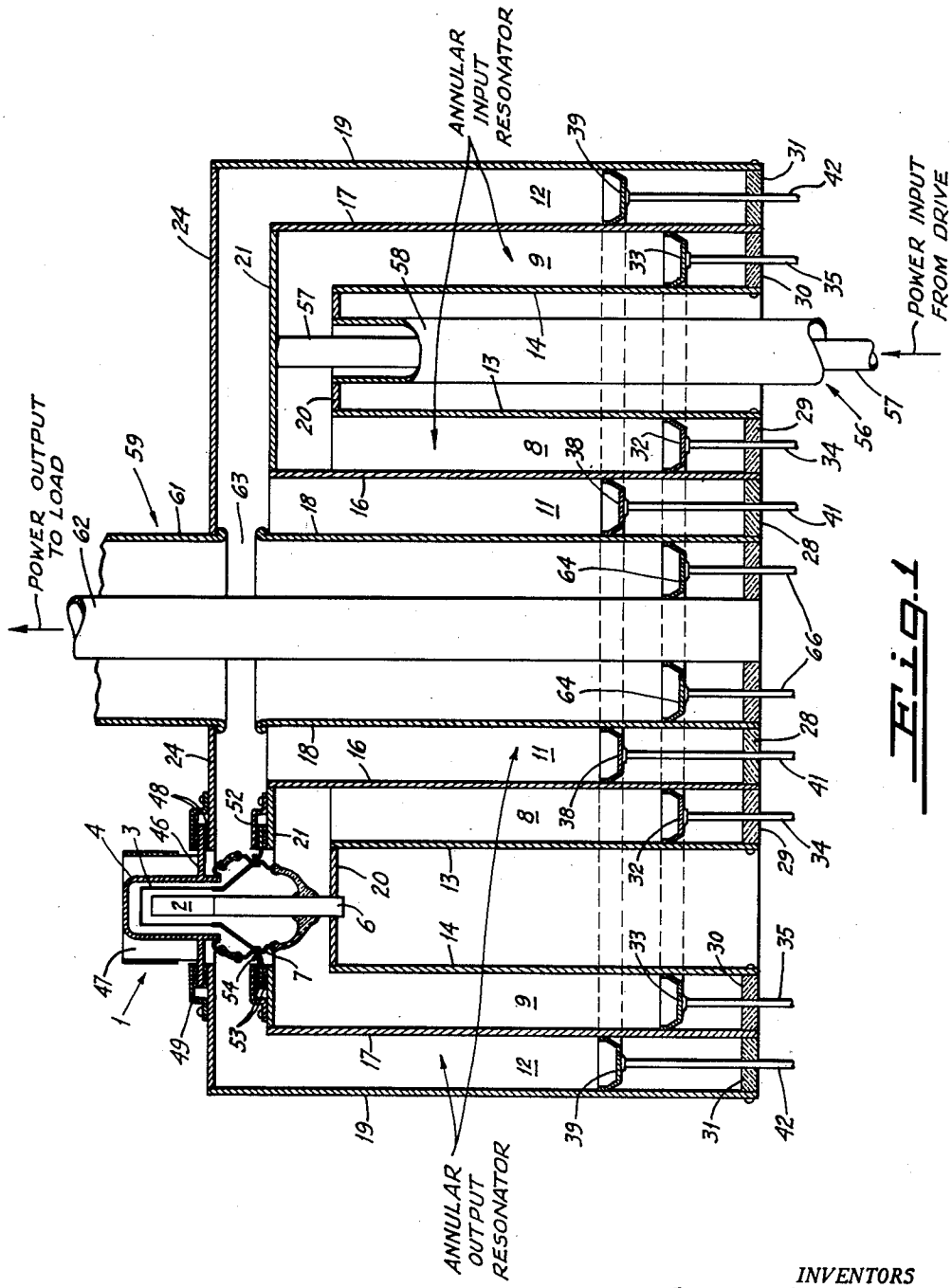



Fig. 1

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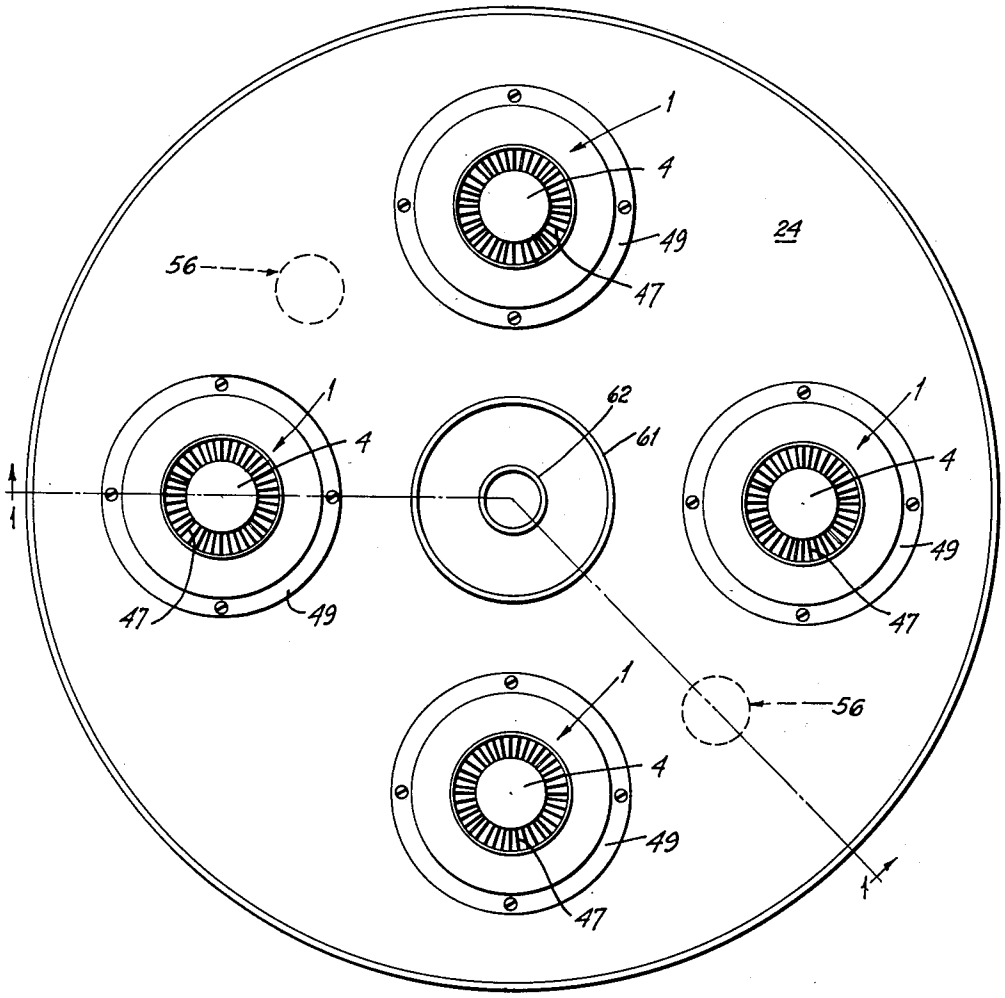



Fig. 2

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## RADIO-FREQUENCY TRANSMISSION DEVICE

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2 Claims. (Cl. 179—171)

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Our invention relates to generators of radio-frequency power, and more particularly to such a generator capable of delivering large orders of power in the higher frequency ranges, say above 100 mcs./sec., using conventional type negative grid tubes.

In the copending application of Donald H. Preist, Serial No. 42,171, filed August 3, 1948, now Patent No. 2,554,500, issued May 29, 1951, there is disclosed a new type of R. F. generator embodying an annular cavity resonator operating in conjunction with a plurality of tube units, whereby the power outputs of the individual tube units are combined without appreciable loss.

The object of our present invention is to provide an improved construction for such a multiple unit tube generator.

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 power amplifier embodying the improvements of our invention; and

Figure 2 is a plan view of the same, the line 1—1 indicating the plane of section of Figure 1.

In terms of broad inclusion, the radio-frequency generator of our invention comprises a plurality of tube units disposed in a circle about an axis, and a pair of annular cavity resonators coaxial with the circle and having conductors connected to electrodes of the tube units, each resonator comprising two communicating annular cavity sections. As embodied in an amplifier one of these cavity resonators functions as the input circuit and the other as the output circuit. In our generator of such annular construction improved means are provided for feeding R. F. power into and out of the resonators. The output transmission line coupled to the output resonator is arranged coaxially with the generator, and the input transmission line coupled to the input resonator is spaced from the generator axis, a plurality of the input lines being provided and so spaced as to lie in the circle defined by the tube units. An output tuning stub is also preferably provided, formed as an extension of the output line and located centrally of the generator.

In greater detail, and referring to the drawings, our improved R. F. generator constructed as an amplifier comprises a plurality of electron tube

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units 1 disposed in a circle about a common axis, which tube units are of like structure and have like characteristics. While four tube units are shown, it is understood that any desired number may be employed, depending upon the power output required. Any conventional type of negative grid electron tube may be used for the units 1, the triode type of tube illustrated having a cathode 2, grid 3 and anode 4, the anode being external and all the electrodes being preferably cylindrical and coaxial.

The tube units employed also preferably have coaxial terminals for the electrodes, such as the cathode terminal 6 opposite the anode and the grid terminal ring 7 interposed in the glass envelope wall between the cathode terminal and anode. The heating structure for the cathode is not shown but may comprise any suitable means such as an inner filament for heating the cathode cylinder 2 by electron bombardment, in which case the filament leads preferably extend out through the tubular cathode terminal 6.

The amplifier has a pair of annular cavity resonators common to the tube units 1, functioning as the input and output resonant circuits for such units. Each resonator has two communicating annular cavity sections arranged coaxially with the circle of tube units, thus the input resonator has the two annular cavity sections 8 and 9 communicating through spaces between the lower portions of the tube units, and the output resonator has the two annular cavity sections 11 and 12 communicating through spaces between the upper portions of the tube units. This symmetrical arrangement of the cavity resonators with respect to the tube units is an important feature in our R. F. generator.

The two cavity sections 8 and 9 of the input resonator extend downwardly from a plane defined by the circle of tube units, say a plane passing through the mid-portions of the units 1. Cavity sections 11 and 12 of the output resonator also extend downwardly from such plane and surround the input resonator.

The several cavity sections of the resonators are defined by metallic boundary walls or conductors which make up the physical structure of the amplifier. As illustrated, the annular cavity sections of the resonators are defined by six concentric wall conductors 13, 14, 16, 17, 18 and 19. The shorter walls are connected across the top by a metal ring 20, these parts comprising an inner conductor of the input resonator. This inner conductor is connected to the cathode 2 of each of the tube units, preferably by having cathode terminals 6 seated in apertures or sockets in the

ring 20. Suitable leads for the cathode heater means may conveniently extend out through the hollow space formed between the walls 13 and 14.

A transverse conductor member or metal ring 21 extends across the top of the input resonator in the plane of the grid terminal rings 7 and is connected to the cylinders 16 and 17. This transverse conductor comprises the top wall of the input cavity 8—9 and also forms a common dividing wall between the input and output resonators. Cavity sections 8 and 9 of the input resonator are thus connected about their circumference by the communicating space formed between the transverse wall members 20 and 21. Conductor 21 is electrically connected for R. F. to the grid 3 of each of the tube units through suitable bypass condensers as hereinafter described.

Wall conductors 18 and 19 are joined across the top by a transverse wall conductor 24. Cavity sections 11 and 12 of the output resonator are thus also connected about their circumference by the communicating space formed between the transverse wall members 21 and 24. Conductor 24 is electrically connected for R. F. to the anode 4 of each of the tube units through suitable bypass condensers as hereinafter described.

By this arrangement it will be seen that the cavity resonators are coaxial with the circle of tube units, and are disposed in such a manner that the tube units are located between the annular cavity sections of the resonators, with the cathodes connected to a conductor of the input resonator, the anodes connected to a conductor of the output resonator and the grids connected to a common transverse conductor between the resonators.

It will thus be noted that each resonator comprises two cavity sections, each section being constituted by the space between a pair of concentric cylinders. The length of each section, measured axially of the circle of tube units, is substantially greater than the width of the section, measured radially of the circle of tube units, i. e., the difference in radius of the concentric cylinders which define the section (ignoring the thickness of the cylinders). An annulus having a greater axial than radial dimension, measured as described, is defined hereinafter as an axially extending annulus.

The several cylindrical conductors of the resonators are held mechanically in position by rings 28, 29, 30 and 31 of suitable insulating material located between the conductors at the bottom of the generator. Any suitable metal such as brass may be used for the various cylindrical and transverse conductors described.

Adjustable means are provided for tuning the input and output resonators to the desired resonant frequency. For this purpose a pair of movable annular metal plungers or shorting bars 32 and 33 are provided in the input resonator, forming end walls in the cavity sections 8 and 9 respectively. These plungers are slideably mounted on the wall conductors, and axial adjustment is achieved by means of plunger rods 34 and 35 of insulating material projecting out through the supports 29 and 30. These rods may be connected externally to insure that the plungers are adjusted in unison.

In a like manner plungers 38 and 39 are provided in the cavity sections 11 and 12 of the output resonator, which plungers are slideably mounted on the wall conductors and adjusted by plunger rods 41 and 42.

The D. C. voltages may be applied to the tube electrodes in any suitable manner. In the amplifier illustrated, which is essentially a grid-separation type of circuit, the positive D. C. anode potential and bias voltages are applied through suitable leads to the anodes and grid terminal rings. Suitable leads for the cathode heaters for the several tube units are conveniently brought out through the hollow space between the conductors 13 and 14.

The D. C. voltages are preferably isolated by suitable bypass condensers at the anode and grid terminals of the tube units. For example, each anode 4 is preferably provided with a terminal disk 46 located below the anode cooler 47; the latter being either of a finned type as illustrated for forced air cooling or of the jacket type for water cooling. The bypass condenser is conveniently formed by rings 48 of insulating material separating the terminal disk 46 from the conductor 24 at one side and a retaining ring 49 on the opposite side. In a like manner a terminal disk 51 is connected to the grid terminal ring 7 and separated from the conductor 21 and a retaining ring 52 by rings 53 of insulating material. For convenience of replacing the tubes, the grid terminal disk 51 preferably has contact fingers 54 for engaging the grid ring 7 so that the tube plugs into this part as a socket, whereby the tube may be withdrawn by merely removing the retaining ring 49 or having a suitable joint in the terminal disk 46.

An important feature of our present invention is the means employed for transferring and coupling R. F. power into and out of an annular generator of the character described. Driving power from a suitable source to the input resonator is transferred by a coaxial transmission line 56 extending up through the open space between conductors 13 and 14 and suitably arranged between the tube units 1. This line comprises an inner conductor 57 terminating at the transverse member 21 and an outer conductor 58 terminating at the transverse member 20, thus providing the desired coupling for transferring energy from the transmission line 56 to the input resonator, it being noted that the input transmission line 56 terminates at the communicating space between the cavity sections 8 and 9. At least two of the input lines 56 are preferably incorporated, diametrically disposed as illustrated in Figure 2, so as to provide a balanced coupling. These lines are preferably connected externally to a common transmission line (not shown) which feeds the power from the driving source. In other words, the input transmission lines 56 are spaced from the axis of the generator and lie in the same circle as the tube units 1. The advantage of this off-center arrangement of the input lines is that it provides a satisfactory means for coupling the driving power into the annular input resonator without taking up space along the axis of the generator, which central space may be then utilized for other purposes.

Power is preferably transferred from the output resonator by a transmission line 59 along the axis of the generator, and comprising an outer conductor 61 terminating at the transverse conductor 24 and an inner conductor 62 extending downwardly within the conductor 18. Coupling of energy from the output resonator is established by the circular slot 63 formed between the ends of aligned conductors 61 and 18. The extension of the inner conductor 62 together with the surrounding conductor 18 provides an output tuning stub which is tuned by an annular shorting bar

64 adjusted by plunger rods 66. This arrangement of the input and output transmission lines and the output tuning stub provides a very compact generator construction.

In our improved R. F. generator the overall diameter of the generator may be increased indefinitely to accommodate an indefinite number of tube units, depending upon the amount of power required. Furthermore, the multiple unit tube generator described will operate well in the higher frequency ranges, say above 500 mcs./sec., without loss of efficiency compared to that obtainable from a single tube unit. The total power output from $n$ tube units, as measured at the load, is substantially $n$ times that obtainable from a single tube unit in an efficient single unit tube generator.

While we have described our generator in connection with triode units, it is understood that tube units having additional electrodes such as tetrodes may be employed, in which case additional annular, coaxial and symmetrical circuit members are employed.

We claim:

1. A radio-frequency transmission device comprising a plurality of electron tube units disposed in a circle about an axis and each having electrodes including an anode and cathode, an output cavity resonator common to the tube units and having two communicating, axially extending, annular cavity sections, the output resonator being coaxial with said circle and having a conductor connected to an anode of each of the tube units, an input cavity resonator common to the tube units and having two communicating, axially extending, annular cavity sections, the input resonator being coaxial with said circle and having a conductor connected to a cathode of each of said tube units, the axial dimension of each cavity being substantially greater than the radial dimension thereof, an output transmission line coaxial with said circle and coupled to the output resonator, a tuning stub coaxial with said circle and forming an extension of the output line, and an input transmission line spaced from said axis and coupled to the input resonator.



2. A radio-frequency transmission device comprising a plurality of electron tube units disposed in a circle about an axis and each having electrodes including an anode and cathode, an output cavity resonator common to the tube units and having two communicating, axially extending, annular cavity sections, the output resonator being coaxial with said circle and having a conductor connected to an anode of each of the tube units, an input cavity resonator common to the tube units and having two communicating, axially extending, annular cavity sections, the input resonator being coaxial with said circle and having a conductor connected to a cathode of each of said tube units, the axial dimension of each cavity being substantially greater than the radial dimension thereof, an output transmission line coaxial with said circle and coupled to the output resonator by a circular slot, and a tuning stub coaxial with said circle and forming an extension of the output line on the opposite side of said slot.

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