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SHORT WAVE RADIO TRANSMITTER

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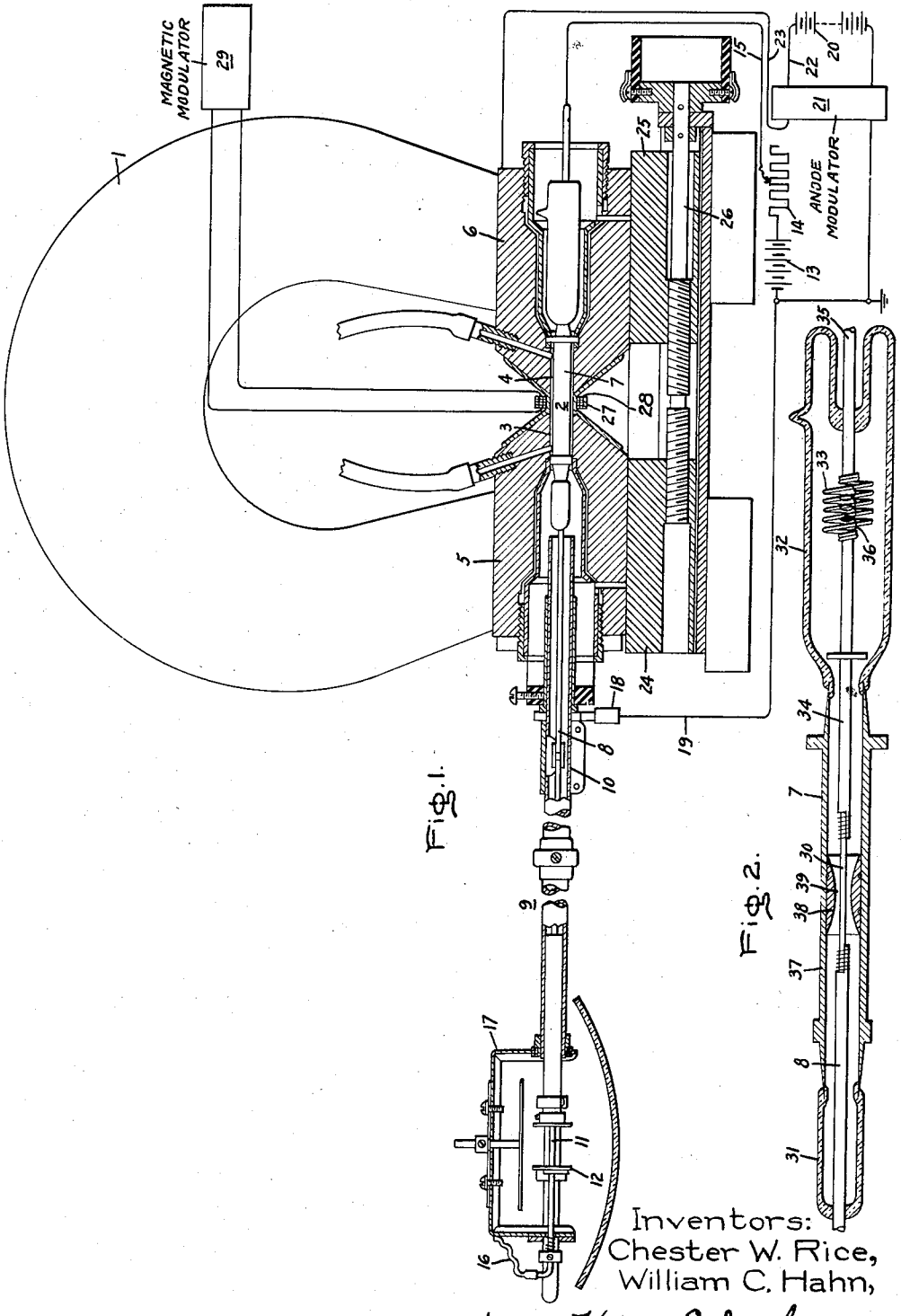


Fig. 1.

Fig. 2.

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SHORT WAVE RADIO TRANSMITTER

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9 Claims. (Cl. 250—27.5)

Our invention relates to short wave radio transmitters and more particularly to those of the electronic oscillator type in which the electron transit time governs the period of oscillation.

The present invention is especially applicable to the transmitter systems which constitute the subject matter of copending application, Serial No. 61,377, Chester W. Rice, filed January 29, 1936, Patent No. 2,145,735, issued January 31, 1939.

It is an object of our invention to provide an improved form of ultra short wave radio transmitter of the electronic oscillator type.

Another object of our invention is to provide an ultra short wave radio transmitter having improved power output characteristics and frequency stability.

A further object of our invention is to provide means for increasing the electron velocity in electronic oscillator devices of the magnetron type thereby still further to improve the power output characteristic of the ultra short wave radio transmitter.

The novel features which are believed to be characteristic of our invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is an elevational view partly in cross section of a transmitter shown and described in the above mentioned patent of Chester W. Rice and embodying our present invention, and Fig. 2 is an enlarged cross sectional view of the magnetron of Fig. 1.

Referring to Fig. 1 of the drawing, the transmitter shown therein comprises a permanent magnet 1, and an electron discharge device 2 housed almost entirely within axial apertures 3 and 4 of two truncated conical pole pieces 5 and 6 which are secured to the ends of permanent magnet 1. The discharge device 2 is preferably but not necessarily of cylindrical form having a cylindrical metal anode 7, the opposite ends of which are supported in the respective apertures 3 and 4 of the pole pieces.

It will be understood that the cathode (not shown in Fig. 1) of electron discharge device 2 is a continuation of a conductor 8 which forms the central conductor of a concentric transmission line 9 the outer conductor of which comprises a hollow tube 10. An exposed portion 11 of conductor 8 constitutes the radiating member of the transmitting system. This exposed portion 11 has a length determined in accordance with the radiation pattern desired. Conductor 8 is terminated for radio frequencies by a tuning disk 12 which slides on conductor 8.

Two electrical energizing circuits are provided for the transmitter. A suitable low potential source 13 heats the cathode of discharge device 2 to the desired temperature. A variable resistor 14 is provided in series with source 13 to facilitate regulation of the potential applied across the cathode. The complete cathode heating circuit extends from the high side of source 13 through resistor 14, a conductor 15, the cathode of discharge device 2, conductor 8, a jumper wire 16, a frame 17, concentric conductor 10, a binding post 18, and a conductor 19, to the grounded side of source 13.

A high potential (for example, 4000 volts) is applied to the anode of discharge device 2. The source of this potential is illustrated as a battery 20 but any other suitable source of supply may be used such as a rectifier or the like. Since modulation of the electronic oscillations may be obtained by causing a fluctuation of the anode potential at the modulating frequency, a modulator of this type is indicated conventionally by rectangle 21. The complete anode circuit extends from the high side of source 20 through a conductor 22, anode modulator 21, a conductor 23, pole piece 6, the anode of discharge device 2, the cathode (not shown in Fig. 1) of discharge device 2, conductor 8, and thence through the cathode circuit previously traced to ground and to the negative side of source 20.

From the foregoing description, it is apparent that high frequency oscillations are produced solely on the cathode and in the associated cathode circuit. That is, the cathode potential rises and falls above and below ground potential at an extremely high frequency, and the anode is maintained at a fixed potential above ground and no variation thereof occurs.

The frequency of oscillations generated in the magnetron is primarily a function of the magnetic field intensity. Therefore, a variable magnetic shunt is provided comprising two soft iron plates 24 and 25, which slide on the under surfaces of pole pieces 5 and 6 respectively. A control shaft 26 is provided having a set of right-hand screw threads and a set of left-hand screw threads, which threads cooperate with corresponding threads in plates 24 and 25 in such a manner that the plates may be moved closer together or farther apart, depending upon the

direction of rotation of the control shaft. Since the soft iron plates 24 and 25 act as a magnetic shunt path for the main field, a control of the magnetic field strength in the air gaps between the pole pieces 5 and 6 is thus obtained.

A soft iron ring 27 is mounted near the air gap, the provision of this ring having been found to increase the power output of the transmitter.

Since the oscillation amplitude of the transmitter is extremely sensitive to the distribution of flux lines in the air gap, modulation of the electronic oscillations may be obtained by superimposing a small magnetic field upon the main magnetic field, and by causing the small field to vary at modulating frequency. Such a small magnetic field is obtained by mounting a small coil 28 in the air gap between pole pieces 5 and 6 and by applying thereto an alternating current having the frequency with which it is desired to modulate the short wave oscillations. A source of such alternating current is conventionally indicated by a rectangle 29.

The electron discharge device 2 is illustrated in detail in Fig. 2 and includes an axial cathode 30, a long concentric anode 7 which is preferably cylindrical, a pair of end envelopes 31 and 32 and a cathode tensioning spring 33. Cathode 30 is supported between two conductors 8 and 34. Spring 33 is connected between conductor 34 and conductor 35 and maintains cathode 30 taut at all times. If spring 33 be not a satisfactory conductor of electricity, a jumper 36 may be employed as a current carrying means between conductors 34 and 35.

Anode 7 is built considerably longer than cathode 30 in order that substantially all of the electrons emitted from the cathode will eventually be collected on the anode 7. It should be noted that because the electron discharge device 2 is mounted with its opposite ends in axial apertures of the pole pieces and that since a portion of the anode 7 is also located within these axial apertures, the electrons in this region will pass rapidly to the anode for the reason that the magnetic field is greatly reduced within the apertures of the pole pieces. The combined effect of the long anode and the released magnetic field at the ends prevents electron puncture trouble at the ends of the discharge device.

Where a uniform straight magnetic field, such as may be obtained by widely separating the pole pieces 5 and 6, is used for magnetron operation, it has been proposed to rotate the magnetron from 5 to 10 degrees with respect to the direction of the magnetic field in order to increase the output. It has been found that this is not generally necessary where a slightly non-uniform magnetic field is provided. The special construction of pole pieces 5 and 6 having receding faces and provided with apertures for housing the ends of the electron discharge device produces the desired concentration of flux density in the air gap and gives it the desired slightly non-uniform character and in addition provides the desirable weak field within the axial apertures for electron release to the anode.

In the magnetron embodied in the transmitter systems to which the above mentioned Patent No. 2,145,735, was directed, the internal diameter of the hollow anode was approximately constant from end to end thereof. In accordance with the present invention, however, the anode is so formed that its diameter, or the cross-sectional area of the space therewithin if the anode is not circular in cross section, is least in the region of the cathode, the cathode 30 being preferably so spaced within the anode that this region is intermediate the ends of the anode. The anode is preferably of circular cross section throughout its length, being so formed that its internal diameter is relatively small in the cathode region, or the region intermediate the anode ends, and the internal diameter is relatively large in the regions at and toward the ends of the anode. The internal diameter of the anode if of circular cross section, or the cross sectional area of the space within the anode if of other than circular cross section, may be relatively small in the cathode region and may progressively increase to the ends of the anode.

In what we now believe to be the preferred form of our present invention, for simplicity and ease of construction a ring or sleeve member 38 is mounted within the main cylindrical body member 37 of anode 7 and in contact with the walls thereof. Member 38 is composed of conductive material having a relatively small axial opening 39 therethrough, and may be so formed that the opening 39 is of increasing diameter from the center thereof to the ends. The cathode 30 is thereby brought, over at least a portion of its length, relatively close to the internal walls of member 37, which is electrically a part of anode 7.

In operation of the transmitter herein described and incorporating the anode structure in accordance with the present invention, cathode 30 is heated to the required temperature by source 13 and anode 7 is raised to the proper high potential by source 20. The intensity of the magnetic field about discharge device 2 is then adjusted by the magnetic shunt 24—25 until a wave length is obtained at which the transmitter operates with good output. Tuning disk 12 is adjusted along conductor 19 until maximum power output is obtained.

As a result of the combined effect of the electrostatic and electromagnetic fields, electrons leave cathode 30 and follow spiral paths to anode 7. The transit time of an electron depends largely upon the strength of the magnetic field. Apparently, the electrons leaving cathode 30, migrate in groups at a frequency depending upon their transit time. In consequence a high frequency wave is produced on conductor 8 and is radiated from the exposed portion 11.

It will be particularly noted that in accordance with the present invention the interior walls of the anode 7 are brought much closer to at least a portion of the cathode than is the case in the anode structure disclosed in the above mentioned prior patent. The improved anode construction described herein effects a concentration of the electrostatic field in the region of the cathode, producing an acceleration of the electrons and a resulting increase in power. It has been found that by employing the electrostatic field concentrating means in accordance with the present invention, other conditions being the same as in the oscillator systems of the above mentioned application, as much as three times the power output is obtainable from these systems.

If a modulated wave be desired, either modulator 21 or modulator 29 may be placed into operation. Application of an alternating current having a frequency of the desired modulating signal to modulating coil 28 causes a variation of the flux distribution in the air gap between pole pieces 5 and 6 at the modulating frequency. This causes an amplitude modulation of the generated

oscillations. Variation of the magnitude of the high voltage applied to anode 7 at the modulating frequency also causes an amplitude modulation of the electronic oscillations since a variation of anode potential also varies the output of the discharge device. If desired, both modulators may be used together.

While we have shown a particular embodiment of our invention, it will be understood that we do not wish to be limited thereto since many modifications may be made both in the circuit arrangement and in the instrumentalities employed, and that we therefore contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of our invention.

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

1. A magnetron oscillator including a relatively long hollow anode having open ends, a relatively short linear cathode mounted within said anode, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, and a conductive member connected to said anode and surrounding a portion of said cathode.

2. A magnetron oscillator including a hollow anode having open ends, a linear cathode substantially shorter than said anode mounted therewithin centrally thereof, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, and a conductive member connected to said anode and extending therefrom closely adjacent to and surrounding the central portion of said cathode.

3. A magnetron oscillator including a hollow anode, a linear cathode mounted therewithin and extending only a relatively short distance longitudinally thereof, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, the cross sectional area of the space within said anode in the region of said cathode being substantially less than the cross-sectional area of the space within said anode beyond the extremities of said cathode.

4. A magnetron oscillator including a linear cathode, a cylindrical anode concentric therewith and extending a substantial distance beyond the ends thereof, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, and a relatively short cylindrical conductive member having a small axial opening therethrough mounted within said anode in contact with the walls thereof and surrounding said cathode.

5. A magnetron oscillator including a linear cathode, a cylindrical anode concentric therewith and extending a substantial distance beyond the ends thereof, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, the internal diameter of said anode being substantially less in the region of said cathode than in the other regions of said anode.

6. A magnetron oscillator including a linear cathode, a cylindrical anode concentric therewith and extending a substantial distance beyond the ends thereof, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, and a ring of conductive material within said anode connected to the walls thereof and surrounding a portion of said cathode centrally thereof.

7. A magnetron oscillator including a linear cathode, a cylindrical anode concentric therewith and extending a substantial distance beyond the ends thereof, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, and a conductive ring within said anode connected to the walls thereof and surrounding said cathode, the opening in said ring through which said cathode passes being of increasing diameter from the center of said ring to the ends thereof.

8. A magnetron oscillator including a cylindrical anode, a linear cathode extending a relatively short distance therewithin longitudinally and centrally thereof, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, and conductive means connected to and extending around the central portion of the inner wall of said anode, said conductive means having a narrow and relatively short central opening through which said cathode extends.

9. A magnetron oscillator including a long and narrow cylindrical anode, a linear cathode extending a relatively short distance therewithin longitudinally and centrally thereof, a magnet having opposed pole pieces to produce a magnetic field parallel with said cathode and within said anode, the cross-sectional area of the space within said anode in the region thereof centrally of said cathode being relatively small and said cross-sectional area becoming progressively larger in the spaces within said anode at both sides of said region centrally of said cathode.

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