Sept. 16, 1947. R. C. JENSEN ET AL 2,427,558

HIGH FREQUENCY OSCILLATOR

Filed June 24, 1942

Fig. 1.

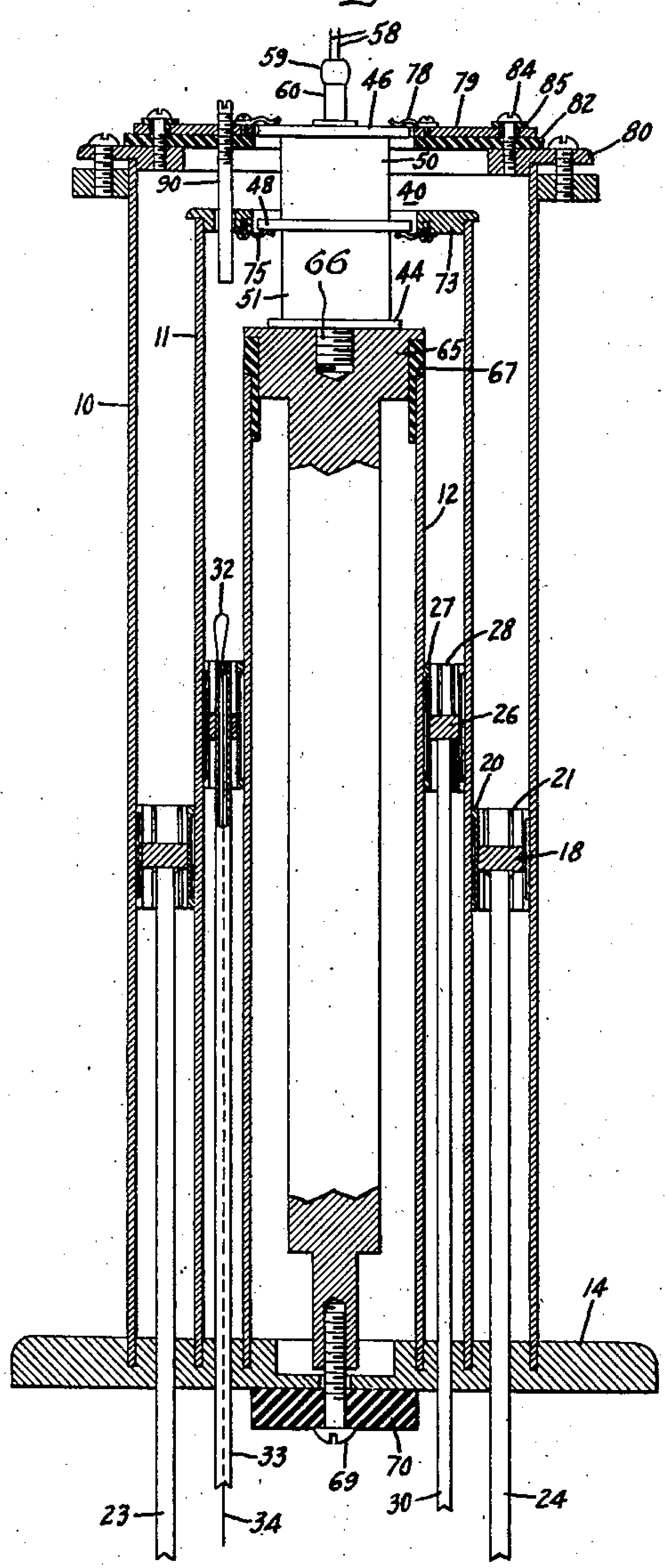


Fig. 2.

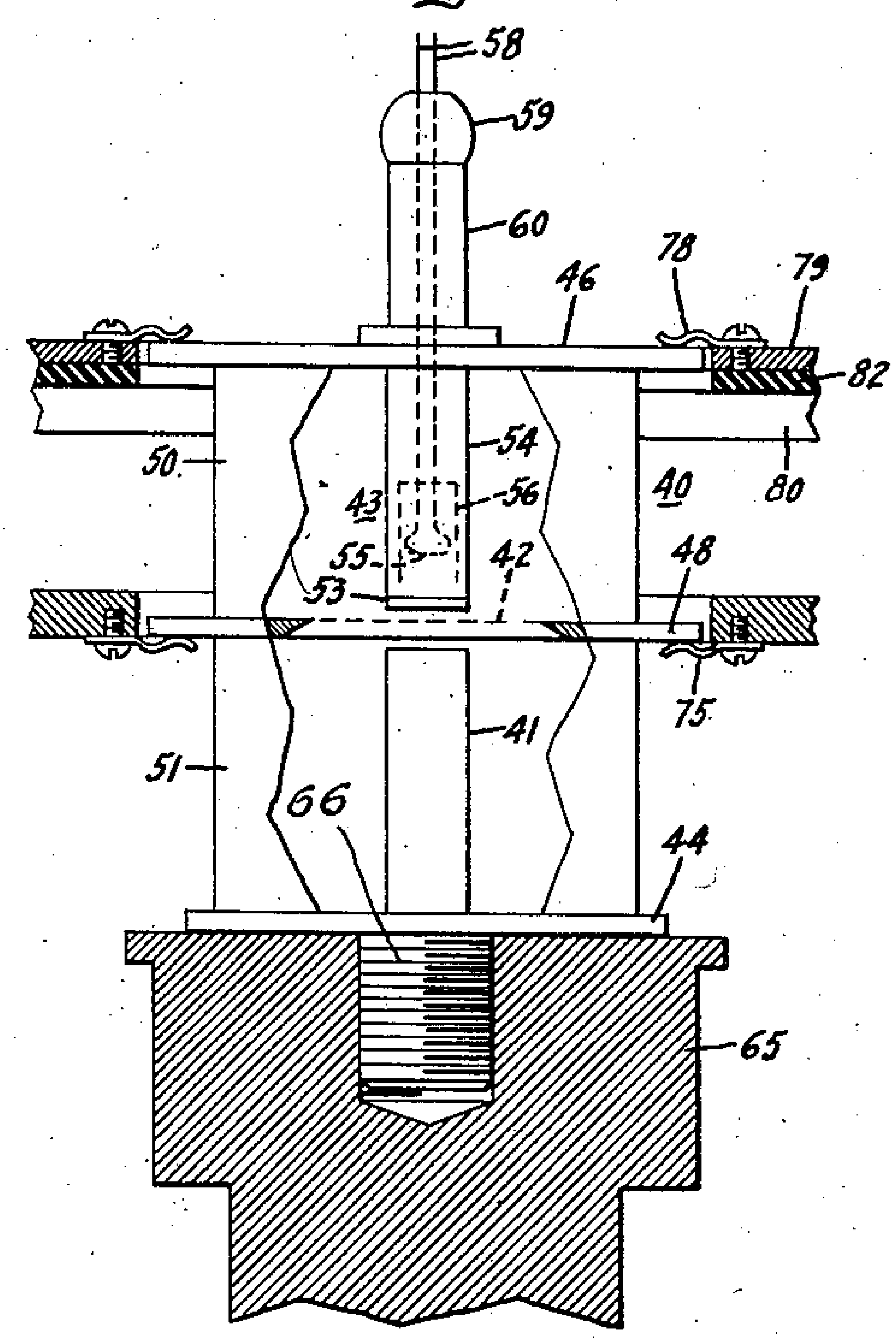


Fig. 3.

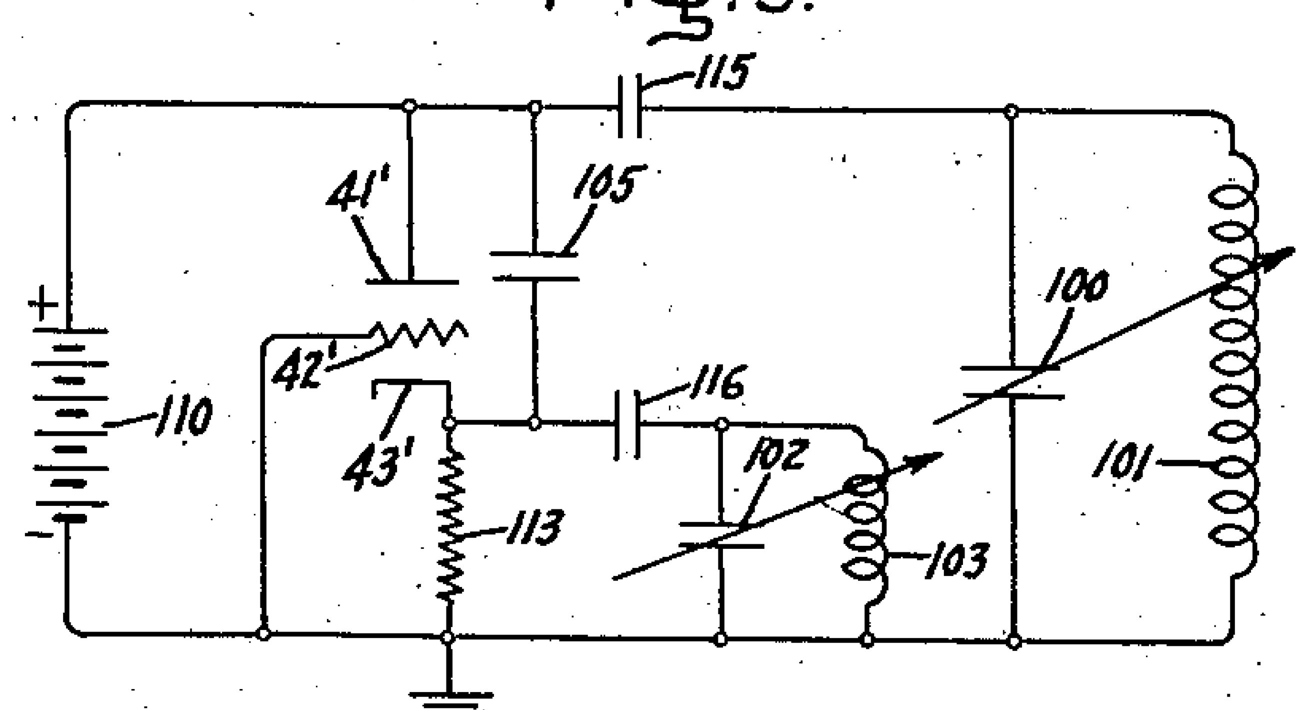
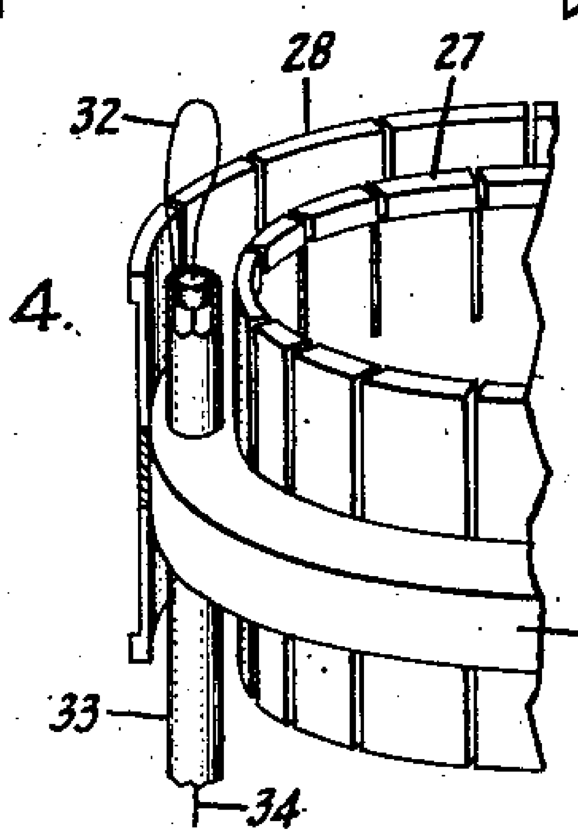


Fig. 4.



Inventors:
Richard C. Jensen,
James E. Keister,
by Harry E. Dunham
Their Attorney.

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UNITED STATES PATENT OFFICE

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HIGH-FREQUENCY OSCILLATOR

Richard C. Jensen and James E. Keister, Scotia, N. Y., assignors to General Electric Company, a corporation of New York

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5 Claims. (Cl. 315—5)

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The present invention relates to high frequency electronic apparatus and more specifically to an improved oscillator for use in a range of wavelengths between a few meters and a few centimeters.

At wavelengths within the band specified, conventional lumped circuit arrangements for generating oscillations become usable only with difficulty because of the fact that the conductors employed to link the various circuit elements provide an appreciable and uncontrollable part of the total circuit impedance. For this reason various arrangements employing transmission line sections and resonant cavities in place of conventional tuned circuits have been devised in an effort to circumvent the difficulties referred to. In most cases, however, the arrangements proposed are complicated and costly to construct and are not readily adjusted to a desired condition of operation.

It is an object of the present invention to provide an improved high frequency oscillator which is characterized by simplicity of organization and by ease of use.

In a typical embodiment the invention employs three telescoped and radially separated conductors which define concentric space-resonant cavities between them. These are used in combination with an electronic tube having its grid coupled to the intermediate conductor and its anode and cathode coupled respectively to the remaining conductors. Oscillations are sustained by feedback coupling between the two cavities in a manner which will be explained more fully at a later point.

The features desired to be protected herein are pointed out with particularity in the appended claims. The invention itself, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the drawing, in which Fig. 1 is a sectional view of an oscillator suitably embodying the invention; Fig. 2 is an enlarged view, partially broken away, of certain of the structure of Fig. 1; Fig. 3 is a circuit diagram useful in explaining the invention, and Fig. 4 is a fragmentary detail of a further part of the structure of Fig. 1.

Referring particularly to Fig. 1, there is shown an oscillator which comprises a series of three concentric and mutually telescoped conductors 10, 11 and 12, suitably consisting of brass or copper. At one end the conductors are secured to a common base 14 which may be either of metal or of insulating material. By virtue of their mutual

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spacing, the conductors provide, in effect, a pair of concentric transmission line sections each of which, by proper termination, can be made to function as a tank circuit having a particular resonant frequency. With this consideration in mind, the outer conductor pair is provided with a movable short-circuiting device in the form of an annular metal ring 18 which bears two sets of contact fingers 20 and 21 respectively arranged at its inner and outer peripheries. These contact fingers bear symmetrically upon the opposed surfaces of the conductors 10 and 11 so that these conductors are effectively directly connected through the ring 18. The position of the ring may be adjusted by means of externally accessible operating rods 23 and 24 which are associated with the ring so that tuning of the transmission line section in question is possible. A similar tuning device comprising a conductive ring 26 and contact fingers 27 and 28 is provided in connection with the conductors 11 and 12, and an adjusting rod 30 permits external adjustment of this device.

A coupling loop 32 (see Fig. 4) extends into the cavity formed between the conductors 11 and 12 and makes it possible to abstract high frequency energy from this cavity when it is in excited condition. The loop has a connection with a conductive tube 33 and a further connection with a wire 34 which is concentrically arranged within the tube 33, the elements 33 and 34 forming a coaxial transmission line. The tube 33 is secured to the ring 26 in such fashion as to be movable with it and is capable of being rotated to vary the linkage of the loop 32 with the magnetic field existing in the cavity between the conductors 11 and 12. This makes it possible to adjust the loop so as to obtain optimum coupling effect.

The extremities of the conductors 10, 11 and 12 which are remote from the base part 14 are axially offset so as to provide a stepwise arrangement which is regressive as one proceeds from the outer conductor 10 toward the inner conductor 12. This is for the purpose of facilitating the combination of the conductors with an electronic tube 40 which is illustrated in detail in Fig. 2, and which includes an anode 41, a grid 42 and a cathode 43 arranged in end-to-end relation in the order named. The anode, which is a solid metallic cylinder, is supported from a metal disk 44 which serves both as an end wall for the tube and as a terminal for the anode, and a like disk 46 is provided in connection with the cathode 43. A third disk 48 having a central aperture over which the grid 42 is affixed extends laterally from the central portion of the envelope and provides a grid terminal. The three disks 44, 46 and 48 are insulatingly separated by means of glass cylinders 50 and 51 which are sealed to the disks and which provide the lateral wall structure of the tube.

The cathode of the tube includes an emissive disk or cap 53 and a heating arrangement for the disk which is enclosed within a hollow tubular structure 54. The heating arrangement comprises a filamentary emitter 55 and a concentrating sleeve 56 for directing electrons emitted by the filament against the disk 53 from which the principal discharge of the tube is to be realized, the elements 55 and 56 being indicated in dotted outline. Lead-in conductors 58 associated with the filament 55 are sealed in insulatingly spaced relation through a glass bead 59 which is fused into the end of an outwardly projecting metal eyelet 60, the eyelet being affixed by welding or otherwise to the surface of the disk 46.

The tube 40 is preferably highly evacuated and by virtue of its construction is well adapted to serve as a generator of high frequency oscillations. In the present case, an oscillating circuit is set up by coupling the various electrode terminals of the tube to the respective conductors 10, 11 and 12 in the manner illustrated. The anode is coupled to the extremity of the conductor 12 through a cylindrical metal member 65 which abuts the anode terminal disk 44 and which is separated from the conductor 12 only by a thin layer 67 of dielectric material, such as mica or glass. By virtue of the capacity between the adjacent surfaces of the member 65 and the conductor 12, the anode is, in effect, directly connected to the conductor 12 as far as high frequency currents are concerned. It is, however, insulated from it with respect to unidirectional currents so that the member 65 may be employed as a terminal conductor for applying positive voltage to the anode. To this end a terminal screw 69 set in an insulating block 70 is provided at the extremity of the member 65.

The connection between the anode terminal 44 and the conductive member 65 is made by means of a threaded stud 66 which is secured to the outer surface of the terminal. With this arrangement the member 65 is enabled to serve not only as a D.-C. terminal connection for the anode but also as a means for dissipating the heat generated at the anode during operation.

The grid terminal 48 is directly conductively connected to the extremity of the intermediate conductor 11 through a metal ring 73 having a circular array of spring contact fingers 75 which bear upon the under surface of the terminal disk 48. With this arrangement the grid is grounded to the resonant structure.

A somewhat similar arrangement is provided in connection with the cathode terminal 46, which is engaged by spring contact fingers 78 mounted upon a metallic ring 79, this ring being secured to a further ring 80 which rests upon the upper extremity of the conductor 10. A direct contact between the rings 79 and 80 is prevented by the interposition of an insulating (e. g., mica) washer 82 which is thin enough to assure effective capacitive coupling between the two rings so that the cathode terminal is, in effect, connected directly to the conductor 10 as far as high frequency currents are concerned. The screws 84 by which the ring 79 is held in place are insulated from the ring by means of insulating eyelets 85 so that these screws do not constitute a short-circuiting connection. The arrangement is accordingly such that the cathode system as a whole can be given a desired D.-C. bias with respect to the other electrodes of the tube.

It will be noted that the anode terminal 44 is of smaller diameter than the grid terminal 48 so that the tube may be readily inserted in the oscillator assembly even with the grid contact ring 73 in place. The cathode contact ring 79 is not applied until after the tube is inserted in the assembly.

In the use of the apparatus, potential is applied between the cathode filament 55 (Fig. 2) and the main body of the cathode structure in such fashion as to cause bombardment and heating of the emissive cap 53 to occur. Thereafter positive potential is applied to the anode and an appropriate potential relationship is established between the cathode and grid by a suitable biasing arrangement (not shown). Under these circumstances and assuming proper tuning of the inner and outer transmission line sections (i. e., by proper adjustment of the shorting rings 18 and 26), high frequency oscillations may be developed.

The occurrence of such oscillations depends, of course, upon the assumption that proper resonance conditions are provided by the tuning of the transmission line sections and that suitable feedback exists between the anode and grid circuits. Under some conditions such feedback may occur solely as a result of the internal plate-to-cathode capacity of the tube. In most cases, however, it is desirable that this coupling be augmented in some way, and to this end there is provided in the present instance a coupling element 90 which extends between the inner and outer resonant cavities. This element comprises a conductive rod which has a screw-threaded engagement with the ring 79 and which extends through an opening provided in the ring 73. By appropriate rotation of this rod its degree of extension into the space between the conductors 11 and 12 can be adjusted to produce a desired feedback relationship, the plate-to-cathode capacity obviously being increased as the rod is moved in an inward direction.

The operation of the oscillator described in the foregoing may be further explained by reference to the schematic diagram provided in Fig. 3. In this figure the parallel combination of condenser 100 and inductance 101 may be assumed to represent the transmission line section provided between the conductors 11 and 12 in Fig. 1, whereas the combination of condenser 102 and inductance 103 represents the transmission line section between conductors 10 and 11. The condenser 105 represents the feedback capacity between the anode 41′ and the cathode 43′ (these elements corresponding to the similarly numbered elements of Fig. 2). This capacitance is provided partly by internal tube capacity and partly by the effect of the coupling element 90 (Fig. 1).

It will be understood that the desired tuning of the transmission line sections is accomplished by moving the adjustable rings 18 and 26 (Fig. 1) until each transmission line has an effective length close to that of a quarter wave (or, alternatively, an odd multiple of quarter waves) at the operating frequency. As previously indicated, some detuning from the exact quarter wave value will ordinarily prove necessary with respect to one or both lines in order to obtain desired phase relationships. The high frequency energy realized during operation of the oscillator may be coupled to an external circuit, such as an amplifier or a radiating antenna, by means of the coupling loop **32** and its associated conductors **34** and **35**.

The D.-C. provisions for the circuit of Fig. 3 include a potential source **110** which is indicated conventionally as a battery having its positive terminal connected to the anode **41'** and its negative terminal connected to ground and thus to the grid **42'**. Grid bias is obtained by a resistor **113** located in the grid-to-cathode circuit. By-pass condensers **115** and **116** which correspond respectively to the dielectric spacers **67** and **82** of Fig. 1 isolate the D.-C. system from the high frequency circuits. The absence of choke coils in the cathode and anode circuits is explained by the fact that all high frequency effects are confined to the space resonant cavities enclosed by the transmission line sections so that, except for leakage through the dielectric spacers **67** and **82**, no high frequency currents appear in the anode connection **65** or in the external cathode connections. In the event high frequency leakage through the spacer **67** proves troublesome it can be readily eliminated by the use of suitable filtering means such as a quarter-wave filter section (not shown) associated with the conductor **65**.

The arrangement shown in Fig. 1 is exemplary only, and it is entirely feasible and within the scope of the invention to reverse the orientation of the tube **40** so that its cathode terminal is coupled to the inner conductor **12** while its anode terminal is coupled to the outer conductor **10**, the grid terminal being still directly connected to the intermediate conductor **11**. Under these circumstances, a somewhat different tuning of the transmission line sections will be necessary and, of course, appropriate changes must be made in the D.-C. connections. With these alterations oscillations may be expected to occur on a basis explainable by a diagram such as that of Fig. 3.

It should be noted that the tube shown in Fig. 2 is of a type which is more fully described in U. S. Patent 2,284,405, granted to E. D. McArthur, May 26, 1942, and assigned to the General Electric Company, corporation of New York.

A further embodiment of which our invention has been found capable is described in A. M. Gurewitsch application, S. N. 452,946, filed July 30, 1942, this application being also assigned to the General Electric Company.

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

1. An oscillator comprising three concentric conductors in telescoped relation, a first transmission line section being provided by the combination of the inner conductor and the intermediate conductor and a second transmission line section being provided by the combination of the intermediate conductor and the outer conductor, a rotationally symmetrical electronic tube having its structure mounted substantially wholly within the confines of said outer conductor and having its axis of symmetry colinear with the common axis of said conductors, said tube including a planar anode, a planar grid and a planar cathode mounted in the order named, terminal means for said anode, grid, and cathode spaced axially of said tube and connecting respectively said grid with said intermediate conductor, said anode with one of the other of said conductors and said cathode with the remaining one of said conductors, and a coupling between said transmission line sections for maintaining oscillations therein.

2. An oscillator comprising three telescoped conductors providing between them a pair of concentric cavity resonators, the telescoped extremities of the conductors being axially offset providing a stepwise arrangement regressive from the outer conductor toward the inner conductor, an electronic tube having anode and cathode terminals located at the respective ends of the tube and a grid terminal projecting from an intermediate portion of the tube, said tube interfitting with said stepwise conductor arrangement with one of its said end terminals lying close to the extremity of the inner conductor and its grid terminal lying close to the extremity of the intermediate conductor, means providing high frequency connections between the various terminals and the various conductors, and feedback coupling between the two cavity resonators.

3. An oscillator comprising three telescoped conductors providing between them a pair of concentric cavity resonators, the telescoped extremities of the conductors being axially offset providing a stepwise arrangement which is regressive from the outer conductor toward the inner conductor, and an electronic tube having a cathode, a grid and an anode mounted in end-to-end relation in the order named, said tube interfitting with said stepwise conductor arrangement with its anode terminal coupled with the inner conductor, its grid terminal with the intermediate conductor and its cathode terminal with the outer conductor, and a mutual coupling between said cavity resonators for sustaining operation of said tube as an oscillator.

4. An oscillator comprising three telescoped conductors defining between them a pair of concentric transmission line sections, movable means interposed between the various conductors for determining the effective length of the said transmission line sections, means projecting from one end of the said conductors for adjusting the said movable means and for thus tuning the transmission line sections, and a grid-controlled electronic tube extending within the other end of said conductors, said tube having its grid coupled to the intermediate conductor and its anode and cathode respectively coupled to the inner and outer conductors whereby oscillations may be developed upon proper tuning and feedback adjustment of said transmission line sections.

5. An ultra high frequency device comprising three telescoped conductors defining between them a pair of concentric transmission line sections, movable means interposed between one pair of said conductors for determining the effective dimensions of the transmission line section between such conductors, means at one end of said conductors for adjusting the said movable means and thus tuning the said transmission line section, said telescoped conductors terminating at the other end at different axially displaced points to provide a stepwise arrangement progressing from the inner to the outer conductor, and a grid-controlled electronic tube extending within the other end of said conductors, said tube having terminals connected respectively with said anode, said grid, and said cathode and supported in axially spaced relation with the intermediate one of said terminals coupled to the intermediate conductor and the terminals connected with its anode and cathode respectively coupled to the other conductors, whereby oscillations may be developed upon proper relative tuning of said trans-

mission line sections by adjustment of said movable means.

RICHARD C. JENSEN.
JAMES E. KEISTER.

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