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HIGH FREQUENCY RADIO APPARATUS

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FIG 1

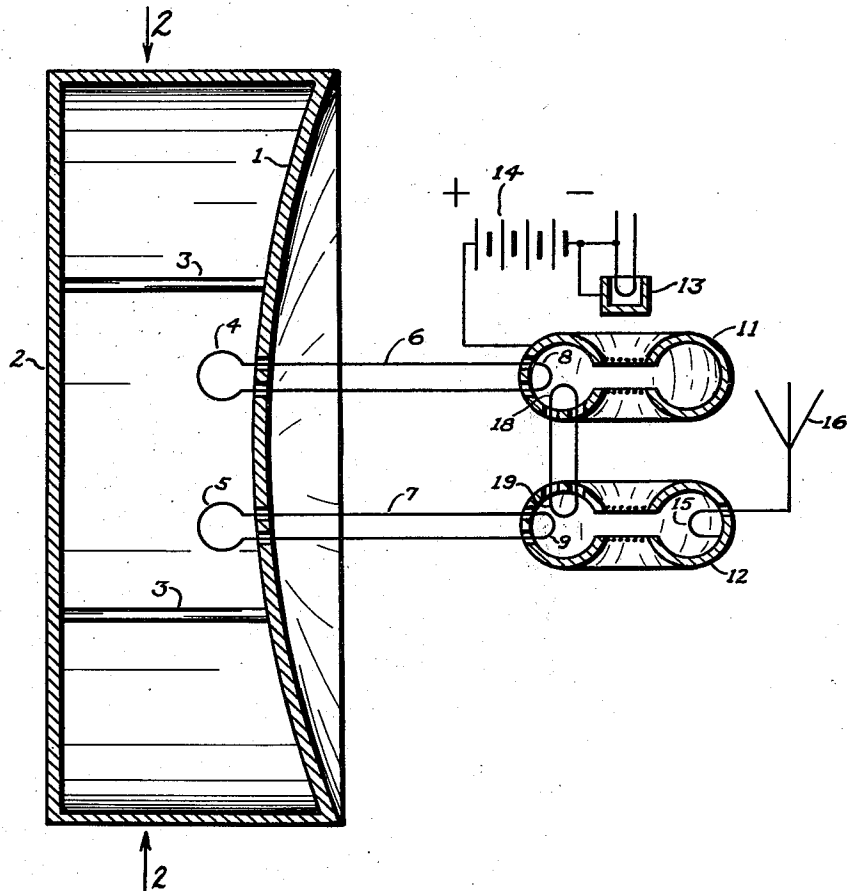
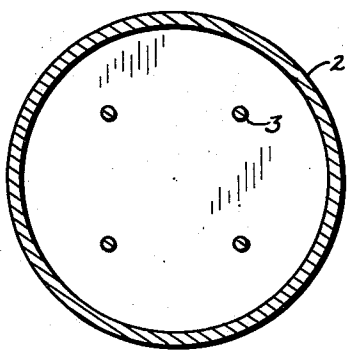


FIG 2



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HIGH FREQUENCY RADIO APPARATUS

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Application June 21, 1938, Serial No. 214,895

5 Claims. (CL 250—11)

This invention relates, generally, to the transmission of high frequency radio signals and the invention has reference, particularly, to the directional transmission of such signals by the aid of reflecting surfaces and the invention has reference also to the stabilization of high frequency radio oscillators. This invention is related to copending applications Serial No. 92,787, W. W. Hansen, High efficiency resonant circuit, filed July 27, 1936, Patent No. 2,190,712, granted February 20, 1940; Serial No. 168,355, R. H. Varian, Electrical converter, filed Oct. 11, 1937, now Patent No. 2,242,275, granted May 20, 1941; Serial No. 185,382, R. H. Varian and W. W. Hansen, Radio measurement of distances and velocities, filed Jan. 17, 1938; and Serial No. 201,898, R. H. Varian and W. W. Hansen, Radio transmission and reception, filed April 14, 1938.

In the patents and copending applications cited there are disclosed a number of embodiments of related inventions which have come to be known by names "rhumbatron," "klystron," "buncher," and "catcher." These names are used in the present specification and may be defined as follows: "Rhumbatron": A resonant circuit characterized by an electromagnetic field bounded by a substantially closed conducting surface, energy being transferred to or from the electromagnetic field by inductive loops or capacitive elements in the field or by a beam of electrons projected through the field. "Klystron": An electrical converter composed of two or more "rhumbatrons" excited and coupled by a beam of electrons projected through the fields contained in the "rhumbatrons." "Buncher": In a "klystron" the "rhumbatron" nearest the emitter of the electron beam, in which the electrons are alternately accelerated and decelerated at the frequency of oscillation of the "klystron." "Catcher": In a "klystron" the "rhumbatron" farthest from the emitter of the electron beam, in which energy of the "bunched" electron beam is converted into electromagnetic field energy. "Reflex klystron": An oscillator operating on the "klystron" principle but with only one "rhumbatron" which acts as both "buncher" and "catcher," an electron beam being projected through the "rhumbatron" in one direction and reflected back into the "rhumbatron" by an additional electric field between two grids outside the "rhumbatron."

The principal object of the present invention is to produce a novel arrangement of high frequency oscillators, reflectors, and resonant circuits which provide for directed transmission of

signals, stabilization of frequency and combination of parts for effective operation and economy.

Another object of this invention is to produce a convenient combination of reflecting surfaces and conducting walls of resonant circuits of the kind described.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawing wherein the invention is embodied in concrete form, and in which

Fig. 1 is a schematic diagram of an embodiment of this invention, and

Fig. 2 is a sectional view taken along line 2—2 of Fig. 1.

In the copending application Serial No. 185,382 arrangements of high frequency transmitters and receivers with parabolic reflectors are shown for various purposes. The principle of using parabolic reflectors for radio transmission has long been known in the art, but in Serial No. 185,382 novel arrangements of transmitters and receivers with reflectors are shown with particular reference to the special apparatus disclosed therein.

In copending application Serial No. 201,898, there are shown novel combinations of resonant circuits and high frequency oscillators which are specially adapted to uses in which great stability of oscillation is desired. The form of oscillator particularly concerned is that referred to as the "klystron." The stability of operation of oscillators of the "klystron" type is dependent to a considerable degree on the resistance-reactance characteristics of the resonant circuits used in the oscillators. In general the frequency stability is improved by increasing the ratio of reactance to resistance of the resonant circuit. The "klystron" makes use in most of the embodiments thereof of resonant circuits of the type referred to as "rhumbatrons."

In Patent 2,190,712, the theory of the type of resonant circuit known as the "rhumbatron" is disclosed. As a consequence of the "rhumbatron" theory it is known that a "rhumbatron" is capable of operation at frequencies which are harmonics of the fundamental frequency, although in general the harmonics are not Fourier harmonics, and it is known also that the ratio of reactance to resistance increases with increase of ordinal number of the harmonic. That is, the ratio of reactance to resistance is greater for the "rhumbatron" oscillating at a harmonic frequency than for the same "rhumbatron" oscillating at its fundamental frequency.

In Patent 2,190,712, the relationship of "rhumbatron" dimensions to "rhumbatron" frequencies is given. As an approximation for purposes of explanation it may be said that the diameter of "rhumbatrons" of generally cylindrical form is of the order of one-half of a wave length. The value of the ratio of reactance to resistance for a resonator operating at a given wave length is approximately proportional to the linear dimensions of the resonator in which resonance is set up. Hence, if a large resonator is excited on one of its high harmonics, the ratio of reactance to resistance is much higher than is the case if a small resonator is excited on its fundamental frequency and consequently frequency stability is increased.

The reflectors used in the transmission and reception of high frequency radio signals are made conveniently with diameters of about two or three meters. These reflectors are usually in the form of a shallow parabola having a conducting metallic surface. A copper sheet is usually the preferred material although a copper screen may be used under some conditions.

In Patent 2,242,275 it is explained that in the operation of a "klystron" energy is transferred from the "catcher rhumbatron" to the "buncher rhumbatron" through interconnected coupling loops in the two "rhumbatron" resonant circuit fields concerned. It is further explained in Serial No. 201,898 that if the transfer of energy from the "catcher" to the "buncher" takes place through a circuit of very high selectivity the frequency of the oscillation will be relatively insensitive to disturbing influences such as changes in supply voltage and current. An arrangement for attaining this condition is shown in Serial No. 201,898. In that arrangement energy from the "catcher rhumbatron" is coupled into a second "rhumbatron" operated at one of its harmonic frequencies, and energy is transferred from the second "rhumbatron" to the "buncher rhumbatron." This arrangement is used also in the present invention.

Referring to the present drawing, a cylindrical metallic box 2 is combined with a parabolic metallic reflector in the front wall thereof. The walls of the box 2 and the reflector 1 are connected into a unitary structure that is adapted to form an electrically closed resonant circuit of the "rhumbatron" type. In such a circuit, as explained in Patent 2,190,712, contained electromagnetic fields with the electric and magnetic vectors of the field located in various ways in the circuit are possible. For example, the electric forces can exist between the front and back surfaces of the "rhumbatron" 2 and the magnetic force lines can be in circular paths concentric with the structure. The distribution of the electric and magnetic fields will be different for each of the harmonic frequencies. When operating the "rhumbatron" at any desired frequency, regions in the "rhumbatron" exist where there are electric field nodes at which places the front and back of the "rhumbatron" can be electrically connected without any disadvantage and with the advantage of preventing the existence of fields pertaining to frequencies requiring electric fields between the points connected and hence suitable stiffening means or braces may be provided at these nodes for giving mechanical rigidity to the structure. Such connections or braces 3 are shown in the drawing in illustrative locations.

In the field of resonant circuit member 2 there are two coupling loops 4 and 5 shown placed on

opposite sides of the center thereof so as to suitably link the magnetic flux component of the electromagnetic field therein. Loops 4 and 5 are connected by transmission lines 6 and 7 to coupling loops 8 and 9, respectively, in the "buncher rhumbatron" 11 and the "catcher rhumbatron" 12. An electron emitter 13 cooperates with a battery 14 in projecting a stream of electrons through the grids of resonant circuit members 11 and 12 as in the usual "klystron" arrangements, thereby setting up electromagnetic oscillations in said circuit members. A coupling loop 15 connected with an antenna 16 is shown in "rhumbatron" 12 for radio transmission. Loop 15 could be, as explained in Serial No. 185,382, placed in "rhumbatron" 11 for reception. Additional optional interconnected coupling loops 18 and 19 are provided in "rhumbatron" 11 and 12 respectively to provide feed back from 12 to 11. The mechanical arrangement is ordinarily such that the antenna 16 is at the focus of reflector 1. "Rhumbatrons" 11 and 12 and the several coupling loops may be adjusted as to position, i. e., these "rhumbatrons" may be placed to one side of "rhumbatron" 2, if desired. In the drawing the usual arrangements for maintaining the electron emitter and other parts in a vacuum by use of a suitable enclosing evacuated envelope are omitted for convenience but they will be readily understood by reference to Patents Nos. 2,190,712 and 2,242,275 and application 201,898. In any case "rhumbatron" 2 would not ordinarily be evacuated, although "rhumbatrons" 11 and 12 may or may not be depending upon the mechanical arrangement.

In the operation of the system, the "klystron" comprising "rhumbatrons" 11 and 12 operates in general as described in Patent 2,242,275. In that patent, the action of coupling loops 18 and 19 is described, i. e., by feed back action from member 12 to 11 and in Serial No. 201,898 the action of coupling loops 4, 5, 8 and 9 is described i. e., 5, 7, and 9 feed energy from 12 to 2, setting up electromagnetic oscillations in 2, which operates at a harmonic. 4, 6, and 8 couple the field of 2 to that of member 11, thereby acting to stabilize the frequency of the system. Two modes of operation of the system for stability of frequency are possible. In one mode, the energy transferred from "catcher" to "buncher" may be transferred through loop 9, line 7, loop 5, "rhumbatron" 2, loop 4, line 6, and loop 8 in succession. This interposes a path of high ratio of reactance to resistance between the "catcher" and "buncher". In the other mode of operation, energy may be transferred from "rhumbatron" 12 to "rhumbatron" 11 through loops 19 and 18, and "rhumbatron" 2 may be connected only to "rhumbatron" 11 by coupling loops 4 and 8. This arrangement has the effect of increasing the ratio of reactance to resistance and thus the selectivity of "rhumbatron" 11. Either mode of operation tends to hold the frequency of the system within narrower limits than obtain without other arrangements of exceptional frequency stability.

The construction of reflector 1 and box or member 2 comprising the selective "rhumbatron" should be rigid to avoid fluctuations in natural frequency during operation. Connections or braces 3 assist in maintaining this rigidity. It would not always be necessary for satisfactory frequency stability to use a harmonic frequency "rhumbatron" of as large dimensions as might be desired for reflectors but the economy of material and the mechanical advantages derived

from the combination of the reflector with the circuit as shown are such as to make it frequently desirable to use a large "rhumbatron" operated on a high harmonic. This gives the advantage of high selectivity at little additional expense of material. The precise shape of the box or member 2 is subject to design. It may be flat as shown or it may be curved. The exact shape is determined in part by the frequency at which it is to be operated. The locations of loops 4 and 5 relative to the box or member 2 and the reflector 1 are drawn in illustrative locations. Their exact locations must be determined by the delineation of the electromagnetic field in "rhumbatron" 2. For example, loops 4 and 5 might be at opposite ends of a diameter at the periphery of member 2. The lines 6 and 7 are preferably of the concentric form, which form is well known in the art, so as to be non-radiating.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A high frequency oscillating circuit comprising an electrically closed conducting member providing a chamber arranged to contain high frequency electromagnetic oscillations, said member having said chamber provided with a bounding external wall providing an exterior surface of substantially continuous concave curvature for serving as a directional reflector of electromagnetic radiation tabilized as to frequency by the oscillations of said member.

2. The combination of a high frequency resonant circuit and a concave reflector for radio transmission and reception, an oscillator, said resonant circuit consisting of an electrically closed hollow container formed of conducting ma-

terial arranged to act as the boundary of an oscillating electromagnetic field resonant therein and maintained by said oscillator, the oscillating electromagnetic field within said container serving to stabilize said oscillator; said reflector being formed and combined with said resonant circuit in such a way as to serve on one side as reflector into space of electromagnetic waves produced by said oscillator and on the other side as part of the boundary of said electromagnetic field.

3. A high frequency resonant circuit consisting of an electrically closed container formed of conducting material adapted to act as the boundary of an oscillating electromagnetic field contained therein, and braces inside said container connecting opposite sides thereof and extending through regions where electric field nodes obtain, said braces adding to the mechanical rigidity of the structure and adding stability to the resonant frequency of said circuit.

4. In a high frequency resonant circuit, an electrically closed container formed of conducting material arranged to act as the boundary of an oscillating electromagnetic field contained therein, and conducting braces inside said container connecting opposite sides thereof, said braces being at places in said circuit where currents will not be induced in said braces at the desired frequency of operation, said braces increasing the mechanical rigidity of the structure and the frequency stability of the said circuit.

5. In a radio frequency oscillator, means for generating high frequency radio waves and a hollow member having a bounding external wall providing an external uniformly concaved reflecting surface for directively reflecting said waves into space, said member being arranged to contain a standing oscillating electromagnetic field electrically coupled to said generating means for stabilizing the frequency of the radio waves emitted therefrom.

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