Nov. 11, 1930. L. W. CHUBB 1,781,268

RADIO SYSTEM

Filed June 16, 1926

Fig. 1.

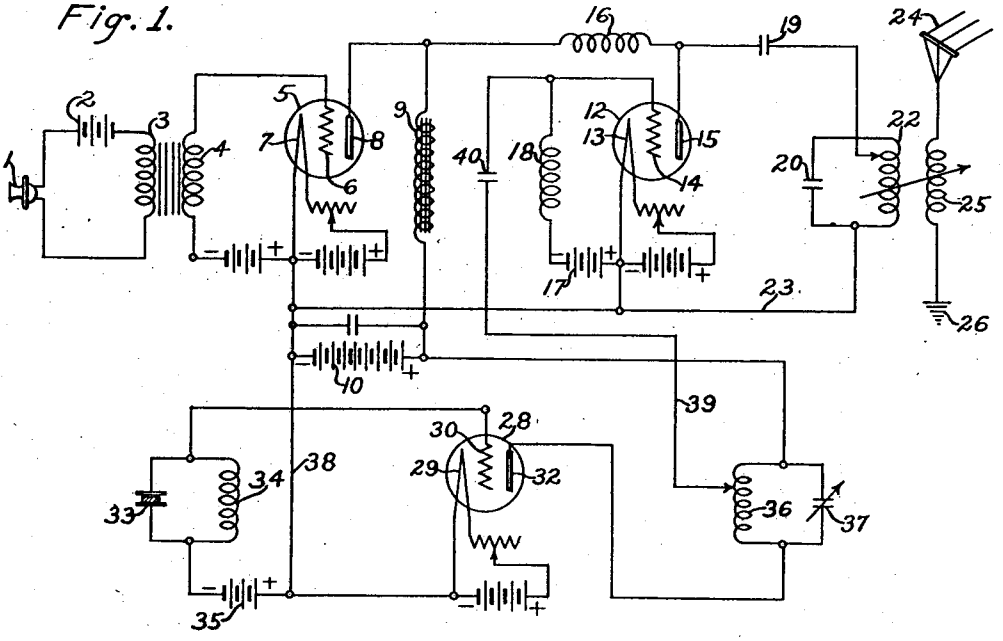
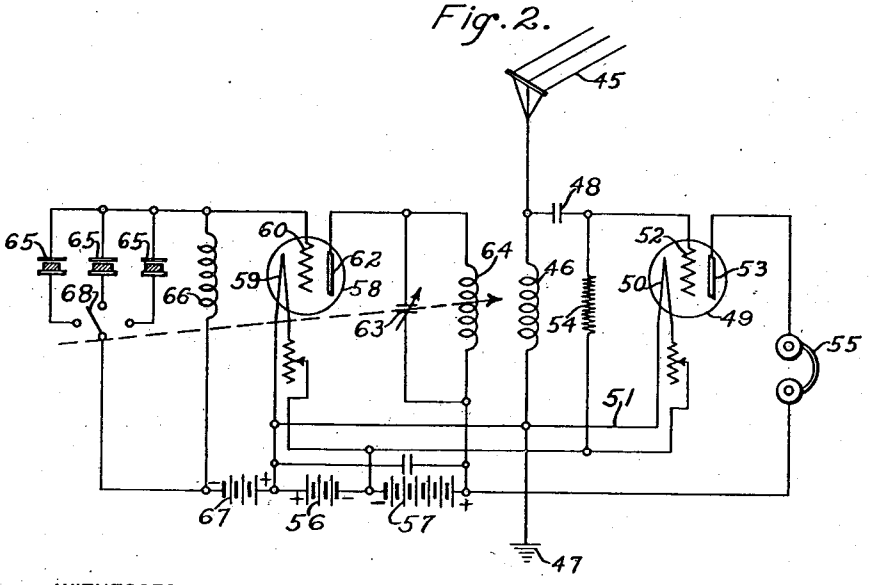


Fig. 2.



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UNITED STATES PATENT OFFICE

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RADIO SYSTEM

Application filed June 16, 1926. Serial No. 116,281.

My invention relates to radio receiving systems, and it has particular relation to such systems in which regeneration is used to increase selectivity and sensitivity.

One object of my invention is to provide a system in which regeneration may be employed without danger of radiating energy to interfere with neighboring reception.

Another object of my invention is to provide a system which may be operated with the detector tube constantly in an oscillating state.

Another object of my invention is to provide a system which makes use of a piezo-electric-crystal control to keep a receiving circuit in accurate tune with a transmitting station.

Another object of my invention is to provide a system which operates on the zero-beat principle, but which will not cause radiation of a frequency which will beat with the incoming wave.

A still further object of my invention is to provide a receiving system having a fixed tuning for each station it is desired to receive.

It is well known in the radio art that, in order to obtain the best results with a regenerative detector, the zero-beat method of detection should be employed. This method involves the use of a thermionic tube in a state of oscillation, the frequency of the oscillation being the same as that of the incoming carrier wave. Such a method, however, has the serious drawback of radiating a frequency that will heterodyne the incoming radio frequency whenever the local oscillation frequency and the incoming frequency differ slightly. This heterodyne effect, when detected, gives a beat frequency that is extremely annoying to persons operating other receiving sets nearby.

In order to prevent an oscillating receiver from heterodyning the incoming wave, my present invention contemplates the use of means for positively determining the frequency at which the receiver can oscillate. I provide also a plurality of such control means, each of which is adapted to influence the receiving circuit for a particular transmitting station, thus reducing the operation of tuning to a mere shifting from one control means to another.

For a more complete understanding of my invention, reference is now made to the drawing forming a part of this application, and to the following description.

Fig. 1 is a diagrammatic view of a transmitting circuit to be used in connection with my invention; and

Fig. 2 is a diagrammatic view of a preferred form of my receiving circuit.

In Fig. 1, which illustrates a constant-current modulated crystal-controlled type of transmitting circuit, a microphone 1 is connected in series with a source of potential 2 and the primary 3 of an audio-frequency transformer having a secondary 4. A thermionic tube modulator 5, provided with a grid 6, a filament 7 and a plate 8, is so arranged that its grid-filament circuit comprises the transformer secondary 4.

Plate potential for the modulator tube 5 is supplied through an audio-frequency choke 9 from a source of potential 10. An amplifier tube 12, having a filament 13, a grid 14 and a plate 15 also has its plate potential supplied from the source 10 through the choke 9 and a radio-frequency choke 16. The grid 14 of the amplifier tube 12 is maintained at the proper operating potential by means of the C battery 17, conductively connected to the grid through a radio-frequency choke 18.

The plate of the amplifier tube 12 is coupled, through a condenser 19, to an output circuit comprising a condenser 20 and an inductor 22. The filament of the amplifier tube is conductively connected to the output circuit by means of a conductor 23. The output circuit referred to is coupled to a radiating system comprising an antennæ 24, an inductor 25 and a ground connection 26.

In order that the amplifier tube 12 shall supply a constant frequency to the output circuit 20, 22, I have shown coupled to the input circuit of the tube, an oscillation generator controlled by a piezo-electric crystal. In the generator, a thermionic tube 28, having a filament 29, a grid 30 and a plate 32, has a piezo-

electric crystal 33 connected across its grid-filament leads and shunted by a choke coil 34, this crystal-coil combination being in series with a C battery 35. Plate potential for the thermionic tube 28 is supplied by the source 10 through a tuned circuit comprising an inductor 36 and a condenser 37. The filament circuits of tubes 5, 12 and 28 are conductively connected together by means of lead 38. The output circuit 36—37 is coupled to the grid circuit of the amplifier tube 12 by a lead 39, having a stopping condenser 40 in series therewith.

In the operation of a transmitting circuit of this general type, the input circuit of the amplifier section 12 is supplied with an alternating potential of constant frequency by means of the crystal-controlled oscillation generator. This oscillation frequency is amplified by the tube 12 and appears in the output circuit 20, 22 which is coupled to the radiator.

When the microphone 1 is spoken into, voice-frequency potentials are impressed upon the grid circuit of the modulator tube 5, causing its impedance to vary at an audio frequency. In view of the fact that the modulator tube 5 is supplied with plate current from the same source which supplies the amplifier tube, it is apparent that variations in the impedance of the modulator plate-filament path will cause corresponding variations in the current supplied to the amplifier tube 12. The radio-frequency choke 16 prevents oscillations at radio frequency from being by-passed through the tube 5 and compels them to take a path comprising the output circuit 20—22. This type of circuit is now generally known as the constant-current-modulation type, and the single tubes diagrammatically shown are usually replaced by a plurality of water-cooled high-power tubes in the actual operating set.

Referring to Fig. 2, a receiving antenna 45 is connected through an inductor 46 to a ground 47. Coupled to the antenna-ground circuit, through a condenser 48 and a conductor 51, is a thermionic detector tube 49 having a filament 50, a grid 52 and a plate 53. The input circuit of tube 49, comprising inductor 46, is not tuned to any definite frequency. In order to prevent the accumulation of excessive negative charges on the grid 52, a grid leak 54 is connected across between the grid and filament. In the output circuit of the tube 49, may be connected a pair of telephones 55 or the primary of an audio-frequency transformer feeding a multi-stage amplifier. Filament potential for the tube 49 is furnished by an "A" battery 56, while plate potential is furnished by a "B" battery 57.

An oscillator tube 58, having a filament 59, a grid 60 and a plate 62, is provided and between the plate 62 and the filament 59 is inserted an oscillating circuit comprising a condenser 63 and an inductor 64. The plate potential for the oscillator tube 58 is also supplied by the source 57 connected across between the plate 62 and the filament 59. Connected between the grid 60 and the filament 59 are a plurality of piezo-electric crystals 65, each of which may be shunted by a choke coil 66. The grid potential of the tube 58 is determined by the "C" battery 67. A switching device 68 permits the insertion of the desired crystal in the circuit.

The switching device 68, may, if desired, be inter-connected with an arrangement (not shown) for varying the antenna tuning in a step-by-step manner, the arrangement being such that, when any crystal is in circuit, the antenna will be approximately tuned to the same frequency as that determined by the crystal. An arrangement of this type, while increasing somewhat the selectivity of the system, will, at the same time, give greater signal strength.

The portion of the receiving system comprising the tube 58, the piezo-electric crystals and the tuned output circuit 63—64, constitutes an oscillation generator, the frequency of which is positively and definitely determined by the physical characteristics of the piezo-electric crystal selected by the switch 68. As is now well known in the art, the tuning of the output circuit of such crystal-controlled oscillator has but little effect upon the frequency of the oscillations generated, such frequency being solely determined by the crystal.

When it is desired to receive signals from a certain station, the oscillation generator and the detector portion, comprising the thermionic tube 49, are energized. By properly choosing the crystal in the circuit, the oscillation generator may be made to generate a frequency which is the same as that of the incoming carrier wave. When operated in this manner, known to those skilled in the art as the zero-beat method, the receiver will be extremely sensitive and will also be quite selective.

The zero-beat method of reception has a further distinct advantage in that detection follows a linear law rather than a square law. The output of the detector is directly proportional to the impressed signal potentials and is not proportional to the square thereof. As a result, the relative volume of loud and soft passages in music and the inflection of a speaker's voice are reproduced more nearly as they would be heard by a listener located at the position of the transmitting microphone.

Although a system constructed according to my invention may be operated at all times in the oscillating state, there will be no radiations of an annoying beat frequency caused by the interaction of the locally generated oscillations and the incoming carrier wave.

If the transmitting station is also crystal-controlled, as illustrated in Fig. 1, my invention provides for extreme selectivity.

It is also within the spirit of my invention to use what is commonly termed a single-circuit receiver, in which case, the reception frequency is controlled by piezo-electric means. I also contemplate the use of a regenerative system, such as that shown in the patent to Langmuir, No. 1,313,093, modifying the patented arrangement by shunting a plurality of crystals and crystal-selecting across the grid circuit thereof.

It is further entirely feasible to provide a blocking tube between the antenna and the piezo-electric crystal-controlled oscillating detector of my invention. When such a tube is employed, the likelihood of a beat frequency being radiated is of course greatly minimized. Also all disturbing radiation of the same frequency as the radio transmission will be eliminated, for this would be disturbing when coming from many receivers at different points.

A system constructed according to my invention is capable of being effectively tuned merely by the adjustment of an element analogous to switch 68. In other words, it is possible to construct a receiving station having therein any number of accurately tuned crystals to correspond to the main broadcasting stations to which it is desired to listen.

A system constructed according to my invention will not radiate an annoying beat frequency and, even though the incoming carrier frequency deviates somewhat from the locally generated oscillation frequency, such deviation will be, in general, extremely slight and unimportant. If the incoming signal is extremely strong, it is very likely that the frequency of the local oscillation generator will be shifted slightly and pulled into step therewith.

While I have shown my invention in a preferred form, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or are specifically set forth in the appended claims

I claim as my invention:

1. In combination, an untuned detecting circuit, and means whereby the effect of variable tuning is obtained by positively controlled regeneration.

2. In combination, an untuned detecting circuit, an oscillation generator coupled thereto, and means for positively and definitely controlling the frequency of oscillation, whereby the detecting circuit is rendered extremely sensitive and the effect of tuning is secured.

3. In combination, a detecting circuit, means for impressing potentials thereon representative of signals, and means for obtaining the effects of tuning without altering the constants of said detecting circuit.

4. In combination, a detecting circuit having fixed constants, means for impressing potentials thereon representative of signals selective means for impressing thereon a predetermined local frequency, and means whereby said local frequency is prevented from changing, whereby the effect of tuning is secured without altering the constants of the detecting circuit.

5. In combination, a detecting circuit having aperiodic characteristics, means for impressing thereon potentials representing signals, means for impressing thereon a locally generated oscillation, and piezo-electric means for positively and definitely fixing the frequency of the locally generated oscillations.

6. In combination, a source of radiant energy having a definite frequency, a receiving system adapted to operate by the zero-beat method of reception and embodying a detecting circuit having aperiodic characteristics, and means whereby the oscillation frequency of the receiving system may be definitely and positively predetermined so as to coincide with that of the radiant energy source.

7. In combination, a piezo-electric crystal controlled source of radiant energy having a definite frequency, a receiving system adapted to operate according to the zero-beat method of reception and embodying a detecting circuit having aperiodic charactistics, and means, including a piezo-electric crystal, whereby the oscillation frequency of the receiving system may be definitely and positively predetermined so as to coincide with that of the radiant energy source.

In testimony whereof, I have hereunto subscribed my name this 25th day of May, 1926.

LEWIS W. CHUBB.