Oct. 27, 1925. 1,559,116

W. A. MARRISON

WAVE GENERATING AND MODULATING SYSTEM

Filed Oct. 16, 1924

Fig. 1

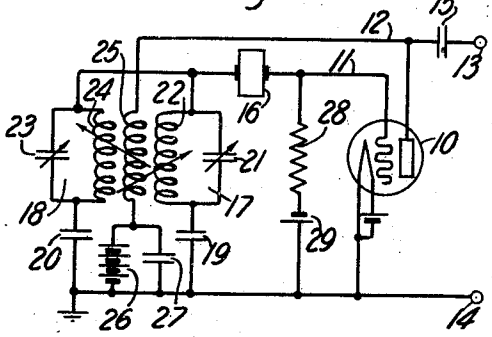


Fig. 2

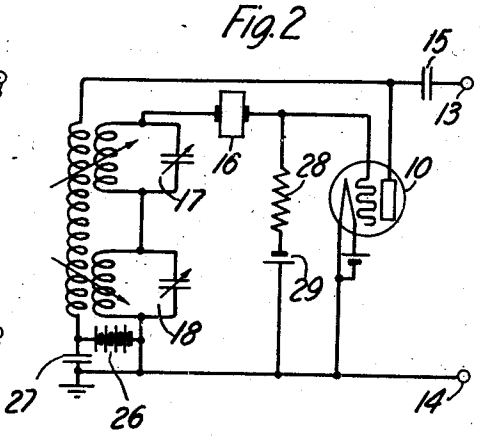


Fig. 3

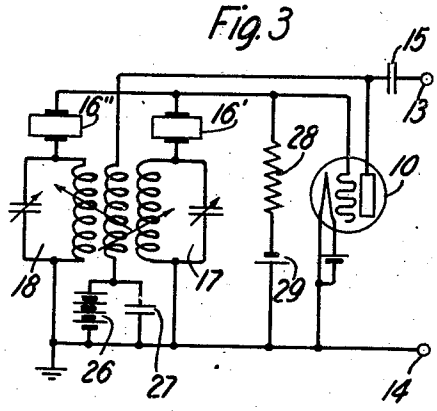
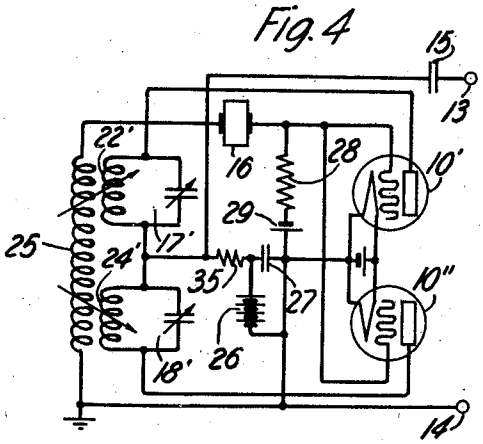


Fig. 4



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UNITED STATES PATENT OFFICE.

WARREN ALVIN MARRISON, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

WAVE GENERATING AND MODULATING SYSTEM.

Application filed October 16, 1924. Serial No. 743,915.

To all whom it may concern:

Be it known that I, WARREN A. MARRISON, a subject of the King of Great Britain, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Wave Generating and Modulating Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to wave generating and modulating systems and more particularly to constant frequency systems.

It is now well known that piezo-electric devices may be employed in connection with oscillation generators for determining the frequency of oscillations and for maintaining the frequency substantially constant. Piezo-electric crystals having natural frequencies that are high may be designed without great difficulty, but serious difficulty is encountered when an attempt is made to design crystals having natural frequencies that are low, for example, within the audible range. Quartz piezo-electric crystals in the shapes ordinarily employed and of sufficient size to have natural frequencies within the audible range are difficult to secure. A quartz crystal in the shape of a parallelepiped of such size as to have a natural frequency within the audible range would be extremely cumbersome.

An object of the invention is to simultaneously control the frequency of a plurality of oscillations of different frequency.

Another object is to control low frequency oscillations by means of piezo-electric devices.

A further object is to cause a piezo-electric frequency control device to vibrate in a plurality of modes.

A feature of the invention relates to an oscillation generator arranged to produce oscillations at a plurality of frequencies.

Another feature relates to a piezo-crystal controlled oscillator, wherein the piezo-electric device is arranged to vibrate in a plurality of modes.

A further feature concerns an oscillation generator for producing low frequency oscillations under control of a piezo-electric device vibrating at a plurality of frequencies.

A still further feature relates to a space discharge tube oscillator capable of producing oscillations at two frequencies under control of a single piezo-electric device and capable of producing intermodulation of the resulting waves.

This invention comprehends a continuous oscillation generating system which may include one or more space discharge devices in which a plurality of waves of different frequency are produced. The frequency of the waves is controlled by one or more piezo-electric devices which are caused to vibrate in one or a plurality of independent modes at different frequencies. The frequency of of the waves generated by the oscillator may be determined by the natural frequencies of vibration of one or a plurality of piezo crystals in one or a plurality of modes.

The system is also arranged to produce intermodulation of the waves of different frequencies to give resulting waves having frequencies represented by the sum and difference of the frequencies of the original waves. If desired, the oscillation generating system may be adjusted to generate simultaneously two waves having frequencies whose difference is within the audible range.

In the drawings:

Fig. 1 illustrates the circuit arrangement of a single tube crystal controlled oscillator for producing waves of a plurality of frequencies.

Fig. 2 illustrates a circuit arrangement similar to Fig. 1 for generating oscillations of widely different frequencies.

Fig. 3 illustrates the circuit arrangement of a single tube oscillator employing two piezo-electric frequency control devices.

Fig. 4 illustrates the circuit arrangement of an oscillator controlled by a single piezo-crystal and having a plurality of tubes designed to oscillate independently.

Like reference characters have been used throughout the various figures of the drawings to indicate like parts.

In Fig. 1 the oscillation generator illustrated comprises a space discharge tube 10 having an input circuit 11 connected to its control electrode and cathode and a space current or output circuit 12 connected to its anode and cathode. Terminals 13 and 14, to which a load device may be connected, are also connected to the anode and cathode

of tube 10. The lead from terminal 13 to the anode includes a blocking condenser 15. The input circuit includes the piezo-electric device 16 connected in series with parallel branch paths including the resonant circuits 17 and 18 in series with impedances represented as condensers 19 and 20, respectively. Resonant circuit 17 comprises a variable condenser 21 connected in shunt to a coil 22. Resonant circuit 18 comprises variable condenser 23 connected in shunt to coil 24, Coils 22 and 24 are preferably so arranged as to have substantially no mutual inductance. The space current circuit of tube 10 includes the coil 25 in series with battery 26. The latter is shunted by condenser 27. Coil 25 is coupled to both coils 22 and 24 whereby energy may be fed back from the anode cathode circuit to the input circuit of tube 10, to cause the generation of sustained oscillations. In order to provide a suitable average polarizing potential upon the control electrode of tube 10, as well as to cause intermodulation of the waves in tube 10, a path including resistance 28 in series with battery 29 is provided between the control electrode and cathode.

Oscillations are established in the circuit in a manner now well understood and their frequency is determined by the piezo-electric device 16 in cooperation with the resonant circuits 17 and 18. The circuits 17 and 18 are preferably tuned to two different frequencies which are relatively close together in order that the one circuit shall have a high impedance to waves at which the other circuit is resonant to prevent each circuit from acting substantially as a short circuit for the other. The coils 22 and 24 are aranged to have no mutual inductance in order that the resonant circuits 17 and 18 may each be adjusted without materially affecting the tuning of the other. The condensers 19 and 20 are provided as an additional means for preventing reaction of one circuit upon the other. Condenser 27 serves to provide a low impedance path around the battery 26 for high frequency oscillations, whereas condenser 15 serves to prevent the flow of direct current from battery 26 into a load device connected to terminals 13 and 14.

Piezo-electric device 16 may comprise a parallelepiped of quartz positioned with opposite sides closely adjacent to two conducting plates to which the circuit conductors are connected. A crystal so positioned is capable of vibration in two modes as, for example, longitudinal vibrations in two perpendicular directions at a plurality of natural frequencies. By properly designing the crystal 16 and by properly adjusting the resonant circuit 18, the system may be caused to generate oscillations at some particular one of the natural frequencies at which the crystal vibrates in one of its modes. By further adjusting the resonant circuit 17 the system may be caused to produce other oscillations at some particular one of the natural frequencies of vibration of the crystal in its other mode.

The method of designing a piezo-electric crystal so that a desired one of its natural frequencies of vibration may be selected is described in applicant's application, Serial No. 730,165, filed August 5, 1924, relating to oscillation generators. In that application it is stated that the crystal is preferably a parallelepiped cut from quartz along one of the axes of symmetry of the crystal. The plates may be placed adjacent to the sides of the parallelepiped which lay in planes parallel to the axis of symmetry of the mother crystal. The dimensions of the parallelepiped are preferably all of the same order. It is found that a crystal of such proportions has a plurality of natural frequencies, but that its response to the fundamental frequencies is substantially greater than its response to other frequencies, which moreover are not in the same neighborhood.

If desired the resonant circuits 17 and 18 and the piezo-electric device 16 may be designed to cause the system to oscillate at two frequencies considerably above the audible range. By so doing, it is possible to select natural frequencies for the crystal 16, such that its design may be relatively simple and its dimensions such that it may be conveniently mounted and adjusted. The two frequencies at which the system is arranged to generate oscillations may also, if desired, be such that their difference is within the audible range. Then by providing resistance 28 of proper value and battery 29 of proper voltage, the waves of the two frequencies selected may be intermodulated in the tube 10 to supply to a circuit connected to terminals 13 and 14 waves having a frequency represented by the sum or difference of the frequencies of the original waves. The waves of difference frequency will then be within the audible range.

The oscillation generator shown in Fig. 2 is very similar to that described in connection with Fig. 1. It comprises space discharge tube 10 having an input circuit including piezo-electric device 16 connected in series with resonant circuits 17 and 18. The circuit of Fig. 2 is identical with that of Fig. 1 with the exception that resonant circuits 17 and 18 are connected in series with each other in the input circuit and the condensers 19 and 20 of Fig. 1 are omitted in Fig. 2.

The system shown in Fig. 2 is designed to produce oscillations at two frequencies which are widely separated. In order to accomplish this, the resonant circuits 17 and

18 are connected in series instead of in parallel as in Fig. 1. In this arrangement the impedance of each resonant circuit is low for waves of a frequency to which the other is tuned. By virtue of this fact substantially the whole voltage of waves of the resonant frequency available at the terminals of each resonant circuit is impressed upon the control electrode of tube 10.

The circuit arrangement of an oscillation generator similar to that illustrated in Fig. 1, but having individual piezo-electric devices associated with the resonant circuits 17 and 18 is shown in Fig. 3. Here the piezo-electric devices 16′ and 16″ are connected, respectively, in the branch paths of the input circuit of tube 10 in series with the resonant circuits 17 and 18. These piezo-electric devices are arranged to vibrate in only one mode. In other respects the system of Fig. 3 operates in a manner corresponding to that of Fig. 1.

The oscillation generator illustrated in Fig. 4 comprises a single piezo-electric device 16 and a plurality of space discharge tube devices 10′ and 10″. The tubes 10′ and 10″ comprise input and output circuits connected to their control electrodes and cathodes and control electrodes and anodes, respectively. The control electrodes of the tubes are connected in parallel to a path including piezo-electric device 16 in series with coil 25. The anodes of tubes 10′ and 10″ are connected in push-pull relation by individual leads including resonant circuits 17′ and 18′ respectively to a common path including space current battery 26. The coils 22′ and 24′ of resonant circuits 17′ and 18′ preferably have negligible mutual inductance but are adjustably coupled to the coil 25. Condensers 15 and 27, resistance 28 and battery 29 perform the same functions in the circuit of Fig. 4 as described in conection with the circuit of Fig. 1.

In the operaton of the system of Fig. 4, the piezo-electric device 16 also functions in a manner similar to the piezo-electric device 16 in Fig. 1 to control the frequency of oscillations of two different frequencies generated independently by the devices 10′ and 10″ and their associated circuits. By properly adjusting the voltage of battery 29 and the resistance 28 intermodulation of the oscillations generated by tubes 10′ and 10″ may be produced in the common input circuit, whereby modulated waves representing the sum and difference frequencies may be supplied to a load device connected to terminals 13 and 14.

Although this invention has been illustrated and described in connection with certain specific embodiments, it is to be limited, nevertheless, only as indicated by the scope of the appended claims.

What is claimed is:

1. An oscillation generator comprising means for generating a plurality of different frequency oscillations and a piezo-electric device traversed by said oscillations and vibrating at a plurality of natural frequencies corresponding to the frequency of said oscillations.

2. An oscillation generating system comprising means for establishing a plurality of oscillations of different frequencies, and a piezo-electric device arranged to vibrate at a plurality of frequencies, said device acting to simultaneously control the frequency of said oscillations.

3. An oscillation generator which comprises means for generating oscillations at a plurality of frequencies, and a piezo-electric device traversed by oscillations of at least one frequency, said device being arranged to vibrate at a corresponding frequency.

4. Means for generating oscillations comprising a space discharge tube, circuits associated with said tube in which a plurality of waves of different frequency are generated, and means for simultaneously controlling the frequency of all of said waves comprising a mechanically vibrating device.

5. An oscilllation generator comprising means including an electrical system generating waves or a plurality of frequencies, a mechanically vibrating device maintained in vibration in a plurality of modes by said waves, said device acting to maintain the frequency of said waves substantially constant.

6. An oscillation generator comprising a space discharge tube, a circuit connected to said tube having waves of a plurality of frequencies generated therein, and means for simultaneously controlling the frequency of all of said waves comprising a mechanically vibrating device vibrating in a plurality of modes.

7. In an oscillation generator, a space discharge tube, a circuit so associated with said tube that oscillations of a plurality of frequencies are produced therein, a piezo-electric device capable of vibration in a plurality of modes and at a plurality of natural frequencies in each mode, and means to cause said device to vibrate at a selected natural frequency in each mode as a means of determining the frequency of said oscillations.

8. In an oscillation generator, a space discharge device, a circuit so associated with said device that oscillations of a plurality of frequencies are produced therein, and means comprising a piezo-electric device for simultaneously determining the frequency of all of said oscillations.

9. In an oscillation generator a space dis-

charge tube, a circuit so associated with said tube that oscillations of a plurality of different frequencies are generated therein, and means comprising a piezo-electric device for simultaneously determining and maintaining constant the frequency of all of said oscillations.

10. In an oscillation generator, a space discharge tube, a circuit so associated with said tube that oscillations of a plurality of frequencies are produced therein, a piezo-electric device arranged to control the frequency of said oscillations and capable of vibration in a plurality of modes and at a plurality of natural frequencies in each mode, and means comprising resonant circuits to determine the natural frequency of vibration of said device in each mode.

11. In an oscillation generator a space discharge device, a circuit so associated with said device that oscillations of a plurality of frequencies are generated therein, and means comprising a piezo-electric device and a resonant circuit for simultaneously determining the frequency of all of said oscillations.

12. In an oscillation generator a space discharge device, a circuit so associated with said device that oscillations of a plurality of frequencies are generated therein, and means comprising a piezo-electric device and a plurality of resonant circuits for simultaneously determining the frequency of all of said oscillations.

13. In a space discharge tube system a three-electrode space discharge tube, input and output circuits for said tube, said circuits being coupled to produce continuous oscillations of a plurality of frequencies, a piezo-electric device for maintaining the frequency of said oscillations constant, and means for causing intermodulation of said oscillations.

14. In an oscillation generating system a space discharge tube, a piezo-electric device, a circuit including said tube and said device having generated therein a plurality of continuous waves having frequencies above audibility, means for obtaining from said waves a wave of audible ffequency, said audible frequency wave being controlled as to frequency by said piezo-electric device.

In witness whereof, I hereunto subscribe my name this 15th day of October A. D., 1924.

WARREN A. MARRISON.