May 3, 1949. J. G. BEARD ET AL 2,469,289

FREQUENCY MODULATION

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Fig. 1.

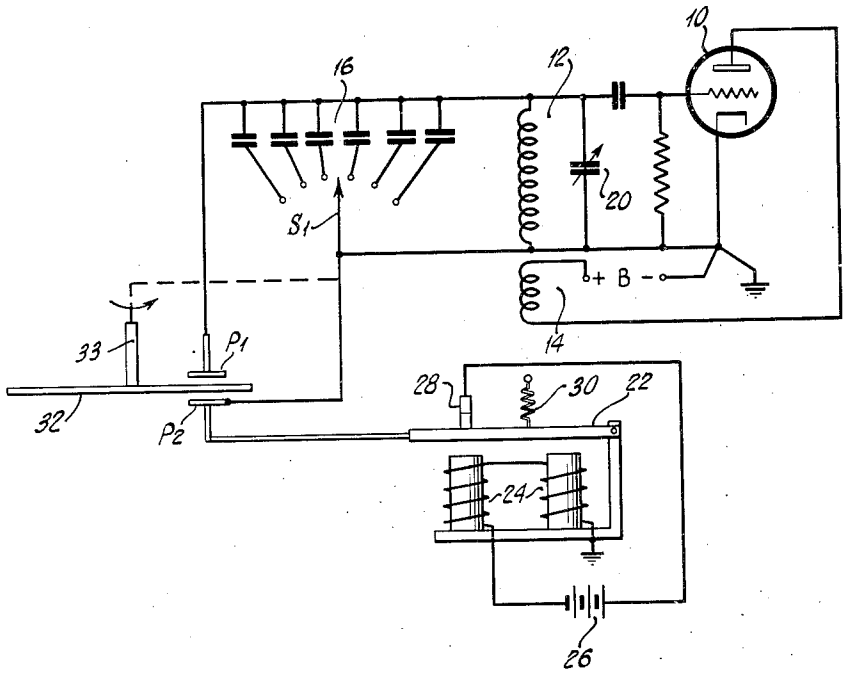
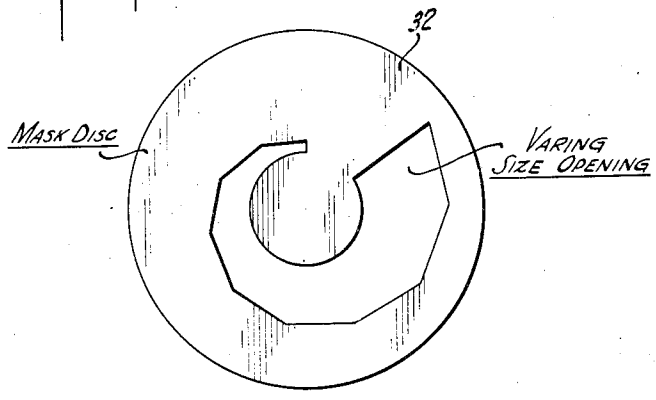


Fig. 1a.



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Fig. 2.

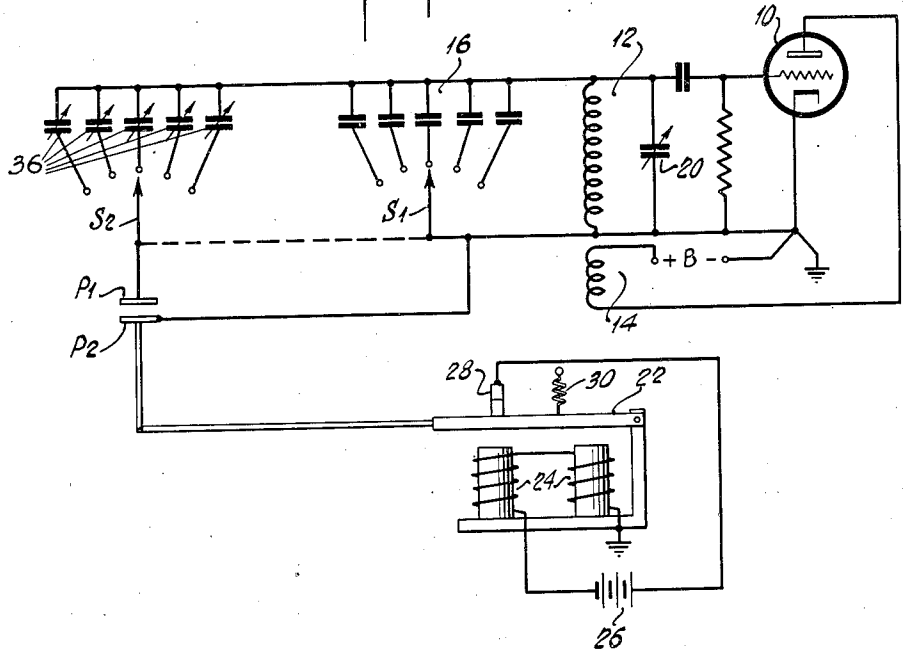
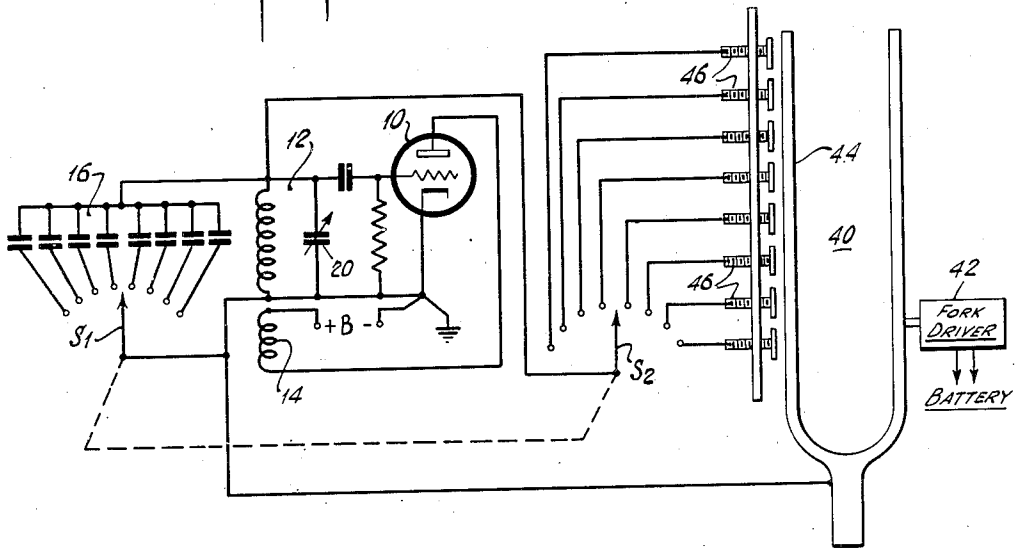


Fig. 3.



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FREQUENCY MODULATION

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6 Claims. (Cl. 250—36)

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This application relates to frequency modulation systems and in particular to means for generating oscillatory energy of carrier wave frequency the frequency of which may be shifted as desired from band to band, means for modulating the frequency of the generated oscillatory energy through a desired range or sweep, and means for changing the range or sweep when the band in which the oscillator is operating is changed to hold the percentage modulation as desired. In a preferred embodiment the oscillations are modulated by tone frequency and the modulation range is so controlled that the amount of modulation is constant.

Tone modulated generators of the type described herein are of wide use in the radio art, and in particular are useful as testing equipment.

The general object of my invention is to provide a simple and reliable apparatus and circuits for generating oscillatory energy of changeable frequency, modulating the frequency of the generated oscillations as desired and controlling the percentage modulation of the oscillations when the frequency thereof is changed.

In describing my invention, reference will be made to the attached drawings wherein Figs. 1, 2 and 3, each illustrate the essential features of a wave generator and modulator and percentage modulation regulating means arranged in accordance with my invention, while Fig. 1*a* illustrates details of an element of the arrangement of Fig. 1.

In Fig. 1, 10 designates generally a tube oscillation generator which may be of any type and for the sake of simplicity is shown as a triode tube with its input and output electrodes regeneratively coupled by a tank circuit 12 and a feedback circuit 14. The tank circuit 12 may include an inductance and a bank of condensers 16, a selected one of which may be connected by a switch S1 in shunt to the inductance of tank circuit 12. If desired, an additional variable condenser 20 may be connected in shunt to this circuit. Inductance 12 is also shunted by an additional condenser formed by plates P1 and P2, one of which is substantially fixed and the other of which, say P2, is movable and is connected to the tank circuit 12 so that the capacity between P1 and P2 shunts this circuit. The plate P2 is connected to the vibratory element 22 of a mechanical vibrator comprising as is well known in the electrical art, magnetic windings 24 mounted as shown on field poles and connected with a source 26, through an element 28 against which the vibratory element 22 is retained by

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spring 30. The elements 22 to 30 are known in the art as a buzzer, and are proportioned and adjusted to vibrate at the desired modulation frequency which may be a tone frequency. As the member 22 vibrates the distance between the electrodes P1 and P2 is varied to thereby vary the capacity in the tank circuit 12 and frequency modulate the generated oscillations. When the unmodulated operating frequency of the generator 10 is changed by changing switch S1 a metallic masking disc 32 which extends between the plates P1 and P2 is rotated on its axis 33 to vary the coupling between P1 and P2. This coupling is varied due to the fact that as shown in Fig. 1*a* the masking disc 32 has therein an opening the size of which changes as the disc is rotated on its axis. In the embodiment illustrated when the switch S1 is changed to put a larger condenser of the bank 16 in the tank circuit the metallic disc 32 is simultaneously rotated to present a larger opening between the plates P1 and P2 because more capacity variation is required at the low frequency end of the range than at the high frequency end. By properly proportioning the opening in the masking or shield plate 32 the amount of frequency shift of the oscillator 10 may be held constant over the entire range thereof.

In the embodiment illustrated in Fig. 2, the plate 32 is not used. In this embodiment the bank of condensers and switch S1 operate as in the prior embodiment, as does the capacity between plates P1 and P2. In this arrangement, however, to hold constant the amount of modulation the plates P1 and P2 are placed in series with a selected one of a bank 36 of condensers. The capacity P1, P2 is now in series with a selected one of the condensers of bank 36 in shunt to the tank circuit 12. The condensers of the bank 36 are of proper value to produce the desired resultant capacity variations for each frequency band of operation of the oscillator as selected by switch S1. Switch S2, which may be a section of switch S1, operates in unison with switch S1 and the bank of condensers 36 is so arranged that the effective capacity variation or vibration of plate P2 holds the amount of modulation constant. The small series capacitors of bank 36 may be selected by the same switch which selects the desired frequency band or may be selected by a separate switch S2. These capacitors may be made adjustable to thereby permit compensation for the inherent tolerances and variations in the components of the oscillator circuit including tank circuit 12.

In the embodiment illustrated in Fig. 3, the mechanical vibrator now comprises a tuning fork 40 operated by a fork driver 42 in a well known manner to oscillate or vibrate at a frequency depending upon its dimensions. Located adjacent to one tine 44 of the fork 40 is a series of adjustable electrodes 46 each of which forms the plate of a separate condenser, the other plates of which are formed by the said one tine of the fork 40. These condensers are adjustable by movement of the screws on which they are mounted. The relative movement of the fork tine with respect to the adjustable electrodes 46 provides the required capacity variation for the desired frequency modulation of the oscillator. The condensers formed by the plates 46 and tine 44 are connected in shunt to the tank circuit 12 of the oscillator 10 so that as the tine vibrates the generated oscillations are modulated in frequency. Since the tip of the tine 46 sustains greater amplitude of vibration, the resultant capacity change will be larger for the electrode 46 placed at the tip of the fork and the resultant capacity variation will decrease as the electrode is moved along the fork, assuming the same are equally or substantially equally placed from the tine. Thus the electrode at the tip of the tine is selected by the oscillator frequency band switch S2 for the lowest frequency band, as are electrodes 46 toward the base of the fork for successively higher bands. This produces an inherent variation in the magnitude of the vibrating capacitance which is such as required to maintain a uniform frequency shift with frequency band change. Each electrode 46 is individually adjustable so that the precise adjustment may be obtained for each frequency band. The range of operation is as in the prior embodiment changed by changing the switch S1 or a section thereof to select a desired condenser of the bank 16 and connect the same in shunt to the tank circuit 12, and at the same time couple a selected condenser plate 46 in shunt to the tank circuit 12.

In the embodiments described, the amount of modulation is to be held constant irrespective of the frequency at which the generator operates in the unmodulated condition. It will be understood that in accordance with our invention the reactances fixing the extent of swing may be proportioned so as to hold the percentage modulation constant over the operating range of the oscillator or other relations between the amount of swing and the carrier frequency may be established as desired by proper proportioning of P1, P2, 32 and the condensers of bank 36.

What is claimed is:

1. In a frequency modulated oscillation generator, an electron discharge device having its electrodes coupled in wave generating circuits including reactances at least two of which are variable, one of said reactances comprising condensers of different value, switching means for including a selected one of said condensers in said circuits to change the frequency at which said generator operates, said other of said reactances comprising a variable condenser having a fixed plate and a movable plate, mechanical means for varying said movable plate at a tone rate to modulate the frequency of the oscillations generated, and mechanical means linked to said switching means for operation therewith for changing the effective capacity of said variable condenser when the frequency of operation is changed to hold the extent of modulation deviation of the oscillations generated throughout the range of operation of said generator substantially constant.

2. A modulated generator as recited in claim 1 wherein said first mechanical means is a mechanical vibrator operating at tone frequency and linked to said movable plate.

3. A frequency modulated oscillator as recited in claim 1 wherein said second mechanical means for changing the effective capacity of said variable condenser is a metallic disc-like element between the plates of said variable condenser and having an opening therein the size of which varies with movement, and wherein said disc-like element is moved by being linked to said switching means, said disc-like element acting as an electrostatic shield between the plates of the variable condenser.

4. In a timing modulated wave generator, an electron discharge device having its electrodes coupled in wave generating circuits including a variable reactance and a bank of substantially fixed reactances, a switch for selecting one of said reactances of said bank of reactances to change the frequency at which said generator operates, mechanical means for varying the other of said reactances at a tone rate to modulate the timing of the oscillations generated, and mechanical means linked to said switch for varying the range through which said other reactance is varied when the fixed reactance is changed by said switch to maintain substantially constant the extent of modulation of the generated wave throughout the range of operation of said generator.

5. In a frequency modulated wave generator, an electron discharge device having its electrodes coupled in wave generating circuits including reactances at least two of which are variable, means for varying one of said reactances to change the frequency band in which said generator operates, the other of said variable reactances comprising a selected one of a plurality of capacitors, one plate of each of which is fixed and spaced along the length of a tuning fork which forms the other plates of said capacitors to provide a plurality of capacitors the capacity variations of which depend on the said spacing along the length of the tuning fork, means for vibrating said tuning fork by varying said selected one of the plurality of capacitors at a predetermined rate to modulate the frequency of the generated wave, and means, linked with said first named means, for changing said other reactance included in said generator circuit, when said one reactance is varied, to maintain substantially constant the amount of modulation of said generated wave energy throughout the range of operation of the generator.

6. In a frequency modulated oscillation generator, an electron discharge device having its electrodes coupled in wave generating circuits including reactances at least two of which are variable, one of said reactances comprising condensers of different value, switching means for including a selected one of said condensers in said wave generating circuits to change the frequency at which said generator operates, said other of said reactances comprising a variable capacitor arrangement including fixed and movable plates, mechanical means for varying said movable plates at a modulation rate to modulate the frequency of the oscillations generated, and mechanical means linked to said switching means for operation therewith for changing the effective capacity of said variable capacitor arrangement

when the frequency of operation is changed to hold the extent of modulation deviation of the oscillations generated throughout the range of operation of said generator substantially constant.

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