Nov. 7, 1933. W. F. CURTIS 1,933,970

FREQUENCY DIVIDER

Filed March 17, 1931

FIG. 1

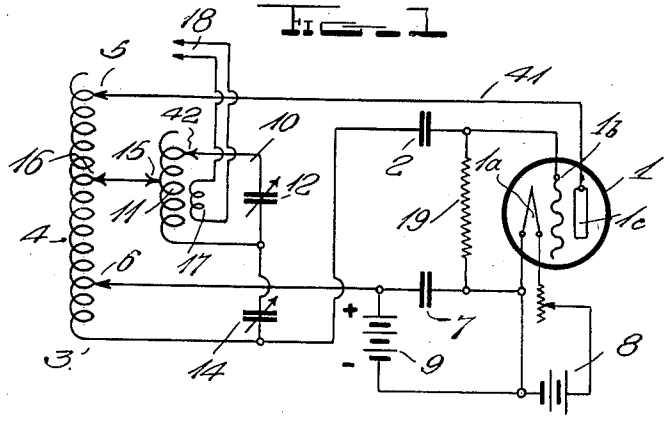


FIG. 2

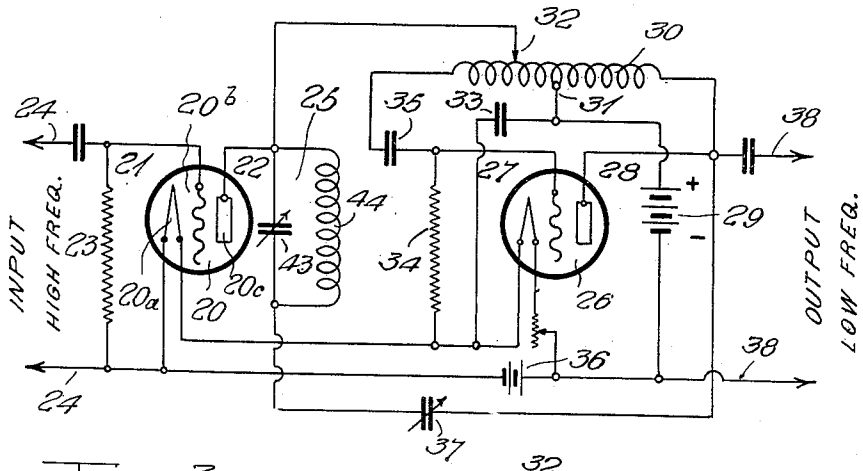
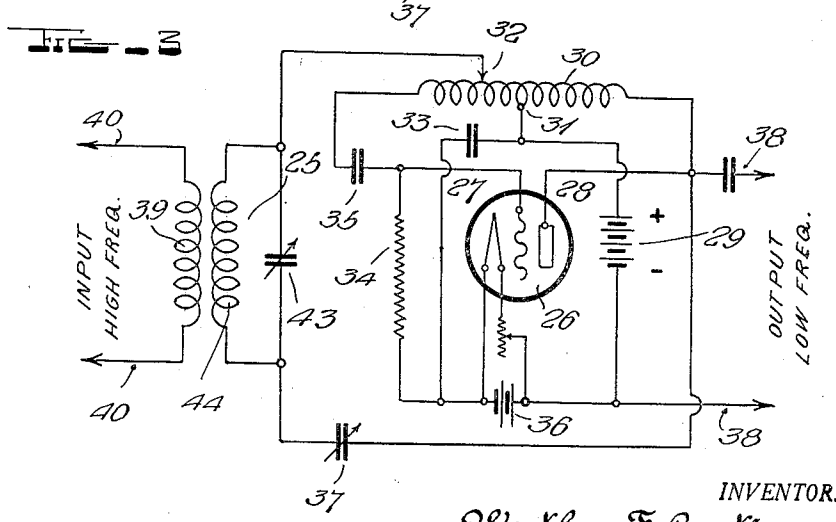


FIG. 3



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FREQUENCY DIVIDER

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5 Claims. (Cl. 250—36)

My invention relates broadly to oscillator systems and more particularly to a circuit arrangement for effecting a division of frequency.

One of the objects of my invention is to provide a circuit arrangement for a frequency divider by which a submultiple of a predetermined fundamental frequency may be sustained at a constant value.

Another object of my invention is to provide a circuit arrangement for a frequency divider wherein a fundamental frequency may be applied to the input circuit of the divider and a submultiple frequency derived from the output circuit of the frequency divider and maintained at constant frequency in synchronism with the impressed fundamental frequency.

Other and further objects of my invention reside in the circuit arrangement for a frequency divider as set forth more fully in the specification hereinafter following by reference to the accompanying drawing, in which:

Figure 1 diagramatically illustrates a circuit for the purpose of describing the theory of my invention; Fig. 2 shows a circuit arrangement embodying my invention and employing a high frequency amplifier directly coupled with the low frequency oscillator constituting the frequency division circuit of my invention; and Fig. 3 shows an arrangement of an inductively coupled circuit by which connection may be made to the low frequency oscillator of the frequency division circuit.

Referring to the drawing in detail, reference character 1 designates an electron tube having cathode 1*a*, grid 1*b*, and plate 1*c* with the input and output circuits coupled through the inductance 4. The grid electrode 1*b* is connected through through condenser 2 to the terminal 3 of inductance 4. The plate electrode 1*c* is connected through conductor 41 to the adjustable tap 5 on inductance 4. A tap 6 adjustable along inductance 4, connects through condenser 7 with the circuit of the cathode 1*a*. Battery 8 is employed for heating the cathode 1*a*. High resistance leak path 19 is connected across the grid 1*b* and circuit of the cathode 1*a*. A resonance circuit 10 is shown constituted by inductance 11 and variable condenser 12 which connects to the inductance 11 through the adjustable tap 42. A sliding connection 15 on inductance 11 is connected through sliding contact 16 to the inductance 4. A resonance circuit is provided by the connection of variable condenser 14 across a portion of inductance 4 by means of the adjustable tap 16. The high potential for the plate circuit of the oscillator system is obtained from battery 9. A coupling coil 17 is coupled to inductance 11 of resonance circuit 10 and is connected through circuit 18 to a constant frequency oscillator. An oscillator which is piezo electric crystal controlled may be employed for delivering constant frequency energy through inductance 17 to the resonance circuit 10. The resonance circuit 10 is tuned by condenser 12 and adjustable tap 42 on inductance 11 to correspond with the frequency of the piezo electric crystal controlled oscillator circuit. The circuit constituted by inductance 4 and variable condenser 14 is adjusted to $\frac{1}{N}$ times the frequency of the circuit 10. When the high frequency is impressed upon the circuit 10, it operates in synchronism with the impressed frequency and the circuit 4—14 is thus controlled by the impressed frequency at a value of $\frac{1}{N}$ times the impressed frequency.

Fig. 2 shows the application of the frequency divider principle which has been illustrated in Fig. 1. A high frequency amplifier 20 constituted by an electron tube having a cathode 20*a*, a grid 20*b* and a plate 20*c* is provided with an input circuit 21 and an output circuit 22, the input circuit 21 being connected to the input terminals 24. A high resistance leak path 23 is connected across the grid electrode 20*b* and the cathode 20*a*. The output circuit 22 of the high frequency amplifier 20 includes a resonance circuit 25. A connection extends from resonance circuit 25 through condenser 37 to one end of an inductance 30 forming part of the low frequency oscillator circuit which includes electron tube 26. The inductance 30 has a sliding tap connection 32 thereon which is connected to the opposite end of the resonance circuit 25. The low frequency oscillator 26 includes an input circuit 27 which is bridged by a high resistance leak path 34 and connected through condenser 35 with one end of the inductance 30 on one side and connected to the cathode circuit on the other side. Battery 36 is provided for heating the cathode circuit of tubes 20 and 26. The plate circuit energy for both tubes 20 and 26 is obtained from battery 29 by means of the connection to the mid-point 31 of inductance 30 thus completing the high potential circuit through the right hand portion of inductance 30 to the plate circuit of tube 26 and completing the high potential circuit for tube 20 through that portion of inductance 30 included between center tap 31 and slidable tap 32. The output of the frequency division circuit is shown at 38.

In lieu of the conductive connection to the low

frequency oscillator from the high frequency amplifier 20 I may apply the high frequency energy prior to the frequency division operation to the circuit as illustrated in Fig. 3, where the high frequency energy is applied across terminals 40 to the inductance 39 which is inductively coupled to the inductance constituting part of the resonance circuit 25.

As illustrated in the circuit in Fig. 1, a fundamental frequency f, equal approximately to some multiple of the frequency of the oscillator circuit is applied to the terminals 18. In Figs. 2 and 3, the resonance circuit 25 is tuned to the fundamental frequency applied at the input terminals 24. The circuit of the low frequency oscillator including inductance 30 and condenser 37 is tuned to a sub-multiple of the fundamental frequency whereby the fundamental frequency controls the sub-multiple frequency. The energy delivered at the output terminals 38 is sustained at a sub-multiple frequency at an extremely constant value. The tuning range of the inductance 30 and condenser 37 is made sufficiently broad to include a number of sub-multiple frequencies of a fundamental frequency which may be impressed on the low frequency oscillator 26 from resonance circuit 25.

The operation of the circuit of my invention has been found to be markedly independent of variable battery voltages. When the frequency is controlled by an external source of high frequency, the filament voltage on both the amplifier and the oscillator may be changed by 50% without changing the frequency, or the plate voltage may be changed by 50%, or both simultaneously may be changed 25% without changing the operation of the frequency divider system. The capacity of condenser 37 must be maintained within 1% but the condenser 43 in resonant circuit 25 may change 20% without appreciable damage. The amplitude of the harmonic in circuit 25 and hence the stability of control increases with increasing coupling between the circuit 30—37 and the circuit 25. As the inductance 44 is common to the two circuits 30—37 and 25, increasing the ratio $L_2=C_2$ and decreasing the ratio $L_1=C_1$ as well as increasing the inductive coupling between inductance 30 and inductance 44 increases the stability, where:

L_1=inductance of coil 30.
C_1=capacity of condenser 37.
L_2=inductance of coil 44.
C_2=capacity of condenser 43.

While I have described my invention in certain preferred embodiments, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

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

1. A frequency divider comprising an electron tube oscillator including input and output circuits, an inductance connected in common to the input and output circuits of said oscillator, a series circuit external to said inductance and extending between one end thereof and an adjustable tap along said inductance, said series circuit including a resonant circuit, means for impressing energy upon said resonant circuit at a frequency which is a multiple of the fundamental frequency of said oscillator and means for tuning said series circuit to a sub-multiple of said impressed frequency for deriving from said oscillator a sub-multiple of the impressed frequency.

2. A frequency divider comprising an electron tube oscillator, input and output circuits for said oscillator, an inductance connected in common to said input and output circuits for sustaining oscillations at a fundamental frequency, a circuit connected in series between separated points on said inductance for impressing energy on said inductance at a frequency which is a multiple of the fundamental frequency of said oscillator and a tuning element connected with said output circuit for tuning said output circuit to a sub-multiple frequency of the fundamental frequency for deriving from said oscillator a sub-multiple of the impressed frequency.

3. A frequency divider comprising an electron tube oscillator, input and output circuits for said oscillator, an inductance connected in common to said input and output circuits, an auxiliary circuit comprising a resonant circuit and a variable reactance connected in series said auxiliary circuit being connected in shunt with a portion of said inductance, said resonant circuit having energy impressed thereon at a multiple of the fundamental frequency of said oscillator, and said variable reactance being tuned to a sub-multiple of the fundamental frequency for deriving a sub-multiple of an impressed frequency from said oscillator.

4. A frequency divider comprising an electron tube oscillator, input and output circuits for said oscillator, an inductance connected in common to said input and output circuits, an auxiliary circuit connected between separated points on said inductance, said auxiliary circuit including a resonant circuit and a variable condenser in series, means for impressing energy upon said auxiliary circuit whose frequency is a multiple of the fundamental frequency of said oscillator, said variable condenser being tuned to a sub-multiple of the impressed frequency and a circuit connected with said output circuit for deriving a sub-multiple of the impressed frequency from said oscillator.

5. A frequency division system comprising an electron tube oscillator having input and output circuits, an inductance common to said circuits, an amplifier circuit having a tuned output system, a source of potential for said oscillator connected with the midpoint of said inductance, a connection extending from one side of said tuned output system of said amplifier circuit to a tap on said inductance for supplying operating potential to the output circuit of said amplifier, a connection between the other side of the tuned output system of said amplifier circuit and one end of said inductance, and a tuning device in said last mentioned connection, said tuning device being adjustable to a frequency which is a sub-multiple of the fundamental frequency of said oscillator circuit for controlling the generation of a sub-multiple ferquency of the fundamental frequency having constant characteristics.

WESTLEY F. CURTIS.