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FREQUENCY SUB-DIVIDING SYSTEM

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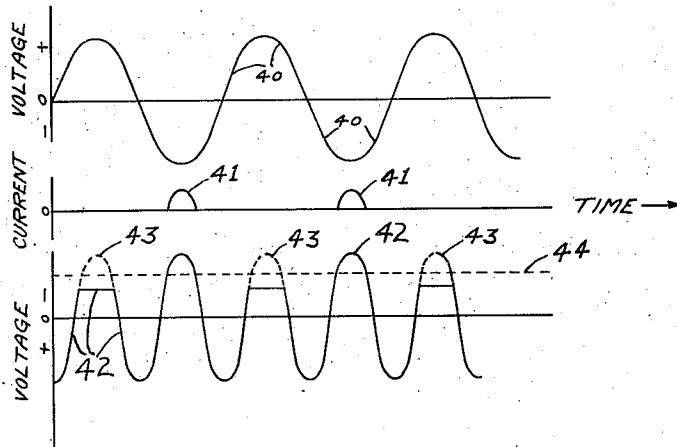
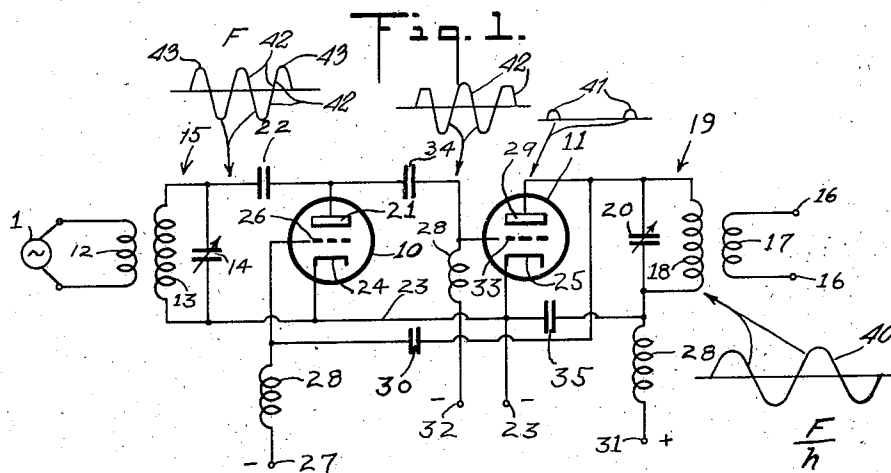


Fig. 2.

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FREQUENCY SUBDIVIDING SYSTEM

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This invention relates to frequency-changing systems and more particularly to such systems adapted to produce an output frequency which is an integral sub-multiple of the input frequency.

In certain radio signalling systems, it is desirable to have the output frequency different from the input frequency but having a definite relation thereto, such for example as a sub-multiple. Also for practical application, it is desirable that this frequency dividing or converting apparatus consist of a simple electronic circuit which may be made integral with other apparatus or which may be constructed as a compact separate unit.

Accordingly, it is a principal object of this invention to provide an electronic circuit adapted to produce electrical energy at its output at a frequency which is an integral sub-multiple of the input frequency.

It is another object of this invention to provide an electronic circuit including two grid-controlled tubes for receiving alternating current signals or pulses and which is so arranged that conduction through the last grid-controlled tube stage of the circuit is caused only by the alternate half waves of like polarity.

It is another object of this invention to provide an electron tube arrangement which is so arranged and biased that it conducts on alternate positive signals only, and thereby produces energy at its output at one-half the frequency of the input energy.

It is a further object of this invention to provide an electronic frequency sub-divider or frequency conversion circuit for use in connection with various types of radio and electronic apparatus wherein the frequency conversion is accomplished by decreasing the amplitude of the alternate positive half waves of alternating current below a predetermined threshold level.

One of the features of this invention is that the conversion of the frequency of the received alternating current waves is accomplished by a pair of grid-controlled electron tubes and a comparatively small number of associated circuit elements.

Another feature of the invention is the provision of a pair of grid-controlled tubes the primary function of the first being the clipping or suppression of the peaks of alternate positive alternating current waves of energy, while the intervening unaffected positive waves cause the second tube to act as a class "C" amplifier, thereby producing in the output of the second tube a

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substantially sinusoidal wave of energy which is at one-half the frequency of the input wave.

Another feature relates to a frequency sub-divider comprising a pair of grid-controlled electron tubes the first of which acts as a peak-limiter only on alternate positive half waves of an input frequency and the second tube acts as a class "C" amplifier and also serves to control the cutoff grid bias of the first tube.

Other objects, features and advantages of this invention will be apparent to those skilled in the art as will be evident from the following descriptions taken in connection with the accompanying drawing, in which:

Fig. 1 is a circuit diagram embodying the principles of this invention.

Fig. 2 shows the time relationship of the wave forms at various places in the circuit shown in Fig. 1.

Generally, this invention comprises a system using two grid-controlled electron tubes which are operated in such a way that the first tube acts as a peak-limiter for clipping alternate positive lobes of the applied waves, and the second tube acts as a class "C" amplifier and also controls the plate current conductivity of the first tube. Only the unclipped alternate positive input waves cause the amplifier tube to conduct. Associated with the amplifier is a high "Q" tuned circuit which cooperates with the amplifier to produce an output at one-half the frequency of the input frequency to the clipper tube.

Referring now more particularly to Fig. 1, the peak-limiter tube 10 and amplifier tube 11 are preferably in the form of grid-controlled electron tubes of any well-known type. Inductance 12 is connected to a source 1 of alternating current energy which is transferred by transformer action to inductance 13. Inductance 13 and parallel-connected condenser 14 constitute a tank circuit 15 which is tuned to resonate at the frequency of the source 1. The output energy is taken from terminal 16—16 of inductance 17, which is coupled by transformer action to inductance 18. Inductance 18 and its parallel-connected condenser 20 constitute the output tank circuit. Circuit 19 is tuned by condenser 20 to resonate at one-half the frequency to which tank circuit 15 is tuned. The resonant tank circuit 19 is a very high "Q" circuit, and as such will, in the well-known manner, continue to produce oscillations after the decay of energy flow into it. As the energy alternately flows or oscillates from condenser 20 to inductance 18, it encounters a resistance which in time causes the complete

dissipation of the energy. This required time is dependent upon the "Q" of the tank circuit.

Circuit 15 at one end is connected to plate 21 of tube 10 through condenser 22, and at its other end is connected to the negative or low potential terminal 23 of the system. The cathodes 24 and 25 of tubes 10 and 11 respectively are also connected directly to this negative terminal. This negative potential is supplied to terminal 23 from any source of D. C. supply having appropriate potential to furnish the desired cathode bias with relation to the respective grids of tubes 10 and 11, so that tube 11 can deliver maximum output.

A fixed value of negative bias is supplied to the control grid 26 of tube 10 with respect to its cathode, which grid is connected to terminal 27. It will be clear from the following description that the value of the negative bias supplied to grid 26 may vary over a wide range of values and in some cases may be entirely omitted. The inductances 28 are high frequency choke coils to oppose the flow of high frequency currents therethrough. Grid 26 of tube 10 is coupled to the plate 29 of tube 11 through the coupling condenser 30. Terminal 31 is connected to a source of high positive D. C. potential suitable for application to the plate 29 of tube 11. Terminal 32 is connected to a source of negative direct current potential such that the negative bias applied to control grid 33 causes tube 11 to operate as a class "C" amplifier and deliver maximum output. Condenser 34 is a blocking condenser and insulates the plate 21 of tube 10 from the negative D. C. potential at terminal 32. Condenser 35 is of such value that it offers a low impedance path between the negative or low potential side 23 of the system and the junction of choke coil 28 with tuned circuit 19.

The value of the negative bias applied to grid 33 of tube 11 with respect to its cathode, in the absence of excitation voltage from source 1, is approximately twice that required for plate current cutoff. Plate current flows only during a fraction of the positive cycle of the signal from source 1 applied to grid 33. This signal is of sufficient positive value to drive tube 11 to plate current saturation. Hence tube 11 operates as a class "C" amplifier and as such will produce a distorted output wave shape. The operating frequency of source 1 is however sufficiently high so that the fly-wheel action is sufficient to allow the tuned circuit 19 to eliminate this distortion. As a result, the output produced is substantially sinusoidal (curve 40, Fig. 2), and of one-half the frequency of the input energy (curves 42, 43, Fig. 2).

The tube 10 and its associated circuit suppress alternate positive lobes of the input voltage and thereby allow the excitation or conduction of tube 11 to occur at the desired output frequency. The exact operation of this circuit will be readily understood from the following description of its operation taken in connection with the circuit diagram shown in Fig. 1 and the curves shown in Fig. 2.

Curve 40 represents the output wave form appearing across terminals 16. The pulses 41 represent the plate current present at the plate 29 of tube 11 which cause the generation of the output wave 40. The voltage curve 42 including the dotted positive lobes 43 represent the input waves from source 1. Curve 42 represents the wave form of energy applied to the grid 33 of tube 11 as a result of the clipping action of tube 10. The suppression or cutting-off of the positive lobes

43 by tube 10 causes the maximum value of potential in these alternate lobes to be insufficient to overcome the negative grid bias applied to grid 33 of tube 11 via terminal 32. This grid bias is represented by line 44. From these comparative values it is seen that the clipped lobes will not be of sufficient positive potential to remove the cut-off bias on grid 33. The clipping of lobes 43 is proportioned so that the voltage 42 exceeds the value of the negative bias represented by dotted line 44, on alternate positive cycles only. These alternate cycles result in plate current conduction of tube 11 and produce current pulses 41 at the plate 29. The "fly-wheel effect" of circuit 19 tuned to one-half the frequency of the input voltage 42 causes the output curve 40 to be substantially a sine wave having a frequency equal to one-half the frequency of the input voltage 42, 43.

The voltage on the grid 26 of tube 10 consists of the fixed grid bias applied at terminal 27 and the subdivided frequency voltage fed from plate 29 through condenser 30. During the positive portion of the cycle of voltage 40, grid 26 of tube 10 is therefore biased positively and thereby offers a low impedance path to the negative side 23 of the system. Condenser 22 has a high reactance at the input frequency and in conjunction with the plate resistance of tube 10, a voltage dividing action occurs which, in conjunction with the feedback voltage, suppresses or cuts off the positive lobes 43 of the input frequency. During the remaining portion of the cycle of the output 40 it causes the bias of tube 10 to be sufficiently negative to prevent its conduction, and the input voltage passes to the grid 33 of tube 11 causing this tube to conduct in the manner previously described.

While there has been here described one preferred embodiment, it is understood that various changes and modifications may be made therein without departing from the scope of the invention.

What is claimed is:

1. An arrangement for deriving from an input frequency F an output frequency F/n where n is an integer, comprising a first grid-controlled tube having at least an anode, grid and cathode and having its plate and cathode connected across the source of said input frequency, means normally biasing the grid of said tube to plate current cutoff, a second grid-controlled tube having at least an anode, grid and cathode and having its control grid excited in accordance with the potential variations at the plate of said first tube, means normally biasing said second tube to plate current cutoff in the absence of said excitation, a resonant circuit connected to the plate of said second tube and tuned to said frequency F/n , a connection from said resonant circuit to the grid of said first tube for exciting said grid at said frequency F/n for overcoming the normal plate current cutoff bias of said first tube and thereby causing the peaks of alternate half waves of the input frequency to be clipped below a value requisite to render said second tube plate current conductive.

2. An arrangement for deriving from an input frequency F an output frequency F/n where n is an integer, comprising a first grid-controlled tube having at least an anode, grid and cathode, a resonant circuit tuned to said frequency F and connected for A. C. only across the plate and cathode of said first tube, means normally biasing the grid of said first tube to plate current cutoff, a second grid-controlled tube having at least an anode, grid and cathode, a condenser

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coupling the plate of said first tube to the grid of said second tube, means normally biasing the grid of said second tube to cause said second tube to act as a class "C" amplifier, an oscillatory circuit connected to the plate of said second tube and tuned to said frequency F/n , and a connection from the plate of said second tube to the grid of said first tube for overcoming the cutoff bias on said first tube in consonance with the positive half waves of said frequency F/n .

3. An arrangement for deriving from an input frequency F an output frequency F/n , comprising an oscillatory output circuit tuned to said frequency F/n , a first grid-controlled tube having at least an anode, grid and cathode and having its plate excited by the input frequency F , a second grid-controlled tube having at least an anode, grid and cathode and having its control grid excited by said input frequency F , normal negative bias circuits for the grids of both of said tubes, means interconnecting the plate circuit of the first tube with the control grid of the second tube, means interconnecting the plate circuit of the second tube with the control grid of the first tube to cause said oscillatory circuit to be excited substantially only at said frequency F/n , a source of D. C. plate potential connected to the plate of said second tube, said D. C. plate potential being D. C. insulated from the plate of the first tube.

4. A frequency-changing system including an input circuit connected to a source of periodic waves, an output circuit tuned to a frequency which is a sub-multiple of the input frequency, a first grid-controlled tube, a second grid-controlled tube, each of said tubes having at least an anode, grid and cathode, the waves from said input circuit being applied to the grid of the second tube and to the plate of the first tube, circuit connections for biasing the grid of the first tube under control of the plate potential of the second tube to cause the first tube to clip the peaks only of alternate positive half-waves of the input frequency applied to the control grid of the second tube, means for applying steady bias to the grid of the second tube with respect to its cathode so that the said second tube is normally at plate current cut-off, and circuit connections between the grid of said second tube and the plate of the first tube to cause the second tube to become plate current conductive in synchronism only with the unclipped peaks of the half-waves from the said input circuit.

5. A system according to claim 4, in which said second tube is biased to act as a class "C" amplifier and the plate of the second tube is coupled through a condenser to the grid of the first tube to feed back to the grid of the first tube a positive biasing voltage in synchronism with the alternate positive half-waves of the input frequency.

6. A frequency-changing system comprising a resonant input circuit for connection to a source of periodic waves, a tunable output tank circuit resonant to a frequency which is a sub-multiple of the input frequency, a first grid-controlled tube, a second grid-controlled tube, each of said tubes having at least an anode, grid and cathode, circuit means for applying the positive half-waves of the input frequency to the plate of the first tube and to the grid of the second tube, means biasing the grids of both said tubes so that they normally do not pass plate current in the absence of positive half-waves of the input frequency, a circuit connection between the plate of the second tube and the control grid of the

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first tube for causing the first tube to clip the peaks only of alternate half-waves of the input frequency applied to the control grid of the second tube while said second tube remains at plate current cut-off during the clipped peak periods, the last-mentioned circuit means being effective during the unclipped peaks of the input waves to overcome the normal plate current cut-off bias on the grid of the first tube.

7. A frequency-changing system having an output circuit which is resonant to one-half the input frequency, said system including an input circuit which is resonant to the input frequency, a tunable output tank circuit resonant to a frequency which is a sub-multiple of the input frequency, a first grid-controlled electron tube having at least an anode, grid and cathode, circuit means for causing said first tube to be plate current conductive only during the peaks of the alternate positive half-cycles of the said input frequency, and a second grid-controlled tube having at least an anode, grid and cathode and having its control grid normally biased as a class "C" amplifier, and means connecting the grid of said second tube to the plate of the first tube and the plate of the second tube to the grid of the first tube to render said second tube plate current conductive only during the positive cycles of said input frequency, which cycles intervene between the said alternate half-cycles.

8. A frequency-changing electronic circuit, having an input frequency equal to twice the output frequency, input terminals and output terminals, an input circuit coupled to said input terminals and resonant at said input frequency, a tunable output tank circuit coupled to said output terminals and resonant at said output frequency, a grid-controlled electron tube having at least an anode, grid and cathode for clipping the peaks of alternate positive waves of the input frequency, a grid-controlled amplifier tube having at least an anode, grid and cathode and having its control grid coupled to the plate of the clipper tube and to the input circuit, circuit connections for causing said clipper tube to clip a portion of each alternate positive wave of said input frequency, the last-mentioned circuit connections including a connection between the plate of said amplifier tube and the grid of said clipper tube for causing said amplifier tube to be plate current conductive during the unclipped portions of the other alternate positive waves of said input frequency.

9. A frequency sub-dividing arrangement, comprising an input circuit resonant at an input frequency, an output tank circuit resonant at a frequency which is a sub-multiple of the input frequency, a pair of grid-controlled electron tubes for coupling the input and output circuits, each of said tubes having at least an anode, grid and cathode, means connecting the input circuit across the plate and cathode of the first tube and across the grid and cathode of the second tube, circuit connections for normally biasing the grids of both tubes so that they do not pass the plate current, a source of direct current plate potential connected to the plate of the second tube, a first condenser connected between the plate of the first tube and the grid of the second tube whereby the plate of the first tube is D. C. insulated from said D. C. source, and a second condenser connected between the plate of the second tube and the grid of the first tube for applying to the grid of the first tube a positive potential in synchronism with alternate positive

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half-waves of the input frequency to render said first tube plate current conductive.

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