

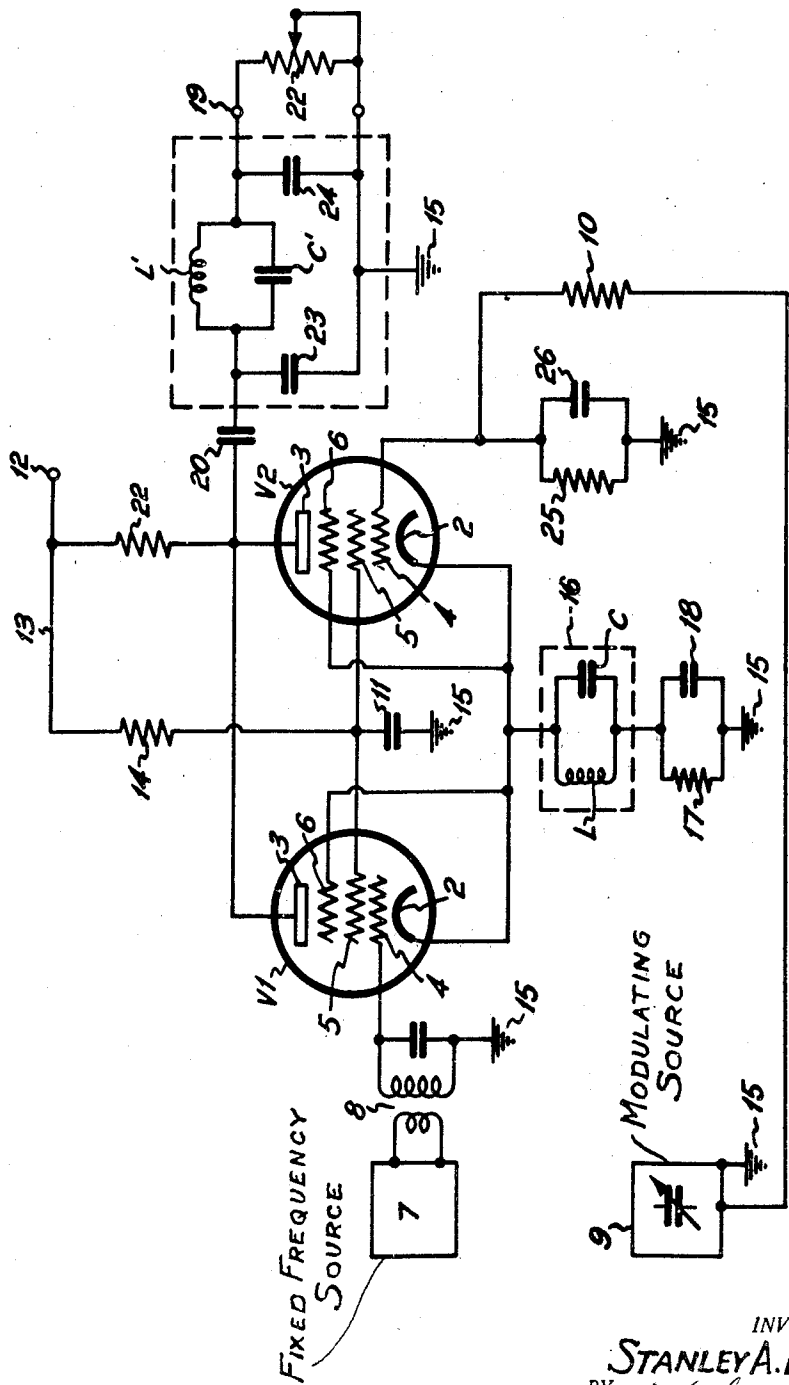
Dec. 6, 1949

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2,490,448

FREQUENCY CHANGER

Filed Nov. 9, 1945



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2,490,448

FREQUENCY CHANGER

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Application November 9, 1945, Serial No. 627,751

4 Claims. (Cl. 250—36)

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This invention relates to modulators and like frequency changing systems in which it is required greatly to attenuate one or both of the original frequencies.

In small beat frequency oscillators of prior art construction, it has been common practice to employ multiple valves, (such as the well known 6A8), in conventional frequency converter circuits in which a low pass filter is provided in the output circuit for rejecting frequencies except the required low frequency beats.

The satisfactory application of these prior art circuit arrangements involves many design problems which are difficult to overcome in an economical manner.

In order to secure frequency stability it is usual, for reasons well understood, to make the fixed and variable oscillators operate at as low a frequency as possible. If, in addition, the upper limit of the beat frequencies is required to be high, then the low pass filter in the output of the modulator or frequency changer must be of elaborate design. For example, if the frequency of the fixed oscillator is 80 kc. and the frequency range of the variable oscillator 60–80 kc., in order to provide output beat frequencies up to 20 kc., then the low pass filter must transmit up to 20 kc. freely and then attenuate sharply at 60 kc. Furthermore, inductances in the filter will require to be rather large, firstly because the impedance level is high. Large coils, in addition to occupying excessive space, tend to produce large fields which may interact upon the output.

From the foregoing it will be appreciated that the necessity for using a filter, in a circuit of the above mentioned type, for the purpose of rejecting the undesired frequencies in the output circuit, complicates design problems and adds greatly to the cost of the equipment.

In the past it has also been the practice, in order to suppress both of the input frequencies in the output, to employ various arrangements of the well known balanced modulator circuit. These prior art modulator circuit arrangements require the use of balanced input and/or output transformers and efficient operation depends on securing and maintaining a high degree of balance, a requirement that is not readily realizable in practice.

In a copending application Serial No. 635,098, filed December 14, 1945, a modulator circuit arrangement has been suggested which secures satisfactory suppression of the modulating frequencies in the output circuit without the use of balancing transformers.

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Briefly the arrangement adopted in the above mentioned copending application is as follows. Both modulating frequencies are applied simultaneously to the grid of one valve and to the cathode of a second similar valve which has its control grid effectively earthed for all operating frequencies and has an unbypassed resistive impedance in its cathode circuit. Due to this unbypassed impedance, so-called cathode phase inversion is achieved and the modulating potentials are effectively applied to the grid of this second valve 180 degrees out of phase with the modulating potentials applied to the grid of the first valve.

The anodes of the two valves in this arrangement are connected together and to an output circuit appropriately tuned to receive the desired beat frequency.

Although the invention set out in the above mentioned copending application overcomes most of the undesirable characteristics referred to above, it suffers from one serious disadvantage which prohibits its use in beat frequency oscillators, i. e., inability to prevent the modulating oscillators "locking in."

The object of the present invention is to provide a comparatively simple modulator or frequency converter circuit utilizing two valves in such a way that both of the modulating frequencies are greatly attenuated in the output, and in which the disadvantages outlined above in respect to prior art practices are substantially avoided.

The above objective is achieved in accordance with the present invention by an improved modulator arrangement comprising a pair of similar thermionic valves each having at least an anode, a cathode and a control grid, means for applying modulating potentials to the control grid of one valve, means for applying modulation potentials of a different frequency to the control grid of the other valve, a cathode circuit common to both valves and having a high value impedance connected effectively in series therewith, and an output circuit for obtaining energy at a frequency equal to the sum and/or difference frequencies of said modulation frequencies.

For a more complete understanding of the invention and the manner in which it is to be carried out, attention is now directed to the following description in connection with the accompanying single figure of drawing, which illustrates one practical arrangement for performing the invention.

Referring to the drawing, valves V1 and V2 employed in the present example are shown as

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pentodes each having a cathode 2 and an anode 3 together with a control grid 4, a screen grid 5 and a suppressor grid 6 located in the order stated in the electron path from cathode to anode.

The control grid 4 of valve VI is connected to a source 7 of modulating potential of fixed frequency through a transformer 8 or other suitable coupling means in conventional manner.

Modulating potentials from a separate source 9 of variable frequency are applied to the control grid 4 of valve V2 through a series resistor 10 and a shunt connected resistance-capacity network 25, 26.

The screen grid 5 of each of valves V1 and V2 is bypassed for all signal frequencies by the capacity 11 and is supplied with operating potentials from the positive terminal 12 of a suitable high tension supply source (not shown) through the lead 13 and the series connected resistor 14. The suppressor grid 6 of each valve is connected to its associated cathode.

The cathodes 2 of the valves V1 and V2 are connected together and to earth 15 through a series connected network comprising an impedance unit 16 and the self biasing resistance capacity combination 17-18.

The nature of the impedance 16 should be such that it maintains a high impedance value for all frequencies to be suppressed.

In the present example the impedance 16 is constituted by a parallel tuned circuit L, C. The value of the bias resistor 17 is selected to provide such biasing potentials on the grids 4 as will cause the valves V1 and V2 to operate on a square law characteristic. It is to be understood that biasing potentials may be applied to the grids 4 in any known manner.

The anodes 3 of the valves V1 and V2 are joined together and connected to the output terminal 19 through the coupling condenser 20 and a filter network shown in a dotted rectangle. Operating potentials from the positive terminal 12 of the H. T. supply source (not shown) are supplied to the anodes 3 through the anode load resistor 22.

With the circuit arrangement thus described modulating potentials, applied between earth 15 and the grid 4 of valve V1, from the source 7, will appear across the cathode load impedance in 16. As the grid 4 of the valve V2 is connected to earth 15, the potentials appearing across the cathode circuit will be applied to the grid 4 of the valve V2 with a phase difference of 180 degrees as compared to the potentials applied to the grid 4 of valve V1. The theory of cathode phase inversion is so well known that a detailed explanation of the operation is considered unnecessary. In like manner modulating potentials applied to the grid 4 of valve V2, from the source 9, appear across the cathode load impedance 16 and are applied to the grid 4 of the valve V1 in reversed phase.

It will thus be seen that the circuit of the present invention provides a simple and economical method of applying modulating potential from each of the supply sources 7, 9 to the control grids of both valves, in phase opposition, without the necessity of using push-pull transformers and in circumstances which prevent, to a large extent, undesirable locking in of the modulating potentials.

With the plates 3 connected together the circuit functions in known manner to produce, in the output circuit, modulation products corre-

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sponding to the sum and difference frequencies of the modulating potentials applied to the grids 4 whilst, at the same time, greatly attenuating the original modulating frequencies from the sources 7 and 9.

In a practical embodiment of the invention as incorporated in a beat frequency oscillator, the fixed modulation source 7 was adjusted to supply an output frequency of 88 kc. whilst the variable frequency modulation source 9 was adapted to provide output oscillations over a frequency range of from 68 to 88 kc. With this selection of modulating frequencies, beat frequencies within the range of from 0 to 20 kc. may be obtained across the output of the output filter and fed to any desired utilization circuit either directly or in controllable amplitude through a resistance potentiometer 22 or other convenient attenuator network in known manner.

The impedance unit 16 in the common cathode circuit comprises a parallel resonant L, C circuit tuned, in the present example, to 78 kc. which maintains a high impedance for all frequencies to be suppressed.

The value of the resistor 25 and the condenser 26 in the shunt connected resistance-capacity network in the input circuit of the valve V2 is chosen to provide an impedance which is low to harmonics generated in the variable oscillator 9 but high enough to supply sufficient grid voltage at the fundamental frequency. In conjunction with a large resistor at 10, this circuit also eliminates interaction due to voltage from the fixed oscillator 7 reacting with the variable oscillator 9 via the grid capacity of valve V2.

The circuit of the present invention permits the output filter to be of simple construction, one section being sufficient to attenuate harmonics and any fundamental appearing in the output.

The output filter in the present example comprises a single pi section network in which the impedance in the series arm is constituted by a parallel tuned circuit L¹, C¹, resonant at the same frequency as the tuned circuit L, C in the common cathode lead, and the shunt arms are capacities as indicated at 23, 24 in the drawing.

The invention could be applied to single sideband or suppressed carrier modulation, in which case the cathode load would be tuned to the carrier frequency.

Although, in the present example, the valves V1 and V2 have been shown as pentodes it is to be clearly understood that performance of the invention is not restricted to the use of valves of this type. Similar triodes or other convenient types may be employed without affecting the scope of the invention.

I claim:

1. In a modulation system, two electron discharge devices each having electrodes including a control grid, a cathode and an anode, a first source of oscillatory energy of carrier wave frequency connected between the control grid and cathode of one device, a second source of energy of lower frequency connected between the control grid and cathode of the other device, a frequency-variable impedance which is low at frequencies materially higher than the frequency of the energy in said last named source coupling the grid of said last named device to its cathode, an impedance which is high at the frequencies of said two sources common to the connections between the control grids and cathodes of both of said devices, whereby voltage variations on the control grid of said other device are set up in

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said last named impedance and are fed in phase opposed relation to the control grid of said one device, and an output including a low pass circuit connected between the anodes and cathodes of said devices.

2. A system as recited in claim 1 wherein said last-named impedance includes an inductance and capacitor in parallel tuned to approximately the frequency of said second-named source.

3. A system as recited in claim 1, wherein said last-named impedance includes a resistor in series with a parallel inductor and capacitor and a capacitor in parallel with said resistor.

4. A system as recited in claim 1, wherein said

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first-named impedance comprises a resistor and capacitor in parallel.

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