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FREQUENCY MODULATION OF KLYSTRONS

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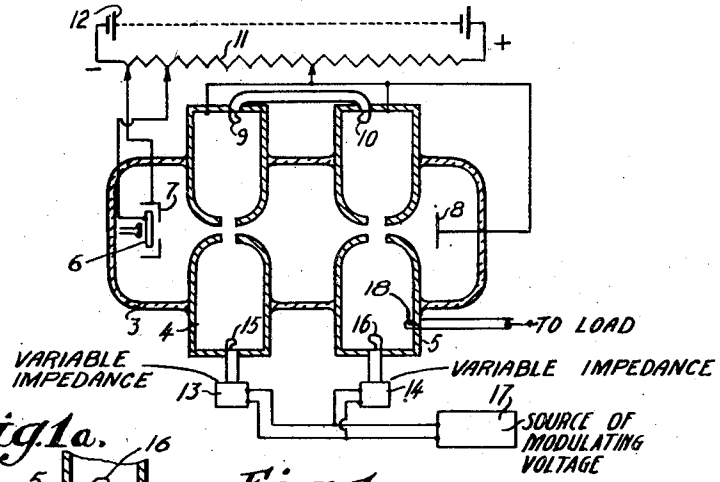
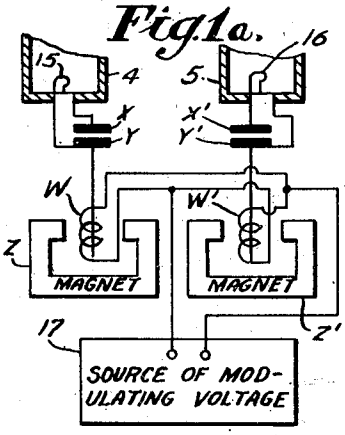


Fig. 1.



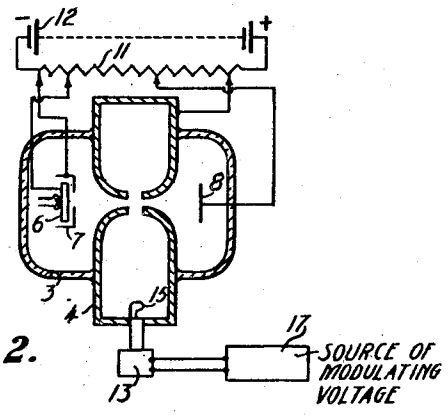


Fig. 2.

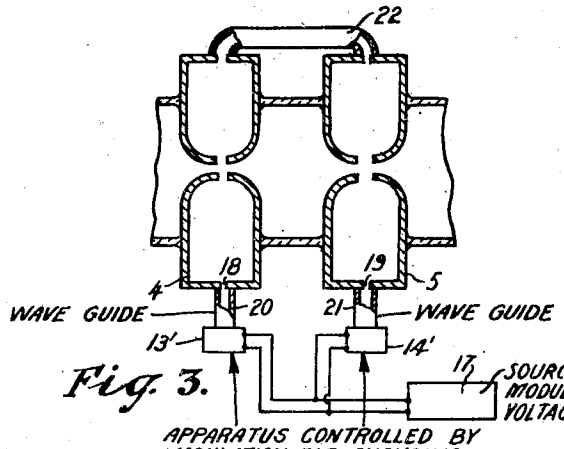


Fig. 3.

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FREQUENCY MODULATION OF KLYSTRONS

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4 Claims. (Cl. 332—25)

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This invention relates to the frequency modulation of oscillations generated by velocity-modulation discharge devices. In the specification of British Patent No. 548,095, dated September 24, 1942, it is suggested in a device, employing a resonator for imparting velocity modulation to a stream of electrons and a further resonator for abstracting the high frequency energy therefrom and for feeding it back to the first resonator, to effect frequency modulation of the generated oscillations by the provision of a variable impedance coupled to the output resonator, the impedance being varied at a modulation frequency. It is apparent that in this prior proposal frequency modulation is effected by effectively varying the tuning of the output resonator. This however results in a reduction of the amplitude of the signal output and furthermore the frequency modulation is thus accompanied by unwanted amplitude modulation. The object of the present invention is to provide an improved apparatus with a view to avoiding these disadvantages.

Although the specification aforesaid refers to oscillators having two resonators which are intercoupled for the purpose of generating oscillations, oscillators of the velocity-modulation type are also known which employ only a single resonator, the electron beam being velocity-modulated on passing through the resonator and then being reflected back through the resonator after the beam has become charge - density - modulated. The present invention can be applied both to this type of oscillator and the type of oscillator employing two resonators.

According to one feature of the present invention apparatus is provided for effecting frequency modulation comprising a velocity - modulation discharge device having a pair of resonators coupled together for the generation of oscillations and means for varying the tuning of both of the resonators simultaneously at the modulation frequency so as to effect frequency modulation of the generated oscillations.

According to another feature of the invention there is provided apparatus for effecting frequency modulation comprising a velocity-modulation discharge device employing a single resonator and means for reflecting the electron stream back into the resonator for the purpose of generating oscillations and means for varying the tuning of said resonator at the modulation frequency so as to effect frequency modulation of the generated oscillations. Any suitable means may be employed for varying the tuning of said resonators.

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In order that the said invention may be clearly understood and readily carried into effect, it will now be more fully described with reference to the accompanying drawings, in which—

Figure 1 is a diagrammatic view of apparatus according to the first-mentioned feature of the invention;

Fig. 1*a* is a similar view showing a detail of Fig. 1;

Figure 2 is a similar view according to the second-mentioned feature of the invention, and

Figure 3 illustrates a modification of Figure 1.

Referring now to Figure 1 of the drawings, the reference numeral 3 indicates the envelope of a discharge device of the velocity-modulation type, the device comprising a pair of hollow resonators 4 and 5 through which an electron beam emanating from a cathode 6 is caused to pass. The cathode 6 is associated with a cathode shield 7 and after the electrons have passed through the resonators 4 and 5 the beam is collected by an electrode 8. The two resonators 4 and 5 are coupled together so as to function as a regenerative oscillator by means of coupling loops 9 and 10. If desired, however, the resonators 4 and 5 may be coupled together in any other suitable manner. In operation of the device the cathode 6 is maintained at a negative potential, for example, by connecting it to a tapping point on a resistance 11 connected across a source of potential 12, whilst the cathode shield may be maintained at a more negative potential, as shown. The resonators 4 and 5 are maintained at a positive potential with respect to the cathode, whilst the electrode 8 is maintained at the same potential as that of the resonators 4 and 5 or at a slightly negative potential with respect thereto. The electron beam emanating from the cathode 6 in passing through the resonator 4 becomes velocity-modulated and in the drift space between the resonators 4 and 5 the beam becomes charge-density-modulated and the energy of the beam is then imparted to the resonator 5 as the beam passes therethrough to be collected by the electrode 8. Due to the coupling between the resonators the device functions to generate self-maintained oscillations at the frequency to which the resonators 4 and 5 are tuned. In order to effect frequency modulation of the generated oscillations the tuning of both of the resonators 4 and 5 is varied in any suitable manner. In the example shown in Figure 1, the means for varying the tuning of both resonators is shown diagrammatically as comprising variable impedances 13 and 14 which are coupled to the resonators 4 and 5 via coupling loops 15 and 16.

A source of modulating voltage 17 is applied to the impedances 13 and 14 so that the magnitude of the impedances will be varied at the modulation frequency whereby the tuning of both resonators 4 and 5 is varied at said modulation frequency. Since the tuning of both the resonators 4 and 5 is varied at the modulation frequency the amplitude of the frequency-modulated oscillations is maintained substantially constant thus avoiding the disadvantages hereinbefore referred to. The frequency-modulated oscillations may be fed to a suitable load from a coupling loop 18, coupled to the resonator 5. Each of the variable impedances 13 and 14 may, for example, comprise a pair of plates forming a capacity and one of the plates of each of said capacities may be varied at the modulation frequency by connecting said plates to a moving coil arranged in the gap of a permanent magnet; the voltages from the source 17 being fed to the moving coils. The arrangement may then be as illustrated in Figure 1*a*. One variable impedance includes plates X and Y of which plate Y is movable. The other variable impedance includes plates X' and Y' of which Y' is movable. Windings W and W' in the gaps of permanent magnets Z and Z' are energized by voltages from the source 17.

It is found that the oscillator shown in Figure 1 operates most satisfactorily when the resonators 4 and 5 are tuned to resonate with an optimum difference in their resonant frequencies. This optimum difference in resonant frequencies should of course be maintained for the range over which frequency-modulation is desired.

Figure 2 of the drawings illustrates apparatus according to the second-mentioned feature of the invention in which the device 3 employs only a single resonator 4 and the electron beam emanating from the cathode 6 is caused to be reflected back through the resonator 4 to generate self-maintained oscillations by causing the electrode 8 to function as a reflector by maintaining this electrode at a negative potential with respect to the resonator 4. The tuning of the resonator 4 is varied in any suitable manner to effect frequency modulation of the generated oscillations.

Instead of employing coupling loops 15 and 16 for effecting frequency modulation a waveguide may be employed having a variable quality which functions to cause variation of the tuning of the resonators 4 and 5 at the modulation frequency. Figure 3 of the drawings illustrates a portion of an electron discharge device in which the tuning of the resonators 4 and 5 is effected by the provision of waveguides. The resonators 4 and 5 are each provided with slot-like apertures 18 and 19 communicating with waveguides 20 and 21 of rectangular form in cross-section the minor dimension of each of which is shown in Figure 3. Each waveguide 20 and 21 may be provided with an adjustable element, included in rectangles 14' and 13' in the form of a piston or a conducting pillar projecting into said waveguides or a mass of dielectric material, the position of said adjustable element being varied in accordance with voltages from the source 17. The two resonators 4 and 5 instead of being coupled together by loops 9 and 10 as in Figure 1 may be coupled by a waveguide indicated at 22.

What I claim is:

1. Apparatus for effecting frequency modulation comprising a velocity-modulation discharge device having a pair of resonators coupled together for the generation of oscillations, a source of modulating potentials and means coupled with said source and with said resonators and actuated by voltages from said source for varying the tuning of both of the resonators simultaneously at the modulation frequency so as to effect frequency modulation of the generated oscillations.

2. In an ultra high frequency signalling system, a velocity modulated discharge system including a pair of resonators and electron stream producing electrodes adjacent thereto for passing an electron stream therethrough, feed back couplings between said resonators for the generation of oscillations of ultra high frequency, a variable impedance coupled to each of said resonators, a source of modulating voltage and apparatus coupled to said source and to said variable impedances and adapted to be actuated by modulating voltage from said source for varying said impedances simultaneously in accordance with variations in the magnitude of the modulating voltage.

3. A signalling system as recited in claim 2 wherein said feed back couplings between said resonators for the generation of oscillations include a loop in each resonator and a coupling between said loops.

4. A system as recited in claim 2 wherein said variable impedances each comprise a loop in the resonator and wherein said loops are each coupled with a variable reactance and wherein said reactances are varied simultaneously in accordance with variations in the magnitude of the modulating voltage.

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Disclaimer

2,464,549.—*Norman Charles Barford*, Hayes, England. FREQUENCY MODULATION OF KLYSTRONS. Patent dated Mar. 15, 1949. Disclaimer filed Apr. 17, 1951, by the assignee, *Electric & Musical Industries Limited.*

Hereby enters this disclaimer to claims 1 to 4, inclusive, of said patent.

[*Official Gazette June 5, 1951.*]