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MODULATING SYSTEM

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Fig. 1

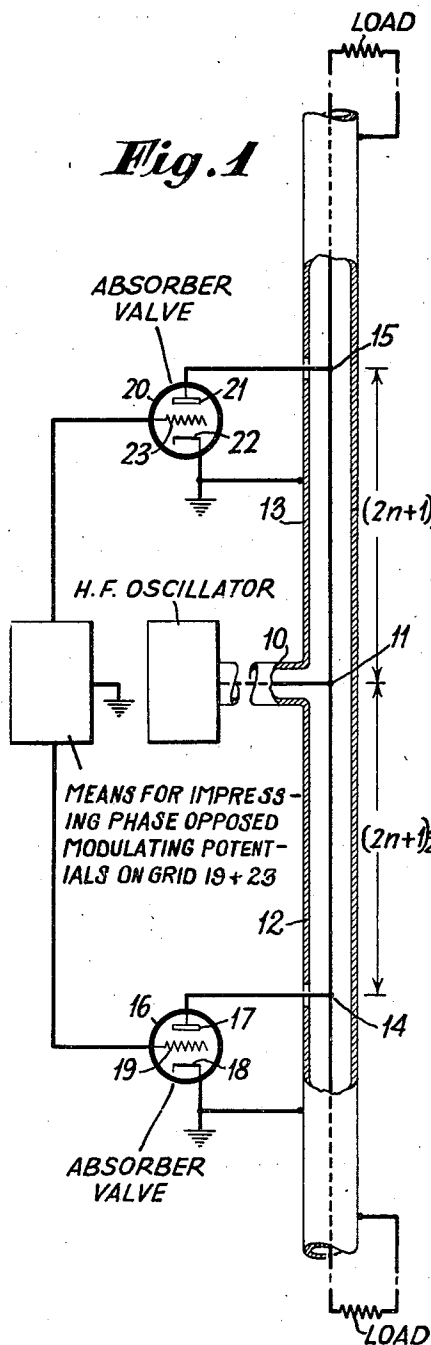
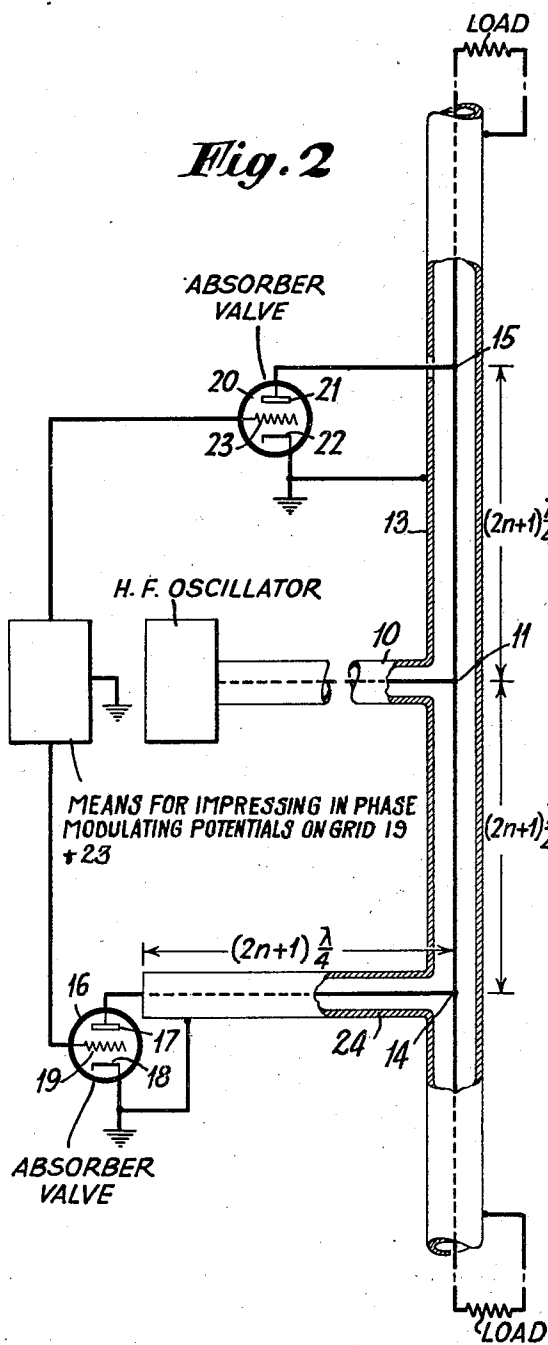


Fig. 2



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MODULATING SYSTEM

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24 Claims. (Cl. 179—171.5)

This invention relates to modulating systems and is more particularly concerned with the modulation of very high frequency oscillations.

For producing continuous oscillations of frequencies of the order of about 600 megacycles per second and greater, the only known sources existing at present are oscillators of the magnetron and Barkhausen-Kurz type. Moreover, with the technique at present available it is not found possible to obtain amplification of oscillations having such frequencies. In a transmitter, therefore, designed to work at those frequencies it is necessary that the oscillator itself should drive the aerial, and that modulation should be effected upon this oscillator. With the only available types of oscillator already referred to, attempts to bring about amplitude modulation in accordance with normal principles, namely, by a variation of supply potentials, result in a simultaneous and appreciable degree of frequency modulation. The addition of this latter modulation is undesirable for various reasons, e. g. it means that the transmitter occupies a wider band of frequencies in the frequency spectrum than is normally required, so that, for instance, difficulties of wide band transmission are increased unnecessarily and it has been proposed in order to overcome this difficulty, that the method of absorption modulation should be applied to such transmitters. Thus it has been suggested to connect an absorber device across the transmission line from the oscillator to the aerial, so as to modulate the energy passed to the aerial, by suitably applying modulation potentials to the absorber device.

This method suffers from the defect that the absorber device must necessarily cause a mismatching of impedance in the transmission line at the point at which it is connected with the result that energy is reflected back upon the oscillator. Thus, the oscillator does not function under steady conditions, and as a result there is again introduced an appreciable degree of frequency modulation.

The present invention is concerned with overcoming this difficulty, and provides novel means for modulating oscillators of the type referred to above by an absorption modulation method in which the load presented to the oscillator remains constant, so that frequency variations do not arise.

In accordance with the invention there is provided a modulation system adapted to be connected in the transmission path coupling a generator of high frequency oscillations with a load,

for modulating the oscillations fed to said load, comprising two modulation paths arranged so as to be capable of modulating oscillations transmitted along them by varying the impedance presented by said paths to said oscillations, wherein one of said paths is adapted to be terminated at one end in a terminating impedance, and the second of said paths is adapted at one end to be connected to said load, the other ends of said paths being joined so that said paths branch out from a branch point which is adapted to be connected to said generator, the second of said paths in operation thus being capable of modulating oscillations transmitted by it to said load from said generator, said system being so arranged that in operation, the modulations effected upon oscillations transmitted by both paths are so interrelated that said system presents to said generator an impedance at said branch point which is substantially independent of the degree of modulation of said oscillations fed to said load.

More specifically there is provided in accordance with the invention a modulation system for modulating high frequency oscillations comprising a pair of high frequency transmission lines joined together at one end so that they branch out from a branch point, each being substantially a quarter of a wavelength long ($\lambda/4$) at the operating frequency or an odd multiple thereof, and each possessing substantially the same characteristic impedance and devices of variable impedance capable of being controlled by modulating signals connected one across each of said lines at the ends remote from said branch point and arranged so that under the control of modulating signals applied to each the product of their impedances can be maintained substantially equal to the square of said characteristic impedance, whereby when said lines at said remote ends have further connected to them impedances substantially equal to said characteristic impedance, high frequency oscillations fed into said system at said branch point appear modulated by said modulation signals at either of said remote ends of said lines, and the input impedance of said system at said branch point is maintained substantially equal to said characteristic impedance.

It will be appreciated that such a modulation method may be employed to modulate in amplitude the oscillations generated by any source, without there being any tendency for the process of modulation to cause a change of frequency of the oscillations generated by the source in par-

ticular, the method is of application to modulating oscillators of the very high frequency electron oscillation type.

The principles of the invention may be better understood by considering a system in accordance with the above more specific statement of invention, namely, a pair of transmission lines of characteristic impedance Z_0 joined at one end and having connected across them respectively, at a distance equal to a quarter of the operating wavelength, impedances R_1 and R_2 , the lines may continue beyond the points at which R_1 and R_2 are located, but it will be assumed that at their ends they are terminated reflectionlessly. That line having the impedance R_2 connected across it may be terminated in a resistive impedance of magnitude Z_0 , the other may be terminated with proper matching in the impedance of a transmitting aerial, so that waves transmitted past the impedance R_1 are not returned. The waves may be fed into the system from a source at the junction or branch point previously referred to.

Suppose that Z_1 is the impedance looking into the branch feeding the aerial, and that Z_2 is the impedance looking into the other branch. Then these impedances are determined by the equations

$$Z_1 \cdot \frac{R_1 Z_0}{R_1 + Z_0} = Z_0^2$$

$$Z_2 \cdot \frac{R_2 Z_0}{R_2 + Z_0} = Z_0^2$$

and the impedance Z presented by both branches to the source is given in accordance with the relation

$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

It follows from these equations that Z may be made to have a constant value Z_0 if the condition

$$R_1 R_2 = Z_0^2$$

is always satisfied. According to a feature of the invention means are provided whereby this condition may be achieved in practice, this feature will be described later.

In modulating system operating in accordance with these principles, and assuming that R_1 and R_2 are substantially resistive, the fraction of the power supplied to the aerial branch which is actually transmitted to the aerial is

$$\frac{R_1}{R_1 + Z_0}$$

The power transmitted into the aerial branch, as a fraction of the total power supplied to the system is easily shown to be also

$$\frac{R_1}{R_1 + Z_0}$$

Thus the fraction of the total power supply to the whole system, which is actually delivered to the aerial, is

$$\left(\frac{R_1}{R_1 + Z_0} \right)^2$$

This is unity for $R_1 = \infty$ and is zero for $R_1 = 0$. Thus by modulating the value of R_1 from an infinite value to zero the carrier wave fed to the aerial may be fully modulated. The depth of modulation will be less, the less nearly the value of R_1 is made to approach zero.

In order to describe more fully the manner in which the invention may be carried into effect, reference will now be made by way of example to the accompanying drawing, in which:

Figure 1 shows, in diagrammatic form, a pair

of quarter wavelength transmission lines in accordance with the invention, to which are connected two absorbing valves for the purpose of modulating the high frequency energy generated by an oscillator (not shown), and

Figure 2 shows a modulating system like that illustrated in Figure 1, but in which means are illustrated whereby the impedance of the absorbing valves may effectively be made to obey the impedance relationship referred to above.

Referring in more detail to Figure 1, high frequency energy is conveyed from an oscillator (not shown) along the coaxial line 10 to the branch point 11, at which the line branches into a pair of lines 12 and 13, both having the same characteristic impedance as the line 10. At the points 14 and 15 respectively on the lines 12 and 13 are connected the absorbing valves 16 and 20, the point 14 being located at one quarter of a wavelength ($\lambda/4$) from the branch point 11, and the point 15 being similarly located on the line 13. The anode 17 of valve 16 is connected to the inner conductor of the line 12 at the point 14, and its cathode 18 is connected to the outer conductor. In a similar manner the anode 21 of valve 20 is connected to the inner conductor of line 13 at the point 15 and its cathode 22 is connected to the outer conductor. The impedances thereby placed across the lines 12 and 13, at the points 14 and 15 respectively, are controlled by applying potentials to the control-grids 19 and 23 respectively of the valves 16 and 20. These control potentials must be of opposite sign to each other and so related in magnitude that the product of the impedances is always maintained equal to the square of the characteristic impedance of the lines. If then the lines 12 and 13 are so terminated that no waves are reflected back along them after transmission past the points 14 and 15, the system will modulate in the manner already described, without reflecting any energy back to the oscillator along the line 10.

Figure 2 shows a system like that illustrated in Figure 1, in which one of the absorbing valves is so connected to the line, that the necessity of applying correctly related control potentials to the grids of the absorbing valves is avoided, and instead the same potential is applied to each grid. This is effected simply by inserting a length of line 24, equal in length to a quarter of a wavelength ($\lambda/4$) at the operating frequency, between one of the absorbing valves, the valve 16 as shown in Figure 2, and its point of connection to one of the branch lines, namely the point 14 on the branch line 12 in this figure. Thus instead of connecting the anode 17 directly to the inner conductor of line 12 at the point 14, the anode is connected thereto via the inner conductor of the line 24. The cathode 18 is connected to the outer conductor of this line. If then the characteristic impedance of the line 24 is the same as that of the other lines, the impedance at the point 14 will be the correct inverse of the impedance at the point 15, assuming that the same potentials are applied to the control grids 19 and 23. The valves are assumed to be similar.

It will be appreciated that the arrangements described above illustrate only the essential features of the invention, and other arrangements are possible, differing in detail, but embodying the same essential features. Thus in Figure 1, for example, if the range of variation of impedance provided by the valves, shown therein, is insufficient to perform proper modulation, these

impedances may be transformed by a suitable transformer arrangement, such as a quarter wavelength line of suitable characteristic impedance or by a transforming network. Also diodes may be used instead of triodes.

We claim:

1. A modulation system for modulating high frequency oscillations comprising a pair of high frequency transmission lines joined together at one end so that they branch out from a branch point, each being substantially a quarter of a wavelength long at the operating frequency or an odd multiple thereof, and each possessing substantially the same characteristic impedance, devices of variable impedance capable of being controlled by modulating signals connected one across each of said lines at the ends remote from said branch point, means applying modulating signals to said devices of such relative values and polarity that the product of their impedances is substantially equal to the square of said characteristic impedance, impedances substantially equal to said characteristic impedance connected to said lines at said remote ends, and means for feeding high frequency oscillations into said system at said branch point, whereby said oscillations appear modulated by said modulation signals at either of said remote ends of said lines, and the input impedance of said system at said branch points is maintained substantially equal to said characteristic impedance.

2. A modulating system according to claim 1, wherein said devices of variable impedance comprise electron discharge devices having preferably in addition to anode and cathode electrodes the impedances of the electron paths between which are used for modulating said high frequency oscillations, control electrodes to which said modulating signals can be applied so as to vary the impedance of said electrons paths.

3. In high frequency signalling apparatus, a source of high-frequency wave energy, a plurality of load impedances, a plurality of similar transmission lines connecting said source to said load impedances, the impedances of said loads matching the impedances of the respective lines by which they are connected to said source, and a controllable resistance which is variable over a desired range shunting each of said lines at a distance equal to

$$(2n+1)\frac{\lambda}{4}$$

from said source, wherein λ represents the length of the operating wave, and a source of signal modulating potentials coupled to said controllable resistance.

4. In high-frequency signalling apparatus, a source of high-frequency wave energy to be modulated, two load impedances, two similar transmission lines connecting said source to said load impedances, the impedances of said loads matching the impedance of the respective lines by which they are connected to said source, a resistance variable at signal frequency shunting each line at a distance equal to

$$(2n+1)\frac{\lambda}{4}$$

from said source, wherein λ represents the length of the operating wave, and means for varying the ratio of said resistances at signal frequency while maintaining their product equal to the square of the characteristic resistance of the lines.

5. In high frequency signalling apparatus a

source of high frequency wave energy to be modulated, two load impedances, two substantially similar transmission lines connecting said source to said load impedances respectively, the impedances of said loads matching the impedance of the respective lines by which they are connected to said source, an impedance variable at signal frequency shunting one of said lines at a distance equal to

$$(2n+1)\frac{\lambda}{4}$$

from said source, a second impedance variable at signal frequency, a third transmission line of a length equal to

$$(2n+1)\frac{\lambda}{4}$$

coupling said second impedance to the other of said similar transmission lines at a point

$$(2n+1)\frac{\lambda}{4}$$

from said source, and means for varying said impedances substantially in phase at signal frequency, wherein λ represents the length of the operating wave.

6. In a modulation system, a wave generator, a load, a first path coupling said generator to said load, a second load of the order of impedance of said first load, a second path coupling said generator to said second load, means for varying the impedances of said paths in accordance with modulating potentials to thereby vary the energy fed to said loads, said means including separate current paths coupled to said first and second paths at points substantially symmetrically located with respect to the junction of said generator and said first and second paths, and including elements for controlling the relative impedances of the respective current paths such that said first and second paths and said loads present to said generator an impedance which is substantially independent of the degree of modulation.

7. A modulation system for modulating high frequency oscillations comprising a pair of high frequency transmission lines joined together at one end so that they branch out from a branch point, each being substantially a quarter of a wavelength long at the operating frequency or an odd multiple thereof, and each possessing substantially the same characteristic impedance, said lines at their remote ends having connected to them impedances substantially equal to said characteristic impedance, means for feeding high frequency oscillations into said system at said branch point, and a pair of electron discharge devices of variable impedance capable of being controlled by modulating signals connected one across each of said lines at the ends remote from said branch point, each device having an anode, cathode and a control electrode, means for applying in-phase modulating potentials to the control electrodes of said devices, means coupling the anode to cathode impedance of one of said devices substantially directly to the said remote end of one of said pair of high frequency transmission lines, means coupling the anode to cathode impedance of another of said devices to the remote end of the other of said pair of transmission lines by a third transmission line of such length that when modulation signals of like phase are applied to said control electrodes of said electron discharge devices the product of the impedances between the anode to cathode

of said devices is maintained substantially equal to the square of said characteristic impedance, and the input impedance of said system at said branch point is maintained substantially equal to said characteristic impedance.

8. In high frequency signalling apparatus, a source of high frequency waves, a pair of transmission line sections having substantially the same characteristic impedance Z_0 joined together at one end, a section of transmission line also having substantially the characteristic impedance Z_0 connecting said source to the junction point of said pair of lines, a load of characteristic impedance Z_0 connected to each of the other ends of said pair of lines, controllable variable impedances R_1 and R_2 in the form of electron discharge devices connected respectively across said pair of line sections at points substantially an odd multiple of one-quarter including unity of the length of the operating wave away from the joined ends of said pair of lines, and means for applying modulating potentials to said devices of such relative values and polarities that the relation $R_1 R_2 = Z_0^2$ holds true over a desired range of variation of said variable impedances.

9. A constant impedance load device including separate current paths, each of said paths including a fixed and a variable impedance, and means for varying the impedance of said paths in accordance with the equation

$$R_1 R_2 = R_0^2$$

where R_1 is the instantaneous impedance of the variable portion of one of said paths, R_2 is the instantaneous impedance of the variable portion of the other of said paths, and R_0 is the fixed impedance portion of each of said paths.

10. A load device adapted to be connected to a source of energy, said device having separate current paths, each of said paths comprising a fixed and a variable impedance, and means for varying said variable impedances in accordance with the equation

$$R_1 R_2 = R_0^2$$

where R_1 and R_2 are, respectively, the instantaneous values of said variable impedances, and R_0 is the impedance of said fixed impedance, whereby the distribution of current in said paths is varied and the load impedance is constant.

11. A modulation system which includes a source of radio frequency currents, a source of modulating energy, a load circuit connected to said source of radio frequency currents and comprising separate current paths, at least one of said paths including an antenna, variable impedance electron discharge device means responsive to said modulating energy in each of said paths for varying the distribution of said radio frequency current between said paths, and an impedance inverter in circuit with one of said variable impedance means for maintaining constant the total radio frequency current from said source.

12. A modulation system which includes a source of radio frequency power, a source of modulating energy, a load circuit connected to said source of radio frequency power and comprising separate parallel current paths, at least one of said paths including an antenna, variable impedance means in each of said paths responsive to said modulating energy for varying the power in said paths, said variable impedance means being connected to its associated path at a point which is an odd multiple of a quarter wavelength at the operating frequency from said

source of radio frequency power, and an impedance inverter in circuit with one of said variable impedance means for maintaining constant the total radio frequency power from said source.

13. A modulation system which includes a source of radio frequency current, a source of modulating energy, a load circuit connected to said source of radio frequency current comprising separate current paths, each of said paths containing a variable impedance and a fixed impedance, and means responsive to said modulating energy for varying said variable impedances in accordance with the equation

$$R_1 R_2 = R_0^2$$

where R_1 and R_2 are, respectively, the instantaneous values of said variable impedances, and R_0 is the value of said fixed impedance, whereby the radio frequency current through said paths is varied and the total current is constant.

14. A device of the character described in claim 13, in which at least one of said fixed impedances is an antenna.

15. A constant impedance load device for a source of alternating current including separate current paths, each of said paths comprising shunt connected fixed and variable impedances, said variable impedances being connected to their respective fixed impedances at points which are an odd multiple of a quarter wavelength at the operating frequency from said source, the variable impedance of one of said paths being connected to its associated fixed impedance through an impedance inverter, and means for varying said variable impedances in like sense and amount to vary the relative impedances of said paths and to maintain constant the input impedance of said load device.

16. A constant impedance load device comprising two parallel connected load impedances, each of said impedances comprising a fixed and a variable impedance connected in parallel and means for varying said variable impedances in accordance with the equation

$$R_1 R_2 = R_0^2$$

where R_1 and R_2 are the instantaneous values of the respective variable impedances, and R_0 is a constant.

17. A device of the character described in claim 16, in which at least one of said fixed impedances includes an antenna.

18. A device of the character described in claim 16, in which said means for varying said variable impedances includes a source of modulating voltage, and at least one of said fixed impedances includes an antenna.

19. A constant impedance load device including parallel current paths, each of said paths including a fixed and a variable impedance, and means for varying the impedance of said paths in accordance with the equation

$$R_1 R_2 = R_0^2$$

where R_1 is the instantaneous impedance of the variable portion of one of said paths, R_2 is the instantaneous impedance of the variable portion of the other of said paths, and R_0 is the fixed impedance of both of said paths.

20. A constant impedance load device comprising a pair of fixed impedances of equal value and a pair of variable impedances, means for varying said variable impedances in accordance with modulating signals, and means for maintaining

the square root of the product of said variable impedances constant and of said value so that the input impedance of said device is constant.

21. A load device adapted to be connected to a source of energy, said device having separate current paths, each of said paths comprising a fixed and a variable impedance, and means for varying said variable impedances, said means including means for maintaining constant and equal to said fixed impedance the square root of the product of said variable impedances, so that the distribution of current in said paths is varied so as to maintain a constant total current from said source.

22. A load device adapted to be connected to a source of energy, said device having separate current paths, each of said paths comprising a fixed and a variable impedance, the fixed impedances of said paths being equal, and means for varying said variable impedances in accordance with the equation $R_1 R_2 = R_0^2$, where R_1 and R_2 are, respectively, the instantaneous values of said variable impedances, and R_0 is the impedance of said fixed impedance, whereby the distribution of current in said paths is varied and the load impedance is constant.

23. The method of producing modulated signals which comprises applying a carrier signal to each of a pair of loads, varying a pair of resistances in opposite phase in accordance with a modulating signal, coupling one of said varying resistances without inversion thereof to one of said loads, coupling the other of said varying resistances with inversion thereof to said other load, and utilizing the resultant modulated output signal of said pair of loads.

24. A signal modulating system comprising a pair of load circuits having input terminals, means for applying a carrier signal to each of said pair of input terminals to develop power in said loads in accordance with said signal, a pair of variable resistances, means for varying said resistances in opposite phase in accordance with a modulating signal, plural means including one impedance-inverting member for coupling said variable resistances to said input terminals to control the power developed in said loads, said loads developing therein a modulated carrier signal.

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