

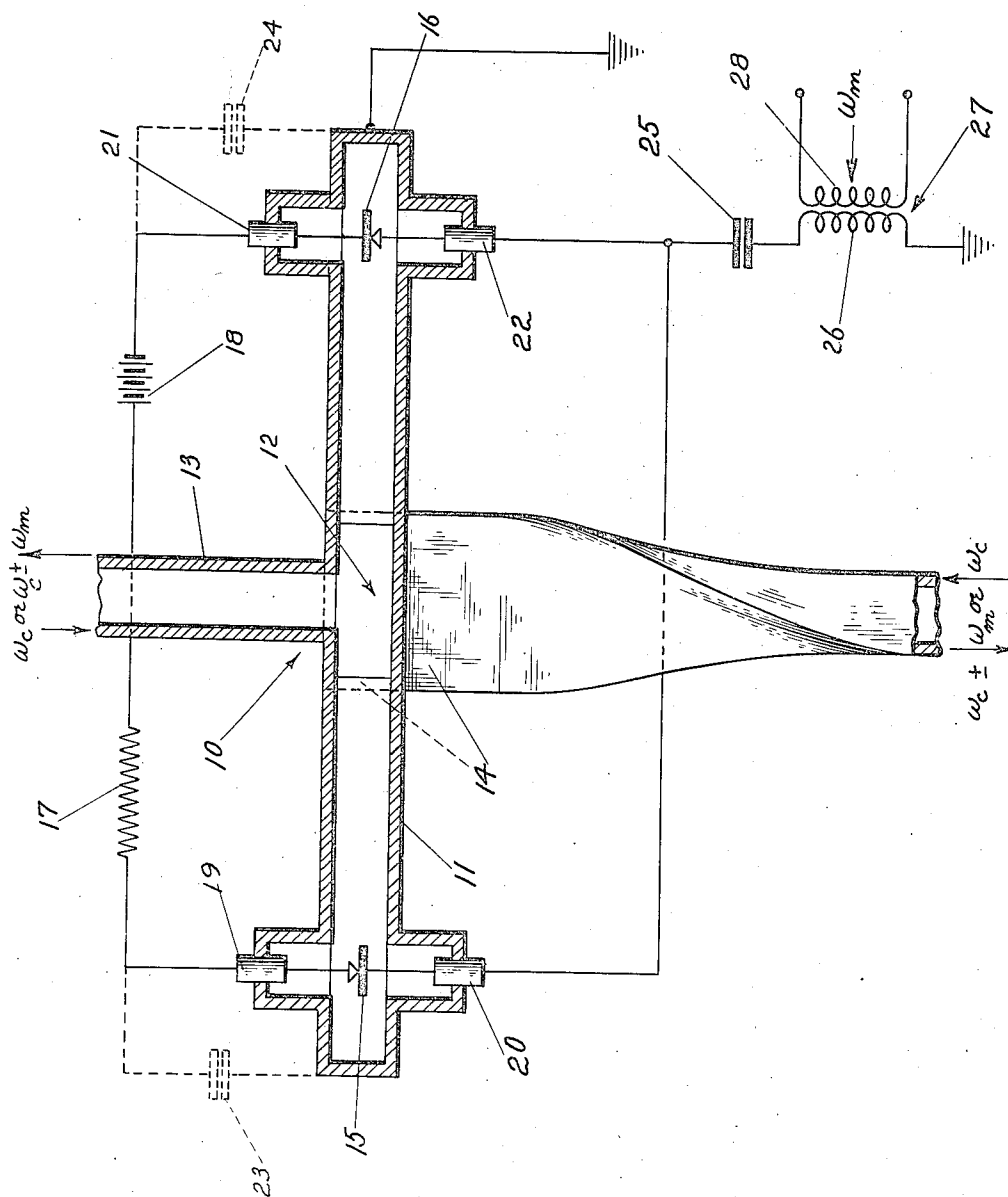
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MODULATOR

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MODULATOR

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This invention relates to modulating apparatus, and more particularly to apparatus for modulating electromagnetic energy in the microwave region of the spectrum.

While not limited thereto, the present invention is admirably adapted for use as a balanced modulator in the local frequency-controlling section of the terminal station disclosed in the co-pending application of George G. Bruck, Philip E. Volz, Paul J. Pontecorvo and Malcolm C. Vosburgh, entitled "Radio communication system," Serial No. 650,716, filed February 27, 1946.

One of the objects of the present invention is to provide a suppressed-carrier modulator in which impedance-matching problems, normally difficult of solution, are considerably simplified.

Another object of the present invention is to provide a balanced modulator capable of handling a relatively wide frequency band with a minimum of distortion.

These, and other objects of the present invention, which will become more apparent as the detailed description thereof progresses, are attained, briefly, in the following manner:

The invention contemplates the provision of means, for example, a wave-guide section, having a perpendicularly extending branch arm receptive of a carrier wave, for deriving from said carrier wave two constituent waves of opposite phase. Said constituent waves are applied to means, for example, a pair of series-connected, non-linear impedances which terminate the opposite ends of said wave-guide section, which are also receptive, in parallel, of a modulation wave, whereby two additional constituent waves of opposite phase are derived and combined, respectively, with said first-named constituent waves to produce sideband waves. Said sideband waves, together with portions of said first-named constituent waves reflected from said non-linear impedances, are fed to means, for example, a second branch arm extending perpendicularly from said wave-guide section, perpendicularly to said first-named branch arm, whereby said sideband waves are combined and transmitted to a load, and said reflected portions of said first-named constituent waves are combined so as to suppress the same in the direction of said load.

In the accompanying specification there shall be described, and in the annexed drawing shown, an illustrative embodiment of the modulating apparatus of the present invention. It is, however, to be clearly understood that the present invention is not to be limited to the details herein shown and described for purposes of illustration

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only, inasmuch as changes therein may be made without the exercise of invention, and within the true spirit and scope of the claims hereto appended.

In said drawing, the single figure is a schematic diagram of a modulating device assembled in accordance with the principles of the present invention.

Referring now more in detail to the aforesaid illustrative embodiment of the present invention, with particular reference to the drawing illustrating the same, the numeral 13 generally designates what may be termed a double T-shaped wave-guide assembly. Such an assembly includes a cross-arm 11 from the center of which, or from what will hereinafter be called a common junction 12, extend two branch arms 13 and 14, said cross-arm being common to both Ts, and said branch arms being perpendicular to said cross-arm, and to each other. As herein shown, the branch arm 14 recedes from the observer for a short distance from the common junction 12, then bends downwardly, and is then twisted through an angle of 90°.

The opposite ends of the cross-arm terminate, respectively, in non-linear impedances, for example, rectifying crystals 15 and 16, said crystals being oppositely disposed with respect to each other, and connected in series through a resistor 17 and a source 18 of direct current. The conductors connecting said crystals pass through insulators 19 to 22, inclusive, mounted in the cross-arm 11, the insulators 18 and 21 being of such construction (not specifically shown) as to present capacitances 23 and 24 between one side of each of said crystals and the cross-arm itself, the latter being grounded as shown. The crystals 15 and 16 are further connected to provide parallel inputs to ground through a capacitor 25 and the primary winding 26 of an output transformer 27 having a secondary winding 28.

The source 18 of direct current constitutes a bias for the purpose of enabling operation of the crystals at favorable points along their characteristic curves, and the series circuit is for the purpose of passing equal currents through said crystals to assure their similar behavior even though both be mismatched to the wave-guide assembly.

For an understanding of the operation of the device, assume that a carrier wave ω_c is traveling down the branch arm 13 toward the common junction 12 with its electric vector pointing, arbitrarily, to the right. As this wave reaches the junction 12, it splits into two constituent waves,

one, having its electric vector pointing downwardly, traveling along the cross-arm wave-guide section 11 toward the crystal 15, and the other, having its electric vector pointing upwardly, traveling along said wave-guide section 11 toward the crystal 16.

Now, further assume that a modulation wave ω_m is applied to the transformer 27, and that the two constituent waves derived therefrom by reason of the parallel connection thereof across the crystals 15 and 16 have their electric vectors pointing in the same direction, arbitrarily, downwardly.

Thus, there arrives at the crystal 15 two similarly-phased constituent waves, and there arrives at the crystal 16 two oppositely-phased constituent waves. However, because of the opposite disposition of the crystals 15 and 16 with respect to each other, it can be considered that the modulating constituent wave arriving at that crystal with respect to whose conducting direction said constituent wave is out of phase, in the case under consideration, the crystal 16, is, in effect, phase shifted 180° . Therefore, effectively, the waves at said crystal 16 are of like phase, although their phase is opposite to that of the similarly-phased constituent waves at the crystal 15. As a result, the phases of the sideband waves $\omega_c \pm \omega_m$ produced, respectively, at the crystals 15 and 16 may be considered positive inasmuch as the component waves of each are of like phase.

The similarly-phased sideband waves thus produced, together with the out-of-phase portions of the carrier constituent waves reflected from the crystals 15 and 16, travel along the wave-guide section 11 toward the common junction 12. At said junction, the sideband waves combine and are propagated along the branch arm 14. The crystal-reflected carrier waves combine and are propagated back along the branch arm 13 from whence the initial carrier wave came, but since these crystal-reflected carrier waves are of opposite phase, they are suppressed in the direction of the branch arm 14. Thus sideband and carrier waves are effectively separated.

While the branch arm 13 has, in the foregoing description, been considered as the input for the carrier wave, it is desired to point out that the branch arm 14 may be used as the input for the carrier, in which case the branch arm 13 becomes the output for the sidebands.

This completes the description of the aforesaid illustrative embodiment of the present invention. Objects and advantages thereof, in addition to those set forth in earlier portions of this specification, will readily occur to those skilled in the art to which the same relates.

What is claimed is:

1. Modulating apparatus comprising: a wave-guide section, having a perpendicularly extending branch arm receptive of a carrier wave, for deriving from said carrier wave two constituent waves; a pair of series-connected, non-linear impedances terminating the opposite ends of said wave-guide section, receptive, in parallel, of a modulation wave and receptive of said constituent waves, for deriving from the former two additional constituent waves of opposite phase, and combining the same, respectively, with said first-named constituent waves whereby sideband waves are produced; and a second branch arm extending perpendicularly from said wave-guide section, perpendicularly to said first-named branch arm, receptive of said sideband waves and receptive of portions of said first-named constituent waves reflected from said non-linear impedances, for combining said sideband waves and transmitting the same to a load, and combining said reflected portions of said first-named constituent waves and suppressing the same in the direction of said load.

2. A balanced modulator comprising: a wave-guide section having series-connected, non-linear impedances terminating the opposite ends thereof; a carrier-receiving branch arm extending perpendicularly from said wave-guide section; a source of modulation; an impedance, receptive of said modulation, connected, in parallel, across said non-linear impedances; and a sideband-receiving branch arm extending perpendicularly from said wave-guide section, perpendicularly to said carrier-receiving branch arm.

3. A balanced modulator comprising: a wave-guide section having crystal detectors terminating the opposite ends thereof; a carrier-receiving branch arm extending perpendicularly from said wave-guide section; a source of modulation; an impedance, receptive of said modulation, connected, in parallel, across said crystal detectors; and a sideband-receiving branch arm extending perpendicularly from said wave-guide section, perpendicularly to said carrier-receiving branch arm.

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The following references are of record in the file of this patent:

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