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MODULATING SYSTEM

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2,055,662

FIG. 1

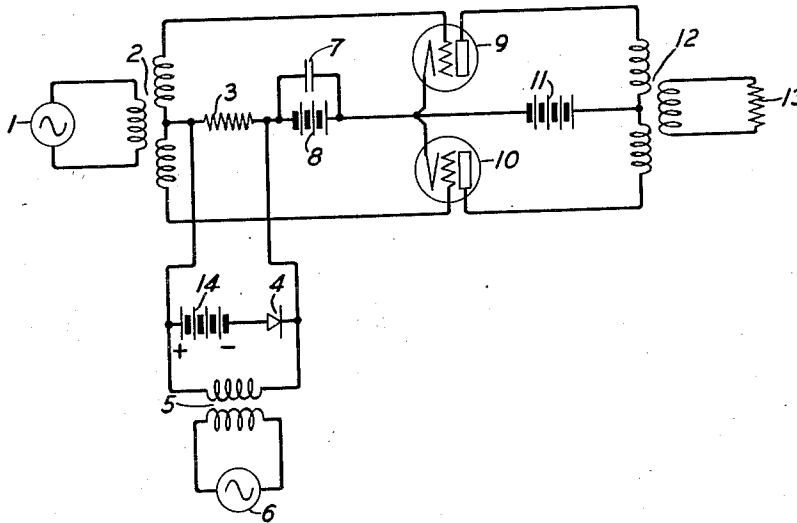
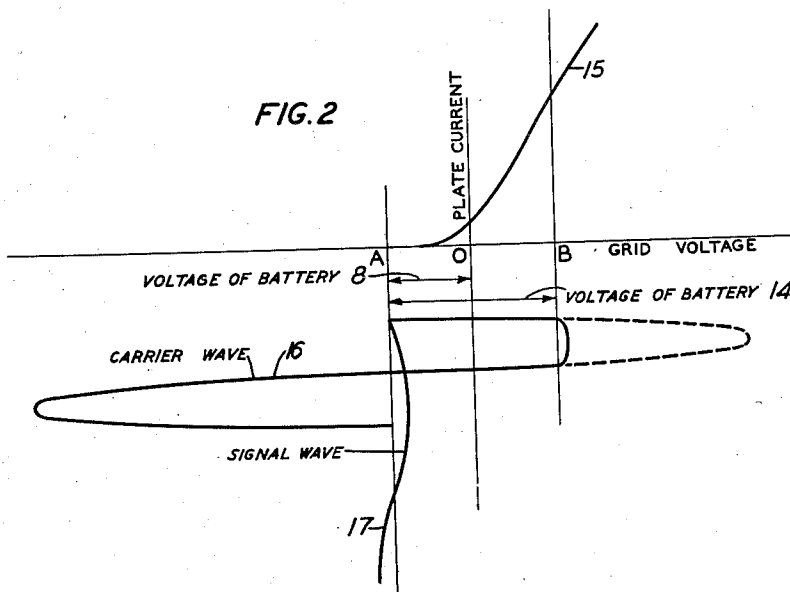


FIG. 2



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MODULATING SYSTEM

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11 Claims. (Cl. 179—171)

This invention relates to modulating or frequency changing systems such as modulators, demodulators or detectors and particularly to arrangements for simultaneously shifting a plurality of transmission channels as a unit from one frequency range to another.

An object is to interrupt or commutate a signal wave at a high frequency rate with improved sharpness and greater definition.

Another object is to effect simultaneous commutation of a plurality of transmission channels with the minimum of inter-channel modulation.

In double modulation arrangements for multiple channel systems the problem arises of modulating a plurality of independent transmission channels with a single carrier frequency to shift the channels to a new frequency range without excessive inter-channel modulation. If the modulating element comprises a variable resistance or other variable impedance the variation necessarily causes inter-modulation between the signals of two or more channels. This effect is known as inter-channel modulation. The condition for securing the desired modulation free from inter-channel modulation is that the signal wave be interrupted periodically at the carrier frequency rate and that in the interval between interruptions the impedance of the modulating element shall be constant. Under these ideal conditions the system transmits a series of undistorted segments of the signal wave. The result is a chain of impulses at the new carrier frequency rate with an envelope which retains undistorted all the characteristics of the original signal wave.

In accordance with the invention a modulator of the variable impedance type such as a vacuum tube modulator is provided with a biasing voltage causing the device to have normally a substantially infinite impedance. The modulator is supplied with a square topped carrier wave instead of the usual sinusoidal form of carrier wave. The impressed carrier voltage causes the modulator to shift from the normally high impedance condition to a condition of very low impedance. The voltage of the impressed carrier is adjusted to bring the operating point of the modulator to the most linear portion of the characteristic. The carrier wave thus causes the modulator to alternate between a non-transmitting condition and a transmitting condition, each being accompanied by a very stable value of impedance. The signal wave is impressed upon the modulator along with the square topped carrier wave, the signal being transmitted without ma-

terial distortion during the low impedance interval and being substantially suppressed during the high impedance interval. The action of the device approaching that of an ideal commutator capable of very rapid operation greatly exceeding the rate of operation of any known mechanical commutator.

Provision is made for converting a sinusoidal carrier wave into a square topped wave by means of a voltage limiting arrangement employing a biased two-element tube.

The invention may be more fully understood from the following description and the accompanying drawing in which Fig. 1 shows a circuit embodying the invention, and Fig. 2 is an explanatory diagram.

The numeral 1 designates a source of signal oscillations the output of which is connected through a three-winding transformer 2 to the grids and cathodes of vacuum tubes 9, 10. The anodes of the vacuum tubes are connected through an output transformer 12 and a battery 11 to the cathodes. The output transformer is associated with a load 13.

In the midbranch, connecting the cathodes to the midpoint of the secondary winding of the input transformer, is a grid biasing battery 8, a by-pass condenser 7, and a resistance 3. In parallel with the resistance is a rectifier 4, a biasing battery 14, and an input transformer 5. The transformer 5 is connected to a source 6 of carrier waves.

In the operation of the circuit, the signal is impressed through the input transformer 2 in opposite phases to the grids of the respective modulator tubes 9, 10. The carrier is impressed in like phase to the grids by means of the resistance 3, the biased rectifier acting as a voltage limiting device. When the carrier voltage, impressed upon the rectifier is less than the voltage of battery 14, the resistance of the rectifier is very large, and the voltage across the resistance 3 is approximately sinusoidal. When the carrier voltage becomes sufficiently positive to overcome the bias so that the rectifier is made conducting, the rectifier resistance decreases rapidly with increasing voltage and as a result the voltage across the resistance 3 no longer increases proportionally to the carrier voltage but remains nearly constant. When the carrier voltage decreases so that the bias again exceeds the carrier, the rectifier once more presents a high impedance to the carrier and the voltage on the resistance 3 varies proportionally to the carrier. The positive half of the resulting wave, impressed upon

the grids of the modulator tubes, is substantially rectangular in form. By a suitable adjustment of the battery 8 the modulator tubes may be made to operate below cut-off when the carrier voltage swings negative. A suitable value of the voltage of battery 8 is indicated by OA in Fig. 2. In this figure, numeral 15 designates the tube characteristic, 16 the carrier wave and 17 the signal wave. Battery 14 is adjusted to a voltage, represented by AB, which limits the impressed carrier wave to the most linear part of curve 15. The dotted portion of curve 16 is the portion suppressed due to the voltage limiting feature, the remainder forming the square topped wave as shown.

By making the carrier voltage impressed on the biased rectifier large compared with the voltage of battery 14, the modulator tubes may be made to operate mainly in the linear part of the current-voltage characteristic and the time spent in the non-linear part may be made a negligibly small portion of the carrier cycle. Thus the impedance which the modulator tubes present to the impressed signal is very large and practically linear over a part of the cycle, shifting sharply to another practically constant resistance for the remainder of the cycle. If the system on which a signal is impressed is linear, there will be no inter-modulation between the frequency components involved in the signal. In this system the non-linearity in the resistances facing the signal source has been minimized with a resulting elimination of inter-modulation in the signal. This feature is especially useful in a double modulation system such as that shown in United States Patent 1,353,698, issued September 21, 1920 to H. A. Affel, wherein by its use crosstalk between the channels may be avoided. To prevent appreciable resistance variation due to the signal voltage variations, the signal should be of considerably smaller amplitude than the carrier. The output portion of the circuit operates in the usual manner of a balanced modulating system with suppression of the carrier wave. If one tube is used alone the operation is essentially the same as before except that the carrier is not suppressed.

The operation of the system approximates that of an ideal commutator in which the carrier operates a switching device which instantaneously switches the modulator resistance in the signal circuit between two constant resistances.

It will be evident that the modulator tubes may be replaced by other forms of non-linear resistances, as for example, copper oxide rectifiers.

What is claimed is:

1. In combination, a modulating element having a current-voltage characteristic with a curved portion lying between a non-transmitting range and a substantially linear portion, means for applying a normal biasing voltage to determine an operating point in said non-transmitting range, a source of square topped waves of carrier frequency associated with said biasing means to periodically shift said operating point to said substantially linear portion of the characteristic, a source of signal waves and means for impressing a signal wave upon said modulating element whereby said signal wave is alternately transmitted and suppressed at the carrier frequency rate, and operation over said curved portion of the characteristic is relegated to a substantially negligible portion of the carrier cycle.

2. In combination, a space discharge tube having a current-voltage characteristic with a curved

portion lying between the current cut-off point and a substantially linear upper range, means for normally biasing said tube beyond the current cut-off point, a source of square topped carrier waves associated with said biasing means to periodically determine an operating point on the substantially linear portion of the tube characteristic, a source of signal waves and means for impressing a signal wave upon said space discharge tube whereby said signal wave is alternately transmitted and suppressed at the carrier frequency rate and operation over the curved portion of the characteristic is relegated to a substantially negligible portion of the carrier cycle.

3. In combination, a modulating element having a current-voltage characteristic with a curved portion lying between a non-transmitting range on one side and a substantially linear range on the other, means for applying a normal biasing voltage to determine an operating point in said non-transmitting range, a source of carrier waves, a voltage limiting device connecting the output of said carrier source with the input of said modulating element whereby square topped carrier waves are supplied to said modulating element, a source of signal waves and means for impressing upon said element a signal wave, the amplitude of the carrier wave being so adjusted as to bring the superposed signal wave into the substantially linear portion of the current-voltage characteristic whereby said signal wave is interrupted at the carrier frequency rate and operation over said curved portion of the characteristic is confined to a substantially negligible interval during each cycle of the carrier wave.

4. In combination, a modulating element having a current-voltage characteristic with a curved portion lying between a non-transmitting range and a substantially linear portion, means for applying a normal biasing voltage to determine an operating point in said non-transmitting range, a source of carrier waves, a voltage limiting device comprising a biased rectifier connected across the output of said carrier source to convert the carrier waves into square topped waves of the carrier frequency, means to associate the output of said current limiting device with said biasing means to periodically shift said operating point to said substantially linear portion of the characteristic, a source of signal waves and means for impressing a signal wave upon said modulating element whereby said signal wave is alternately transmitted and suppressed at the carrier frequency rate and operation over said curved portion of the characteristic is relegated to a substantially negligible portion of the carrier cycle.

5. In combination, a source of signal waves, a load circuit, a coupling element therebetween having a non-linearly transmitting range for impressed voltages lying between a non-transmitting range and a substantially linearly transmitting portion, a negative biasing battery for normally rendering the coupling element non-transmitting, a positive biasing battery of higher voltage than the negative battery, a source of carrier waves, and means including voltage limiting means controlled by the carrier waves for periodically connecting said positive battery to said coupling element together with said negative battery to render the coupling element linearly transmitting, whereby square-topped carrier waves are supplied to said coupling element and the signal waves are intermittently transmitted to the load circuit at the carrier frequency rate

and the transmitted portions are substantially linearly repeated.

5 6. In a modulating system, a source of signal waves, a load circuit, a transmission device therebetween, adapted to be controlled by a biasing voltage and having a non-linearly transmitting range for intermediate biasing voltages lying between negative and positive values that define a non-transmitting and a linearly transmitting range, respectively, negative and positive biasing batteries of voltages appropriate to the outer ranges so defined, a source of carrier waves and means including voltage limiting means controlled by the carrier waves to operatively connect the said biasing batteries alternately with said transmission device while substantially avoiding intermediate voltages, said alternations being made at a rate determined by the carrier frequency, whereby square-topped carrier waves are supplied to said transmission device and signal modulated waves are transmitted to the load circuit substantially free from distortion.

7. In combination, a modulating element having a current-voltage characteristic with a non-transmitting range and a substantially linear range, means for applying a biasing voltage to said element to determine an operating point in said non-transmitting range, a source of carrier waves, voltage limiting means connecting the output of said carrier source with the input of said element whereby square topped carrier waves are supplied to said modulating element to periodically shift said operating point to said linear range, a source of signal waves, and means for impressing upon said element a signal wave whereby said signal wave superposed upon said carrier wave is periodically transmitted at the carrier frequency rate within said linear range of the current-voltage characteristic.

40 8. In combination, a source of signal waves, a load circuit, coupling means therebetween, constant potential means normally rendering said coupling means non-transmitting, additional constant potential means, a source of carrier

waves, and means including voltage limiting means controlled by said carrier waves to intermittently connect said additional constant potential means in opposition to said first-mentioned constant potential means, thereby rendering said coupling means intermittently transmitting whereby square topped carrier waves are supplied to said coupling means and said signal waves are intermittently transmitted to said load circuit at said carrier frequency rate.

9. In combination, a source of signal waves, a load circuit, coupling means therebetween having a non-transmitting range and a substantially linear transmitting range, constant potential means normally rendering said coupling means non-transmitting, additional constant potential means, a source of carrier waves, and means including rectifying means controlled by said carrier waves and by said additional constant potential means for periodically overcoming the effect of said first-mentioned constant potential means to render said coupling means linearly transmitting whereby said signal waves are intermittently transmitted to said load circuit at said carrier frequency rate.

10. Apparatus for intermittently transmitting a signal wave at carrier wave frequency including transmitting means, a source of carrier waves and a source of signal waves connected with the input of said transmitting means, and means including a source of constant voltage and rectifying means for limiting the magnitude of the voltage of said carrier wave supplied to said transmitting means.

11. In a signaling system, space discharge means, a signal wave source, a carrier wave source, a constant voltage source, means connecting all of said sources with the input of said space discharge means, and voltage limiting means including another constant potential source and rectifying means connected with said carrier wave source.

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