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TRANSMISSION CONTROL SYSTEM

Filed June 1, 1946

FIG. 1

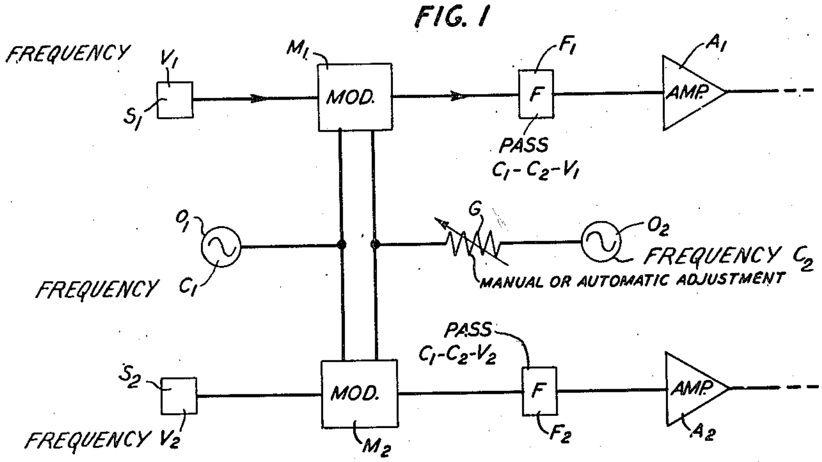
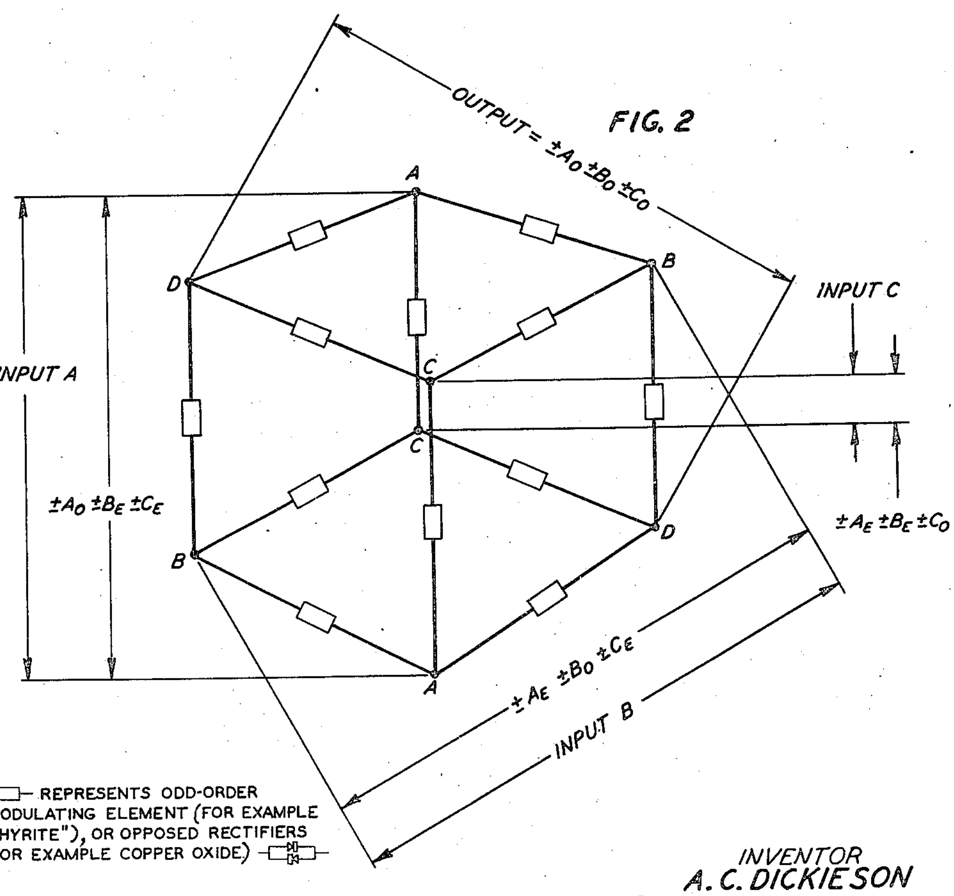


FIG. 2



—▭— REPRESENTS ODD-ORDER MODULATING ELEMENT (FOR EXAMPLE "THYRITE"), OR OPPOSED RECTIFIERS (FOR EXAMPLE COPPER OXIDE)

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TRANSMISSION CONTROL SYSTEM

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6 Claims. (Cl. 179—171.5)

This invention relates to transmission control systems and modulating systems.

An object of the invention is to so control the gain of two or more amplifiers or transmission paths or channels that their gains track, or in other words, the gain changes are accurately alike in all channels.

In conventional automatic gain control systems using variable grid bias, tracking requires matching tube characteristics over a wide range, which is not commercially practical. Various pilot frequency methods are used, involving passing control frequencies through the amplifiers.

An object of the invention is to obtain gain tracking without dependence on matching active elements or on passing pilot tones through them.

In accordance with the invention this may be accomplished by applying two signals to two modulators, respectively, applying to each modulator the same two carrier waves, one of which has its amplitude varied and the other of which has its amplitude always exceeding said varied amplitude and the maximum useful amplitude of the signal applied to the modulator, and selecting from the output of each modulator a modulation product which varies in magnitude directly as the applied signal and the amplitude of the applied variable carrier wave separately.

The modulators preferably are like, passive, odd order modulators. For example, each may comprise twelve odd order modulator elements in the linear configuration of the edges of a cube, with the four pairs of points at the ends of the diagonals of the cube all conjugate to each other. Such a modulator is one aspect of the invention.

Other objects and features of the invention will be apparent from the following description and claims.

Fig. 1 shows a circuit for maintaining gain tracking in amplifiers in accordance with the invention; and

Fig. 2 shows a modulator circuit, in accordance with the invention, which may be used in the circuit of Fig. 1.

In Fig. 1, S_1 is a source of a signal voltage wave of frequency V_1, S_2 is a source of a signal voltage wave of frequency V_2, O_1 is a source of a carrier voltage wave of frequency C_1, and O_2 is a source of a carrier voltage wave of frequency C_2 whose amplitude can be varied by adjustment of a control G symbolically indicated as a variable resistance in the C_2 supply. Though frequencies V_1 and V_2 are not necessarily equal, in many applications of the invention they will be equal and the waves of frequencies V_1 and V_2 will be subject to difference in phase, for example. The symbol V is used herein as a general symbol for V_1 and V_2. The waves of frequencies V_1, C_1 and C_2 are intermodulated in modulator M_1, as indicated in Fig. 1. Similarly, the waves of frequencies V_2, C_1 and C_2 are intermodulated in modulator M_2. The wave of frequency C_1 is of fixed amplitude, larger than the maximum usable magnitude of the wave of frequency V. The wave of frequency C_2 is of variable amplitude always smaller than the amplitude of the wave of frequency C_1.

Thus, in the case of each of the modulators M_1 and M_2, the input waves are of frequencies V, C_1 and C_2. The output frequency used is selected, by filter F_1 or F_2, from the general term $\pm C_1 \pm C_2 \pm V$. In the case shown in Fig. 1, the choice is C_1-C_2-V. The wave of the selected frequency, either C_1-C_2-V or other choice from the general term $\pm C_1 \pm C_2 \pm V$ varies in amplitude directly as the amplitudes of the waves of frequencies V and C_2 separately, and is independent of the amplitude of the wave of frequency C_1. The selected wave may be amplified in amplifier A_1 or A_2. Modulator characteristics do not affect tracking, since the input wave of largest magnitude (the wave of frequency C_1) is kept fixed in amplitude.

With the wave of frequency C_1 large in amplitude, and the magnitude of the wave selected from the modulator output therefore proportional to both the magnitude of the wave of frequency C_2 and the magnitude of the wave of frequency V, the wave of frequency C_2 can be varied in amplitude to vary the modulator loss decibel for decibel. So long as the magnitude of the wave of frequency C_1 has at least a value approximately between 6 and 10 decibels greater than the magnitudes of the waves of frequencies C_2 and V, it is known from experience that the loss varies accurately as either of these other inputs.

The modulators M_1 and M_2 are in the input circuits of the amplifiers A_1 and A_2, respectively. Thus, the amplifiers are controlled in gain by adjustment of the common control G in the C_2 supply. This common adjustment can be controlled by any desired means, as for example manual, time controlled (TVG), reverberation controlled (RCG), or automatic volume control (AVC) means, the control G being intended as symbolic of any such means.

Though the desired term C_1-C_2-V varies in magnitude as C_2, there are other modulation products involving only C_1 and V which do not change at all as C_2 is varied in amplitude. These can be discriminated against by frequency selectivity, as by proper choice of the C_1 and C_2 frequencies, or by balance of rectifier elements. Since the term used is odd order, it is desirable to use an odd order modulator to achieve the most from balances.

Fig. 2 shows an odd order modulator system comprising twelve odd order, two-terminal modulating elements interconnected in the manner of the twelve edges of a cube. Each element may be a Thyrite element or may be formed of two rectifiers, as for example copper oxide rectifiers, connected in parallel and poled oppositely. The four pairs of opposite points AA, BB, CC and DD are all conjugate to each other, from the symmetry of the system. If three input waves of frequencies, A, B, and C, respectively, are applied as shown, it can be demonstrated that the products of the class $\pm A_0 \pm B_0 \pm C_0$ all appear at the fourth pair of points DD (A_0 meaning the term involving odd orders of the frequency A, etc.), and no other terms appear at this outlet except by unbalance. Thus, this modulator is especially well suited for use in the system of Fig. 1.

What is claimed is:

1. The method which comprises intermodulating a first signal voltage, a first carrier voltage of one frequency and of fixed amplitude larger than the maximum usable value of said signal voltage, and a second carrier voltage of another frequency and of variable amplitude always smaller than said fixed amplitude, separately intermodulating a second signal voltage, said first carrier voltage and said second carrier voltage, said first amplitude exceeding the maximum usable value of said second signal voltage, selecting from products of said first modulation one which varies in magnitude directly as each of said first signal and second carrier voltages separately, and selecting from products of said second modulation one which varies in magnitude directly as each of said second signal and second carrier voltages separately.

2. A wave translating system comprising a pair of modulators, means for supplying to said modulators signal waves of frequencies V_1 and V_2, respectively, means for supplying to each of said modulators a carrier wave of frequency C_2 variable in amplitude, means for supplying to each of said modulators a carrier wave of different frequency C_1 whose amplitude is at least approximately twice the amplitude of each of said other waves supplied to said modulators, means connected to one of said modulators for deriving therefrom a wave whose frequency is one of the eight in the general term $\pm C_1 \pm C_2 \pm V_1$ to the exclusion of the other products of said modulation in said one modulator, and means connected to the other modulator for deriving therefrom a wave whose frequency is one of the eight in the general term $\pm C_1 \pm C_2 \pm V_1$ to the exclusion of the other products of said modulation in said other modulator.

3. A system comprising two like modulating devices, circuits for supplying to one of said devices a variable amplitude carrier wave and a first signal wave for modulating said carrier wave in said one device, and circuits for supplying to said other device, said carrier wave and a second signal wave for modulating said carrier wave in said other device, each of said devices being adapted to vary its modulator gain linearly by the same factor with variation of the amplitude of said carrier wave.

4. An odd order modulator comprising twelve like, two-terminal odd order modulating elements interconnected in the manner of the twelve edges of a cube, with the four pairs of points at the ends of the diagonals of the cube all conjugate to each other.

5. An odd order modulating system comprising twelve like, two-terminal odd order modulating elements interconnected in the manner of the twelve edges of a cube, with the four pairs of points at the ends of the diagonals of the cube all conjugate to each other, means for applying to three of said pairs three waves of different frequencies A, B and C, respectively, and means for deriving from the fourth of said pairs modulation products of the class $\pm A_0 \pm B_0 \pm C_0$ to the exclusion of all other terms.

6. A system comprising two like modulators, each including twelve two-terminal odd order modulating elements interconnected in the manner of the twelve edges of a cube with the four pairs of points at the ends of the diagonals of the cube all conjugate to each other, means for applying a signal voltage of frequency V_1, a carrier voltage of frequency C_1 and a carrier voltage of another frequency C_2 to three of said pairs, respectively, of one of said modulators, means for applying a signal voltage of frequency V_2, said carrier voltage of frequency C_1 and said carrier voltage of frequency C_2 to three of said pairs, respectively, of said other modulator, and means for varying the amplitude of said carrier voltage of frequency C_2, said carrier voltage of frequency C_1 having a fixed amplitude always larger than the amplitude of the carrier voltage of frequency V_2 and the maximum usable magnitude of said signal voltages.

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