

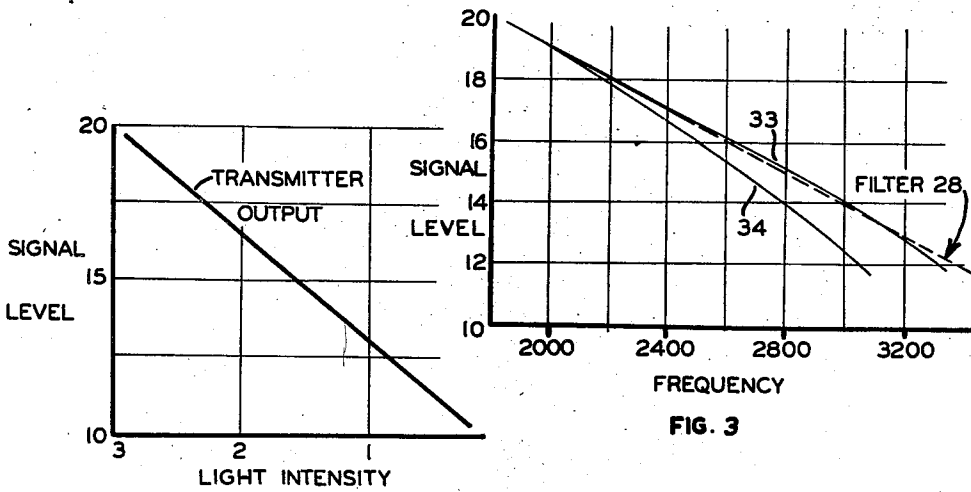
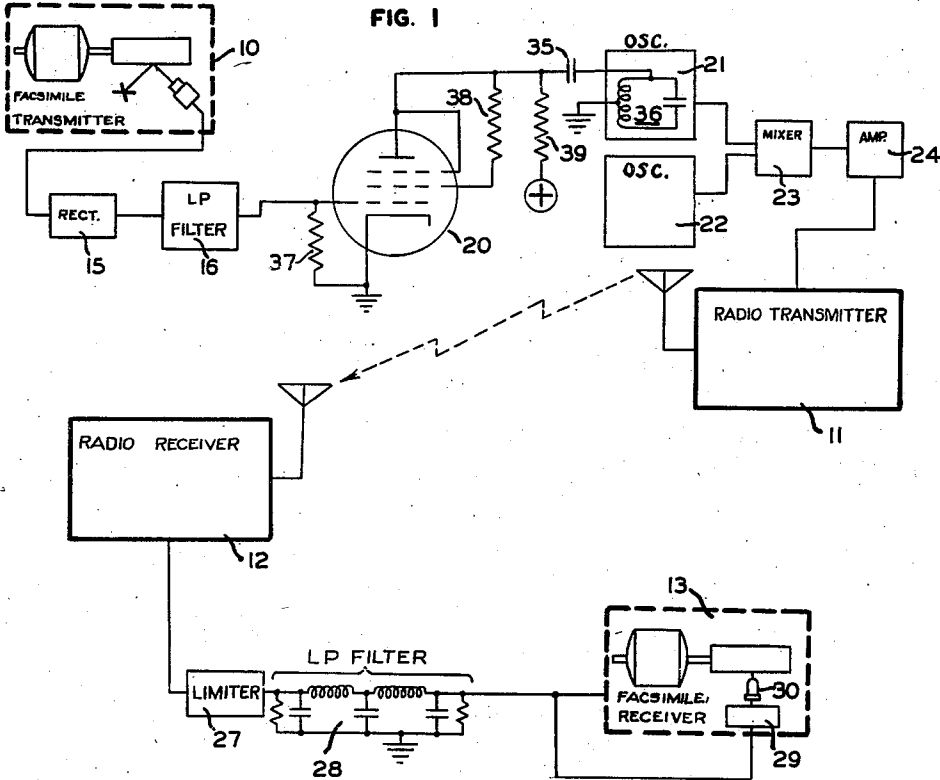
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FREQUENCY MODULATION SYSTEM

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FREQUENCY MODULATION SYSTEM

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5 Claims. (Cl. 178—6)

This invention relates to telephoto or telefacsimile systems, and more particularly to a system of this character employing a constant-amplitude, variable-frequency sub-carrier.

Frequency modulation has been proposed for facsimile transmission but the prior systems have been rather complex and difficult to line up and maintain in adjustment. However the use of a frequency-modulated sub-carrier presents outstanding advantages where high quality recording is desired, especially where a long radio channel is employed, since the distortion produced by fading, echo, parasitic disturbances and the like is substantially eliminated. Consequently the object of my invention, in general terms, is to simplify systems of this character in which the frequency of the sub-carrier is varied in accordance with signal variations.

A further object of my invention is to provide an improved arrangement for generating a frequency-modulated sub-carrier.

A still further object of my invention is to improve wave-signalling systems employing a low-pass filter having a linear frequency-attenuation characteristic as a signal discriminating element at the receiver.

Other objects and advantages of the invention will become apparent from the following description of the preferred embodiment thereof shown on the accompanying drawing, wherein

Fig. 1 is a circuit diagram of a phototransmission system embodying the invention, and

Figs. 2 and 3 are graphs illustrating the relation between light intensity, signal amplitude and frequency in the system of Fig. 1.

For purposes of illustration, the invention is shown as embodied in a phototransmission system having a transmitter and receiver of conventional type but is not necessarily limited to such a system. It may also be utilized in connection with other systems involving the transmission of variable signals over a radio link or high frequency channel. Referring to Fig. 1 of the drawing, the system shown comprises a facsimile transmitter 10 arranged to modulate a radio transmitter 11. The receiving station comprises a radio receiver 12 connected to a facsimile receiver or recorder 13 adapted to reproduce the photograph or copy on the drum of the transmitter 10 in response to transmitted signals. The transmitter 10 and receiver 13 are illustrated as of the drum type, and may be of any conventional construction; for example, as shown in the prior Patent No. 2,015,742 to A. G. Cooley dated October 5, 1935 or of the well-known type

using a recording lamp in the receiver. The transmitting and recording drums may be phased as shown in the patent to A. G. Cooley No. 2,275,249 dated March 3, 1942, and the drums may be driven by constant-speed motors to avoid the necessity for transmitting synchronizing signals, if desired.

The output signals from the facsimile transmitter 10 are rectified in the full-wave rectifier 15 and smoothed out in low-pass filter 16. It may be assumed for purposes of explanation that the output signal level variations from transmitter 10 are directly proportional to the changes in light or shading of the picture or copy being scanned. This relationship is represented by the graph of Fig. 2. If a non-linear relationship between signal and light pick-up is involved, suitable correction or compensation can be made if desired.

The low-pass filter 16 is designed to reduce the component of the rectified current resulting from the alternating-current variation or chopping impulses employed in connection with the optical pick-up in the transmitter 10. If the latter is 1800 C. P. S., the filter 16 may cut off at 1200 C. P. S., for example.

The rectified signal variations in the output of the filter 16 are applied to a frequency modulator tube 20 arranged to control the beat frequency generated by the oscillators 21 and 22, in connection with the mixer 23. The variable-frequency signals are controlled in accordance with the invention, as explained in detail hereinafter, so that a linear relation obtains between the variations in power of the amplitude-modulated picture signals and the variations in frequency of the sub-carrier generated by the oscillators 21 and 22. The frequency-modulated sub-carrier is amplified in amplifier 24 and utilized to modulate the radio frequency carrier, as indicated.

At the receiving station, the signals from the radio transmitter 11 are detected and applied through the limiter 27 and low-pass filter 28 to an amplifier 29 and lamp or recording device 30 of the facsimile receiver 13. As shown, the low-pass filter 28 may comprise series inductance and shunt capacitance, and a simple filter of this type has a substantially linear frequency-attenuation characteristic over the working range. The assumed linear characteristic of the filter 28 is represented by the dotted line in Fig. 3. It is also assumed that the signal level varies from about plus 12 db. to plus 20 db. from "black" to "white," and that the corresponding frequency shift of the sub-carrier is from 3400 C. P. S. to 1800

C. P. S. In cases where because of apparatus limitations or other reasons it is desirable to employ other ranges than those referred to, appropriate adjustment or changes in the amplifiers, oscillators, filters and recording equipment could be made, while still using the principle of the invention.

Since the frequency-attenuation characteristic of the simple low-pass filter may be made linear over the entire range of frequency shift of the sub-carrier, the output of the filter consists of amplitude variations proportional to the changes in frequency of the frequency-modulated sub-carrier; and these amplitude-modulated signals to control the receiver will correspond over the entire range to the variations in power at the output of the facsimile transmitter 10 if the frequency modulation system matches the linear demodulation characteristic of the filter 28. The curve 33, Fig. 3, represents the amplitude-frequency characteristic of the frequency modulation system of Fig. 1 which in connection with a low-pass filter 28 having a linear frequency-attenuation characteristic at the receiving station provides substantially distortionless recording without elaborate compensating circuits or apparatus. On the other hand, the curve 34 represents the amplitude-frequency characteristic of the modulation system of Fig. 1 when a triode is substituted for the vacuum tube amplifier 20, the varying amplitude picture signals, after rectification, being impressed upon the control grid of said triode. The discrepancy between the curve 34 and the dotted line representing the characteristic of filter 28 renders evident the reason why such an arrangement is unsatisfactory, and it is difficult to match the filter to the modulation characteristic of the modulator.

The frequency modulator embodying the invention comprises the vacuum tube 20 coupled through a small condenser 35 to the resonant circuit 36 of oscillator 21 whereby the tube impedances are effectively connected in the resonant circuit and variations in the grid and plate impedances are reflected in frequency variations in the output of the oscillator 21. The frequencies of the oscillators 21 and 22 may be for example approximately 100 to 150 kilocycles or more, and the beat frequency of the sub-carrier may vary between, say, 1800 C. P. S. and 3400 C. P. S.

The tube 20 is a high gain pentode amplifier, for example type 7C7, but may be any similar tetrode or pentode, preferably a tube in which screen-cathode capacity, suppressor-cathode capacity and plate-cathode capacity are low. In the case of a pentode, the suppressor is connected to the plate, as shown. The input circuit may include a grid bias resistor 37. The screen grid of tube 20 is connected to the plate of the tube through a resistor 38 of, say, one-half megohm, and the plate is connected to the high-voltage source through a resistor 39 of, say, one-quarter megohm.

The described arrangement is substantially similar to conventional systems with the exception of the resistive grid-plate connection 38. It has been found that this connection results in a constant proportionality between the variations in frequency of the sub-carrier and the variations in the power of the input signals, as shown by actual tests (see curve 33, Fig. 3). The grid bias on the modulator control tube varies logarithmically with the power of the input signal, and this causes a disproportionate

change in the frequency of oscillator 21, as the level increases, unless the screen-grid resistor 38 is employed. When the resistor 38 is used, as the tube 20 draws more current, the potential of the screen grid becomes less positive than the plate potential and the combined change in cathode-plate impedance and cathode-screen grid impedance maintains the desired linear relation between input power changes and the frequency changes in the sub-carrier.

Various changes in the arrangement described above for the purpose of explaining the invention may be made without departing from the scope thereof as defined in the appended claims.

I claim:

1. In a facsimile transmitter adapted to generate a frequency-modulated sub-carrier, the combination of an oscillator, a vacuum tube amplifier of the screen-grid type connected to the resonant circuit of said oscillator to control the frequency of its output current, means for impressing variable-amplitude picture signals on the input to said amplifier and means including a resistor connected between the screen grid and plate of said tube for changing the normal tube impedance curve or characteristic and thereby affecting the modulation characteristics of the combination set forth.

2. In a facsimile transmitter adapted to generate a frequency-modulated sub-carrier, the combination of an oscillator, a vacuum tube amplifier of the screen-grid type having its plate impedance effectively in the resonant circuit of said oscillator to control the frequency of its output current, means for impressing variable-amplitude picture signals on the input to said amplifier and means including a resistor connected between the screen grid and plate of said vacuum tube amplifier for obtaining a linear relation between the amplitude of the input signals and the frequency of the oscillator output current.

3. In a facsimile transmitter adapted to generate a frequency-modulated sub-carrier, the combination of an oscillator, a vacuum tube amplifier of the screen grid type having its plate impedance effectively in the resonant circuit of said oscillator to control the frequency of its output current, means for impressing signals of varying power on the input to said vacuum tube amplifier, a resistor of the order of $\frac{1}{2}$ megohm connected between the screen grid and plate of said vacuum tube amplifier and means for supplying positive potential to the plate through a second resistor of the order of $\frac{1}{4}$ megohm.

4. A facsimile system comprising sending and receiving stations, a vacuum tube amplifier of the screen grid type at the sending station, means including an oscillator for generating a frequency-modulated sub-carrier at said sending station, means for impressing picture signals of varying power on the input to said amplifier, a small condenser coupling the plate circuit of said amplifier to said oscillator to control the frequency of its output current in accordance with said signals of varying power, a resistor connected between the screen grid and plate of said amplifier for obtaining a linear relation between the power of the input signals and the frequency of the sub-carrier, and receiving means at the receiving station for reproducing transmitted facsimile copies in accordance with the frequency variations of said sub-carrier, said receiving means including a limiter, a low-pass filter having a substantially linear frequency-at-

tenuation characteristic and recording means responsive to the modulated signal output variations from said filter.

5. A frequency modulation facsimile system in which picture signals of varying amplitude are converted into frequency variations of a sub-carrier characterized in that a screen grid tube is connected to be responsive to the signals of

7 varying amplitude and to control the sub-carrier generator, said screen grid tube having resistance of the order of one-half megohm connected between the screen grid and plate of said tube to obtain the desired relationship between the signals of varying amplitude and the corresponding output signals of varying frequency.

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