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WHAT IS CLAIMED IS:

1. A facsimile transmitter comprising a machine for translating tone values into a corresponding modulated audio frequency carrier, means to double the frequency of said carrier, means to rectify said doubled frequency carrier and to derive therefrom substantially pure d.c. signals corresponding to the original tone values, a variable frequency oscillator, a control tube for said oscillator for controlling the frequency thereof, and means to vary the conductivity of said control tube by said d.c. signals.

2. A facsimile transmitter according to claim 1 in which the variable frequency signals are confined to an audio frequency spectrum wherein the frequency corresponding to one extreme range of tone value is less than the second harmonic of the lowermost frequency corresponding to the opposite extreme range of tone value.

3. A facsimile receiver comprising means to receive and detect frequency modulation in an audio frequency spectrum, the limits of which correspond to the tone value limits of a picture to be received, means to convert said audio frequency spectrum into corresponding d.c. amplitude variations, the last-mentioned means comprising a network which has a variable attenuation effect on said spectrum in accordance with the individual frequencies thereof, a frequency doubler for said spectrum, and a rectifier and filter for converting the doubled frequencies into substantially pure d.c. variable amplitude signals, and a facsimile reproducer controlled by said d.c. signals.

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Claim 4.

In a facsimile system, means to receive, over a transmission channel which is subject to harmonic distortion, facsimile signals in the form of a frequency modulated carrier wherein the carrier frequency is within the same order of frequency as the modulations and which modulations represent the tone values of the original subject-matter to be transmitted, means to detect said modulations, means including a resonant network to eliminate therefrom all parasitic frequencies which are a second or higher harmonic of any frequency within the said modulation range, means to double the frequency of said detected modulations, and a rectifier and filter for converting the doubled frequencies into substantially pure D. C. variable amplitude signals, and a facsimile reproducer controlled by said D. C. signals.

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This invention relates to facsimile transmission systems and more especially to such systems which employ a transmission medium or link that is subject to fading, harmonic distortion and the like.

A principal object is to provide an improved system for transmitting facsimiles and the like over a radio channel, whereby the effects of selective fading, harmonic distortion and the like are materially reduced.

A feature of the invention relates to an improved system for converting picture shades and the like into a frequency-modulated carrier the spectrum of which is confined to the audio frequency range.

Another feature relates to an improved frequency-modulating arrangement whereby the signal amplitude variations corresponding to picture shades are converted into a frequency-modulated audio frequency carrier by a novel combination of oscillator tubes and a control tube therefor.

A further feature relates to an improved manner of varying the frequency of an oscillator tube by varying the impedance of a grid-controlled tube whose anode-cathode discharge path is effectively in shunt to an oscillatory circuit through a condenser of low capacity, whereby the variations of impedance of the control tube are reflected as variations in shunt capacitance across said oscillatory circuit.

Another feature relates to an improved converter for translating the output of a facsimile transmitting machine of the type producing picture signals in the form of an amplitude-modulated audio frequency carrier, into a frequency-modulated carrier limited to the audio frequency range.

Another feature relates to a receiver for facsimile systems wherein the subject matter is transmitted as a frequency-modulated audio frequency carrier, the receiver having means to convert the frequency-modulated carrier into corresponding amplitude modulations while limiting the conversion to a frequency spectrum wherein the uppermost frequency is less than the second harmonic of the lowermost frequency.

Another feature relates to an improved converter for translating a received frequency-modulated audio frequency carrier into corresponding variable-amplitude d. c. signals.

A still further feature relates to the novel organization, arrangement and relative interconnection of parts which constitute an improved facsimile transmission system.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

Referring to the drawing which by way of example shows one preferred embodiment,

Fig. 1 is a schematic wiring diagram of the transmission end of a facsimile system embodying features of the invention.

Fig. 2 is a schematic wiring diagram of the receiving end of a facsimile system embodying features of the invention.

Referring to Fig. 1, the numeral 1 represents diagrammatically any well-known form of facsimile transmitting machine whereby the shades or tone values of

successive elemental areas of the subject matter are scanned and translated into a corresponding amplitude-modulated audio frequency carrier, for example a carrier of 1800 c.p.s. Reference may be had to U.S. patent No. 2,015,742 for a typical machine of this type. The output of machine 1 is applied through transformer 2 across the potentiometer resistance 3, the adjustable arm 4 of which is connected to grid 5 of amplifier tube 6. The potentiometer is also connected through condenser 7 to the cathode 8. Grid 5 is negatively biassed with respect to the cathode by the IR drop caused by the plate current flow through resistor 9; and a suitable series resistance 10 is connected between potentiometer 3 and ground. The steady high voltage potential for plate 11 is applied over conductor 12, series resistor 13 and transformer primary 14. Conductor 12 is supplied with high voltage d.c. from any well-known source consisting for example of the a.c. mains 14a; step-up transformer 15; full wave rectifier 16; filter 17, 18, 19, 20, and any well-known voltage stabilizer 21.

The amplitude-modulated a.c. wave from transformer 14 is applied to a frequency doubling arrangement comprising a twin triode tube 22, the input circuits between the grids 23, 24, and cathodes 25, 26, being connected in balanced relation while the plates are connected in phase to the primary winding of transformer 27. The output of tube 22 therefore consists of a 3600 c.p.s. wave which is amplitude-modulated in accordance with the original picture signals from machine 1. This wave is then impressed upon a full wave rectifier tube 28 in the output circuit of which is connected a suitable filter comprising elements 29,

30, 31, 32, whereby substantially all frequency flutter is eliminated and there is developed across the potentiometer resistance 37, a d.c. voltage of varying amplitude corresponding to the shades of the original subject matter scanned by the machine 1.

The rectified signal from tube 28 is applied to control a frequency modulator comprising a variable-frequency oscillator tube 33 and a fixed-frequency oscillator tube 34 and a control tube 35. The tube 35 may be of the triode type whose control grid 36 is connected to the adjustable arm of potentiometer 37 through a suitable bias battery 38 whereby grid 36 is negatively biassed with respect to cathode 39. Plate 40 is connected to ground, as is the low potential end of potentiometer 37. The grid-cathode return circuit of tube 36 is completed through the control-grid to cathode circuit of tube 33 and includes the grid leak resistor 41 and the lower section of oscillator coil 42. Coil 42 is shunted by an adjustable tuning condenser 43 and this combination of coil and condenser is connected to the control grid 44, through a very low capacity condenser 45, for example of about .0001 m.f.d. It will be seen therefore that the oscillatory circuit formed by 42 and 43 is effectively shunted by a circuit consisting of the condenser 45, resistance 41 and the cathode-to-plate discharge path of tube 35. Consequently, the frequency of oscillation of tube 33 is determined in part by the elements 42, 43, as well as by the effective shunt capacitance of condenser 45 which in turn is controlled by tube 35. It will be noted that while the plate 40 of the control tube 35 is connected to ground, it is

effectively at positive potential with respect to the cathode 39 when the tube 33 is in an oscillating state since in that condition a grid current flow exists between the grid 44 and the cathode 46 is of such a polarity as to render the grid 44 and consequently the cathode 39 negative with respect to ground. This is a d.c. potential difference because of the rectifying effect between the cathode 36 and grid 44.

Tube 33 is a so-called electron-coupled oscillator, for example a tube of the type 6J7 comprising a cathode 46, control-grid 44, shield grid 47, suppressor grid 48 and plate 49. The upper section of coil 42 is connected between 44 and 46 while the lower section of coil 42 is connected between 46 and 47, thus generating oscillations by feed-back action. The elements 44, 46 and 47, form in effect a triode oscillator of which the element 47 is in effect the anode, the plate 49 acting as a collector electrode for the electrons passed by grid 47. The oscillator 34 is similar to oscillator 33 except that the feed-back coil 50 is shunted by a fixed condenser 51 and the control grid 52 is returned directly to ground through the leak resistor 53. In both oscillators the respective suppressor grids may be connected directly to the associated cathodes. The controlled oscillator 33 is designed and set so that variations of frequency can be effected over a range of 1000 cycles corresponding respectively to the range of tone values or shades in the subject matter being scanned by the machine 1. Thus oscillator 33 by means of potentiometer 37 and bias battery 38 can be adjusted so that for white shades there is generated a frequency of 265.5 k.c.,

and for black there is generated a frequency of 266.5 k.c. The oscillator 34 may generate a fixed frequency of 262.0 k.c. The outputs of the two oscillators are applied to a common mixing tube 54 which may be of the type 6L7. The variable frequency voltages developed across resistor 55 are applied through coupling condenser 56 to the first control grid 57 of tube 54, the said grid being normally negatively biassed by cathode resistor 58; a suitable leak resistor 59 being provided. Likewise, the fixed frequency voltage developed across resistor 60 is applied through coupling condenser 61 to the second control grid 62. A suitable steady positive potential is applied to the "anode-grid" 63 by means of conductor 64. The fourth grid 65 is connected directly to the grid 57. By the well-known action of this type of tube, there is developed across the plate load resistor 66 voltages whose frequency is determined by the difference frequency between the oscillators 33 and 34. In other words, under the above assumed conditions, there is developed an audio frequency band of from 3500 to 4500 c.p.s. This variable frequency signal is applied to the output transformer 67 through a radio frequency choke coil 68 and coupling condenser 69 of the order of .005 m.f.d. The audio frequency modulations may then be applied to control the amplitude modulation of any well-known form of radio transmitter represented schematically by the numeral 70. It will be observed therefore, that the signals representing the shade values are in the form of audio frequency modulations having a frequency spectrum between 3500 and 4500 c.p.s., so that the uppermost signal frequency, namely 4500 c.p.s. is less than the

second harmonic of the lowermost signal frequency, namely 3500 c.p.s.

At the receiving station, the received radio wave is detected and amplified by any well-known form of radio receiver 71 whereby the 3500-4500 audio frequency spectrum is applied to the coupling transformer 72. Part of the output of transformer 72 is fed to a volume controlled amplifier tube 73, for example of the type 6L7; and part of the output of transformer 72 is applied to the volume control or regulator tube 74 which may be of the type 6R7. For the purpose of controlling the output levels, the first control grid 75 of tube 73 is connected to a variable tap 76 on the potentiometer resistance 77. Likewise, the control grid 78 of the regulator tube 74 is connected to an adjustable tap 79. The tube 74 is of the delayed action type and does not start functioning until a predetermined minimum input level e.g. -12 d.b. is reached, then the regulator tube 74 takes control and holds the output of tube 73 constant to within approximately 0.5 d.b. until a level of 2 d.b. is reached corresponding to the beginning of overloading of the amplifier. The steady potentials for the plate 80 and for the plate 81 are applied over conductor 82 from the high voltage d.c. supply unit which may be similar to that used at the transmitter comprising a.c. mains 83; step-up transformer 84; full wave rectifier 85; filter 86, 87, 88, 89, and voltage stabilizer 90. In accordance with the well-known operation of the type 6R7 tube, that is tube 74, as the plate current increases it applies a corresponding increased potential to the auxiliary anodes 91 whereby a corresponding biassing potential is

developed across the cathode resistor 92 thus controlling the current to plate 80 and therefore determining the potential of the second control grid 93 of tube 73. A suitable combination of resistors 94, 95 and condenser 96, are provided having a predetermined time constant to determine the extent of delay of action of the regulator tube 74 on grid 93.

The plate or output circuit of tube 73 is connected through a resonant circuit consisting of the series condenser 97, 98, resistor 99 and a parallel winding 100 of the coupling transformer 101 and shunt condenser 103. The elements of the combination 97 to 103 are chosen in magnitude so as to provide a resonant circuit which is resonant at 3500 c.p.s. and which has a sloping characteristic on either side of 3500 cycles with a maximum attenuation at 2500 and 45 cycles respectively. Consequently the signals that are applied to the control grid 104 of a succeeding amplifier tube 105 are confined to the range between 2500 and 4500 c.p.s. Consequently, if there has been any harmonic distortion in the form of frequency doubling at any point between the transmitter 70 and the receiver 71, it is effectively eliminated since the second harmonic of the lowermost signal frequency of 3500 c.p.s. is not passed to the amplifier tube 105. Tube 105 may be of the type 6N7 for amplifying the 2500-4500 spectrum applied to the control grid thereof. The output of tube 105 is then passed through a frequency doubling tube 106 of the type 6N7 similar to the tube 22 at the transmitter. The doubled frequency signals are then applied to the full wave rectifier tube 107, the circuit of which includes a suitable filter comprising elements 108,

109, 110, 111, 113, 114, 115, 116, whereby substantially all frequency flutter is eliminated and the voltage developed across the potentiometer resistor 117 consists of d.c. signals with amplitude variations substantially identical with the amplitude variations from the tube 28 at the transmitter. These d.c. amplitude variations which represent the original picture shades at the transmitter machine 1, can be used to control the reproducing element of any well-known form of facsimile reproducing machine represented by the numeral 118 which is maintained in time and phase synchronism with the transmitting machine 1 in any manner well-known in the facsimile art. If the machine 118 is of a type which is controlled by a modulated audio frequency wave, then it is necessary to convert the variable amplitude d.c. signals across resistor 117 into a corresponding amplitude-modulated audio frequency carrier. For this purpose, there is provided an audio frequency oscillator tube 119 which may be of the type 6J7 having a feed-back oscillator coil 120 connected between the control grid 121 and the cathode 122, another section of this coil being connected between the cathode 122 and the "anode-grid" 123. The suppressor grid 124 may be connected directly to the cathode. A tuning condenser 125a is connected across the oscillatory circuit to control the oscillation frequency, for example 1800 c.p.s. The operating potentials for the "anode-grid" 123 and the collector plate 126a are derived over conductor 82. The 1800 cycle signal from oscillator 119 is applied in push-pull relation to the input grids 125 of the mixer tubes 126, 127, which may be of the type 6L7. The d.c. signals representing the picture shades are

tapped off from the potentiometer 117 and are applied in parallel to the second control grids 128 of tubes 126, 127. The plates of the tubes 126 and 127 are connected in balanced relation through the output resistor 129, the steady plate potentials being derived over conductor 130. Consequently there is developed across resistor 129 an 1800 cycle signal having amplitude modulations corresponding to the original picture shades. This amplitude modulated wave is then passed through a suitable amplifier 131 which may be of the type 6N7 preferably connected to operate as a "class A" output amplifier to raise the signal to the desired level for controlling the reproducing element of the facsimile machine 118.

I have found that with the foregoing arrangement, a satisfactory picture having a wide range of tone values can be transmitted over long distances either by wire or by radio and the effects of fading and harmonic distortion such as frequency doubling and the like in the transmitting link, are substantially eliminated. While specific apparatus and circuits have been disclosed for achieving the objects of the invention, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

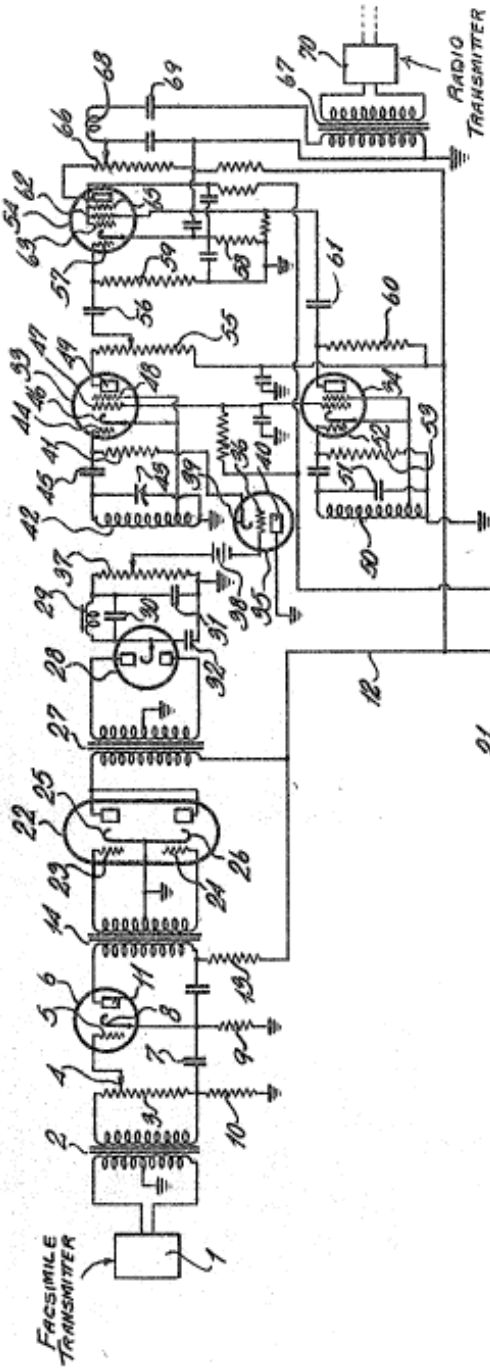

Fig. 1.

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Certified to be the drawing referred to in the specification hereunto annexed.

Ottawa, Ontario, Canada, Aug. 6th, 1943.

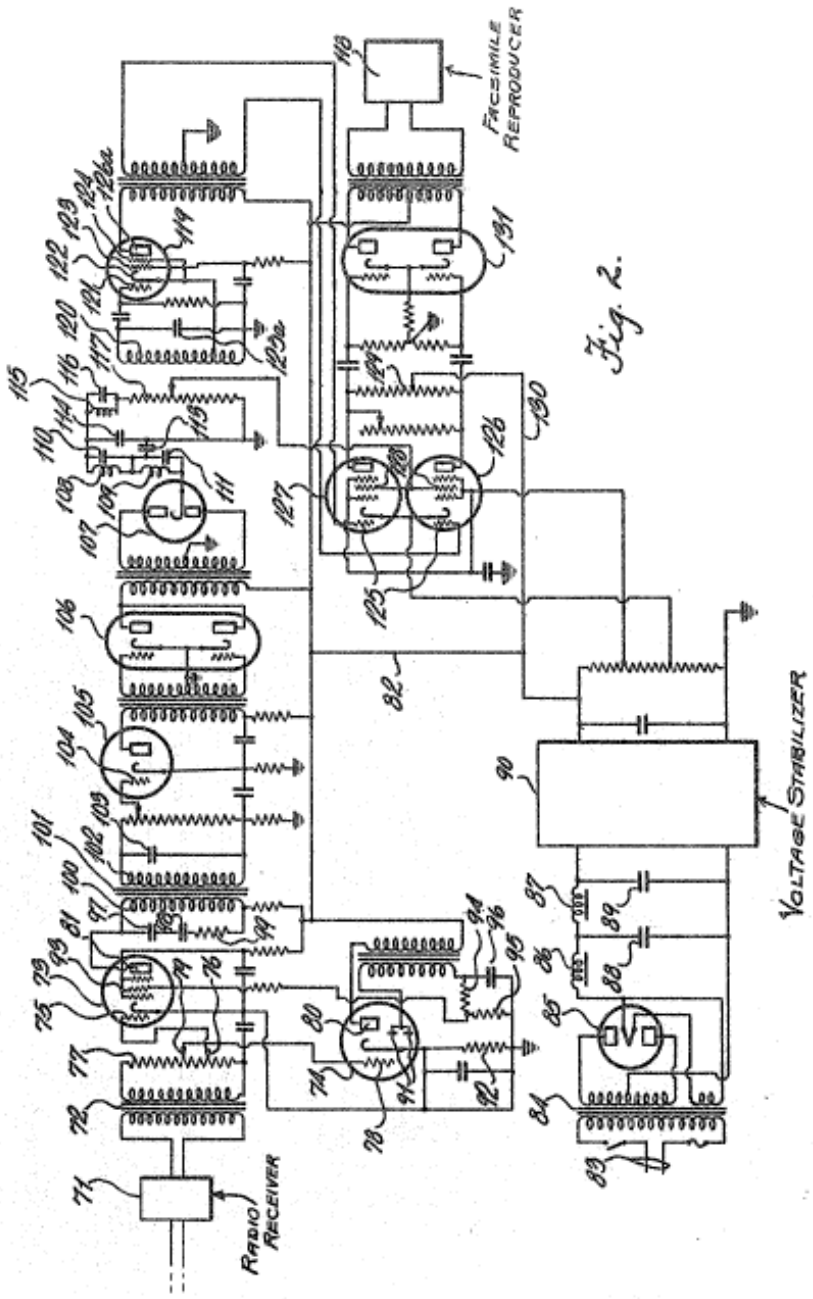

Fig. 2.

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