March 16, 1954 E. S. GRIMES 2,672,504

FACSIMILE RECEIVER

Filed March 16, 1951 6 Sheets-Sheet 1

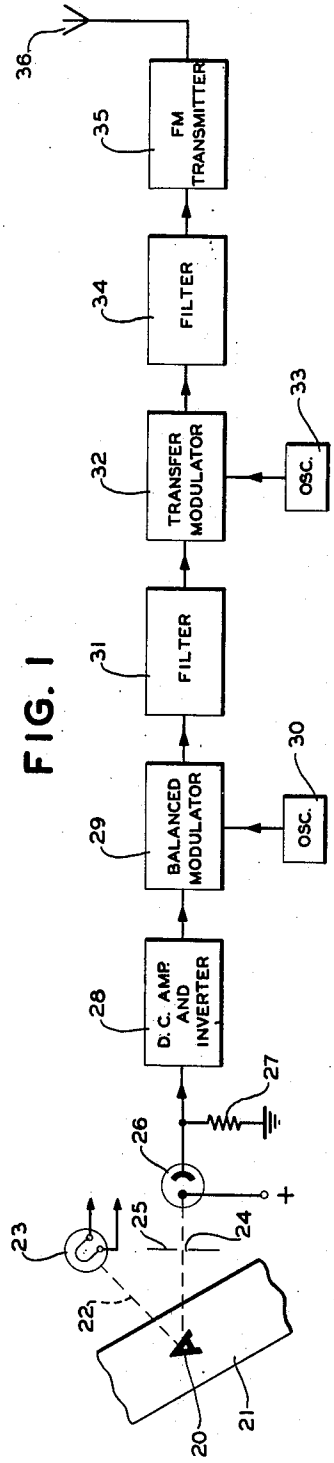


FIG. 1

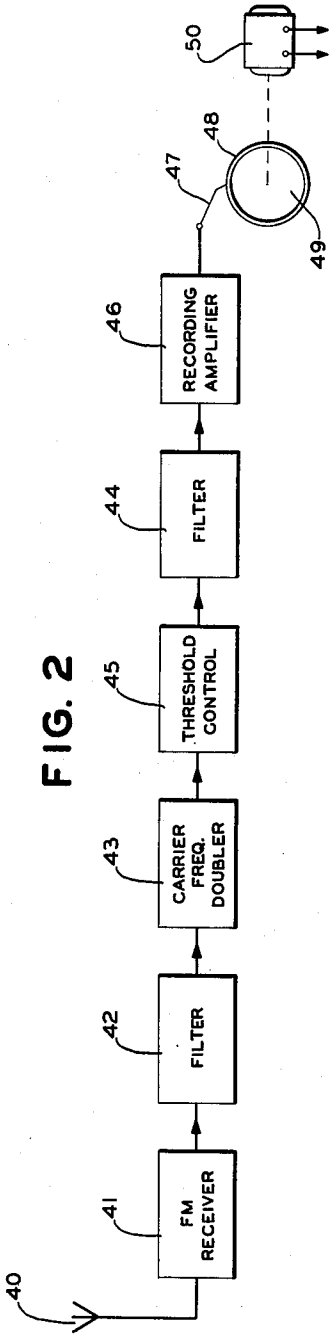


FIG. 2

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FIG. 3

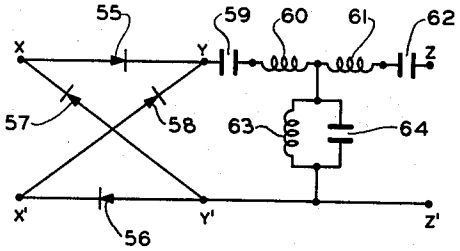


FIG. 4

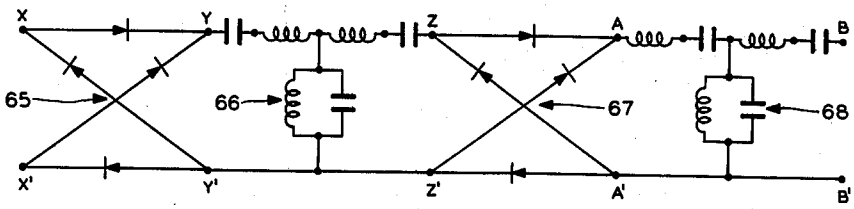
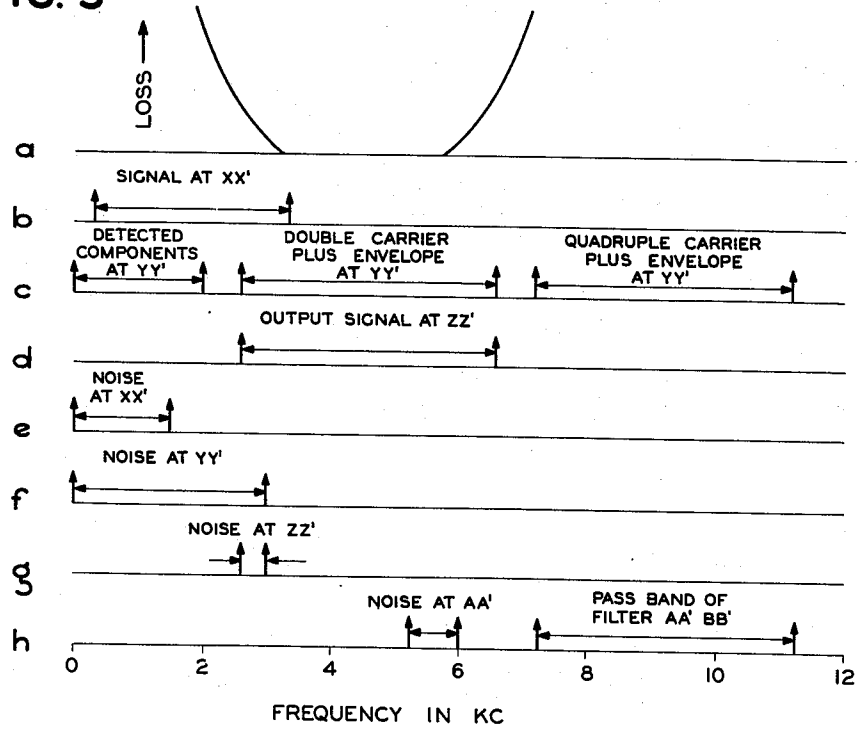


FIG. 5



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FIG. 6

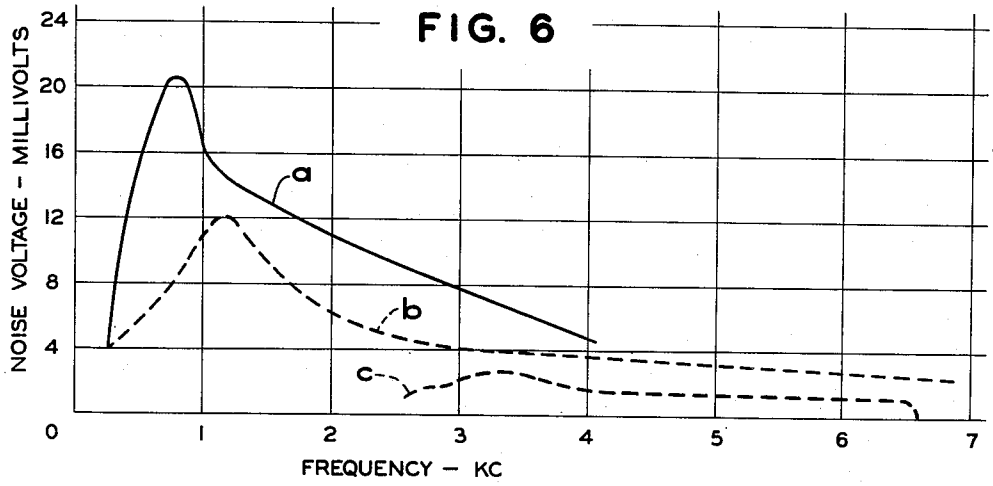


FIG. 7

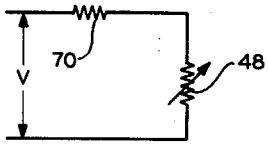


FIG. 8

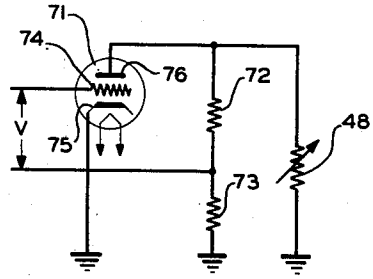
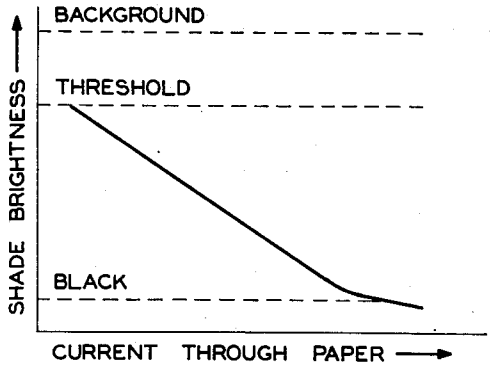


FIG. 9



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FIG. 10

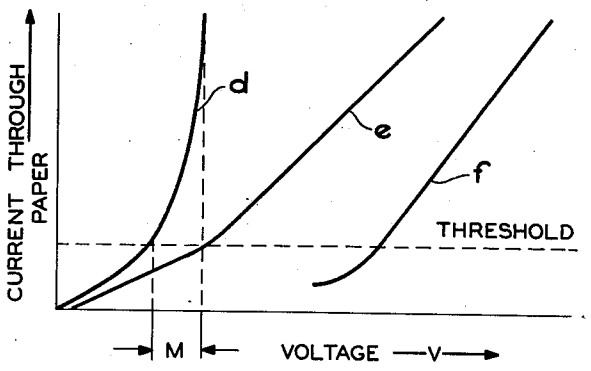


FIG. 11

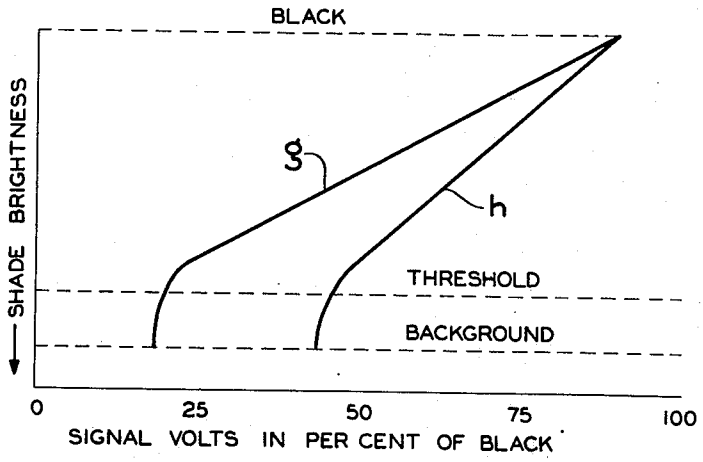


FIG. 12

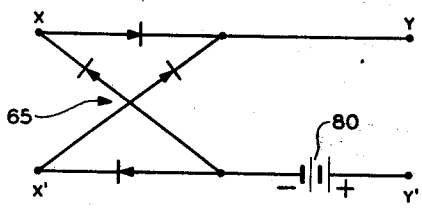
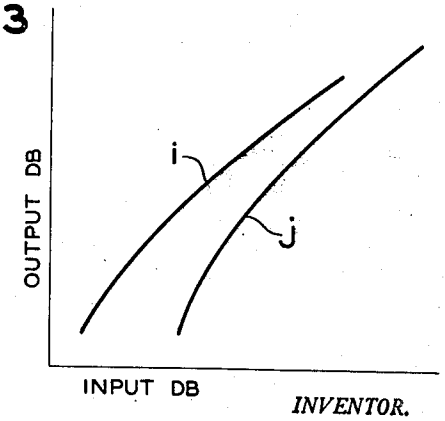


FIG. 13



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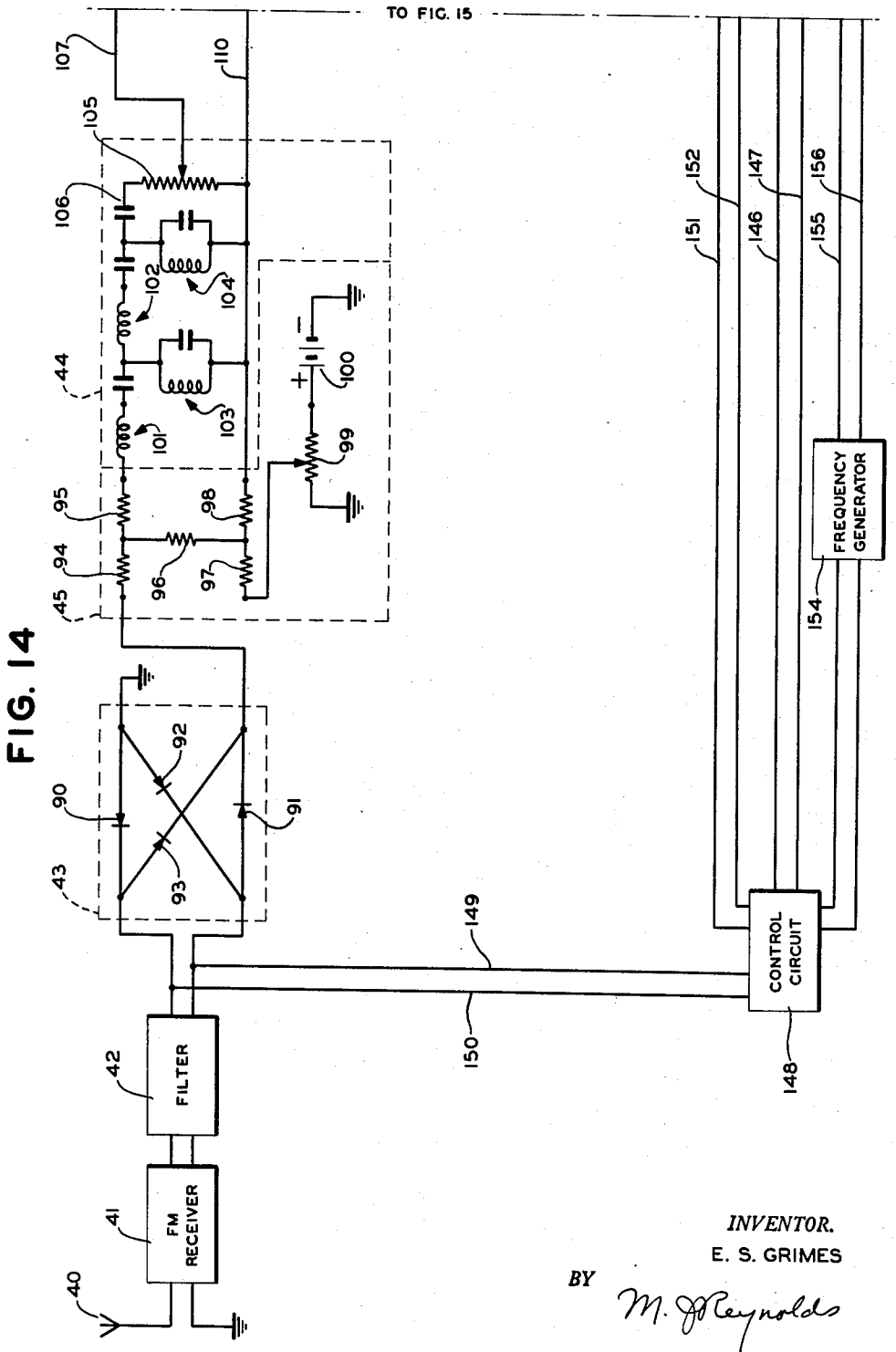


FIG. 14

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FACSIMILE RECEIVER

Filed March 16, 1951 6 Sheets-Sheet 6

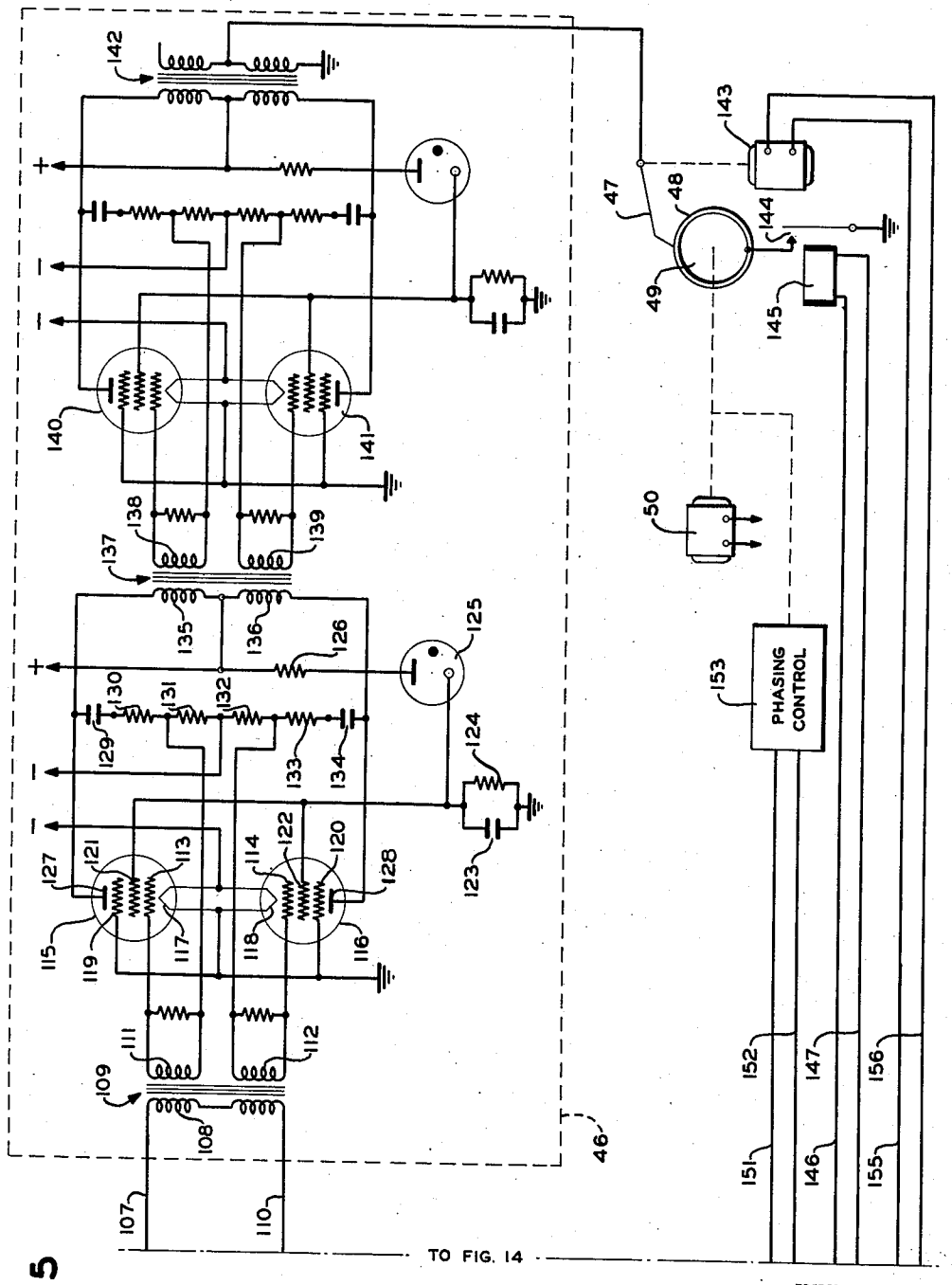


FIG. 15

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Patented Mar. 16, 1954

2,672,504

UNITED STATES PATENT OFFICE

2,672,504

FACSIMILE RECEIVER

Edgar S. Grimes, Ridgewood, N. J., assignor to The Western Union Telegraph Company, New York, N. Y., a corporation of New York

Application March 16, 1951, Serial No. 215,967

9 Claims. (Cl. 178—6.6)

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The present invention relates to telegraphic communication by facsimile signals and more particularly to receiving and recording facsimile signals.

When receiving facsimile signals transmitted over a radio channel, interference or noise signals tend to produce background marks on the recording copy sheet during spacing intervals, i. e., intervals during which the received carrier is not modulated with a facsimile signal. These interference or noise signals may emanate from various sources. One such source, which is particularly troublesome when using a frequency modulation channel, is an adjacent voice modulated FM signal. Another source, which is of particular importance in mobile facsimile recorders, is automotive ignition noise.

The presence of background marks on a facsimile copy sheet causes the copy sheet to appear soiled and materially reduces the legibility of the recorded information.

Accordingly, it is an object of the invention to provide facsimile receiving and recording apparatus in which the copy sheet will be substantially free of background marks caused by interference or noise signals.

More particularly, it is an object of the invention to provide facsimile receiving and recording apparatus having low sensitivity to interference or noise signals during spacing intervals.

A further object of the invention is to provide a facsimile receiver and recorder suitable for use on a frequency modulation channel and in which background marks on the copy sheet resulting from interference due to voice modulated FM channels are substantially eliminated.

Another object of the invention is to provide a simple and compact facsimile receiver and recorder suitable for use in a mobile installation and in which copy sheet background marks resulting from ignition or other noise signals are substantially eliminated.

Further objects of the invention will appear from the following description.

According to the invention, these objects are achieved by providing a facsimile receiver and recorder coupled to the output of a radio receiver and comprising a biased facsimile carrier frequency multiplier and a recording amplifier arranged to shorten and straighten the effective recording characteristic of the recording copy sheet.

The invention will now be described in greater detail with reference to the appended drawings in which:

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Fig. 1 is a block diagram of a facsimile transmitter station;

Fig. 2 is a block diagram of a facsimile receiver and recorder in accordance with the invention;

Fig. 3 illustrates a carrier frequency doubler and filter in accordance with the invention;

Fig. 4 illustrates a carrier frequency quadrupler and filter in accordance with the invention;

Fig. 5 is a series of curves showing the noise and interference suppression characteristics of the circuits of Figs. 3 and 4;

Fig. 6 is a series of curves illustrating the noise frequency-energy relationship at various points in the circuit of Fig. 3;

Figs. 7 and 8 illustrate recording circuits for facsimile copy sheets;

Fig. 9 illustrates the current-shade characteristic for a typical recording copy sheet;

Fig. 10 shows the voltage-current characteristic curves for a typical recording copy sheet included in various recording circuits;

Fig. 11 shows voltage-shade characteristic curves for a recording copy sheet;

Fig. 12 illustrates a carrier frequency doubler provided with a threshold control voltage;

Fig. 13 shows the transmission loss characteristics of the circuit of Fig. 12 for two values of threshold control voltage; and

Figs. 14 and 15 show a facsimile receiver and recorder in accordance with the invention.

Referring now to the drawing and more particularly to Fig. 1, the markings 20 on a copy sheet 21 are scanned by a light beam 22 from lamp 23, the reflected light passing through a small aperture 24 of a diaphragm 25 and onto a phototube 26. The speed of movement of the copy sheet 21 is adjusted relative to the markings thereon so that the facsimile signal developed across phototube load resistor 27 contains the desired frequency range. For purposes of illustration, a frequency range of from 0 to 2000 cycles will be assumed. It is to be understood, however, that this frequency range, as well as other frequencies and ranges to be specified hereinafter, are given solely for purposes of illustration and are not to be considered as limiting.

The facsimile signal developed across resistor 27 is applied to D. C. amplifier and inverter 28, the output of which is applied to a balanced modulator 29. Amplifier and inverter 28 may comprise, for instance, a single stage triode amplifier.

Those portions of the facsimile signal applied

to modulator 29 which correspond to marks on copy sheet 21 are characterized by maximum voltage. The facsimile signal in modulator 29 is modulated on an oscillation from an oscillator 30. If this oscillation has a frequency of 11,700 cycles, the output of modulator 29 will include frequencies lying within the range 9,700 to 13,700 cycles. A filter 31, intercoupling modulator 29 and a transfer modulator 32, suppresses all frequencies lying outside this range. The facsimile signal in transfer modulator 32 is modulated on an oscillation of 14,000 cycles from an oscillator 33, the modulated signal being applied to a filter 34 to suppress all modulation components lying outside the range 300 to 4300 cycles. The resultant facsimile signal constitutes a 2300 cycle carrier having a 2000 cycle envelope. This signal is applied to a frequency modulation transmitter 35 and the resultant FM wave is transmitted from an antenna 36.

The double modulation process described produces an undistorted facsimile signal envelope on a carrier having a frequency only slightly higher than the range of facsimile signal frequencies. Other modulation methods tend to produce appreciable amounts of distortion.

Balanced modulator 29 and transfer modulator 32 may be of any conventional type. For instance, transfer modulator 32 may conveniently be realized as a modulator of the type shown in U. S. Patent 2,462,093, issued February 22, 1949, to E. S. Grimes.

In Fig. 2, an FM wave received on an antenna 40 is applied to an FM receiver 41. The received FM wave may emanate from a transmitter of the type shown in Fig. 1 or from any other FM transmitter. The demodulated output of receiver 41 is applied to a filter 42. Assuming the frequency ranges of Fig. 1, filter 42 should suppress all frequencies lying outside the range of 300 to 4300 cycles.

The output of filter 42, which comprises a 2300 cycle carrier with a 2000 cycle envelope, i. e., 300 to 4300 cycles, is applied to a frequency doubler 43, the output of which includes a carrier frequency of 4600 cycles having a 2000 cycle envelope, i. e., 2600 to 6600 cycles. The output of doubler 43 is applied to a filter 44 which suppresses frequencies lying outside the 2600 to 6600 cycle range. A threshold control 45 prevents transmission of energy from doubler 43 to filter 44 except when the energy level exceeds a predetermined value.

The output of filter 44 is applied to a recording amplifier 46, the output of which is, in turn, applied to a stylus 47 arranged to scan a copy sheet 48 on a drum 49 driven by a motor 50. The arrangement of Fig. 2 will be described in greater detail hereinafter in connection with Figs. 14 and 15.

During spacing intervals, i. e., intervals during which a blank portion of the copy sheet at the transmitter is being scanned, the FM receiver output should have some predetermined minimum value such as zero. In practice, however, the receiver output during spacing will exceed the desired minimum value because of interference or noise signals modulated on the FM carrier or otherwise present in the receiver. For instance, voice modulated FM signals having the same or an adjacent FM carrier frequency will produce interference signals in the receiver output lying within the voice frequency range. Automotive ignition noise, which is predominantly high frequency in character, will appear at the output of receiver 41 as voice frequency noise signals.

During marking intervals, these interference and noise signals will be modulated on the low frequency facsimile carrier and will tend to vary the shade of the marks produced on copy sheet 48. However, such shade variations are not unduly objectionable. During spacing intervals, on the other hand, the interference and noise signals will tend to cause stylus 47 to record marks, thereby producing the effect of a soiled copy sheet. If these signals are sufficiently strong, it may become difficult to differentiate between the background and marks.

The carrier frequency doubler and filter illustrated in Fig. 3 serves to suppress a large proportion of the interference and noise signals present in the receiver output during spacing intervals. The carrier frequency doubler, which comprises rectifier elements 55, 56, 57 and 58 poled as shown in Fig. 3, causes the low frequency facsimile carrier frequency to double, although modulation components in the envelope thereof retain the same absolute spacing from the doubled carrier.

In the example assumed, the instantaneous value e of the voltage at terminals XX' is given by the relationship:

$$e=A \sin 2\pi f_2 t+Am_a \sin 2\pi f_2 t-E_0 \cos 2\pi f_1 t$$

where A is the amplitude of the unmodulated 11,700 cycle output of oscillator 30, f_2 equals 2300 cycles, m_a is the percentage modulation, E_0 is the amplitude of a voltage having a frequency of 2000 cycles, and f_1 equals 2000 cycles. This wave is rectified by the carrier frequency doubler, the resultant wave at terminals YY' being given by the relationship:

$$e=-E_0 \cos 2\pi f_1 t+\frac{A_2}{K_2}+\frac{m_a A_2}{K_2}(-E_0 \cos 2\pi f_1 t)+$$
$$\frac{A_4}{K_4}+\frac{m_a A_4}{K_4}(-E_0 \cos 2\pi f_1 t)+ \ldots$$

where

$A_2=\sin 2(2\pi f_2 t)$,
$A_4=\sin 4(2\pi f_2 t)$,

and K_2 and K_4 indicate amplitude constants. In this latter equation, the low frequency facsimile carrier of 2300 cycles has been suppressed by being balanced out, and new components have been generated. These new components include a second harmonic of the carrier, indicated by $A_2=\sin 2(2\pi f_2 t)$ where the sin is a function of $2f_2$ or 4600 cycles, and having the original 2000 cycle envelope. Also included are successive even harmonics each with the original envelope.

A T filter section comprising a first series branch 59 and 60, a second series branch 61 and 62 and a shunt branch 63 and 64 intercouples terminals YY' and ZZ'. The filter passes substantially only the second harmonic of the carrier plus or minus the envelope frequencies, so that the wave at terminals ZZ' is constituted almost entirely by frequencies within the range 2600 to 6600 cycles.

Fig. 4, which illustrates a carrier frequency quadrupler, comprises a first doubler section 65 and a first filter section 66, identical to the doubler and filter section, respectively, of Fig. 3. However, at terminals ZZ' of Fig. 4 there is added a second doubler section 67 similar to section 65 and a filter section 68 tuned to a frequency double that of filter 66. The carrier frequency at terminals BB' is 9200 cycles, while the envelope

at this point extends from 7200 cycles to 11,200 cycles.

The function of the carrier frequency multiplier and filter circuits in suppressing interference and noise signals during spacing intervals will now be described in connection with Fig. 5.

Fig. 5*a* illustrates the attenuation characteristics of the filter of Fig. 3 or filter **66** of Fig. 4. As is apparent from the drawing, the filter passes a band of frequencies from 2600 to 6600 cycles. Fig. 5*b* shows that the input facsimile signal at terminal XX' extends from 300 to 4300 cycles. Fig. 5*c* shows that the major components present at terminals YY' constitute a detected band from 0 to 2000 cycles, a doubled carrier plus envelope band from 2600 to 6600 cycles, and a quadrupled carrier plus envelope band from 7300 to 11,200 cycles. As indicated in Fig. 5*d*, the output signals at terminals ZZ' are constituted by the double carrier plus envelope band extending from 2600 to 6600.

The above discussion has had reference to marking periods during which a facsimile signal is applied to terminals XX'. In Fig. 5*e* there is shown a noise or interference voltage band extending from zero to 1500 cycles. During spacing intervals no facsimile signal is present in the receiver so these noise or interference voltages will not be modulated on the facsimile carrier. The major portion of the power from interfering voice signals and from ignition noise falls in the band from zero to 1500 cycles, so any suppression which can be produced in this band will greatly lessen the copy sheet background marking. From Fig. 5*f*, it can be seen that at terminals YY' the undesired voltages occupy a doubled band extending from zero to 3000 cycles. As indicated in Fig. 5*g*, the filter action suppresses the undesired voltages except those within the narrow band of 2600 to 3000 cycles.

If the undesired voltages are again doubled in frequency, as by adding additional double-filter sections **67** and **68**, the undesired voltages at terminals AA' will lie outside the pass band of filter **68**, so that there will be substantially none of the original undesired voltages present at terminals BB'. Of course, some undesired voltages will be present at terminals BB' because some of the noise and interference signals will lie above 1500 cycles and because some of the undesired voltages will be quadrupled in frequency by doubler **65** and will pass through filter **66**. However, the power of the undesired voltages at terminals BB' of Fig. 4 or terminals ZZ' of Fig. 3 will be sufficiently low so that marking of the copy sheet background will be substantially reduced.

Suppression of noise and interference signals in the circuit of Fig. 3 is also illustrated in Fig. 6 which is a plot of noise voltage versus frequency. Curve *a* represents automotive ignition noise present at terminals XX'. Curve *b* shows the noise voltages at terminals YY', while curve *c* shows the substantially reduced noise voltages present at output terminals ZZ'.

Fig. 7 shows one recording circuit for copy sheet **48**. Copy sheet **48** may comprise a non-electrolytic conducting paper having an electro-sensitive marking coating thereon and may be of the nature disclosed in U. S. Patents Nos. 2,251,742 and 2,528,005, issued August 5, 1941, and October 31, 1950, respectively, to B. L. Kline. This sheet, which may be represented as a variable resistance element, is connected in series with a resistance **70**, the facsimile signals V being applied across the series combination.

In Fig. 8, copy sheet **48** is included in the anode circuit of a tube **71**. A pair of resistance elements **72** and **73** are coupled in series across copy sheet **48**, the facsimile signal V being applied between grid **74** and the junction of resistors **72** and **73**. Cathode **75** is connected to ground, while anode **76** is connected to the junction of resistor **72** and copy sheet **48**.

Fig. 9, which illustrates the current-shade characteristic of a typical copy sheet material for a given stylus pressure, indicates that the shade is proportional to current through the copy sheet over most of the recording range. However, at a given low value of current, no mark will be recorded on the copy sheet. This constitutes the threshold shade of the copy sheet. At high values of current, shade ceases to vary with current. This constitutes the black shade of the copy sheet. It is evident that noise or interference voltage applied to the copy sheet during spacing intervals need only produce the threshold current through the copy sheet in order to produce an objectionable mark thereon.

The voltage range required to traverse the shade producing current range of Fig. 9 is shown in Fig. 10, which is a plot of current through the copy sheet versus signal voltage. Curve *d*, which represents the copy sheet alone, indicates that the impedance of the copy sheet decreases from a relatively high value at low signal voltages to a relatively low value at high signal voltages. Using a typical copy sheet, the impedance measured at 85 volts was 27,000 ohms, while the impedance at 125 volts was 3,600 ohms. Because of the variable impedance characteristic of the copy sheet, the voltage range required to cover the entire contrast range may be modified by modifying the circuit in which the copy sheets constitutes a circuit element.

The voltage range M of Fig. 10 represents the voltage variation necessary to cover the contrast range of curve *d*. The voltage range M, with a typical copy sheet, might be in the order of 4 db, or a facsimile carrier percentage modulation of 37%. If a resistance element in the order of 10,000 ohms is connected in series with the copy sheet, as in Fig. 7, the resulting current voltage characteristic is that of curve *e*. The voltage range now required to cover the entire contrast range is materially increased, for instance, from 4 db to 14 db.

If the copy sheet is included in the anode circuit of an electron discharge tube provided with negative feedback, as in the circuit of Fig. 8, the voltage range required to cover the entire contrast range decreases to about 8 db. Curve *f* represents the copy sheet included in the circuit of Fig. 8. The voltage scale of curve *f* differs from that of curves *d* and *e* in that it represents grid voltage. When the copy sheet is included in a circuit similar to that of Fig. 8, the ratio of the voltage required to cause a threshold marking current to the total contrast voltage range is increased relatively to the same ratio for the copy sheet alone, as in curve *d*, or in series with a resistor, as in curve *e*. Since an interference or noise voltage must be higher than the threshold voltage to produce a mark on the background, a circuit which increases this threshold voltage and which also permits use of a high percentage modulation provides a material reduction in background marking.

A comparison of the circuits of Figs. 7 and 8 with respect to these characteristics is given in Fig. 11, which is a plot of shade brightness versus

signal voltage in percent of signal voltage for full black. Curve *g* represents the copy sheet in series with a resistor, which may be the circuit of Fig. 7 or the copy sheet included in the anode circuit of a pentode. The contrast of curve *g* varies linearly from black to the threshold shade. Below the threshold shade there is a sudden change in contrast to the background shade. The threshold occurs at approximately 20% of full black voltage, and interference or noise voltages below this level will not be recorded in the absence of a carrier signal, i. e., during spacing intervals.

Curve *h* represents the circuit characteristics when negative feedback is employed in the recording amplifier, as in Fig. 8. The threshold level has now been raised to approximately 46%, so that more than twice the interference or noise level can be tolerated during spacing intervals. This represents an improvement of about 6 db and has been achieved by shortening and straightening the recording characteristic of the copy sheet circuit.

The threshold level of the copy sheet can be increased further by adding a small negative bias to the rectifiers of the carrier frequency doubler, as shown in Fig. 12 where as bias battery 80 is shown connected between doubler 65 and terminal Y'. Fig. 13 illustrates the transmission loss characteristics of doubler 65 for two values of bias voltage. Curve *i* represents zero bias, while curve *j* represents a small negative bias such as —1.5 volts. Making the bias voltage adjustable provides a convenient means of varying the recording characteristic secured by using negative feedback in the recording amplifier.

In a preferred embodiment of the invention using a single carrier frequency doubler-filter stage, a recording amplifier of the type shown in Fig. 8 and a doubler bias voltage of —1.5 volts, a clear background was recorded on a copy sheet in the presence of interference at the output of the radio receiver having a peak value equal to 65% of the full black signal level. This advantage was achieved, in part, by shortening and straightening the voltage-current recording characteristic and, in part, by suppressing interference voltages.

In order faithfully to reproduce the transmitted copy and to achieve full advantage in noise suppression, it is desirable that the facsimile transmitter have a threshold similar to that of the receiver, that the message background produces no carrier output, and the lightest shade desired to be recorded delivers approximately 50% of the black level.

Figs. 14 and 15, which illustrate a complete receiver circuit arrangement in accordance with the invention, correspond generally to the arrangement shown in Fig. 2.

Facsimile signals intercepted by an antenna 40 are demodulated in FM receiver 41 and applied to filter 42. It is to be understood that the invention is equally applicable to communication systems other than frequency modulation.

The output of filter 42 is applied to carrier frequency doubler 43 which comprises rectifiers 90, 91, 92 and 93 poled, as indicated in the drawing, to provide full-wave rectification. The junction of rectifiers 90 and 92 is connected to ground, while the junction of rectifiers 91 and 93 is connected to one end of a resistor 94. Resistor 94 is part of a resistance pad intercoupling doubler 43 and filter 44 and comprising resistors 94, 95, 96, 97 and 98 coupled together to form an H pad. The free end of resistor 97 is connected to the movable tapping of a potentiometer 99. One end of potentiometer 99 is connected to ground, while the other end thereof is connected to the positive terminal of a battery 100. Adjustment of the tapping of potentiometer 99 varies the threshold bias applied to doubler 43 through resistors 97, 96 and 94. The effect of varying the bias voltage applied to the doubler is discussed hereinbefore in connection with Figs. 12 and 13.

Filter 44 comprises two series arms 101 and 102 and two shunt arms 103 and 104. The output of the filter is applied to a potentiometer 105 through a capacitor 106. The tapping of potentiometer 105 is connected through a conductor 107 to one end of a primary winding 108 of an input transformer 109. The low side of potentiometer 105 is connected to the other end of primary winding 108 through a conductor 110.

The secondary winding of transformer 109 is split into two halves 111 and 112, opposite ends of the respective halves being coupled to control grids 113 and 114, respectively, of amplifier tubes 115 and 116 in push-pull relationship. One end of each of cathodes 117 and 118 are connected together and to ground. The other ends of cathodes 117 and 118 are connected together and to a source of heating current. Suppressor grids 119 and 120 are connected together and to ground. Screen grids 121 and 122 are connected together and coupled to ground through the parallel combination of a capacitor 123 and a resistor 124. Screen grids 121 and 122 are also connected to a source of positive potential through a voltage regulator tube 125 and a resistor 126. Inclusion of a voltage regulator tube in the screen grid supply circuit prevents amplifier tubes 115 and 116 from drawing current until the high voltage supply exceeds a predetermined value. Thus, if a dynamotor is used as a source of high voltage, the dynamotor will not be damaged by undue current drain before it reaches operating speed.

Anodes 127 and 128 of tubes 115 and 116, respectively, are intercoupled by a series circuit including a capacitor 129, resistors 130, 131, 132 and 133 and a capacitor 134. The junction of resistors 130 and 131 and the junction of resistors 132 and 133 are coupled to control grids 113 and 114, respectively, through secondary winding halves 111 and 112, respectively. These connections provide voltage negative feedback for each of amplifier tubes 115 and 116. The junction of resistors 131 and 132 is connected to a source of negative potential thereby to provide an operating grid bias potential for amplifier tubes 115 and 116.

Anodes 127 and 128 are also intercoupled through the primary winding halves 135 and 136 of a coupling transformer 137. Adjacent ends of winding halves 135 and 136 are interconnected and connected to a source of positive potential.

Secondary winding halves 138 and 139 of transformer 137 are connected, respectively, to the control grids of amplifier tubes 140 and 141. The circuit connections of amplifier tubes 140 and 141 are identical with those of tubes 115 and 116, and will therefore not be set forth in detail.

When the receiver is to be used in a mobile installation where power consumption becomes a significant factor, the amplifier tubes may advantageously be realized as type 5618 and the voltage regulator tubes as type OA2. Other tubes

could, of course, be used and the voltage regulator tubes might be dispensed with.

The amplified output signal of tubes 140 and 141 is applied to the primary winding of an output transformer 142, the secondary winding of which is coupled to stylus 47. Stylus 47 is caused to scan copy sheet 48 by means of a stylus motor 143. Copy sheet 48 is mounted on a conductive surface of drum 49 which is rotated by motor 50. The surface of drum 49 is connected to ground through normally open contacts 144 of a relay 145. Relay 145, which may be, for instance, a half nut solenoid, is energized through conductors 146 and 147 connected to a control circuit 148.

Control circuit 148, which is connected to the output of filter 42 through conductors 149 and 150, is fully disclosed in the copending U. S. patent application of C. Jelinek, Ser. No. 230,123, filed June 6, 1951.

Control circuit 148 is also coupled, through conductors 151 and 152, to a phasing control 153 which is mechanically coupled to motor 50 and which serves properly to phase the rotation of drum 49 in accordance with the received facsimile signal. Phasing control 153, including the mechanical coupling to drum 49, is fully disclosed in the copending U. S. patent application of Frederick G. Hallden et al., Ser. No. 6,846, filed February 7, 1948.

Stylus motor 143 is driven by a frequency generator 154 connected thereto through conductors 155 and 156. Frequency generator 154, which may be of any desired type that will produce a substantially constant frequency, is caused to deliver a driving voltage for motor 143 under control of control circuit 148.

While the invention has been described in specific embodiments thereof and in specific uses, it is not desired that it be limited thereto for obvious modifications thereof will occur to those skilled in the art without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing intervals of said signal, comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, a first carrier frequency doubler coupled to said demodulation means thereby to double the carrier frequency of said facsimile signal, means to prevent operation of said carrier frequency doubler for signal voltage levels below a predetermined value, first filter means coupled to said first carrier frequency doubler to suppress transmission of frequencies lying outside the range of the doubled facsimile carrier frequency and its associated modulation envelope, a second carrier frequency doubler coupled to the output of said first filter means to thereby quadruple the carrier frequency of said facsimile signal, second filter means coupled to said second carrier frequency doubler to suppress transmission of frequencies lying outside .the range of the quadrupled facsimile carrier frequency and its associated modulation envelope said facsimile recorder comprising an electric stylus arranged to scan a copy sheet having a given voltage-current recording characteristic, a recording amplifier having an input circuit coupled to said second filter means and an output circuit coupled to said stylus, and circuit means intercoupling said output circuit and said input circuit in degenerative relationship at the frequency of said multipled carrier thereby substantially to straighten and shorten the effective recording characteristic of said copy sheet.

2. A receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing intervals of said signal, comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, a first carrier frequency doubler coupled to said demodulation means thereby to double the carrier frequency of said facsimile signal, first filter means coupled to said first carrier frequency doubler to suppress transmission of frequencies lying outside the range of the doubled facsimile carrier frequency and its associated modulation envelope, a second carrier frequency doubler coupled to the output of said first filter means to thereby quadruple the carrier frequency of said facsimile signal, second filter means coupled to said second carrier frequency doubler to suppress transmission of frequencies lying outside the range of the quadrupled facsimile carrier frequency and its associated modulation envelope said facsimile recorder comprising an electric stylus arranged to scan a copy sheet having a given voltage-current recording characteristic, a recording amplifier having an input circuit coupled to said second filter means and an output circuit coupled to said stylus, and circuit means intercoupling said output circuit and said input circuit in degenerative relationship at the frequency of said quadrupled carrier thereby substantially to straighten and shorten the effective recording characteristic of said copy sheet.

3. A receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing intervals of said signal, comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, a carrier frequency doubler comprising a full wave rectifier circuit coupled to said demodulation means thereby to double the carrier frequency of said facsimile signal, means to prevent operation of said carrier frequency doubler for signal voltage levels below a predetermined value, filter means coupled to said carrier frequency multiplier to suppress transmission of frequencies lying outside the range of the doubled facsimile carrier frequency and its associated modulation envelope, said facsimile recorder comprising an electric stylus aranged to scan a copy sheet having a given voltage-current recording characteristic, a recording amplifier having an input circuit coupled to said filter means and an output circuit coupled to said stylus, and circuit means intercoupling said output circuit and said input circuit in degenerative relationship at the frequency of said doubled carrier thereby substantially to straighten and shorten the effective recording characteristic of said copy sheet.

4. A receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing in-

tervals of said signal, comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, a carrier frequency multiplier comprising a full wave rectifier circuit coupled to said demodulation means thereby to multiply the carrier frequency of said facsimile signal, biasing means coupled to said rectifier circuit to prevent operation of said carrier frequency multiplier for signal voltage levels below a predetermined value, band pass filter means coupled to said carrier frequency multiplier to suppress transmission of frequencies lying outside the range of the multiplied facsimile carrier frequency and its associated modulation envelope, said facsimile recorder comprising an electric stylus arranged to scan a copy sheet having a given recording characteristic, a recording amplifier having an input circuit coupled to said filter means and an output circuit coupled to said stylus, and circuit means intercoupling said output circuit and said input circuit in degenerative relationship at the frequency of said multiplied carrier thereby substantially to straighten and shorten the effective recording characteristic of said copy sheet.

5. In a receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing intervals of said signal, the combination comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, a first carrier frequency doubler comprising a full wave rectifier circuit coupled to said demodulating means, first band pass filter means coupled to said first carrier frequency doubler to suppress transmission of frequencies lying outside the range of the doubled facsimile carrier frequency and its associated modulation envelope, a second carrier frequency doubler comprising a full wave rectifier circuit coupled to the output of said first band pass filter means to thereby quadruple the carrier frequency of said facsimile signal, second band pass filter means coupled to said second carrier frequency doubler to suppress transmission of frequencies lying outside the range of the quadrupled facsimile carrier frequency and its associated envelope, said facsimile recorder comprising an electric stylus arranged to scan a copy sheet, a degenerative amplifier having an input circuit coupled to said second band pass filter and an output circuit coupled to said stylus.

6. In a receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing intervals of said signal, the combination comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, carrier frequency multiplier means coupled to said demodulating means, filter means coupled to the output of said carrier frequency multiplier means, said facsimile recorder comprising an electric stylus arranged to scan a copy sheet having a nonlinear voltage-current characteristic, a recording amplifier having an input circuit coupled to said filter means and an output circuit coupled to said stylus, and circuit means intercoupling said output circuit and said input circuit in degenerative relationship at the frequency of said multiplied carrier thereby to substantially straighten and shorten the effective recording characteristic of said copy sheet.

7. In a receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing intervals of said signal, the combination comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, a first carrier frequency doubler coupled to said demodulating means, a first filter coupled to the output of said first carrier doubler means, a second carrier frequency doubler coupled to the output of said first filter, a second filter coupled to the output of said second carrier frequency doubler, whereby noise signals are suppressed during the spacing intervals of said facsimile signal, and means operatively coupling the output of said second filter to the said facsimile recorder.

8. In a receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing intervals of said signal, the combination comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, a first carrier frequency doubler comprising a full wave rectifier circuit coupled to said demodulating means, first band pass filter means coupled to said first carrier frequency doubler, a second carrier frequency doubler comprising a full wave rectifier circuit coupled to the output of said first band pass filter means, second band pass filter means coupled to said second carrier frequency doubler whereby noise signals are suppressed during the spacing intervals of said facsimile signal, and means operatively coupling the output of said second band pass filter means to the said facsimile recorder.

9. In a receiver circuit arrangement for energizing a facsimile recorder during marking intervals of a facsimile signal and for suppressing energization of said recorder during spacing intervals of said signal, the combination comprising means to demodulate a received radio wave having a modulation component comprising said facsimile signal, said facsimile signal comprising a modulated facsimile carrier, filter means coupled to said demodulating means, a recording amplifier, circuit means coupling said filter means to said recording amplifier input, a facsimile recorder comprising an electric stylus arranged to scan a copy sheet having a nonlinear voltage-current characteristic, said recording amplifier having an output circuit coupled to said stylus, and circuit means intercoupling said amplifier output circuit and said amplifier input circuit in degenerative relationship.

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