Nov. 21, 1939. R. W. CARLISLE 2,180,397

FACSIMILE SYSTEM

Filed Feb. 18, 1935 3 Sheets-Sheet 1

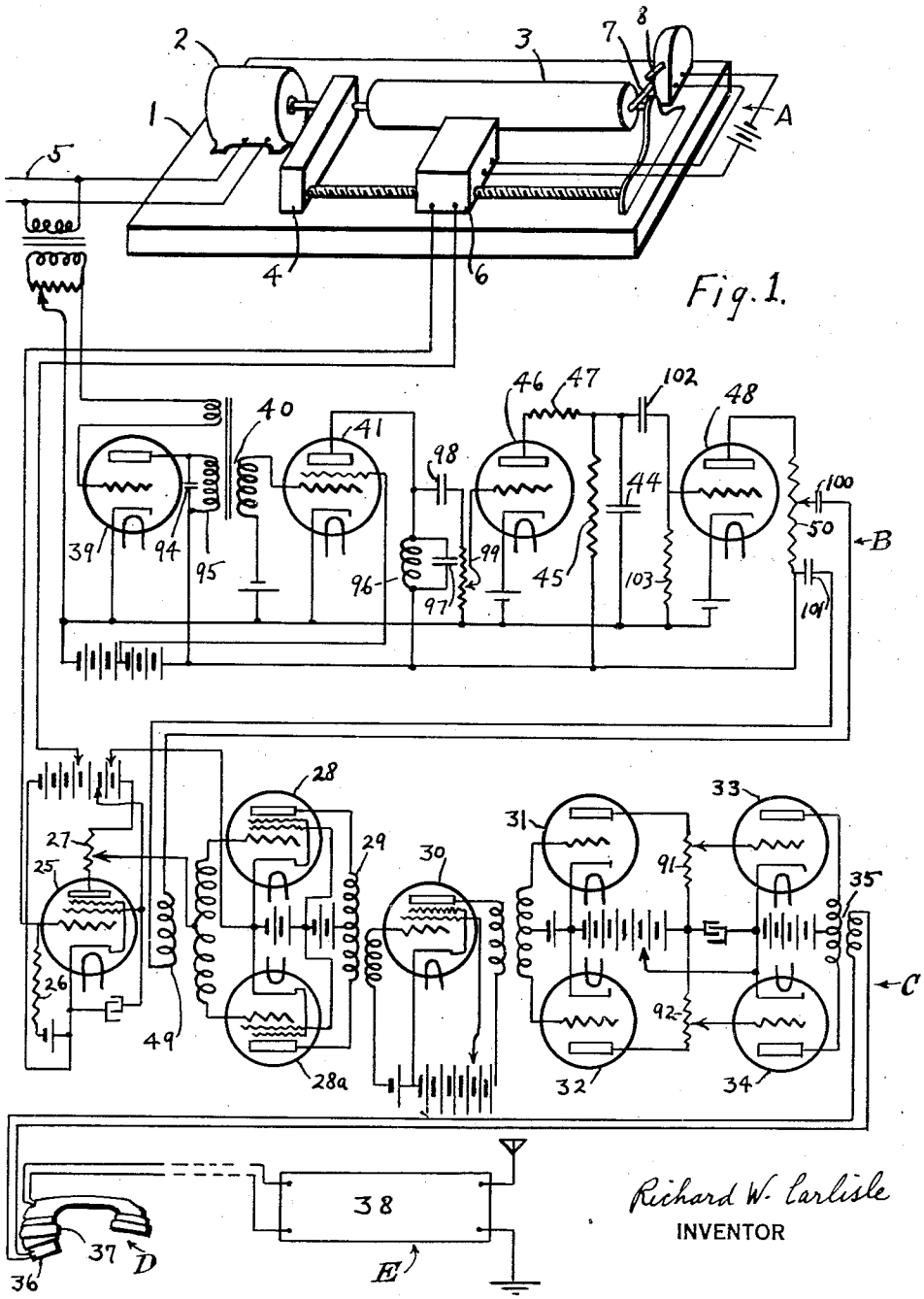


Fig. 1.

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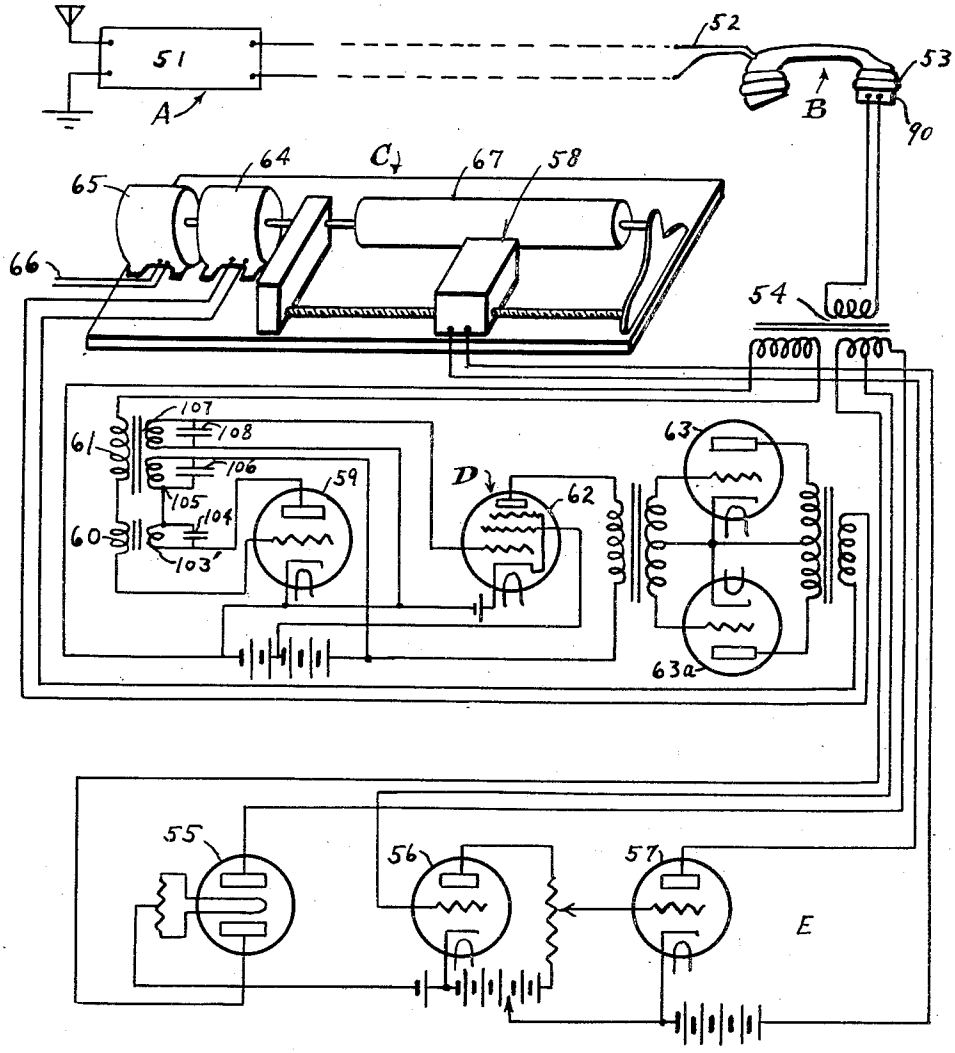


Fig.2.

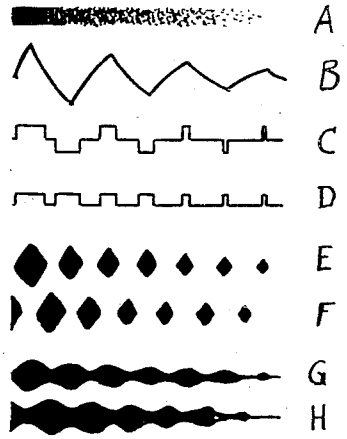


Fig.3.

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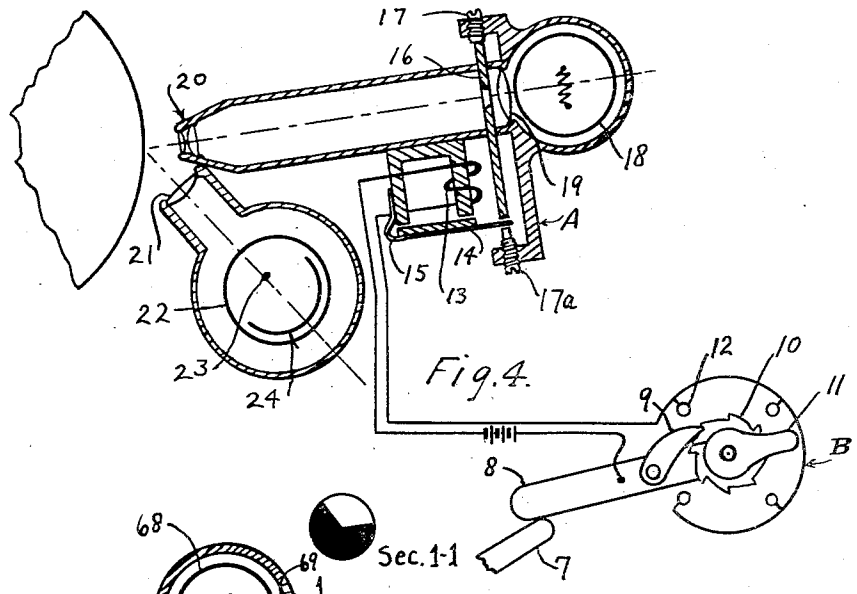


Fig. 4.

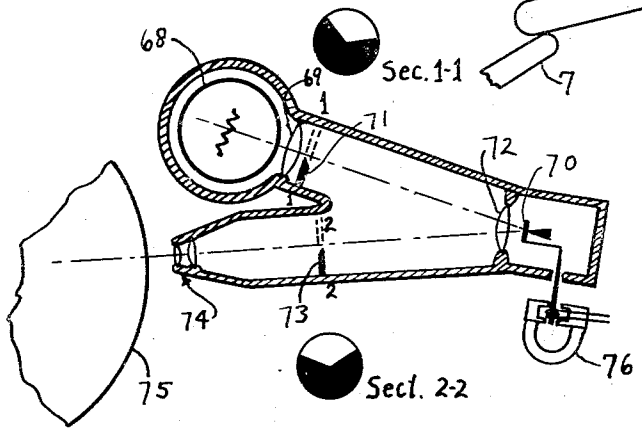


Fig. 5.

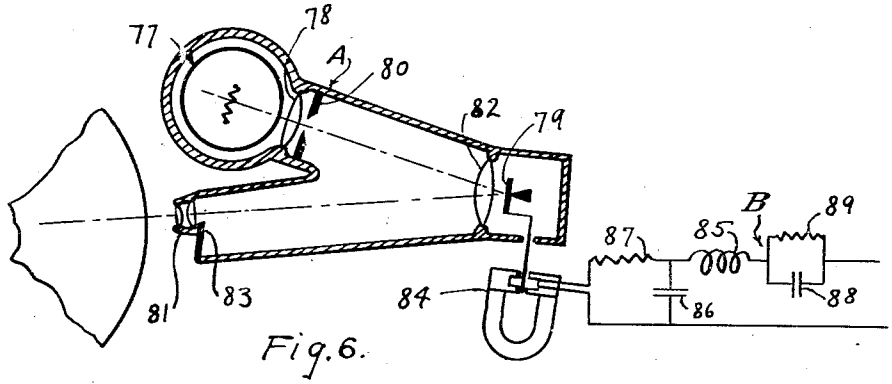


Fig. 6.

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2,180,397

UNITED STATES PATENT OFFICE

2,180,397

FACSIMILE SYSTEM

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Application February 18, 1935, Serial No. 6,993

14 Claims. (Cl. 178—6)

The invention relates to apparatus in which items of visual matter, particularly pictures, are scanned by a photoelectric apparatus which yields an electrical current whose wave form varies in accordance with variations in the degree of light or dark in the picture. This electrical current is transmitted over a communication channel such as a telephone or telegraph line, or a radio transmitter and receiver, to the recording apparatus. At the recording end, a printing mechanism is caused to traverse a recording surface in synchronism with the spot of light at the scanner, and the printer records each picture element with a degree of light or shade which is proportional to the original.

When it is necessary to transmit pictures a long distance, either over a wire line or over a radio channel, certain deleterious influences tend to mutilate the picture. The principal difficulties encountered are diminution of frequency range, echoes, random variations in signal strength, ground noise and phase distortion.

The best way to distinguish real signals from unwanted impulses and variations is to make the ratio of signal to noise as high as possible at the transmitting end, with no value of signal in use except full-on and completely-off. With this type of signal, it is possible to use a circuit at the recorder which will reject all impulses except those having high intensity, and make every strong impulse have exactly the same intensity. If the random disturbances are not too serious, no random impulses will actuate the printing mechanism. In this manner as close a reproduction to the original impulses will be effected as possible under the above-mentioned conditions.

In order to have no signal occurring at any instant on the channel except a full-on or full-off one, it is necessary to divide a half-tone picture into elements like dots in a half-tone engraving, and to distinguish between light and dark by the length of pulse corresponding to each picture element, the elements being scanned in succession.

In systems of this type constructed according to the prior art, an amplifier or a radio transmitter is keyed fully on for the duration of each of a regular succession of pulses, each pulse having a length proportional to the degree of blackness of the particular element of the picture. The amplifier or transmitter is fully off between pulses.

It is impossible to transmit a wave of the nature just described through an audio amplifier or over a telephone line, however, because there are frequency components therein which are below the band which can be transmitted thereon. For instance there is a distinct magnitude to the direct current component in such a wave comprised of the average value of the pulsating currents.

It is the principal object of this invention to devise a wave form which subscribes to the above specification of being all-on or all-off at any given instant, yet has all its frequency components within the spectrum of an ordinary telephone line and also within the spectrum of an ordinary audio amplifier such as used in a radio broadcast receiver.

I accomplish this, in brief, by alternating each consecutive pulse in polarity, so as to balance out any direct current in the line. The pulses are distributed at regular intervals, the frequency of which is the lowest frequency to be transmitted.

It is one object of my invention to provide means at the receiver for printing each impulse as a separate picture element, thus laying down a mosaic pattern like a half tone engraving.

It is furthermore an object of my invention to provide means whereby a picture may alternatively be recorded without this mosaic pattern.

This is desirable in cases where it is necessary to print a picture with a half-tone screen having a different pitch from the screen with which the picture was transmitted.

To accomplish this I use integrating means to average the pulse energy over the length of each picture element, and I make the average density of recording a given picture element proportional to this integrated energy. Previous systems of this character have lacked this feature.

It is furthermore an object of this invention to show how signals transmitted over a telephone line to a radio transmitter may be transformed to a wave shape which will key the transmitter wholly on or off, with the advantage of diminished distortion in said telephone line.

It is furthermore an object of this invention to show how a radio transmitter may be modulated with the same wave shape as supplied to a telephone line, and how this may be picked up by a standard radio receiver and applied to a facsimile recorder connected in place of and in the same manner as a loud speaker.

This modulation system differs from that of the prior art in that the radio transmitter is not keyed all-on and all-off, but is keyed all-on, half-on, all-off and half-on, successively and at regular intervals. This is nearly as advantageous from the point of view of eliminating radio static as the all-on, all-off system, and it has the advantages of being able to actuate, to pass

through and to be amplified in any standard radio receiver designed for use with a loud speaker, thus making it possible to connect a facsimile recorder in place of the loud speaker.

It is also an object of my invention to show how, if it be desired to reduce static to a minimum in the last-mentioned system, it is necessary only to introduce a limiting device between the radio receiver and the facsimile recorder.

According to my invention, I provide an alternating current of triangular wave shape synchronized with the scanning mechanism, modulate it with variations in the picture being scanned, limit the peaks to a definite value, eliminate currents having less than a pre-specified value, transmit this wave over telephone and radio channels, rectify and limit it again at the recording end, synchronize the recording mechanism with the incoming wave, and print a picture either with a mosaic dot pattern, a variable density impression or a variable width line impression.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and as to its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of certain specific embodiments of my invention, when read in connection with the accompanying claims, in which:

Fig. 1 shows a schematic view of the complete transmitting system, in which:

A is a schematic view of the mechanical assembly,

B is a schematic diagram of the triangular wave generator,

C is a schematic diagram of the phototube amplifier, modulator and limiter,

D shows an acoustic connection to a telephone line and

E shows schematically the use of a radio transmitter in the communication channel.

Fig. 2 shows a schematic view of the complete recording system, in which:

A schematically represents a radio receiver,

B represents an acoustic pickup from a telephone line,

C is a schematic layout of the mechanical reproducing system,

D is a schematic diagram of the electrical synchronizing circuits and

E is a schematic diagram of the rectifier and limiter.

Fig. 3 is a chart showing respectively,

A, a portion of original picture grading from black to white,

B, a triangular wave modulated by a signal proportional thereto,

C, said modulated wave after "limiting",

D, said "limited" wave after full rectification,

E, a line of dots printed from D,

F, a consecutive line of dots, staggered with respect to E,

G, a variable-width line printed from D,

H, a line consecutive to G.

Fig. 4 shows a schematic layout of the complete scanner optical system, in which

A is a schematic view of the optical parts, including a schematic representation of a magnetic device for moving the mask and hence the image in order to stagger dots of alternate rows;

B is a schematic representation of a ratchet-operated switch to cause said magnetic device to be actuated during each alternate line.

Fig. 5 is a schematic view of an optical system designed for mosaic recording.

Fig. 6 is a schematic view of a system designed for variable-density recording, in which

A is the optical system and

B is a schematic diagram of a circuit having the frequency characteristics required for integration of the succession pulses.

The manner in which the various parts of the system function in order to produce a wave form suitable for transmission is as follows: The visual matter which it is desired to transmit is affixed to the drum 3 of the scanner shown in Fig. 1, which is a typical scanner as used in the art, although any scanning mechanism may be used. An alternating current of substantially triangular wave form, as shown by the first cycle of Fig. 3B, is generated in the circuits of Fig. 1B. A phototube is used on the scanner, which causes variations in the light and shade of the visual matter such as is indicated by Fig. 3A, to be translated into variations in electrical current. The electrical variations are amplified and caused to modulate the triangular wave previously alluded to, in the circuits of Fig. 1C. After these operations have been performed the electrical wave form appears as shown in Fig. 3B. It is also a function of the circuits of Fig. 1C to limit the peaks of each electrical pulse to a definite value, and to eliminate instantaneous values having less than a pre-determined value. The wave form then becomes as shown by Fig. 3C. This wave form may be impressed upon a telephone line, either by electrical connection or by acoustic coupling as indicated in Fig. 1D.

The telephone line may be used to connect directly to the recorder, or a radio link may be used, as schematically indicated in Fig. 1E. In this case it is intended that the radio transmitter 38 be modulated 50% with no impressed tone, the modulation swinging to zero or 100% in accordance with a positive or negative impulse. Either positive or negative keying may be used. A radio broadcast transmitter may be modulated by the wave form herein discussed in various ways as well known in the art.

In the drawings, the scanning mechanism of Fig. 1 is mounted on the base 1. The motor 2 drives the drum 3 and the gear box 4, and is connected to the alternating current power line 5. The optical assembly 6 is moved along the drum by a screw driven from the gear box 4. Movement of the mask 16 during alternate scanning lines causes the phase of the transmitted wave to be altered in its relation to the scanned page. This in turn causes the picture elements to be staggered transversely at the recorder in which, of course, a corresponding shift is made since, as is well understood, the recorder must always operate in conformity to the scanner. This eliminates the deleterious appearance of vertical rows of dots. At each revolution of the drum a projection 7 thereon (shown enlarged in Fig. 4B) engages with an extensible member 8, the movement of which causes the pawl 9 to push the ratchet 10 one-eighth revolution, which is sufficient to cause the switch arm 11 to alternately contact with and disconnect from the circuit connected to the group 12 of four switch points in parallel. This circuit includes the actuating coil 13 of the magnetic structure of Fig. 4A. When

this coil is energized, magnetic attraction on the armature 14, which is suspended by the spring 15, causes movement of the mask 16, within the limits imposed by set screws 17 and 17a. The remainder of the scanning optical system is comprised of the light 18, the condenser lens 19, the objective lens assembly 20, the pickup lens 21 and the phototube 22.

The cathode 24 of the phototube is connected to the grid of the amplifier vacuum tube 25 of Fig. 1C, and the anode 23 is connected to a positive voltage. The grid bias of vacuum tube 25 is established through the resistor 26. Coupling to the modulator vacuum tubes 28 and 28a is accomplished by the resistor 27, variation of which controls the value of input voltage. Bias may be controlled by connecting the cathodes of 28 and 28a to the proper potential on the B supply of tube 25.

In one specific embodiment of this invention, pentodes such as the RCA type 6C6 vacuum tubes are used for 25, 28 and 28a; resistor 26 is 1 megohm and 27 is 50,000 ohms.

A transformer 49 is used to couple the triangular wave generating circuits of Fig. 2 to the modulators 28 and 28a. Connection may alternatively be made to the respective screen grids or suppressor grids of said modulators. The output of said modulators is taken through the push-pull transformer 29 to an amplifier one tube of which is indicated at 30. This may be constructed either as a D. C. or an A. C. amplifier, the specific frequency range requirements being that it pass alternating current from the fundamental frequency of the triangular wave up to the highest harmonic utilized. The output of this amplifier may be transformer-coupled to the push-pull "limiter", comprised of vacuum tubes 31, 32, 33, and 34. The tubes 31 and 32 have their grids biased negative to cutoff, so that only a powerful positive signal can affect either one; such a signal will, however, cause the grid of either tube 33 or 34 respectively to be driven negative. The latter grids are, however, biased positive, so that the maximum plate current is that with no impressed signal and, since the driving potential will tend to be either negligible or very large, this maximum plate current will be either unaffected or driven to cutoff at the beginning of each pulse. A square-shaped wave will thus result. The action wil be polarized, 31 and 33 being actuated by one half cycle and 32 and 34 by the other half cycle, respectively. The push-pull transformer 35 couples these currents to a line.

The operation of the system thus far may be reviewed by reference to Fig. 3. In Fig. 3A, a section of picture is indicated as grading from black to white.

In Fig. 3B, the substantially triangular wave generated by the circuits of Fig. 2 is shown modulated in intensity by the phototube output.

In Fig. 3C, the output of the limiter system is shown as a series of alternating pulses, the strength of each of which is proportional to the modulated triangular wave.

In this specific embodiment, a power pentode such as the RCA type 41 may be used for 30, driving two Class B dual triodes such as the RCA type 79 tubes in tandem, the first exercising the functions of 31 and 32 and the second those of 33 and 34. respectively. The potentiometers 91 and 92 may be 3500 ohms each.

Connection to a telephone line may either be a direct electrical connection, or an acoustic connection as indicated in Fig. 1D, wherein a sound radiator (an earphone or loudspeaker) 36 is placed in juxtaposition to the telephone microphone 37.

The triangular wave generator of Fig. 1B consists of several stages. The grid of the vacuum tube 39 is energized by the motor supply line 5 to which it is connected. It generates harmonics, one of which is chosen for the "screen" frequency. The "screen" frequency is the frequency at which pairs of individual picture elements are transmitted over the communication channel connecting the scanner to the recorder. It should be so chosen that picture elements will lie in diagonal fashion on the recorded picture.

The harmonic chosen for the screen frequency is segregated in the tuned transformer 40. In one specific embodiment a triode such as the type 37 tube is used for 39; the line frequency may be 60 cycles; and in order to be resonant to the fifth harmonic of a line frequency of 60 cycles, i. e. 300 cycles, the capacitor 94 may be 0.014 microfarad and the inductance of winding 95, 20 henries.

The plate circuit of 41 may likewise be tuned to the screen frequency by the tuned circuit comprising the inductor 96 and the capacitor 97, which with a type 37 tube for 41, may be 20 henries and 0.014 microfarad, respectively.

Coupling to the triangular-wave generating tube 46 is made through the capacitor 98, which may have a capacitance of .005 microfarad. The intensity of signal applied to the grid of the tube 46 is controlled by the setting of the potentiometer 99, which may be 100,000 ohms.

The discharge tube 46 should be of the "grid-glow" or "gas triode" type such as the RCA 885.

This discharge tube is so termed because its function is to cause the discharge at the proper time of condenser 44 through the resistor 47 in series with its own plate circuit. This condenser 44 is always being charged at a constant rate by the current which passes through the resistor 45 from the B supply. It may be seen that the potential on the grid of the coupling tube 48 will rise steadily as the condenser bank charges, and that when the tube 46 is biased instantaneously positive, the plate resistance will fall to a very low value.

In order to secure a triangular wave form, resistor 47 is made equal to substantially half of resistor 45. During discharge, a current twice as great as that through 45 will therefore flow through 47 and the condenser bank will be discharged at approximately the same rate as that at which it was charged. This is the criterion for a triangular wave form voltage. This is impressed on the grid of the coupling tube 48.

In one specific embodiment of my invention, the resistor 45 may have a value of 100,000 ohms, capacitor 44 may have a value of 0.0072 mfd., coupling capacitor 102 may have a value of .005 mfd., and grid resistor 103, 1 megohm. Coupling tube 48 may be a triode such as the RCA type 37, and be coupled to the modulators 28 and 28a by the output control potentiometer 50, which may have a value of 10,000 ohms. If it is desired to keep D. C. potential out of the interconnecting line, the capacitors 100 and 101 may be used, each having a value of 0.1 mfd.

The following description refers to the receiver and to the received impulses. Signals are taken alternatively from a radio receiver 51 or from a telephone line 52, or the two may be used in tandem as illustrated. Connection may be made directly to the line, or acoustic coupling thereto

accomplished by the use of the microphone 90 coupled closely to the telephone receiver 53.

When the signals generated in the manner described are sent over a considerable distance, the long square pulses tend to degenerate into rounded pulses of irregular shape, and the short square pulses tend to degenerate into rounded pulses of relatively diminished intensity and irregular shape.

When received, these signals may be utilized to print the transmitted matter as well as their distortion will permit, by simply connecting a printing element to an alternating-current amplifier actuated by these impulses. In one specific embodiment of my invention, a standard radio receiver 51 may be used, and the printer is connected in place of the loudspeaker. This constitutes the most economical method of receiving visual matter in homes, and in this respect is an improvement over any system of this type in the prior art. In this case every alternate pulse, i. e. all pulses of one polarity, will be recorded on the recording surface.

In another specific embodiment, the full wave rectifier 55 is interposed, in which case every pulse will be recorded, resulting in an improvement in definition.

In another specific embodiment, in order to restore the wave form as nearly as possible to its shape as it left the scanner, a limiting device is interposed between the rectifier and the printer, or between the line and the rectifier. This limiting device may be identical with that used in the scanner, in which case it is comprised of the vacuum tube 56 biased to cutoff and the vacuum tube 57 with a specified positive bias.

The operation of the limiter is as follows: signals too weak to bring the negatively-biased tube above cutoff will have no effect on the output. This action eliminates random impulses of a subordinate nature. Signals sufficiently strong to affect the first tube will swing the second to cutoff. Since the latter is originally biased positive and operates with a phase opposite to that of the first, all values of signal actuating it will cause the plate current to swing from a definite predetermined value to zero. All waves passing through it will therefore appear square-topped as shown in Fig. 3D. In this way every pulse sent out from the transmitting point will be restored to substantially its original length. Amplifying means in addition to that shown may be used if required. The output of this limiter is connected to the recording mechanism 58, which in specific embodiments may take different forms.

Synchronizing may be accomplished by the system diagrammatically illustrated in Fig. 2D, in which the fundamental line frequency is fed to the grid of the vacuum tube 59 by the transformer 54. Tube 59 is arranged to oscillate at some frequency to which rotating apparatus on the recording mechanism may be synchronized. This oscillator 59 is also arranged to be regenerative at the line frequency, which must be harmonically related to the fundamental frequency of said oscillator. Such a coupling relation is established by the tuned transformers 60 and 61. Transformer 60 is tuned to the line frequency of the picture impulses. Transformer 61 is tuned to the proper sub-harmonic thereof, and is used to couple the oscillator to the amplifier stage 62. The latter drives the grids of the output stage 63.

In one specific embodiment of my invention, transformer 60 is tuned to 300 cycles, transformer 61 to 60 cycles; in order to accomplish this, the effective inductances of windings 103', 105 and 107 are 12, 300, and 300 henries respectively, and the capacitances of capacitors 104, 106, and 108 are each 0.04 mfd. A triode such as the RCA type 37 tube may be used for 59, a power pentode such as the type 41 for 62, and one dual Class B triode such as the type 79 may be used to exercise the functions of 63 and 63*a*. The plates of this stage are electrically coupled to an alternating current generator 64, which is mechanically coupled to the non-synchronous driving motor 65 fed by the power line 66, said motor being set to run slightly above synchronous speed. This drives the recording mechanism, which in one specific embodiment is typified by the drum 67 on which the recording surface is affixed. Electrical power is thus fed from the generator 64 to the plates of stage 63. If the recorder is running in synchronism, the plate circuit impedances will be high and little power will be drawn from the generator 64. These impedances will be high because each grid will be driven negative at the instant that a voltage is applied to the respective plate. Any other phase relation will lead to a lower plate impedance at the instant power is applied to that respective plate, with a consequent dissipation of power and a consequent slowing down of the rotating system until synchronism is again established.

Operation of the system may be reviewed by referring to Fig. 3, Figs. 3A, B, and C having already been discussed.

In Fig. 3D the wave form is shown after transmission over a communication channel, rectification, and subsequent squaring-up by a second limiter.

In one specific embodiment of my invention, the picture is printed as a mosaic of individual dots.

In Figs. 3E and F, two consecutive lines of picture elements are shown. A multiplicity of such lines would constitute a mosaic of dots, reproducing the original in the same way that a halftone engraving reproduces a photograph.

One form of printer by which a mosaic of individual picture elements may be printed is shown in Fig. 5. In the drawing, the light 68 is focussed by the objective lens 69 upon the galvanometer mirror 70. The mask 71 shaped as in the section 1—1 comprises an open V. A virtual image of this is formed at the position of the mask 73 by the lens 72. The shape of mask 73 is shown in the section 2—2 to be another open V. The objective lens 74 causes images of the two masks to be superposed at the recording surface 75. The mirror 70 is rotatably suspended and arranged to be tortionally actuated by the electromagnetic driver 76. If the masks were comprised of 45 degree V's, it may be seen that the image on the recording surface would be square and that, due to the motion of said surface relative to the optical system, this square image would produce a record elongated in the direction of motion. In order to compensate for this, the angle of said V's is adjusted so as to diminish the dimension of the image in the direction of motion.

In another specific embodiment of my invention, the mosaic effect is minimized. One form of printer by which a picture may be recorded without much evidence of a mosaic pattern is schematically illustrated in Fig. 6A. The light 77 is focussed by the condenser lens 78 upon the mirror 79. The mask 80 having a rectangular aperture is focussed on the objective lens assembly 81 by the lens 82. Any movement of the mirror therefore swings a beam on or off of the field of the

objective, which is limited near one side by the mask 83. The mirror is actuated by an electromagnetic mechanism 84. In order to integrate each pulse over the entire average period of a pulse, it is necessary to have either a mechanical system or an electrical circuit or a plurality of either or both, each with a critically-damped action and a natural period equal to the fundamental period of the applied pulses.

An electrical resonant system has been chosen for illustration. Shown in Fig. 6B, it is comprised essentially of the inductor 85, the capacitor 86 and the resistor 87. Since such a system tends to discriminate against short impulses, the capacitor 88 and the resistor 89 have been inserted in series to diminish low frequencies in such proportion that the high frequencies, and consequently the short impulses, are reproduced at their proper respective value.

In a specific embodiment of my invention, utilizing a pulse or "screen" frequency of 300 cycles, resistor 87 has 2000 ohms, inductor 85 has one henry, capacitor 86 has 0.27 mfd., resistor 89 has 4000 ohms and capacitor 88, 0.1 mfd.

In another embodiment of my invention, a plurality of such aperiodically tuned systems is used connected in tandem, which causes the mosaic nature of the recorded picture to be practically eliminated. The appearance of such a picture is substantially identical to that of the original, lacking only detail as limited by the screen frequency chosen.

In another specific embodiment of my invention, a metal plate is cut by the incoming impulses, using either a wire line or a combination of wire line and radio circuits. In this case a sharp tool may be used to cut a variable-width groove in a metal plate. This will have an appearance similar in general to Figs. 3G and 3H, the latter being a line consecutive with the former. The degree of mosaic utilized may be controlled so as to yield the best looking picture, by control of the circuits of Fig. 6B or by equivalent mechanical resonant systems. A picture composed of variable-width lines presents a monotonous parallel-line effect, which is greatly relieved by using a mosaic similar to Figs. 3G and 3H having dots laid out in a substantially diagonal pattern.

In the event that it is desired to transmit a picture over a long line and then key a radio transmitter with the wave form shown in Fig. 3D, in which the carrier is fully on for an impulse denoting black and off at other times, the scanner may be arranged in an identical manner with that herein described, and the circuits shown in Fig. 2E may be utilized for keying the transmitter instead of for actuating a printer.

While I have shown and described particular forms of my invention, changes may be effected therein without departing from the spirit and scope thereof, as set forth in the appended claims.

I claim:

1. In a facsimile recording system utilizing currents comprised of regularly spaced pulses of similar polarity, substantially equal intensity and varying length, means for averaging the pulses in order to make a substantially grainless variable density record, comprised of, in combination, an electrically actuated mechanical recording member, resilient controlling means associated therewith, and critical damping means therefor, said resilient controlling means having such stiffness that the natural frequency of resonance is similar to the fundamental frequency of the applied pulses.

2. In a facsimile recording system utilizing currents comprised of regularly spaced pulses of similar polarity, substantially equal intensity and varying length, means for averaging the pulses in order to make a grainless variable density record, comprised of in combination, an electrically actuated mechanical recording member, resilient controlling means associated therewith, and damping means therefor, said resilient controlling means having such stiffness that the natural frequency of resonance is similar to the fundamental frequency of the applied pulses, and an electrical circuit associated therewith for controlling the currents driving said recording member utilizing inductance and capacitance in coupled relationship having such values that the natural frequency is similar to the fundamental frequency of the applied pulses, and resistance critically damping said circuit.

3. In a facsimile recording system utilizing currents comprised of regularly spaced pulses of similar polarity, substantially equal intensity and varying length, means for averaging the pulses in order to make a grainless variable density record, comprised of in combination, an electrically actuated mechanical recording member, resilient controlling means associated therewith, and damping means therefor, said resilient controlling means having such stiffness that the natural frequency of resonance is similar to the fundamental frequency of the applied pulses, and a plurality of electrical circuits in cascade associated therewith for controlling the currents driving said recording member, each utilizing inductance and capacitance in coupled relationship having such values that the natural frequency is similar to the fundamental frequency of the applied pulses, and resistance for critically damping each of said circuits.

4. In a facsimile recording system utilizing currents comprised of regularly spaced pulses of similar polarity, substantially equal intensity and varying length, means for making a substantially grainless variable density record comprised of in combination, a recorder and means for averaging the pulses applied thereto, comprised of an electrical circuit associated therewith for controlling the currents driving said member utilizing inductance and capacitance in coupled relationship having such values that the natural frequency is similar to the fundamental frequency of the applied pulses, and resistance for critically damping said circuit.

5. In a facsimile recording system utilizing currents comprised of regularly spaced pulses of similar polarity, substantially equal intensity and varying length, means for making a grainless variable density record comprised of in combination, a linearly responsive recorder and means for averaging the pulses applied thereto, comprised of a plurality of electrical circuits associated therewith for controlling the currents driving said member, each utilizing inductance and capacitance in coupled relationship having such values that the natural frequency of each circuit is similar to the fundamental frequency of the applied pulses, and resistance for critically damping each circuit.

6. In a facsimile recording system, the method of recording a grainless picture comprised of passing incoming pulses through a critically damped resonant system, and subsequently passing it through another critically damped resonant system.

7. In a facsimile transmitting system, in combi-

nation, means for scanning a picture to generate a picture current, means for generating a triangularly shaped wave, means for combining said current and said wave, means for limiting the maximum values of both positive and negative half-cycles and eliminating small instantaneous values of current in said combined current, means for transposing instantaneously the phase of said limited current by a predetermined angle of 90 degrees relative to said triangular wave, and means for causing said transposition of phase to occur at the end of each scanning line.

8. The method of transmitting shaded pictures which comprises scanning a picture, generating a constant frequency alternating current the amplitude of which is substantially proportional to the shade of the elemental areas of the picture being scanned, limiting the maximum values of both positive and negative half-cycles of said current, eliminating small instantaneous values of current, transposing instantaneously the phase of said limited current by a predetermined angle of substantially 90 degrees relative to said constant frequency alternating current at the end of each scanning trace, and transmitting signals at constant frequency intervals whose pulses are alternately positive and negative.

9. The method of modulating and transmitting shaded pictures which comprises scanning a picture, generating a low frequency electrical wave the amplitude of which is substantially proportional to the shade of the elemental areas of the picture being scanned, limiting the maximum values of both positive and negative half-cycles and eliminating small instantaneous values of current in said low frequency wave, transposing instantaneously the phase of said limited current by a predetermined angle of substantially 90 degrees relative to said low frequency electrical wave at the end of each scanning trace, and varying an alternating current of carrier frequency from a nominal value of half-maximum to either maximum value or zero in accordance with the polarity of said limited low-frequency wave.

10. In a successive-line picture transmission system, an optical scanning system for producing a scanning spot, means for producing electrical currents having a constant frequency controlled by said spot, and means for transposing instantaneously the phase of said currents by a predetermined angle of substantially 90 degrees relative to said constant frequency currents at the end of each scanning trace, comprised of means for moving the position of said spot from one of two predetermined positions to the other in the direction of scanning at the end of each scanning trace whereby vertical striations are avoided.

11. In a successive-line picture transmission system, an optical scanning system for a scanning spot, means for producing electrical currents having a constant frequency controlled by said spot, and means for transposing instantaneously the phase of said currents by a predetermined angle at the end of each scanning trace comprised of means for moving the position of said spot from one of two predetermined positions to the other at the end of each scanning trace.

12. In a successive-line picture system, a successive line mechanism, means for producing a light spot, and means for alternately positioning said light spot during alternate scanning traces at one or the other of two points separated in the direction of scanning by a predetermined distance, said positioning means being comprised of a mechanical member disposed for movement by said successive-line mechanism at a predetermined point in its action between scanning of successive lines and means for changing the position of said light spot from one position to the other and return in response to successive movements of said mechanical member.

13. The method of transmitting shaded pictures which comprises scanning a picture, generating a constant frequency alternating current the amplitude of which is substantially proportional to the shade of the elemental areas of the picture being scanned, limiting the minimum values of both positive and negative half-cycles of said current, eliminating small instantaneous values of current, and transmitting signals at constant frequency intervals whose pulses are alternately positive and negative.

14. In a facsimile transmitting system, in combination, means for scanning a picture to generate a picture current, means for generating a triangular shaped wave, means for combining said current and said wave, and means for limiting the maximum values of both positive and negative pulses and eliminating small instantaneous values of current in said combined current, whereby a wave is generated having no direct component and having the shade of the pictures denoted by the relative duration of the component pulses.

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