

Nov. 10, 1942.

E. BRUCE ET AL

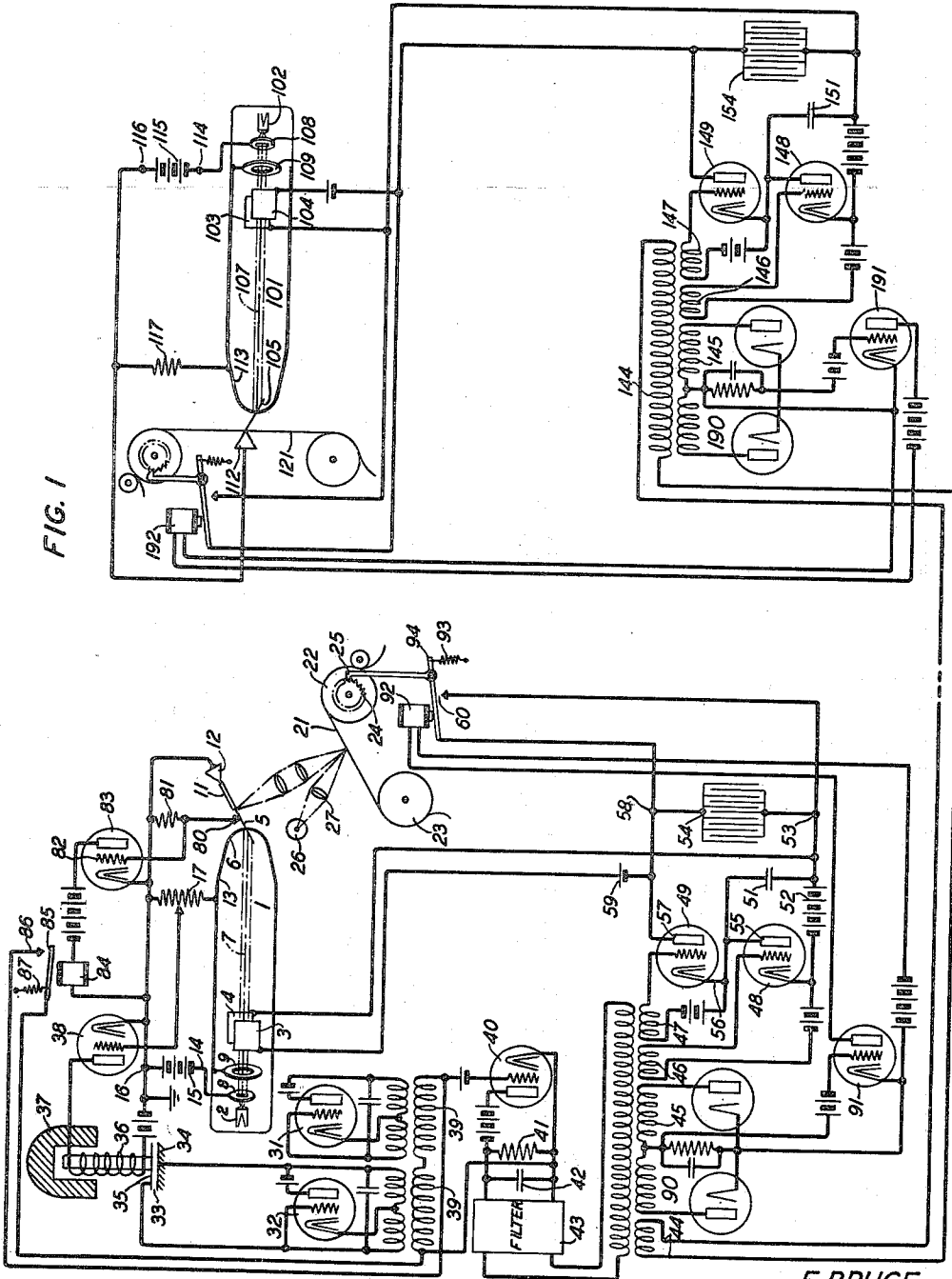
2,301,199

FACSIMILE SYSTEM

Filed April 26, 1940

2 Sheets-Sheet 1

FIG. 1



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2 Sheets-Sheet 2

FIG. 2

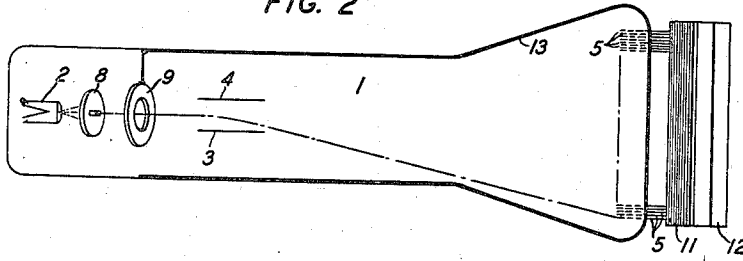


FIG. 3

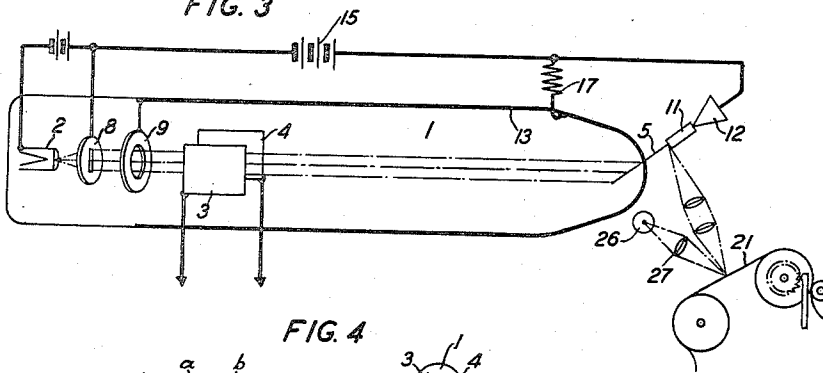


FIG. 4

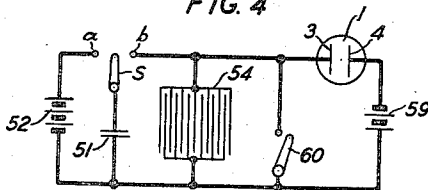


FIG. 5

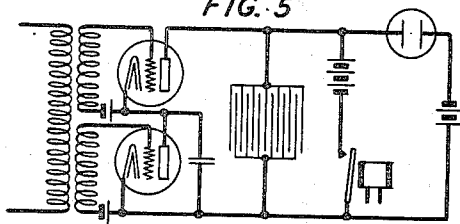
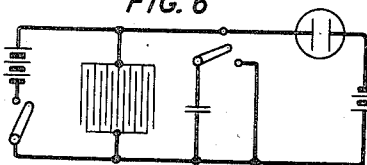


FIG. 6



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2,301,199

FACSIMILE SYSTEM

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Application April 26, 1940, Serial No. 331,716

30 Claims. (Cl. 178—6.7)

This invention relates to signaling systems, and particularly to systems, commonly known as facsimile systems, for transmitting a picture or a printed page to a remote point and there receiving and reconstituting it by electrical means.

An object of the invention is to reduce the time required for the transmission and reconstitution of a given picture or sheet of copy.

Another object is to provide a system in which the transmitter and receiver apparatus are to a large extent identical so that the units shall be interchangeable; all the apparatus being rugged, compact and inexpensive.

Another object is to execute the transmission and reception through the medium of a signal of novel character which is at once a picture signal and a synchronizing signal.

A further object is to provide a system in which the control of transmission takes place entirely at the transmitter, the receiver operating with a minimum of attention from its attendant.

These and other objects may be accomplished in accordance with the invention by the following scheme: There is first provided an oscillation voltage of undetermined frequency. The frequency of oscillation is then determined at one value for dark elements of the picture to be transmitted and at another value for light elements and at intermediate values for values of illumination in between, thus providing an oscillation signal which is frequency-modulated in accordance with the degree of light and shade of successive picture elements; and at the same time the scanning element, for example a cathode beam, is swept over a line of picture elements at a speed related to the oscillation frequency as modulated. This causes the beam to traverse parts of the picture, for example, the lighter portions, much more rapidly than other parts, for example, the darker portions.

This same frequency-modulated signal is then transmitted, without the addition of any other signal, to a receiving station where it causes an appropriate scanning element, for example the cathode beam of a special printing tube, to scan a beam-receiving element at a speed proportional to the instantaneous frequency of the signal; and there are derived from the moving beam impressions whose intensity is related to the speed, for example inversely proportional thereto, being heavier for slow motions of the beam which correspond to dark portions of the picture and lighter for fast motions which correspond to light portions.

A feature of the invention is the use, at both

transmitter and receiver, of a special cathode ray tube which will be more fully described hereinafter.

Another feature is the use of a special cycle-counting circuit arrangement at both transmitter and receiver which holds the two beam deflections in step at all times, thus eliminating the possibility of distortion in the reconstituted picture and the necessity of special synchronizing signals.

The invention will be more readily understood by referring to the following description of a preferred embodiment thereof taken in connection with the accompanying drawings, in which:

Fig. 1 is a circuit diagram of a system according to the invention including the apparatus at the receiver station as well as the apparatus at the transmitter station;

Fig. 2 is a plan view of a special cathode ray tube which may be employed in connection with the invention, showing parts of the output circuit thereof;

Fig. 3 is a side view of the tube of Fig. 2;

Fig. 4 is a simplified equivalent circuit diagram of a portion of the apparatus of Fig. 1;

Fig. 5 is a circuit diagram showing an alternative modification of the same portion of Fig. 1; and

Fig. 6 is a simplified equivalent circuit diagram indicating the operation of the circuit of Fig. 3.

The preferred electro-optical translating device for use with this invention includes a special cathode ray tube 1 which forms the subject-matter of application Serial No. 328,816, filed April 10, 1940, now Patent 2,273,433, issued February 17, 1942, and application Serial No. 328,819, filed April 10, 1940, now Patent 2,273,793, issued February 17, 1942. As shown in Figs. 2 and 3 the tube 1 contains an electron gun which may comprise a cathode 2, a beam-defining anode 3 and a focussing anode 4, as well as a single pair of beam-deflecting elements 5, 6. It is characterized in particular by a receiving element consisting of a single row of discrete insulated conductors 7 spaced close together, which protrude through the end wall 8 of the tube 1 in position to be impinged by the cathode beam 9, thus providing a current window of improved type. The individual wires or conductors 7 of the comb are preferably spaced about 0.01 inch apart.

As employed in connection with a facsimile transmitter in accordance with the invention, this special tube 1 is connected as shown in Figs. 1, 2 and 3 with a strip 10 of photosensitive mate-

rial, for example selenium, in contact with the outer ends of all the wires 5 of the comb, and a conducting member 12 preferably in the form of a knife edge in contact with the rear surface of the selenium strip 11. The beam-receiving end 6 of the tube and the inner walls adjacent thereto are lined with a conductive coating 13 such as that commonly known as "aquadag," or the like, in well-known manner. The negative terminal 14 of a battery or other source 15 of steady potential is connected to an appropriate electrode of the electron gun, such as the beam-defining anode 8 and the positive terminal 16 of the source 15 is connected to the knife edge 12 as shown. The positive terminal 16 is also connected through a resistance 17 to the aquadag lining 13 of the tube and to the focusing anode 9.

The picture or other copy to be transmitted may be mounted or supported on a belt or tape 21 which passes over rollers 22, 23 one of which, 22, is provided with a ratchet and pawl mechanism 24, 25 for intermittent line-by-line advance thereof. Light from a long line filament 26 is sharply focused through a cylindrical lens 27 onto a single line of the copy. Light reflected from this illuminated copy line is focused as a line image on the selenium strip 11 at the line of contact of the tube comb wires 5 therewith. With this arrangement, it will be understood that, due to the characteristic of the selenium, the electrical resistance between the knife edge 12 and any particular wire 5 of the tube comb is a function of the illumination of the surface of the selenium 11 in contact with that particular wire, and therefore of the degree of light and shade of a particular element of the illuminated line of copy.

The cathode beam 7 originating at the electron gun is caused to scan the inner ends of the wires 5 which form the comb in a manner shortly to be described. As is well known, the cathode beam carries a substantially constant current which divides between the wires of the comb and the conductive lining 13 of the tube, a greater part of the current passing through a comb wire to a part of the selenium surface whose resistance is low due to high illumination and a smaller part through a comb wire in contact with a part of the selenium whose resistance is high due to low illumination. The balance of the current in each case travels to the conductive lining 13 and returns to the cathode 2 through the resistance 17 and the source of potential 15.

Thus the current through the resistance 17 fluctuates in accordance with the degree of illumination of the line image on the selenium strip 11 and may be utilized as a picture signal in a manner to be described shortly.

In accordance with the invention there is further provided an oscillation generator of variable frequency. This oscillation generator may be of any desired type but for the purposes of this facsimile system the well-known beat-frequency oscillator is preferred. Therefore two separate discharge devices 31, 32 are provided, connected in well-known manner to produce sustained oscillations, the first 31 of a constant high frequency and the second 32 of a high frequency variable between limits through the operation of a variable condenser 33 connected between its control electrode and its anode. This variable condenser may conveniently comprise a stationary plate 34 and a movable plate 35 onto which is mounted a coil 36 disposed in

the field of a permanent magnet 37 after the familiar fashion of a loud-speaker. This coil is connected as shown to be energized from the output circuit of a discharge tube 38, to the control electrode of which is applied a voltage derived from the resistor 17. Thus the current through the winding 36 and therefore the spacing of the plates 34, 35 and the capacitance of the condenser 33 vary in accordance with the light and shade values of successive picture elements imaged on the selenium strip 11. This, in turn, results in a variation of the frequency of oscillations of the oscillator 32.

The two oscillators 31, 32 are together coupled to coils 39 connected in the input circuit of a modulator tube 40, across the output resistor 41 of which there will therefore appear an oscillation, known as a "lower side frequency," whose frequency is the difference between the oscillation frequencies of the two primary oscillators 31, 32 and which varies in accordance with the illumination of successive picture elements impinged by the cathode beam. The modulator output will also contain an upper side frequency component, but this may be rejected by a bypass condenser 42, or otherwise disposed of in any desired manner.

Suitable choice of the constants of the oscillator circuit permits the mean frequency of the oscillations appearing in the output winding 41 to be selected as desired and also permits its deviation from its mean to be as large or as small as may be desired. For black-and-white copy, suggested frequencies are 200 cycles per second for black and 2000 cycles per second for white.

The beat-frequency oscillator is capable of delivering oscillations of continuously variable frequencies, and is therefore appropriate to continuous gradations of light and shade of the copy. If desired, in the case of black-and-white copy, a system capable of supplying only a "black" frequency or a "white" frequency may be employed. Such, for example, would be a system comprising two separate oscillators supplying the same line, one tuned to the "black" frequency and the other to the "white" frequency, and an electronic switch of any suitable type arranged to switch back and forth from one to the other.

Energy from the output circuit 41 of the modulator tube 40 is supplied through a filter 43 to two different paths, the first being a line 44 which may include a radio link, leading to the receiver and which will be described hereinafter, and the second being the novel variable-speed sweep circuit of the invention. The latter path comprises three windings one of which, 45, supplies a rectifier circuit described hereinafter, the other two, 46, 47, being connected to the input terminals of two discharge devices 48, 49 as shown. The output circuit of one of these discharge devices 48 includes a condenser 51 and a battery 52, the positive battery terminal also being connected to one terminal 53 of a second condenser 54 which is many times as large as the first. The anode 55 is directly connected to the cathode 56 of the other device 49 whose anode 57 is in turn directly connected to the opposite terminal 58 of the large condenser 54. The deflecting elements 3, 4 of the cathode ray tube are connected with the interposition of a biasing battery 59 to the terminals of the large condenser 54. The input windings 46, 47 of these two discharge devices 48, 49 are poled 180 degrees apart and their control electrodes are biased below cut-off.

The operation of this portion of the circuit will be understood from a consideration of Fig. 4 which is a simplified equivalent thereof. Referring now to Fig. 4, a small condenser 51 is arranged to be alternately connected to a battery 52 by closing switch S to terminal a, and disconnected therefrom and connected to a large condenser 54 by closing the switch S to the terminal b. Thus alternately connecting the switch S to the points a and b results in charging the small condenser 51 to the voltage of the battery 52 and then discharging it into the large condenser 54. Repetition of this operation therefore results in successively increasing the voltage of the large condenser 54 by discrete voltage increments. Since the terminals of the large condenser 54 are connected to the deflecting elements 3, 4 of the tube 1, successively connecting the switch S to the points a and b results in causing the cathode beam 7 to move across the wire comb 5 in jumps, one jump for each cycle of the switch S and in perfect synchronism with motion of the switch.

A discharging switch 60 is indicated in Fig. 4 as connected to the terminals of the second condenser 54. It will be understood that instantaneously closing this switch 60 will short-circuit the large condenser 54 and return the cathode beam 7 to its initial position.

The battery 59 is interposed in the deflecting element circuit in order that the initial position of the cathode beam 7 shall be toward one side of the beam-receiving comb instead of in the center thereof.

The operation of the cycle-counter circuit of Fig. 1 will now be understood. Since the input windings 46, 47 of the discharge tubes are poled 180 degrees apart and the control electrodes biased below cut-off, these two tubes together operate precisely in the manner above described in connection with the switch S of Fig. 4. On a positive peak, for example, of the signal in the winding 46 the tube 48 is rendered conductive so that the small condenser 51 is charged to the voltage of the battery 52, the second tube 49 being meanwhile non-conductive. On the next negative peak, say, of the signal, the first tube 48 is non-conductive and the second one 49 is rendered conductive so that the small condenser 51 is discharged into the large condenser 54. The deflecting elements 3, 4 of the cathode ray tube are connected, with the interposition of a beam biasing battery 59, across the large condenser 54. A switch 60 is connected across the large condenser 54 instantaneous closing of which short-circuits the condenser 54 and returns the beam to its starting point.

The circuit above described therefore constitutes a signal-operated cycle counter for deflecting the cathode beam in steps of a preassigned magnitude, one step for each cycle of the oscillator output, modulated by the vision signal or not, as the case may be, and independently of signal magnitudes and depending solely upon the instantaneous frequency.

The ratio of the capacitances of the condensers 51, 54 is preferably such that each single step of the beam deflection is about 0.01 inch, which is the same as the distance between successive comb wires. Perfect equality in magnitude of successive condenser voltage increments is obtained in the ideal case in which the condenser 51 is negligibly small in comparison with the condenser 54. In actual practice, the departure from linearity is less than five per cent when the large condenser is 10,000 or more times as great as the

small condenser and this slight departure is substantially harmless. If desired, however, a network having an inverse characteristic may be utilized to compensate for the residual non-linearity of the cycle-counting circuit. Various suitable networks of this kind will occur to those skilled in the art.

Instead of deflecting the cathode beam by successive incremental charges of the condenser 51 it may, if desired, be deflected by successive incremental discharges of a condenser which is originally charged to its maximum voltage for zero deflection of the beam. Fig. 5 shows an alternative modification of the cycle counter of Fig. 1 which operates by successive discharges, and Fig. 6 shows a simplified schematic diagram to illustrate the operation of Fig. 5. From the above description of Figs. 1 and 4, the mode of operation of Figs. 5 and 6 will be understood by those skilled in the art as will also be understood such minor modifications of the circuit of Fig. 1 as may be appropriate for the use in connection therewith of the cycle counter of Fig. 5.

If any device of this character provision must be made for returning the scanning beam to its initial position as soon as it has reached the end of a line. In accordance with this invention the scanning beam is returned to its starting point when a full line of copy has been scanned, independent of the length of the line; that is, independent of whether the copy width utilizes the full length of the comb 5. This is accomplished in the following manner: A movable sliding member 80 bears against the tube comb wires 5 and makes contact with a number of them at the end of the comb 5 remote from the beam starting point. It is connected through a resistor 81 to the positive battery terminal 16 so that when the beam strikes any of the wires 5 with which the slider 81 makes contact, the beam current produces a voltage drop in the resistor 81. This voltage drop is applied to the control electrode 82 of a discharge device 83, normally conductive, to bias the device 83 below its cut-off and so render it non-conductive when the beam strikes these comb wires. The normal output current of the discharge device energizes a relay 84 which holds contacts 85, 86 open against the tension of a spring 87. Thus when the beam strikes the wires in contact with the slider, the relay 84 is deenergized and the contacts 85, 86 close.

These contacts are connected across the input windings 39 of the modulator tube 40 so that on their closure no signal is induced in any of the secondary windings coupled to the modulator output circuit. In particular, no signal is induced in the winding 45 which energizes a full-wave rectifier 90 connected in well-known manner to supply, with or without an intermediate stage of amplification by a discharge device 91, energy to the relay 92 which normally holds the switch 60 open against the tension of a spring 93. When the windings 39 are short-circuited by the contacts 85, 86 as above described, the rectifier 90 ceases to supply energy to this relay 92 which is thereupon closed by its spring 93. Its contacts are connected to the terminals of the condenser 54 and constitute the short-circuiting switch 60 of Fig. 4, so that closure of them operates to restore the scanning beam 7 to its starting point. The relay armature 94 is mechanically linked to the pawl 25 which, upon closure of the contacts 85, 86 advances the roll 22 by one tooth and the copy by a single line. Restoring the beam 7 to its starting point removes it from the wires 5 in

contact with the slider 80 so that the discharge device 83 again becomes conducting and a signal appears in the modulator windings. The relay 92 is thereupon energized and the contacts of the switch 60 opened, allowing the condenser 54 to support a charge and the beam 7 to begin its scan of the following line of copy.

The time constant of this rectifier circuit should of course be substantially greater than the period of the lowest signal frequency to be employed, otherwise the beam might be returned to its starting point at the instant the signal is changing its polarity.

Any desired variation of the relay arrangement above described may be employed. For example, a third relay, operating the copy-moving pawl directly, may be substituted for the mechanical linkage between the pawl 25 and the armature 94; or all three operations may be performed by a single multiple contact relay, ultimately actuated by the electron beam striking comb wires beyond the margin of the copy image, or by any electronic equivalent thereof. Furthermore, short-circuiting the winding 39 is by no means the only feasible scheme for returning the beam to its starting point at the end of the scanning line. Any convenient line-synchronizing signal may be employed as long as the transmitter and receiver respond to it alike. Zero signal serves the purpose adequately, and short-circuiting the winding is a simple scheme for obtaining zero signal.

If desired, the cathode beam 7 may be blanked out during its return stroke, either by modulation of its current or by deflection in a direction perpendicular to the wire comb in an amount sufficient to prevent its impinging on the wires. Such modulation or deflection may be brought about in any convenient manner, for example by exciting a beam control electrode or the deflecting elements upon the occurrence of the zero signal which occurs during fly-back. However, the fly-back due to the short-circuiting of the condenser 54 takes place with such rapidity that no evil results ensue from permitting it to take place, unblanked, along its normal scanning path.

The second path from the output winding of the modulator tube 40 leads, for example, through a standard telephone transmission line 44, to a receiver shown in the right-hand portion of Fig. 1, where the signal appears in the primary input winding 144 to which are coupled the two secondary windings 146, 147 constituting the input circuits of a cycle counter and the third secondary winding 145 which supplies a rectifier 190 to energize a relay 192. Each of these devices may be identical with the corresponding one above described in connection with the transmitter, and operate to modulate the cathode beam of a printer tube which may in turn be identical with the tube above described. The signal therefore deflects the cathode beam 107 of the receiver tube 101 in discrete steps of preassigned magnitude, one step for each cycle of the oscillator output, modulated by the vision signal or not, as the case may be, independently of signal magnitudes and in dependence solely on the instantaneous frequency which, as above described, varies in accordance with the light and shade values of successive line elements of the picture being transmitted. A sheet or tape 121 of appropriately sensitized paper passes close to or in contact with the outer ends of the wires 105 of the printer tube comb, being backed, immediately adjacent the comb wires, by a knife edge 112. The knife edge 112

is connected to the positive terminal 116 of a battery 115 to whose negative terminal 114 an appropriate electrode of the electron gun, for example the beam-defining anode 108 is connected. The printer tube 101 is provided with a conductive lining 113 in the same manner as the transmitter tube 1 and stray electrons, whether primary or secondary, may be collected on the lining 113 and drawn off through the resistor 117. Since, however, scanning at the receiver is controlled wholly from the transmitter, the fluctuating component of the current in this resistor 117 is not utilized.

As the cathode beam, deflected by the incremental voltage on the deflecting elements 103, 104, scans the wires 105 of the comb, current passes out through successive wires, through the sensitized paper 121 to the knife edge 112, and leaves a succession of marks on the paper of character depending on the sensitization thereof. Since the scanning steps are all of equal magnitude and occur once for each cycle of the frequency-modulated signal, the average speed of the beam is low for dark parts of the copy, resulting in dark printing, and higher for light parts, resulting in light printing. When the transmitter beam reaches the end of its line and the interval of zero signal arrives, the receiver rectifier 190 and its associated relay 192 operate, precisely as in the case of the transmitter, described above, to return the beam to its starting point and advance the sensitized paper by the width of one line.

The sensitive paper and the manner in which it is affected by the current emerging from the comb wires 105 may be of any suitable type. For example, the paper may be electrolytically sensitive, being moistened to render it active and conductive. Or it may be a thermally sensitive carbon-loaded paper in direct contact both with the comb wires 105 and the knife edge 112, the marks being made by the heat generated when the current passes through it by conduction.

If sufficiently high voltage is employed, direct conduction is unnecessary, since an arc can be caused to pass through ordinary dry white paper in contact with carbon or dyed wax paper. The heat of the arc may then cause a deposit of carbon or dye on the white paper. Several copies may be made simultaneously by this method if sufficient voltage is available.

Still other types or forms of sensitive paper and methods of forming impressions on them will occur to those skilled in the art as appropriate for use in connection with the invention.

It will be apparent that this system results in continuous synchronization between transmitter and receiver and that the two beams, even while their speeds are varying widely, are in step at all times and at all points of the excursion of each one.

As will now be fully understood, this is because transmitter and receiver are alike in operation and are actuated by the same frequency-modulated signal which is at once a picture signal and a synchronizing signal. The converse, however, is equally true, namely, that the signal at the receiver must contain the same spectrum components as does the transmitter signal in order to produce correct operation. It is to ensure that this shall be the case that the filter 43, whose transmission pass-band is narrower than that of the transmission line, is inserted ahead of the line and of the transmitter scanning circuits.

Herein lies the explanation of the fact that

the residual non-linearity of the cycle counter is substantially harmless. Since the scanning beams remain in step at all times, such non-linearity does not result in geometrical distortion, but only in a printed density slightly greater at the terminating end of each line than at the leading end.

Although the invention has been described in connection with a system as a whole, including both transmitter and receiver, it is, of course, not limited in its scope thereto, the various component elements, subcombinations and methods of operation being likewise aspects thereof, whatever may be the setting or combination in which they appear. Particular circumstances may warrant the use of the receiver in conjunction with a transmitter of quite different character, or the cycle-counting arrangement for the reception and translation of frequency-modulated signals for a purpose different from that described above, or the like. Furthermore, if greater density differences are required of the printer than are obtainable by speed variation of the printer beam alone, intensity modulation may be employed in addition. Apparatus and methods for accomplishing this are well known in the art.

If, for example, the printer tube and cycle counter are used in conjunction with a constant frequency signal to cause constant speed scanning of the printer tube beam, it will be found advisable to employ amplitude modulation of the comb current to produce the correct printer density changes. The modulating voltage may be applied to the tube in any convenient manner. It may also be found advisable under certain conditions to employ a network of an inverse characteristic to that of the cycle counter to prevent geometrical distortion which would otherwise occur in such case due to the residual non-linearity of the cycle counter.

Various other subcombinations will occur to those skilled in the art, together with such modifications of the apparatus described as may be appropriate in the particular case.

What is claimed is:

1. In a picture signaling system, a generator of electric oscillations, frequency-modulated in accordance with the degree of light and shade of successive picture elements of a scanning line, means for translating said frequency-modulated oscillations into a stepped voltage of successive cumulative like increments, each increment of said voltage corresponding to a single cycle of said oscillations, a scanning element, a receiving element and means for moving said scanning element along a scanning line of said receiving element in accordance with said stepped voltage.

2. In the art of transmitting and reconstituting a picture element by element, successive elements of a reconstitution image corresponding to successive elements of a transmission image, the method which comprises modulating the frequency of electric oscillations in accordance with the degree of light and shade of successive image elements of a scanning line, translating said oscillations as modulated into a stepped voltage of successive cumulative like increments, each increment of said voltage corresponding to a single cycle of said oscillations, and scanning the successive elements of said line in accordance with said stepped voltage.

3. In a picture signaling system, a generator of carrier oscillations, means for modulating the frequency of said oscillations in accordance with the degree of light and shade of successive ele-

ments of a scanning line of a picture, means for scanning said elements under the direct control of said frequency as modulated, and means for transmitting said frequency-modulated oscillations alone to a receiving station.

4. In the art of transmitting and reconstituting a picture, element by element, successive elements of a reconstitution image corresponding to successive elements of the picture, the method which comprises generating carrier oscillations modulating the frequency of said oscillations in accordance with the degree of light and shade of successive elements of a scanning line of said picture, scanning said elements under the direct control of said frequency as modulated, transmitting only said oscillations as modulated to a receiver, receiving said oscillations, utilizing said oscillations to move a scanning element in a line scanning direction at a rate proportional to the frequency of said oscillations, and deriving a record from the motion of said scanning element, said record being of intensity inversely proportional to the speed of said scanning element.

5. In the art of transmitting and reconstituting a picture, element by element, successive elements of a reconstitution image corresponding to successive elements of a transmission image, the method which comprises generating carrier oscillations modulating the frequency of said oscillations in accordance with the degree of light and shade of successive image elements of a scanning line, and scanning said elements under the direct control of said oscillation frequency as modulated.

6. The method of transmitting a picture electrically which consists in generating and transmitting an alternating current signal and varying its frequency in accordance with the degree of light and shade of successive picture elements, and at a receiving station intermittently charging a small condenser and, between successive charging steps, discharging it into a larger condenser, and applying the voltage of the larger condenser to control the deflection of a scanning element in the direction of a scanning line.

7. In a picture transmission system, means for producing line-by-line advance of a picture to be transmitted, a light sensitive element, means for imaging a line of said picture on said element, means for sweeping an electron beam over said element to scan said line image, means, associated with said beam-sweeping means, for deriving from said element signals related to the tone values of successive elements of said line image, a generator of carrier oscillations, means for modulating the oscillation frequency of said generator by said tone-dependent signals, and means for supplying oscillations of said generator as modulated to said beam-sweeping means, to vary the speed of sweep in accordance with tone values of said successive line image elements.

8. In a picture transmission system, a sheet of copy to be transmitted, means for scanning a line of said copy, a generator of oscillations, a cycle-counting device having input terminals and output terminals, means for supplying oscillations of said generator to the input terminals of said cycle-counting device, means for supplying energy from the output terminals of said cycle-counting device to said scanning means to scan said line of copy in steps, one step for each cycle of said oscillations, means for deriving from said scanning means a signal proportional to the tone-value of that portion of the copy line instantaneously being scanned and independent of the position of said portion in said line, and means for

modulating the oscillation frequency of said generator by said signal.

9. In combination with a picture to be transmitted, a cathode ray tube having means for generating a cathode beam and beam deflecting elements, a light sensitive member disposed to be scanned by said beam, means for imaging a line of said picture on said light-sensitive member, a generator of electric oscillations of a frequency substantially higher than a line scanning frequency, means for deriving signals varying in accordance with the degree of light and shade of successive elements of said line image from said light-sensitive element as scanned by said beam, means for modulating the frequency of said oscillations in accordance with said signals, and means for applying a voltage of said oscillations as modulated, without demodulation, to said beam-deflecting elements to cause said beam to scan said image line at speeds varying in dependence on the degree of light and shade of said successive line image elements.

10. Apparatus for reconstituting a picture from frequency-modulated carrier signals which comprises a cathode ray tube having means for generating a cathode beam, beam-deflecting elements and a plurality of discrete conductors disposed in the path of said beam and extending through the tube wall, a sheet of electricity-sensitive material disposed adjacent said conductors, means for receiving carrier oscillations which are so modulated that successive values of the instantaneous oscillation frequency are proportional to the degree of light and shade of successive elements of a picture scanning line, means for directly translating said oscillations into a line scanning voltage related to the frequency of said oscillations without demodulation, and means for applying said line scanning voltage to said deflecting elements.

11. Apparatus as claimed in claim 10, in which the translating means comprises a source of constant electromotive force, a smaller condenser, a larger condenser, and means for charging said smaller condenser to the voltage of said source once for each cycle of said oscillations and thereupon discharging said smaller condenser into said larger condenser to accumulate the successive charges of said smaller condenser on said larger condenser, the voltage of said larger condenser constituting the line scanning voltage recited in said claim.

12. In the signaling art, the method which comprises generating carrier oscillations, modulating the frequency of said oscillations in accordance with the tone values of successive elements of a scanning line of an image, instantaneously placing an increment of electric charge of preassigned magnitude on a condenser once for each cycle of said oscillations as modulated to produce a voltage which increases by equal steps at a rate proportional solely to the frequency of said oscillations as modulated, sweeping a recording element over a receiving element in a line scanning direction in accordance with said voltage, and forming on said receiving element a record whose intensity varies from point to point with the rate of increase of said voltage according to an inverse relation.

13. The combination which comprises a generator of carrier oscillations, means for modulating the frequency of said oscillations in accordance with the frequency of occurrence of successive elements of an image line scanned in the process of scanning said line, means for translating

said frequency-modulated oscillations into a stepped voltage of successive cumulative like increments, each increment of said voltage corresponding to a single cycle of said oscillations, a scanning element, a receiving element, and means for moving said scanning element over said receiving element in a line scanning direction in accordance with said stepped voltage.

14. The method of transmitting a picture electrically which consists in generating and transmitting an alternating current signal and varying its frequency in accordance with the tone values of successive picture elements, and at a receiving station intermittently charging a small condenser under control of said signal to a voltage which is independent of said signal and, between successive charging steps, discharging it into a larger condenser, and applying the voltage of the larger condenser to control the deflection of a scanning element in the direction of a scanning line.

15. In a picture signaling system, a line scanning control element, a generator of electric oscillations, means for modulating the frequency of said oscillations in accordance with the tone values of successive elemental areas of a picture, a small condenser, means for charging said small condenser to a preassigned voltage once for each cycle of said oscillations, which voltage is independent of the amplitude and frequency of said oscillations, a larger condenser, means for discharging said small condenser into said larger condenser once for each cycle of said oscillations, and means for applying the voltage of said larger condenser to said line scanning control element.

16. In a system for generating and transmitting signals related to the tone values of picture elements arranged in order along a scanning line, means for scanning said picture elements in succession, a generator of electric oscillations, independent of said scanning means, the number of complete oscillations of said generator occurring during the scanning of said line by said scanning means being substantially equal to the number of picture elements of said line, means for varying the rate of recurrence of said oscillations in accordance with the degree of light and shade of said picture elements of said line, and means for governing the speed of scanning of said scanning means solely in accordance with said recurrence rate as varied.

17. In a picture transmission system, a sheet of copy to be transmitted, means for scanning a line of said copy, means for deriving a signal related to the tone value of that portion of said copy line instantaneously being scanned, a generator of carrier oscillations, means for modulating said oscillations in accordance with said signal, a cycle counting device having input terminals and output terminals, which device is constructed to respond in like manner to each of a succession of cycles of a signal applied to its input terminals, said response being independent of the frequency of recurrence of such cycles, means for supplying said oscillations as modulated to said input terminals, and means for supplying energy from the output terminals of said cycle counting device to said scanning means to scan said line of copy in steps, one step for each cycle of said oscillations.

18. Apparatus for reconstituting a picture from image signals which comprises a cathode ray tube having a non-conductive wall, means for projecting a cathode beam, beam-receptive means comprising a linear array of discrete conductors

sealed into said wall and projecting through said wall in position to be impinged by said beam, said linear array being parallel with a scanning line of a record to be produced, the distance from the center line of each of said conductors to the center line of an adjacent conductor being of the order of the width of a single elemental picture area, means for focusing said beam onto a single one of said conductors, means for deflecting said beam along the line of said conductors, a sheet of electricity-sensitive material disposed adjacent the exterior ends of said conductors, a cycle counting device having input terminals, means for applying received image signal oscillations to said input terminals, said cycle counting device being adapted to deliver a cumulative succession of like voltage increments of desired magnitude, one increment for each cycle of said oscillations, and means for applying said voltage increments to said beam-deflecting means to shift said beam intermittently from each of said conductors to an adjacent conductor, to form on said electricity-sensitive sheet a scanning line record of density inversely related to the frequency of said received image signal oscillations.

19. Scanning apparatus which comprises means for generating and projecting a cathode beam, means for deflecting said beam along a scanning line, a cycle counting device having input terminals, means for applying received oscillations to said input terminals, said cycle counting device being constructed to respond in like manner to each of a succession of cycles of a signal applied to said input terminals, said response being independent of the frequency of recurrence of such cycles, said device being adapted to deliver a cumulative succession of like electric signal increments, one increment for each cycle of said oscillations, and means for supplying said signal increments to said beam-deflecting means to produce deflection of said beam in the direction of a scanning line in relation to said increments.

20. Scanning apparatus which comprises the combination of a cycle counting circuit arrangement comprising a first discharge device having a cathode, an anode and a control element, a source of constant electromotive force and a first storage device connected in circuit with said cathode and said anode, a second discharge device having a cathode, an anode and a control element, said last-named cathode being connected to said first-named anode, a second storage device directly connected from said source of electromotive force to said second-named anode, with means for applying vision-signal-modulated oscillations to the cathode and control electrode of each of said discharge devices in opposite phase, and means for controlling the movement of a scanning element by the voltage of said second storage device.

21. Apparatus for generating and transmitting signals related to the tone values of picture elements scanned in order along a scanning line, which comprises a generator of oscillations, the number of complete oscillations of said generator occurring during the scanning of said line being substantially equal to the number of picture elements of said line, a scanning element, a receiving element, means for adjusting the frequency of said oscillations to a relatively high value corresponding to picture elements having tone values brighter than average and to a relatively low value, of the order of one-tenth of said high value, corresponding to picture elements

having tone values less bright than said average, and means for sweeping said scanning element over said receiving element at a rate proportional to said frequency as adjusted.

22. Means for producing a beam of radiant energy, a target upon which said beam impinges, a condenser, means for intermittently altering the charge on said condenser in cumulative discrete steps, and means for sweeping said beam step by step progressively along successive adjacent linear paths on said target under control of the voltage of said condenser.

23. The combination of a cathode ray tube having a target, means for projecting a cathode beam upon said target and means for sweeping said beam across said target, with a movable circuit control element associated with said target, and means for positioning said element at will along said target to determine the length of the path of travel of said beam over said target under control of said beam.

24. In a picture signaling system, apparatus for scanning copy of various widths which comprises a cathode ray tube provided with a linear array of discrete conductors extending through the tube wall, means within the tube for projecting a cathode beam upon the inner ends of said conductors, means for sweeping said beam over the line of inner ends of said conductors, a strip of photo-conductive material in contact with the outer ends of said conductors, means for imaging a line of copy to be scanned on said photo-conductive strip at its points of contact with said conductors, an adjustable element slidably arranged to make contact with some of said conductors at a desired point of said linear array, means for deriving image signals from the sweep of said beam over said conductors, and means for deriving auxiliary beam-return signals from the sweep of said beam over conductors contacted by said adjustable element.

25. In an image signal transmission system of the variable speed scanning type wherein the frequency of a carrier signal is modulated at constant amplitude by vision signals, means for directly translating said frequency-modulated signal, without intervening demodulation, into a voltage of cumulative incremental steps, said steps being of magnitudes which are alike and independent of the signal, successive steps being of durations dependent on the durations of successive cycles of said carrier as modulated, and means for moving a scanning element stepwise along a scanning line path under control of said stepped voltage.

26. In apparatus for synthesizing an image signal of the variable speed scanning type wherein the frequency of a carrier signal is modulated at constant amplitude by vision signals, means inherently insensitive to signal amplitude variations for directly translating said frequency-modulated signal, without intervening demodulation, into a voltage of cumulative incremental steps, said steps being of magnitudes which are alike and independent of the signal, successive steps being of durations dependent on the durations of successive cycles of said carrier as modulated, and means for moving a scanning element stepwise along a scanning line path under control of said stepped voltage.

27. In an image signal transmission system of the variable speed scanning type wherein the frequency of a carrier signal is modulated at constant amplitude by vision signals, means for directly translating said frequency-modulated sig-

nal, without intervening demodulation, into a voltage of cumulative incremental steps, said steps being of magnitudes which are alike and independent of the signal, successive steps being of durations dependent on the durations of successive cycles of said carrier as modulated, means for moving a scanning element at the transmitter end stepwise along a scanning line path under control of said stepped voltage, said voltage-translating means comprising a source of constant potential, a small condenser, a large condenser, means for charging said small condenser substantially to the voltage of said source upon the occurrence of each cycle of said frequency-modulated signal, and means for discharging said small condenser into said large condenser immediately of said charging operations.

28. In an image signal transmission system of the variable speed scanning type wherein the frequency of a carrier signal is modulated at constant amplitude by vision signals, means for directly translating said frequency-modulated signal, without intervening demodulation, into a voltage of cumulative incremental steps, said steps being of magnitudes which are alike and independent of the signal, successive steps being of durations dependent on the durations of successive cycles of said carrier as modulated, means for moving a scanning element at the transmitter end stepwise along a scanning line path under control of said stepped voltage, like means at the receiver end for translating said frequency modulated signal into a like stepped voltage and for moving a scanning element along a scanning line path under control of said stepped voltage, each of said voltage-translating means comprising a source of constant potential, a small condenser, a large condenser, means for charging said small condenser substantially to the voltage of said source upon the occurrence of each cycle of said frequency-modulated signal, and means for discharging said small condenser into said large

condenser immediately of said charging operations.

29. The method of preventing amplitude variations of a carrier current the frequency of which is modulated in accordance with a signal from affecting the operation of a device utilizing the frequency modulations to reproduce the signal, which comprises repeatedly performing the following sequence of steps under control of the carrier current, coupling a source of constant direct potential to a condenser once per cycle of said carrier current under control of said current, thereafter disconnecting said condenser from said source and connecting it to a condenser of much greater capacity, thereafter disassociating said condensers, and operating the signal reproducing device under control of the charge on said second condenser and maintaining said signal reproducing device isolated at all times from said carrier current of variable amplitude.

30. In a signaling system, the combination with a signal device utilizing the frequency modulations of an incoming carrier to reproduce a signal with which said carrier is frequency-modulated, of means for causing said carrier to control said device so that any amplitude variations of said carrier which are present will not affect said device, said means comprising a source of constant direct potential, a first condenser, a second condenser of greater capacity than said first condenser, means for utilizing a charge on said second condenser to control the operation of said signal device and means under control of the successive cycles of said carrier current and operating repeatedly once per cycle thereof for connecting said source to said first condenser, and thereafter disconnecting said first condenser from said source and connecting it to said second condenser and thereafter disassociating said condensers.

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