

Jan. 5, 1943.

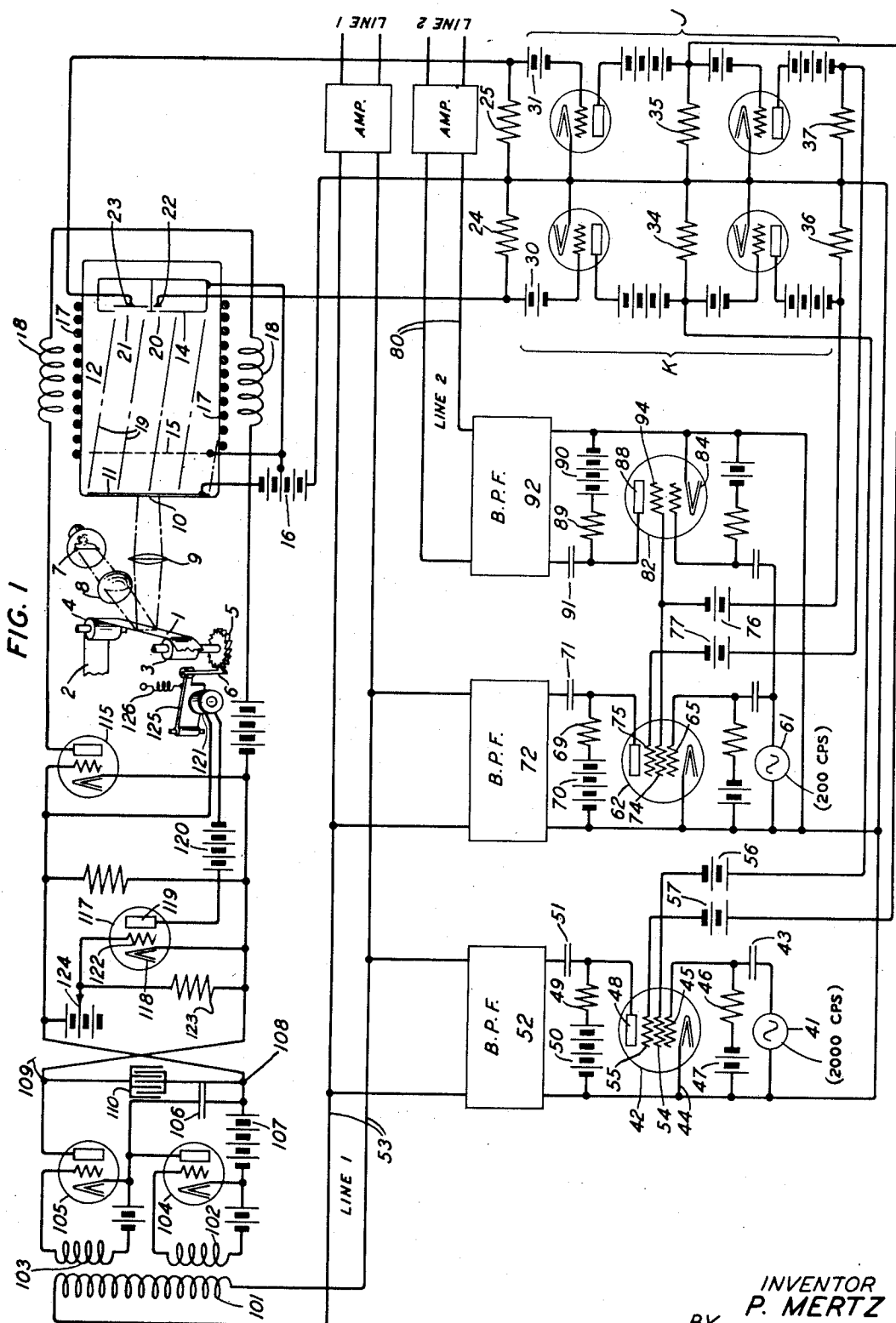
P. MERTZ

2,307,728

SIGNALING SYSTEM

Filed Aug. 10, 1940

3 Sheets-Sheet 1



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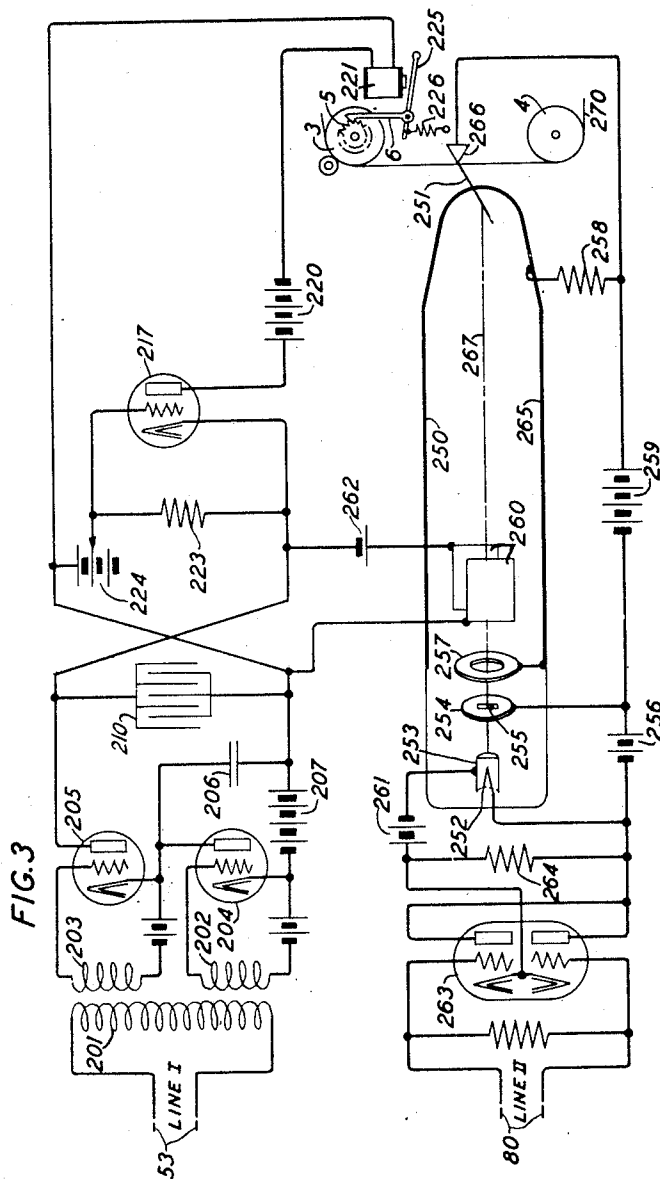
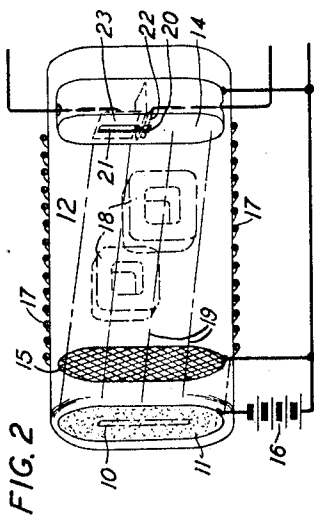
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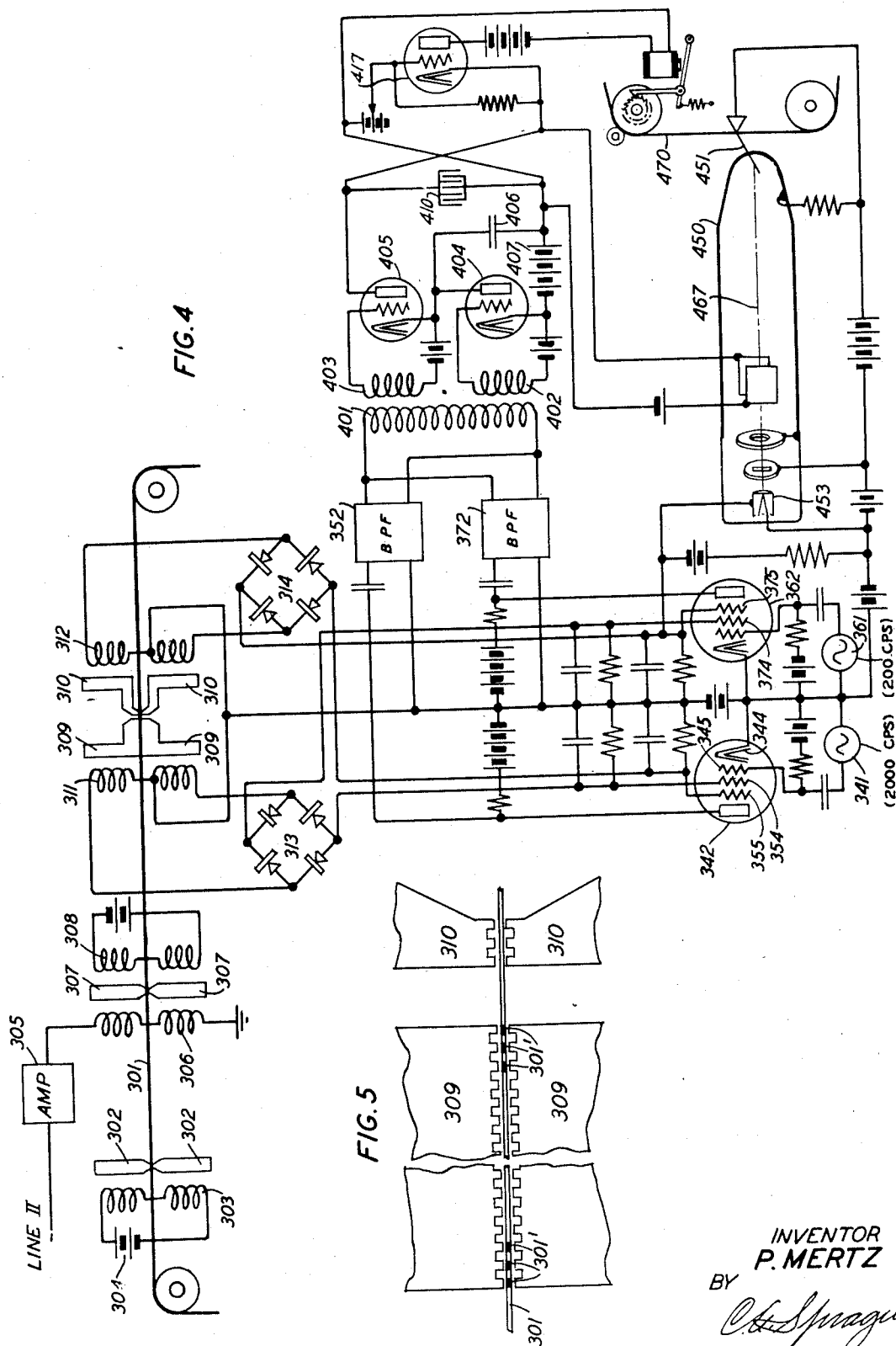
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SIGNALING SYSTEM

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2,307,728

SIGNALING SYSTEM

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This invention relates to signaling and particularly to systems for the production and transmission of image signals and the reconstitution of a picture from such signals at a distant point.

A principal object of the invention is to effect economies in the frequency space and time required for the transmission of image signals.

Other objects are to provide improved apparatus and methods for the production of image signals and the reconstitution of pictures from image signals with a minimum of distortion.

Attention has already been given to the problem of increasing the speed of image signal transmission and therefore reducing the total time required, and various systems directed to the solution of this problem are known. For example, Patent No. 2,301,199 to E. Bruce and W. S. Gorton granted Nov. 10, 1942 on an application filed April 26, 1940, describes and claims a signaling system in which scanning at both transmitter and receiver takes place at high speed for white areas of the picture and at normal speed for dark areas, thus effecting an increase in speed and a saving of transmission time as compared with the speed and time which would be required if the entire process were carried out at normal speed.

In the picture or image signaling art, the frequency space required is governed mainly by the sharpness of the discontinuities or boundaries between light areas and dark areas and the perfection which is required in the reproduction of these areas. In any system employing variable speed scanning this limitation is complicated by the fact that the transmission channel must be capable of conveying information to the receiver as to the precise instant at which it should accelerate or decelerate as each boundary between a dark area and a light area is reached or vice versa. The system of the above-mentioned Patent No. 2,301,199, for example, requires for proper operation a frequency band great enough to carry this important speed change information with such precision that substantially instantaneous response of the receiver apparatus is assured. Thus that system, though it accomplishes an increase in speed and a saving in time, does not, without further modification, effect any reduction in the required frequency space over that required by conventional systems. It turns out, however, that that system lends itself easily to modification whereby a substantial saving in frequency space is achieved.

Accordingly, a particular object of this invention is to provide modifications of variable speed scanning systems which shall effect substantial

economies of frequency space without loss of speed or detail.

The problem of conveying speed change information from a picture signal transmitter to a receiver of the variable speed scanning type has already been recognized, and it has been proposed to provide the transmitter apparatus with an auxiliary scanner, similar to the main scanner and placed in advance thereof, which shall derive from the picture itself a sequence of picture signals in advance of the main picture signals and identical therewith, except in so far as they are advanced in time with respect thereto. These advance signals constitute advance information as to the character of that part of the picture which at any instant is about to be scanned by the principal scanner, either at transmitter or at receiver. It has been proposed to utilize them to control the speed of a motor which determines the scanning speed. This proposal is open to the serious objection that, with two like scanners and no additional discriminating apparatus, the information delivered to the principal scanner by this premonitory signal is just as likely to be wrong as it is to be right, causing the scanning to accelerate when it should decelerate or decelerate when it should accelerate, thus defeating the very purpose which it was designed to serve.

In contradistinction to this proposal and in furtherance of the objects of this invention, there is provided in accordance with the invention in one of its preferred forms an advance scanning device of novel and unique character including, in addition to the principal scanning aperture or its effective equivalent which is effective at each instant to determine the instantaneous value of the resulting image current, an auxiliary scanning aperture which is effectively several times as large as the principal scanning aperture. From this advance scanner there may be derived a premonitory signal differing radically from the main picture signal and peculiarly appropriate for correctly governing the scanning speed both at transmitter and at receiver. This premonitory signal, comprising only two fairly narrow frequency bands, may then be transmitted to the receiver to control the acceleration and deceleration of the printer apparatus. At the same time the principal picture signals may be condensed into a single very narrow frequency band and may be transmitted to the receiver over a separate communication channel. The end result of this system is that the information-carrying frequency band, instead of ex-

tending all the way from a very low frequency to the highest frequency required to convey the information as to boundaries between black and white areas, consists, in the black and white system, of only three narrow frequency bands, two of them transmitted on one channel and one on another.

In accordance with another modification of the invention, still further saving or economy in frequency space may be achieved by entirely eliminating the premonitory signal transmission channel and deriving the equivalent information from the main picture signal itself at the receiver. The frequency space required for transmission of all the necessary information consists, in this modification, solely of a single narrow band. This result is accomplished, in accordance with this second modification of the invention, by the provision of local generators at the receiver station, one being a generator of "white scanning" oscillations and another a generator of "black scanning" oscillations, either one of which, but not both, governs the scanning operation in the reproducer and causes it to progress at a speed related to the transmitter scanning speed. The signal received from the transmitter, which may be a "sole black" signal, the "white" component having been suppressed at the transmitter, operates to switch in the "black" generator when it is coming through and to switch it off and switch in the "white" generator instead when the signal is not coming through. The received "sole black" signal may also operate or control the printing operation to effect printing of dark areas only when the sole black signal is coming through. Thus a feature of this modification is the operation of the reproducer for both black and white printing through the medium of a sole black received signal alone.

In accordance with a preferred form of this modification, the signal characteristic which is related to the characteristic of the picture is its frequency. Thus the sole black signal is a low frequency signal and the suppressed "white" signal is a higher frequency signal. The local "black" signal generator is of a comparatively low frequency and the local "white" generator is of a higher frequency.

In order to assure that the printer scanning shall be taking place at slow speed throughout the time that printing is in progress and that it shall not accelerate unless a considerable white area appears ahead of it, there is preferably provided in addition a temporary storage device for the low frequency sole black signal from which, in turn, both printing signals and scanning speed signals are thereafter derived. In accordance with a preferred form, the incoming sole black signals may be recorded on a magnetic tape or the like and subsequently recovered from the tape by two pick-up devices, the first one being of comparatively large aperture and the second one being of normal picture element aperture. Premonitory signals are derived from the first pick-up device and main scanning signals from the second. The premonitory signals are then utilized to actuate the scanning of the reproducer and the main signals to actuate its printing device. This results in the preservation of definiteness and precision of the operation of the reproducer despite the fact that when the communication channel is very narrow the build-up of the main sole black signal is necessarily slow. This modification therefore permits the insertion

of a narrow band-pass filter in the transmission line.

The invention in its many possible forms will be more fully understood from the following detailed description of preferred embodiments primarily suited to the transmission and reconstitution of black and white pictures or copy taken in conjunction with the appended drawings. It will be understood that the terms "picture," "copy" and the like are herein employed not to distinguish typed or printed material from representations of scenes, portraits, and the like, but rather to emphasize their equivalency for the purposes of the invention. In the drawings:

Fig. 1 is a circuit diagram of a transmitter system illustrative of one embodiment of the invention;

Fig. 2 is a highly schematic diagram of a scanning device in accordance with the invention;

Fig. 3 is a circuit diagram of receiver apparatus adapted to respond to the signals delivered by the transmitter apparatus of Fig. 1;

Fig. 4 is a circuit diagram of receiver apparatus illustrative of a modification of the invention; and

Fig. 5 illustrates the arrangement of parts of the apparatus of Fig. 4 to an enlarged scale.

Referring now to the figures, the picture or other copy 1 to be transmitted may be mounted or supported on a belt or tape 2 which passes over rollers 3, 4 one of which is provided with a ratchet and pawl mechanism 5, 6 for intermittent line-by-line advance thereof. Light from a long line filament 7 is sharply focussed through a lens 8 onto a single line of the copy 1. Light reflected from this illuminated copy line is focussed by another lens 9 as a line image 10 on the photoelectric cathode surface 11 of a double-aperture scanning device 12.

The scanning device which is preferred though not required for use in connection with the signaling system of this invention is shown in greater detail but still schematically in Fig. 2. It may constitute a modification of apparatus known per se and commonly designated by the term "image dissector tube." As shown in Fig. 2, it comprises a glass envelope 13 provided at one end with a photoelectric surface 11 which plays the part, in operation, of a cathode. A screen 15 of wire mesh is placed in front of the cathode and serves as an accelerating anode for the beam 19 of electrons emitted from the photoelectric cathode 11. A battery or other source of potential 16 is connected between the cathode 11 and the screen 15 in well-known manner in order to give the electrons a substantial initial velocity axially of the tube.

The tube may be provided with a magnetic focussing coil to be energized with direct current in well-known manner and also with a single pair of magnetic beam-deflecting coils. Focusing coil 17 and deflecting coils 18 are schematically indicated in Fig. 2, but in the interests of simplicity, source and connections have been omitted in each case. For a more complete description of the construction and mode of operation of the image dissector tube, reference may be made to Farnsworth Patent 1,773,980 and to the Journal of the Franklin Institute, vol. 218, pages 411-444.

As customarily constructed, dissector tubes are provided at the end removed from the cathode end with a plate 14 having therein a small aperture 20 behind which is placed the electron-collecting anode 22 which is connected through a

loading resistor 24 to the high potential end of a battery 16. In accordance with the invention a modification of major importance is the provision in the plate 14 and adjacent the aperture 20 of an auxiliary aperture 21 of several times the size of the ordinary aperture, and a cooperating auxiliary anode 23 likewise connected through an auxiliary loading resistor 25 to the high potential source 16. Since it is contemplated that scanning shall take place only in one direction, motion in the other direction being secured by movement of the copy-supporting tape 2, the photoelectric part of the cathode may consist of a relatively narrow line of photoelectric material instead of a large area. This line emits electrons in the form of a sheet rather than a bundle. The electrons are directed axially of the tube by the focussing coil 17 and, when the tube is in operation, are deflected from side to side in the direction in which the two apertures 20, 21 lie by the magnetic fields of the beam-deflecting coils 18.

In order to economize space and reduce the stresses due to atmospheric pressure the tube may be much narrower in the direction perpendicular to the scanning direction than in the scanning direction and it is so shown in Fig. 2.

Obviously, a dissector tube of ordinary construction, that is, with a photoelectric cathode covering a substantial area and two pairs of deflecting coils may be employed, the tube being modified by the provision as described above of the two apertures and two associated anodes. Again, a cylindrical tube may be provided with a line cathode, or tube of any form may be provided with two pairs of deflecting elements. The deflecting elements may, if desired, be plates which operate by electrostatic deflection, although magnetic deflection is usually more suitable for apparatus of this type. Any or all of the above, or other, variations may be employed provided the tube has the essential feature of two apertures with a separate collector anode associated with each one, or its equivalent.

Returning now to a consideration of Fig. 1, an optical image 10 of a line of copy is formed, as above described, on the photoelectric cathode 11 of the dissector tube 12. An electron beam 19 in the form of sheet is produced at the cathode 11 and accelerated by the screen 15 and travels down the tube toward the apertures to form an electron image of the illuminated copy line 10 in the plane of the apertures 20, 21 in a manner well known per se. This beam is deflected back and forth in the embodiment shown by the magnetic field due to a deflection current in the beam-deflecting coils 18. These deflecting coils 18 are schematically indicated above and below the dissector tube 12 and in the plane of the electron sheet. As is well known, in actual practice these coils should be placed centrally above and below the electron sheet in order to sweep the sheet in its own plane. Placement and design of the deflecting coils form no part of the invention and accordingly the drawings are simplified by showing the coils in highly schematic form and disposition.

The circuit arrangement for delivering current of appropriate wave form to the deflecting coils 18, both to sweep the electron beam 19 past the apertures 20, 21 in the scanning direction and to return it rapidly to its starting point, will be fully described hereinafter. For the present it will suffice to state that the deflection is such that the electron beam 19 sweeps past the apertures in a

direction which is downward in Fig. 2 and at a speed which varies instantaneously in accordance with the brightness or degree of light and shade of the elementary areas of copy being scanned. For example, the "white" speed may be ten times or so as great as the "black" speed.

Electrons which enter the principal aperture 20 strike the principal anode 22 and electrons which enter the auxiliary aperture 21 strike the auxiliary anode 23. In accordance with the invention the principal aperture 20 is preferably of a size corresponding to the size of an element of the picture or copy being scanned. Apart from either optical or electronic magnification it may be equal in size to a picture element. Either optical magnification or electronic magnification or both may be employed with the result that the electron image in the plane of the apertures will depart considerably in size from the copy being scanned, in which case the size of the principal scanning aperture 20 may be adjusted accordingly.

The auxiliary scanning aperture 21 is placed as close as possible to the principal scanning aperture 20 and in the same electron image plane. As above stated, it is considerably larger than the principal aperture being in the preferred embodiment fifteen to twenty times as long. Both apertures, however, are of the same width in the direction perpendicular to the scanning direction, each being preferably as wide as the electron image 10 of a single scanning line of copy.

In the figures the main and auxiliary apertures have been much exaggerated in size in order to bring out their relative sizes and separation. As actually constructed, the main aperture may be about 0.01 inch square and the auxiliary aperture about 0.2 inch long by 0.01 inch wide, the separation between them being about 0.01 inch in length.

From this construction it will be apparent that the electrons which, at any instant, enter the auxiliary aperture 21 were emitted at an earlier instant from a number, for example, fifteen to twenty, of image elements lying immediately in advance of the image elements from which the electrons entering the main aperture 20 were emitted. Therefore, the current flowing in the circuit of the auxiliary anode 23 is a measure of the character of that part of the copy which will be scanned at some later instant by the principal aperture 20 and therefore constitutes an advance signal.

The lower part of Fig. 1 shows a circuit arrangement for utilizing these advance signals in order to attain the object of the invention.

The principal anode 22 and the auxiliary anode 23 of the dissector tube 12 are respectively connected through individual loading resistors 24, 25 to the positive terminal of a source of potential such as a battery 16 whose negative terminal is connected to the cathode 11. The grid 15 and the apertured plate 14 are connected to a point of suitable potential, such as a tap of the battery 16. Currents due to electrons striking the main anode 22 or the auxiliary anode 23 respectively therefore give rise to voltage drops across the loading resistors 24, 25. The input circuit of a two-stage amplifier K which may be of any suitable construction and is represented in the figures as a simple tandem arrangement of triode circuits is connected across the principal anode loading resistor 24 and the input circuit of a similar amplifier J is connected across the auxiliary anode loading resistor 25. As is well

known, each stage of each of these amplifiers constitutes a phase reversing device and consequently voltages at the output resistor 34 of the first stage of the amplifier K, due to a given input signal, will be of opposite phase to voltages at the output resistor 36 of the second stage due to the same signal. The same will be equally true of the phase conditions in the amplifier J.

The first stage of the amplifier J is preferably biased, for example, by a C battery 31, well below its cut-off so that while full current in the circuit of the auxiliary anode 23 serves to make it conductive, 95 per cent full current does not. The amplifier K on the other hand, is preferably biased only slightly below cut-off, for example by C battery 30. The reasons for these differences will appear more fully hereinafter.

Though not in any way essential to the invention, discrimination between white copy areas and black copy areas on the basis of change in signal frequency offers conveniences in carrying out the objects, and accordingly, in illustration of this preferred embodiment a frequency-modulated signal is employed, the tone values of the picture to be transmitted being associated with differences in the signal frequency rather than differences in the signal amplitude or other signal characteristic. In the particular case of two-tone or black-and-white copy, the frequency-modulated signal reduces to oscillations of one frequency corresponding to dark picture areas and oscillations of the same amplitude but of a different frequency to light picture areas. Preferably, the higher frequency corresponds to the lighter areas.

The remainder of the apparatus of Fig. 1 is constructed on the basis of this frequency discrimination. A generator 41 which may be of any desired type, for example, a vacuum tube oscillator whose connections are well known per se, supplies energy of a higher frequency, for example 2000 cycles per second, to the input circuit of a discharge device, for example vacuum tube 42. As shown, the terminals of the generator 41 are connected through a stopping condenser 43 to the cathode 44 and to the first control grid 45 of the tube 42, the grid being returned through a resistor 46 and a biasing battery 47 to the cathode 44. The plate or anode 48 of this tube 42 is connected to a plate loading resistor 49 and an anode voltage supply battery 50 to the cathode 44. With the interposition of a stopping condenser 51 and a band-pass filter 52, the output circuit of the vacuum tube 42 is connected to a transmission line 53 designated as "line I". The filter 52 may be of any desired type and may be constructed to pass only a relatively narrow band of frequencies centered in the neighborhood of 2000 cycles per second.

Another generator or oscillator 61 of a considerably lower frequency, for example 200 cycles per second, supplies the input circuit of another discharge device or vacuum tube 62 whose output circuit is likewise connected, with the interposition of another band-pass filter 72, to line I. The input and output circuits of the second tube 62 and their connections to the generator and the filter may be exactly as above described in connection with the higher frequency generator 41 or may be modified as desired. The band-pass filter 72 may be constructed to pass only a relatively narrow band of frequencies centered at 200 cycles per second.

Each of these tubes 42, 62 is provided, additionally, with two further control electrodes or

grids. The second grid 54 of the tube 42 is connected through a bias battery 56 to the first stage plate resistor 34 of the amplifier K and the second grid 74 of the tube 62 is connected through a bias battery 76 to the second stage plate resistor 36 of the same amplifier. From these connections it will be apparent that the tubes 42 and 62 are partly controlled by the current to the principal scanning anode 22 of the dissector tube 12, such control being in opposite phase with respect to the tubes 42 and 62, so that a current to the principal scanning anode, if it serves to raise the potential of the second grid 54 of the tube 42 and therefore tends to increase the transconductance of that tube, serves equally to lower the potential of the second grid 74 of the tube 62 and thus drive it below its plate current cut-off.

The third grids 55, 75 of the tubes 42 and 62 are similarly connected through bias batteries 57, 77 to the first and second stage plate resistors 35, 37 of the amplifier J. Thus the tubes 42 and 62 are controlled in part by the electron current which strikes the auxiliary anode 23, such control being of opposite phase with respect to the two tubes 42 and 62 in the same manner as above described in connection with the control from the principal scanning anode 22.

The grid bias batteries 56, 57, 76, 77 of the tubes 42 and 62 are selected to hold tube 62 well above its cut-off and to hold tube 42 well below its cut-off, so that a signal on either of the grids 74, 75 of the tube 62 allows it to continue to conduct whereas signals on both grids 54, 55 of the tube 42 are necessary before that tube becomes conductive. The reason for these differences in bias potentials will become apparent hereinafter.

In addition to supplying its low frequency oscillations through the tube 62 and the band-pass filter 72 under control of signals from the main and auxiliary scanning anodes 22, 23 to line I as above described, the low frequency generator 61 also supplies its oscillations to another line 80, which may be referred to as "line II." For this purpose its terminals are similarly connected to the input circuit of a discharge device or vacuum tube 82. The anode 88 of this tube 82 is connected through a loading resistor 89 and an anode supply battery 90 to the cathode 84, and its output terminals are connected through a stopping condenser 91 to a narrow band-pass filter 92 which in turn is connected to line II. This tube 82 is provided with one additional control electrode or grid 94 which is connected directly to the second grid 74 of the tube 62. It will be apparent from this connection that the tube 82 is rendered conductive or non-conductive, as far as the second grids and therefore the principal scanning aperture signals are concerned, in phase with tube 62, so that when signals from the low frequency oscillator 61 are delivered to line I they are delivered at the same time through the tube 82 to line II.

Thus there are supplied either oscillations of 2000 cycles from the first oscillator 41 to line I or oscillations of a frequency of 200 cycles from the second oscillator 61 either to line I alone or to both line I and line II.

As above stated, the electron beam 19 of the dissector tube 12 may be swept past the main and auxiliary apertures 20, 21 at speeds which vary with the tone values of the copy 1 being scanned. Further, as above stated, this result may conveniently be attained through the use of a frequency-modulated signal. A circuit arrangement for securing this result, which may be substantially identical with the circuit arrangement fully

described and claimed in Patent No. 2,301,199, to which reference has been made above, is shown at the upper left-hand part of Fig. 1. Referring to this portion of Fig. 1, a primary winding 101 is directly connected across line I and to this winding 101 are coupled two secondary windings 102, 103 which are poled 180 degrees apart and separately connected to the input terminals of two discharge devices 104, 105 which are biased below their cut-off points. The output circuit of the discharge device 104 includes a condenser 106 and a direct current source, for example a battery 107, the positive battery terminal also being connected to one terminal 108 of a second condenser 110 of a capacitance many times as large as that of the first condenser 106. The anode of the first discharge device 104 is directly connected to the cathode of the other device 105 whose anode is in turn directly connected to the opposite terminal 109 of the large condenser 110.

The deflecting elements of the image dissector tube, if they were plates for electrostatic deflection, might be connected directly across the terminals of this larger condenser. Since in the modification shown magnetic deflection is contemplated, the terminals of the large condenser 110 are connected to the input circuit of a discharge device, for example a vacuum tube 115 of high input impedance whose output plate current is a replica of the input voltage wave form. The output terminals of this tube 115 are directly connected to the beam-deflecting coils 18 so that deflection of the beam 19 of the dissector tube 12 takes place in accordance with the voltage across the large condenser 110.

Another discharge device 117 is connected across the terminals of the large condenser 110 in a manner to serve as a short-circuiting switch. For this purpose its cathode 118 is connected to one terminal of the condenser 110 and its anode 119 is connected through an anode battery 120 and a relay coil 121 to the other terminal of the condenser 110. The control electrode 122 is connected through a high resistance 123 to the cathode 118 and through a large variable biasing battery 124 to the other terminal of the condenser 110. This bias battery 124 is preferably chosen so that, as a charge builds up on the large condenser 110 as hereinafter explained, the tube 117 remains below cut-off until the charge reaches a preassigned value whereupon the tube becomes conductive and short-circuits and fully discharges the large condenser 110 after which the tube 117 becomes non-conductive once more allowing the condenser 110 to sustain a charge. To serve best in this capacity of short-circuiting switch the tube 117 is preferably of the grid-controlled gas discharge type well known per se.

The circuit above described constitutes a convenient form of cycle counter whose operation will now be described. Since the input windings 102, 103 of discharge tubes 104, 105 are poled 180 degrees apart and their control electrodes biased below cut-off, these discharge devices operate in alternation. On a positive peak of voltage in the primary winding 101, for example, the first tube 104 is rendered conductive so that the small condenser 106 is charged to the voltage of the battery 107, the second tube 103 meanwhile remaining non-conductive. On the next negative peak, say, of the signal, the first tube 104 is non-conductive and the second tube 105 is rendered conductive so that the small condenser 106 is discharged into the large condenser 110. Thus the charge on the large condenser 110 is built up

step by step, one step for each cycle of the signal in the primary winding 101, independently of the frequency with which these half cycles recur. As above stated, the voltage of the large condenser 110 is impressed on the input circuit of the discharge tube 115 whose output current supplies the beam-deflecting windings 18 of the dissector tube 12. Thus, the electron beam 19 of the dissector tube 12 is deflected in small steps, one step for each cycle of the signal in line I, the steps being of substantially equal magnitude and recurring at the frequency of that one of the generators 41, 61 which is instantaneously controlling and which, as explained above, is related to the tone values of the picture being scanned. Thus the scanning speed itself is related to the picture-tone values and, in the example given, may be ten times as great for white areas as for black areas. This process continues until the voltage of the large condenser 110 has reached a point such that the gas discharge tube 117 is no longer biased below cut-off. This tube 117 then becomes conductive, effectively short-circuiting the large condenser 110 and allowing the electron beam of the dissector tube 12 to return to its starting point, whereupon the cycle may commence once more. At the same time the pulse of current through the tube 117 energizes the relay 121 which moves an armature 125 against the tension of a spring 126 to draw the pawl 6 through the distance of one tooth of the ratchet 5 and so advance the copy-bearing belt 2 by the width of one scanning line of the copy 1.

The ratio of the capacitances of the condensers 106, 110 is preferably such that each single step of the beam deflection is about 0.01 inch, which is approximately the length of an elemental area of a line of the copy to be transmitted. Perfect equality in the magnitude of successive voltage increments is obtained in the ideal case in which the condenser 106 is negligibly small in comparison with the condenser 110. In actual practice the departure from linearity is less than 5 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.

Fig. 3 shows the circuit of a receiver printer system adapted to print directly from the signals delivered by the apparatus of Fig. 1. Referring to Fig. 3, the terminals of a primary winding 201 are designated line I to indicate that the signals delivered to it are the line I signals produced by the transmitter apparatus as above described. Coupled to this primary winding 201 are two secondary windings 202, 203 which supply the input circuits of two discharge devices 204, 205 associated with which are a small condenser 206 and a large condenser 210. This portion of the receiver apparatus constitutes a cycle counter and the polarities of the windings 202, 203 and the connections of this portion of the receiver circuit may be identical with those of the cycle counter circuit described above in connection with the transmitter. A tripping tube 217 is connected across the terminals of the large condenser 210 in the same manner and to the same effect as the transmitter tripping tube 117.

A suitable printer tube for use in accordance with the invention may be the tube described and claimed in Patent No. 2,273,433 granted to E.

Bruce Oct. 30, 1941, on an application filed April 10, 1940. Such a tube is schematically shown in Fig. 3. It may comprise an evacuated glass envelope 250 through the beam-receiving end of which protrudes a comb in the form of a plurality of small discrete conductors 251 arranged in a single line, preferably lying in a plane at an oblique angle to the direction of the scanning electron beam. The tube is provided with a cathode 252, a beam-modulating grid 253, a beam-defining anode 254 having an aperture 255 therein which is preferably of rectangular form and connected to a source of potential 256 somewhat above that of the cathode, an accelerating and focussing anode schematically indicated by an apertured plate 257 connected through a resistor 258 to a source 259 of relatively high potential and a pair of beam-deflecting elements, for example electrostatic deflecting plates 260. The interior walls of the beam-receiving end of the tube are preferably lined with a conductive coating 265, for example a coating of the material commonly known as aquadag, and this conductive lining is connected to the accelerating anode 257. A conductor in the form of a knife edge 266 is placed with its edge closely adjacent the outer ends of the wires of the comb 251 and connected to the high potential source 259. The path of an electron beam 267 originating at the cathode 252 and striking the comb wires 251 is indicated by a dotted line.

A strip or tape of blank sensitized paper 270 passes close to or in contact with the outer ends of the comb wires 251 and between them and the knife edge 266. It may be mounted on rolls one of which is provided with a ratchet and pawl mechanism 5, 6 for intermittent advance thereof, just as in the case of the copy to be scanned at the transmitter. The deflecting elements 260 of this printer tube are connected to the terminals of the large condenser 210, a biasing battery 262 being interposed to assure that the starting point of the cathode beam 267 shall be not at the center of the comb 251 but to one side of it.

Conductors designated line II are connected through any suitable rectifier, for example a double triode 263 or an equivalent pair of simple triodes, to the cathode 252 and modulating grid 253, respectively, of this printer tube, the grid being returned to the cathode in the usual manner through a biasing battery 261 and a resistor 264. The voltage of the battery 261 is preferably such that in the absence of signals on line I the printer tube is biased below cut-off.

As the cathode beam of this printer tube is deflected by the incremental voltage on the deflecting elements 260 and sweeps over the wires of the comb 251, current passes out through successive wires, through the sensitized paper 270 to the knife edge 266 and leaves a succession of marks on the paper 270 of character depending on the sensitization thereof. This occurs only when the modulating grid 253 is above cut-off potential, and therefore only when a signal is received on line II to provide modulating potential for the grid 253. As above explained, such a signal corresponds to black areas of the copy 1 and may be referred to as a "sole black" signal.

Since the scanning steps of the cathode beam of the printer tube are all of equal magnitude and occur once for each cycle of the frequency-modulated signal appearing on line I, the speed of the beam is low for dark parts of the copy 1, at which time a modulating signal is arriving on line II to cause printing, and higher for light parts of the

copy, at which time no modulating signal is received on line II. As a result, the beam skips rapidly over the light parts of the reproduction where no printing is to be done with a considerable increase in over-all speed and corresponding saving in time.

As above stated a slight inequality of the charging steps of the transmitter condenser 110 is harmless. This is due to the fact that the charging of the receiver condenser 210 remains in step with the charging of the transmitter condenser so that any residual 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 starting end.

When the cathode beam 267 of the printer tube has reached the end of its line, that is, has undergone a deflection corresponding to a certain preassigned voltage on the large condenser 210, the discharge tube 217 operates both to short-circuit the condenser 210 to return the cathode beam 267 to its starting point and to energize the relay 221 which operates the ratchet and pawl mechanism 225, 226 to advance the sensitized tape 270 by the width of a single scanning line.

Proper adjustment of the apparatus above described will suffice to keep transmitter and receiver in step or substantially so over periods which, while short, may be sufficient for the complete transmission of small copy. In case it is desired to maintain perfect synchronism over longer periods, additional synchronizing signals may be resorted to. Such synchronizing signals may be of any desired character and may be transmitted in any convenient manner, for example over an additional channel which, however, may be as narrow as either of the channels of the invention.

The operation of the system as a whole will now be understood. In order to avoid circumlocution the incidence of electrons of the dissector cathode beam 19 on one or other of the two dissector apertures 20, 21 from a particular image point corresponding to a particular picture element of the copy 1 will be referred to in visual language by the statement that the aperture "sees" that particular picture element.

Assume now that the part of the copy 1 which both of the apertures together "see" is entirely white. Under these circumstances both the principal anode 22 and the auxiliary anode 23 will carry full current, the first stages of the amplifiers K and J will both be biased below their cut-off points so that the potentials of the first stage load resistors 34, 35 are raised and the potentials of the second stage load resistors 36, 37 correspondingly reduced. This operates to raise the potentials of the second grid 54 and the third grid 55 of the tube 42 allowing the tube 42 to become conductive and deliver 2000-cycle oscillations from the generator 41 to line I. At the same time this operates to reduce the potentials of the second and third grids 74, 75 of the tube 62 thus driving the tube 62 further below cut-off so that no voltage of the 200-cycle signal from the generator 61 is delivered to line I. At the same time the additional grid 94 of the tube 82 which is directly connected to the second grid 74 of the tube 62 is reduced in potential so that no signal at all is delivered to line II. Under these conditions the cycle counter at the transmitter will cause scanning by the electron beam 19 of the dissector tube to take place at high speed. At the receiver too the cycle counter actuated by the 2000-cycle signal receiver on line I causes the printer tube beam 267 to travel at high speed

while, since no signal appears on line II, the control grid 253 of the printer tube is biased below cut-off and no printing takes place.

Assume next that as scanning at the transmitter proceeds some black portions of the copy enter the field of view of the auxiliary scanner. After a short interval the main scanner will see these black portions and it is desirable that scanning at the receiver be slowed down to a speed such that the black portions can be printed with good definition and in their proper location. This result is secured, in accordance with the invention, by the fact that as soon as the auxiliary scanner aperture 21 sees some black areas the current through the auxiliary anode 23 is reduced, thus producing a rise in the potential of the grid of the first stage of amplifier J past its cut-off point and a corresponding drop in the potential of the first plate of amplifier J and rise in the potential of the second plate. These potential changes, due to the connections of first and second stage load resistors 35, 37, respectively, of the amplifier J to the third grids 55, 75 of the tubes 42 and 62, operate to bias the tube 42 below cut-off thus removing 2000-cycle signal from line I while at the same time permitting the tube 62 to become conductive thus placing 200-cycle signal voltage on line I. The tube 82 in this event continues to be non-conductive since its only additional grid 94 is connected to the second grid 74 of tube 62 which, as above stated, is under these conditions at a reduced potential. Therefore, no printing signal appears on line II whereas, by the substitution of 200-cycle signal for 2000-cycle signal on line I, the scanning speed is reduced at both transmitter and receiver.

As a third condition, assume that scanning has advanced to the point where the main scanner sees black areas while the auxiliary scanner continues to see some black areas. Following the connections and the grid voltage changes in the same manner as above, it will be seen that under these conditions the tube 42 is held below cut-off thus blocking the 2000-cycle oscillator 41 while the tube 62 continues conductive thus permitting 200-cycle signal from the oscillator 61 to continue to appear on line I. This causes the scanning operation, at both transmitter and receiver, to progress at the slow speed. At the same time the additional grid 94 of the tube 82 which is connected to the second grid 74 of tube 62 has been raised in potential. The tube 82, therefore, becomes conductive and 200-cycle voltage is delivered from the oscillator 61 to line II to operate the beam-modulating grid 253 of the printer tube at the receiver station and cause the cathode beam 267 of the latter to pass out of the tube through the comb wires 251 and leave impressions on the sensitized paper 270 corresponding to black areas of the copy being transmitted.

As a last condition, assume that the main scanning aperture 20 sees black areas but that white areas are ahead so that the auxiliary aperture 21 sees only white. In such case it will be seen by following the connections and voltage changes in the same manner as above described that the 2000-cycle oscillator 41 continues to be blocked by non-conductance of the tube 42 while the voltage of the 200-cycle oscillator 61 is delivered to line I through the tube 62 and also to line II through the tube 82. Therefore, due to the low frequency signal on line I scanning continues to take place at a slow rate, and due to the printing signal on line II, the cathode beam

267 of the printer tube continues to form impressions on the tape 270.

Not until the original condition first described recurs, that is to say not until both the main aperture 20 and the auxiliary aperture 21 see white together, will the printing signal on line II and the low frequency scanning signal on line I be blocked and the high frequency scanning signal from the 2000-cycle oscillator 41 come into play once more to operate the scanning process at the higher speed corresponding to white areas.

The choice of different grid bias voltages for the tubes 42 and 62 will now be understood. It is desirable in accordance with the invention that when either one of the two scanning apertures 20, 21 sees black, scanning shall progress at the slow rate. Slow rate scanning, with the circuits shown, means that the tube 42 is below its cut-off while the tube 62 is conductive. When one or other of the apertures 20, 21 sees black, one or other of the additional grids 54, 55 of the tube 42 is raised in potential and one or other of the additional grids 74, 75 of the tube 62 is reduced in potential. Since, as above stated, it is desirable that under these conditions the tube 62 conduct while the tube 42 remains non-conductive, it is preferable that the tube 42 be initially biased below its cut-off point and the tube 62 be initially biased above its cut-off point.

The reason for the large size of the auxiliary aperture 21 as compared with the main scanning aperture 20 will now be appreciated. As above indicated, in the case of ideal apparatus which responds instantaneously to an impressed signal, no advance aperture is required at all. Such instantaneous response, in the case of transmission of an electric signal from one point to another implies a transmission channel of infinite extent. Short of the ideal, response of a variable speed scanning system to a signal derived from the principal scanning aperture 20 itself requires a transmission channel of very considerable extent; and, generally, the narrower the channel, the slower the response.

Therefore, in order to utilize a narrow transmission channel one must be content with relatively slow response. (Slow response to a particular transition is here intended. This is to be distinguished from slow reproduction of a group of signals constituting a message as a whole.) In order that the necessarily slow response of the narrow transmission channels of the system of the invention shall produce reproduction at the receiver station which is of acceptable character, a delay may be introduced between the speed change signal and the printing signal, which delay will allow the scanning beam speed change to take full effect before the printing commences; and this delay is inserted, in accordance with the invention, by the use of the auxiliary advance scanner.

If, however, the advance scanning aperture were of the same size as the principal scanning aperture then, though it could see a picture element far ahead of the principal scanner, it still could not operate correctly unless further assisted by additional discriminating apparatus. Suppose, for example, that a portion of the picture being scanned consists of a row of black dots spaced one picture element apart. Then the signal from the advance scanner will change each time a boundary is crossed between a black dot and its white background and the auxiliary scanner will deliver a series of speed change signals with such rapidity that the apparatus cannot,

when it includes a narrow transmission channel of the character contemplated, distinguish between them at all, and the result will be utter confusion of the printing at the receiver. But with an auxiliary scanner several times as large as the principal scanner as described above, the scanning apparatus at both transmitter and receiver may be arranged to maintain their slow scanning speed throughout such an area of copy, and will rise to the high "white scanning" speed only when the auxiliary scanner sees white areas so far ahead that the scanning can safely be accelerated, travel at high speed, and in turn be decelerated in time to print the next black area correctly.

As stated above, the aperture of the auxiliary scanner is preferably equivalent to some fifteen to twenty picture elements in length as compared with the principal scanner aperture. This choice is based on a scanning speed ratio of ten to one plus a margin, for safety, of five to ten picture elements in addition. Thus when the picture element seen by the principal aperture changes from white to black the principal anode current undergoes a full range change; but when a single black picture element enters the field of view of the auxiliary scanner aperture which, for example, has included only white areas at the previous instant, the auxiliary anode current undergoes a change of the order of only 5 per cent. This relatively small change should operate, in accordance with the invention, to bias the tube 42 below cut-off and render the tube 62 conductive. This result is accomplished with the circuit arrangement of Fig. 1 by the selection of the bias potential of the amplifier J at such a value that the first stage remains non-conductive until the auxiliary anode current has increased to about 95 per cent of its full "white" value, becoming conductive only for full white current. Thus the amplifier J is enabled to discriminate with precision between the condition in which the auxiliary scanner aperture sees only white areas and the condition in which there are one or more black picture elements in its field of view.

It so happens that much of the copy which is normally transmitted commercially, for example, typewritten material, contains on the average several times as much white area as black area and very considerable portions of unrelieved white. By this invention, therefore, the scanning apparatus at both transmitter and receiver is enabled to speed up at such unrelieved white portions thereby saving considerable time while still operating slowly and therefore with exactness in regions of great detail. Moreover, this is accomplished, in accordance with the invention, with a very great saving in frequency space; that is, by the use of the three channels above described, two narrow channels on line I and a single narrow channel on line II.

In accordance with a further modification of the invention still further economies in frequency space may be effected, the two channels of line I being completely eliminated. This may be accomplished by transmitting the sole black signal, storing it temporarily at the receiver, and in turn recovering it from the storage device at two different points by the use of two separate pick-up devices. The signal from the principal pick-up device may operate the printer of the receiver tube in the same manner as does the signal arriving on line II in the modification above described. The signal derived from the auxiliary pick-up device, which is in advance of the prin-

cipal pick-up device with respect to the storage device and which is preferably of a somewhat larger "aperture" than the principal pick-up device, serves to operate the scanning mechanism at the receiver in the same manner as does the signal arriving over line I in the modification above described.

The transmitter apparatus embodying this modification may be identical with the apparatus of Fig. 1 above described with the sole exception that in operation the signals of line I are not transmitted. They are, of course, utilized at the transmitter to effect variable speed scanning as described above.

Fig. 4 shows receiver apparatus embodying this modification of the invention. Referring to Fig. 4, there is provided a storage device of appropriate type, for example, a tape 301 of magnetizable material, which may be driven at constant speed by any appropriate mechanism, not shown. In its uniform progress the tape passes first between poles 302 energized by a coil 303 carrying a direct current from any suitable source 304. This coil 303 serves to remove all traces of previous magnetization of the tape 301 and put it in condition to receive and retain records of the type for which it is intended.

The sole black signals reaching the receiver over line II may be amplified and converted into currents of related wave form in any convenient manner. Apparatus for this purpose is well known per se and is schematically indicated by the block 305 in Fig. 4. These sole black signal currents pass through a winding 306 to energize pole-pieces 307, which are also coupled to a biasing winding 308, through which the signals are impressed magnetically on the tape 301. The tape then progresses past the pole-pieces 309 of an auxiliary magnetic pick-up device and after an interval past pole-pieces 310 of a main pick-up device, after which it has fully served its purpose and may be returned to the demagnetizing coil 303 for reuse. With the exception of the auxiliary pick-up device which will be described below, this apparatus is well known per se and further details will not be given. It will be obvious to those skilled in the art that many other types of storage device may be employed in accordance with the invention. For example, the storage device may be a strip of fluorescent material and the recorder and reproducer appropriate optical or photoelectric units as described in an article which appears in volume 27 of the Proceedings of the Institute of Radio Engineers for December 1939 at page 747. Again, the storage may be effected photographically on a photosensitive film in accordance with the well-known technique of sound moving pictures. If preferred, the storage device may be a wax record, cut by an electro-mechanical stylus and reproduced from by an ordinary phonograph pick-up device. Indeed, a storage device of any description may be employed in accordance with the invention, though the magnetic tape is well suited to secure the desired results.

The terminals of the principal pick-up coil 312 are connected to the input terminals of a rectifier 314 here shown for the sake of simplicity as the well-known bridge connected arrangement of four dry plate rectifier units. It is to be understood that any desired type of rectifier may be employed.

Similarly, the auxiliary pick-up coil 311 supplies an auxiliary rectifier 313 which may likewise be of any desired type.

As in the case of the first modification, discrimination between black signals and white signals on the frequency basis, though not essential to the invention, constitutes a convenience and lends itself readily to incorporation as a part of the preferred embodiment. The second modification will therefore be described in conjunction with a frequency modulated scanning signal similar to that of the first modification. Thus a high frequency generator 341, for example, of 2000 cycles per second, supplies its voltage between the cathode 344 and first control grid 345 of a discharge tube 342 and a low frequency generator 361, for example of 200 cycles per second, supplies its voltage between cathode and first control grid of another discharge tube 362. Each of these tubes is provided with two additional control grids.

The output terminals of the principal rectifier 314 are directly connected to the third grids 355, 375 of tubes 342 and 362, respectively; and the output terminals of the auxiliary rectifiers 313 are directly connected to the second grids 354, 374 of the same tubes. A grid leak and condenser pair are connected between each of the auxiliary grids of each of the tubes 342 and 362 and the cathode of that tube. These grid leaks and condensers are included principally to smooth out the wave shapes obtained from the two rectifiers and may be replaced by any other suitable apparatus for this purpose. The output circuits of the tubes 342 and 362 are connected in a manner well known per se and supply the energy of the 2000 cycle generator 341 through a band-pass filter 352 and the energy of the 200 cycle generator 361 through a band-pass filter 372 to the primary winding 401 of a cycle counter circuit which may be identical with that described above in connection with Figs. 1 and 3 and may operate in a similar manner to deflect the cathode beam 467 of a printer tube 450, which again may be identical with that of Fig. 3, both for scanning and for return of the printer tube beam 267 to its starting point, and to advance the sensitized paper tape 470 intermittently by the width of a single line of copy.

In addition, the beam-modulating grid 453 of the printer tube 450 is directly connected to the third grid of the tube 362 and therefore follows the potential variations of the rectifier 314 associated with the principal pick-up device 310 and operates to extinguish the cathode beam of the printer tube 450 when no signal is being picked up by the principal pick-up device and to permit the cathode beam 467 to impinge on the comb 451 and form impressions on the sensitized tape 470 when black signals are being picked up by the principal pick-up device.

The operation of the circuit above described is closely analogous to that of Fig. 1 which was fully described above. It will be apparent by tracing the connections that when either the principal pick-up scanner or the advance pick-up scanner or both scanners see a black signal on the magnetized tape 301 the 2000 cycle oscillator 341 will be blocked by the tube 342 and the 200 cycle oscillator 361 will deliver its voltage through the tube 362 and the band-pass filter 372 to the cycle counting circuit and cause the cathode beam of the printer tube 450 to progress at the slow speed appropriate for dark areas. Only when both the scanning pick-ups together see that the tape 301 is clear of signals is the 200 cycle oscillator 361 blocked and the 2000 cycle oscillator 341 permitted to deliver its signals

through the band-pass filter 352 to the cycle counter circuit and cause scanning of the cathode beam of the printer tube 450 to take place at the higher speed appropriate for white areas. Lastly, only when the principal scanner 310 sees black does the cathode beam of the printer tube 450 reach the beam receiving comb 451 and produce impressions on the sensitized tape 470, being blocked under all other conditions by the potential of the beam modulating grid 453.

The "aperture" of the auxiliary pick-up device 309 may be some five to ten picture elements in length corresponding to the length of fifteen to twenty elements for the auxiliary aperture at the transmitter. The difference is due to the fact that the receiver storage device, unlike the transmitter scanner, progresses at constant speed, so that the scanning speed ratio component which in part determines the transmitter auxiliary aperture size, takes no part in the corresponding size determination for the pick-up device at the receiver.

In general, the aperture size for a storage device of any type is measured by the size of that element which sees the record. For example, in the case of an optical storage device the aperture is measured by the size of a light gate. In the particular case of the magnetic recording device described above, the aperture is measured by the size of the pole-pieces. Depending on the oscillation frequencies chosen a single picture element may occupy the space of a fraction of a wave-length on the tape or of several wave-lengths. Moreover, a continuous black portion of the copy may occupy any number of picture elements. Under these conditions the portion of the magnetized tape 301 which is included between the auxiliary pole-pieces 309 may include a number of wave-lengths which is the product of the number of elements "seen" by the pole-pieces by the number of tape wave-lengths per element. For example, with auxiliary pole-pieces five elements in length, if one element corresponds to five tape wave-lengths this product would be twenty-five wave-lengths.

In order that the auxiliary pick-up device may respond correctly to the presence or absence of sole black signals on the tape its pole-pieces may be serrated to provide oppositely spaced teeth so that the "black" oscillator frequency is resonated. The same construction may be applied to the main pick-up pole-pieces 310, if they are more than one wave-length in extent. This construction is illustrated in Fig. 5, in which the dots 301' on the tape 301 represent individual wave-lengths of magnetization, and each group of dots 301' is intended to represent a black picture element, here taken by way of example as three wave-lengths long. In the case of the main pole-pieces 310, however, it is not necessary that they be more than one-half of the tape signal wave-length in extent, whether this be equal to a picture element length or not.

Band-pass filters 352 and 372 in the output circuits of the tubes 342 and 362 do not serve the same purpose as the corresponding filters at the transmitter, namely, to economize frequency space in transmission. They are included in the circuit of Fig. 4 rather to insure that the wave form of the frequency modulated signal impressed on the cycle counter circuit shall be the same at the receiver as at the transmitter, so that scanning may take place similarly at the two stations. If these filters were not included, some distortion of wave form might occur due to sec-

ondary effects of the tape 301, the rectifiers 313, 314 and other circuit elements and this might result in differences of scanning performance at the transmitter and receiver.

Each of the circuit arrangements above described includes as a part thereof a cycle counter of a particular type. It will be understood that any appropriate instrumentality may be used to convert the frequency modulated signal into variable speed scanning of the cathode beam both at transmitter and at receiver.

In both modifications described above the oscillation frequencies have been selected as 2000 cycles per second corresponding to white picture areas and 200 cycles per second corresponding to black picture areas. These frequencies are taken by way of example only, and others would serve equally well, it being preferable, however, in order to make use of the advantages offered by the cycle counter circuit that the frequency ratio be equal to the scanning speed ratio. If some other form of demodulating device were to be substituted for the cycle counter, this frequency ratio might be correspondingly altered in which case it would be necessary only that the "white" oscillation frequency and the "black" oscillation frequency differ by enough to enable the apparatus to discriminate readily between them.

The preferred embodiments of the invention have been described in both modifications in conjunction with a frequency modulated signal of peculiar form and in conjunction with apparatus for generating such a signal and responding thereto. It must not be concluded that the invention is limited in its application to frequency modulated signals, which constitute a convenience rather than an essential feature. Signals of any type may be employed as long as they have a characteristic which constitutes a basis for discrimination between dark areas and light areas of the picture to be scanned. Appropriate apparatus for generating and receiving such signals and for responding thereto may if desired be substituted, with appropriate modification, in the system of the invention without in any way departing from the spirit thereof. Furthermore, it will be apparent to those skilled in the art that the circuit arrangements above described may be modified to transmit and reconstitute pictures of more than two tones. Indeed, various features and advantages of the invention may be employed in related signaling arts, since though it is conceived that its chief use will be in the picture signaling art and has been described in terms of illustrative examples suited to that art, it is not exclusively limited thereto.

It is to be understood that in the appended claims, in the absence of specific limitations, the word "aperture" is used to designate whatever sets the limit of the area of the field which is effective at any instant in the scanning operation. The term "picture" in the claims is intended to be a generic term and not to limit the claims with respect to the type of field which is analyzed or synthesized. Likewise, the terms "black" and "white" are used to designate two distinctive tones or colors.

What is claimed is:

1. Signaling apparatus which comprises a principal scanner having an aperture bearing a stipulated relation to the length of a single record element and disposed to scan a record along a stipulated path, and an auxiliary scanner having an aperture bearing a similar relation to the

lengths of a plurality of record elements and disposed to scan said record along said path in advance of said principal scanner, means for deriving principal signals from said principal scanner, means for deriving auxiliary signals from said auxiliary scanner, and means under control of said auxiliary signals for modifying the signals derived from said principal scanner.

2. Apparatus for deriving picture signals from copy to be transmitted, which comprises a principal scanner having an aperture bearing a stipulated relation to the length of a single elemental area of said copy and disposed to scan a line of said copy along a stipulated path, and an auxiliary scanner having an aperture bearing a similar relation to the length of a plurality of elemental areas of said copy and disposed to scan said line along said path in advance of said principal scanner, means for deriving principal signals from said principal scanner, means for deriving auxiliary signals from said auxiliary scanner, and means under control of said auxiliary signals for modifying the signals derived from said principal scanner.

3. Picture signaling apparatus which comprises, a principal scanner arranged to scan a line of a sheet of copy to be transmitted, means for deriving principal signals from said principal scanner, an auxiliary scanner having an aperture related in size to a plurality of picture elements and arranged to scan said line in advance of said principal scanner aperture, means for deriving signals from said auxiliary scanner related to the tone values of a plurality of picture elements seen by said auxiliary scanner aperture, and means for regulating the scanning speed of said scanners in accordance with said principal signals and said auxiliary signals together.

4. Picture signaling apparatus which comprises, a principal scanner having an aperture arranged to scan a line of a sheet of copy to be transmitted and related in size to a single picture element, an auxiliary scanner having an aperture similarly related in size to a plurality of picture elements and arranged to scan said line in advance of said principal scanner aperture, means for deriving signals from said auxiliary scanner related to the tone value of any one of a plurality of picture elements seen together by said auxiliary aperture, and means for regulating the scanning speed in accordance with said signals.

5. Picture signaling apparatus which comprises, a principal scanner having an aperture arranged to scan a line of a sheet of copy to be transmitted and of a size related to the size of a single picture element, an auxiliary scanner having an aperture similarly related in size to a plurality of picture elements and arranged to scan said line in advance of said principal scanner aperture, means for deriving signals from said auxiliary scanner related to the tone values of picture elements seen by said auxiliary aperture, means for utilizing said auxiliary scanner signals, and bias means for causing said signal utilizing means to discriminate between the condition in which said auxiliary aperture sees all white picture elements and the condition in which it sees one or more black picture elements, while not discriminating between the condition in which said auxiliary aperture sees one black element and the condition in which it sees more than one black element.

6. Picture signaling apparatus which comprises, a principal scanner having an aperture

arranged to scan a line of a sheet of copy to be transmitted and of a size related in size to a single picture element, an auxiliary scanner having an aperture similarly related in size to a plurality of picture elements and disposed to scan said line in advance of said principal scanner aperture, means for deriving principal signals from said principal scanner, related to the tone values of successive single picture elements seen by said principal aperture, means for deriving auxiliary signals from said auxiliary scanner related to the tone values of successive pluralities of picture elements seen by said auxiliary aperture, means for regulating the scanning speed for both of said scanners in accordance with said principal signals and said auxiliary signals, means for transmitting said principal signals to a receiver station, means for separately transmitting said auxiliary signals to a receiver station, and means at said receiving station for cooperatively utilizing said principal and auxiliary signals to reconstitute said copy.

7. In a picture signaling system, the combination which comprises, line scanning means for producing a principal signal related to the tone value of an individual picture element of a field to be transmitted, and means for producing auxiliary signals related to the tone values of a plurality of picture elements lying in advance of said first-named element in a scanning line, the first picture element of said plurality being separated from said first-named individual picture element by a single picture element, said plurality containing substantially fewer picture elements than are contained in the whole of said scanning line.

8. In the picture signaling art, the method which comprises scanning successive elements of a picture to be transmitted at a certain instant, deriving from the elements scanned principal picture signals related to the light and shade values of said elements, simultaneously scanning a plurality of other elements in advance of said first-named elements, deriving from said other elements auxiliary picture signals related to the light and shade values of said other elements, regulating the speed of scanning in accordance with said principal signals and said auxiliary signals, transmitting said principal signals and said auxiliary signals to a receiving station, and at said receiving station, scanning an impression-receiving element at speeds related to said principal and auxiliary signals, and printing said element in accordance with said principal signals.

9. In a picture transmission system, the combination which comprises a sheet of copy to be transmitted, a principal scanner disposed to scan a line of said copy, an auxiliary scanner disposed to scan said line in advance of said principal scanner, means for deriving principal signals from said principal scanner, means for deriving auxiliary signals from said auxiliary scanner, means for accelerating and decelerating the scanning of said line in accordance with the signals derived from both of said scanners, means for transmitting said principal signals to a receiving station, means for receiving and recording said principal signals in a storage device at said receiving station, means for recovering signals from two separated points of said storage device, a scanner printer and an impression-receiving element at said receiving station, means for accelerating and decelerating said scanning printer in accordance with the signals reproduced at said two separated points, and means for

causing said printer to impress said receiving element in accordance with the signals reproduced at the second of said points.

10. Apparatus for reconstituting a black and white picture from a sole tone signal received from a distant point, which comprises means for receiving said signal, means for storing said signal at one instant, means for recovering said signal from said storage means at two successive later instants, a scanning printer, an impression-receiving medium, means for causing said printer to scan said receiving medium at a speed proportional to the frequency of electric oscillations supplied thereto, a first generator of lower frequency oscillations and a second generator of higher frequency oscillations connected to supply scanning oscillations to said scanning means, means controlled by the signals recovered at said two successive later instants for activating said first generator and disabling said second generator when one of said signals is present and for activating said second generator and disabling said first generator when neither of said signals is present, and means controlled by the signal later recovered for causing said scanning element to impress said receiving medium when said later recovered signal is present and to be disabled when said later recovered signal is absent.

11. Apparatus for reconstituting a black and white image by successive line scans from a sole tone signal received from a distant point, which comprises means for receiving said signal, a scanning element, an impression-receiving medium, and means controlled by said received signal for sweeping said scanning element over said receiving medium at a definitely determined speed in one direction during a line scan when said signal is received and at a different speed in the same direction during said line scan when said signal is not received.

12. Receiver station apparatus for line-by-line reconstitution of a black and white picture from sole tone signals received from a distant point, which comprises an impression-receiving medium, a printing device, means for causing said printing device to scan said receiving medium along a line at a speed determined by the frequency of electric oscillations supplied thereto, two generators located at said receiver station connected to supply scanning speed determining oscillations to said scanning means, means for disabling one of said generators upon the reception of said signals and the other of said generators in the absence of said signals, and means for returning said printing device to its starting point at the conclusion of said line scan.

13. In the picture signaling art, the method which comprises scanning successive elements of a picture to be transmitted, deriving from the elements scanned a signal of one frequency corresponding to picture areas of one characteristic and a signal of a different frequency corresponding to picture areas of a different characteristic, maintaining receiving apparatus at a receiving station in synchronism with said signals, transmitting one of said signals through a transmission channel to said receiving station while suppressing the other of said signals in said channel, and at said receiving station, recreating areas of one of said characteristics in accordance with said received signal and areas of the other of said characteristics under local control in part independent of said signal.

14. Picture signaling apparatus which comprises, a principal scanner having an aperture

arranged to scan a line of a sheet of copy to be transmitted and of a size related to the size of a single picture element, an auxiliary scanner having an aperture similarly related in size to a plurality of picture elements and arranged to scan said line in advance of said principal scanning aperture, a first generator of higher frequency oscillations, a second generator of lower frequency oscillations, means for passing oscillations of said first generator to a circuit when neither of said apertures sees black picture elements and for passing oscillations of said second generator to said circuit when either or both of said apertures sees black picture areas, said passed oscillations constituting scanning speed signals, and means for regulating the scanning speed of said scanner in accordance with said scanning speed signals.

15. Picture signaling apparatus which comprises a principal scanner arranged to scan a line of a sheet of copy to be transmitted, means for deriving principal signals from said principal scanner, an auxiliary scanner having an aperture related in size to a plurality of picture elements and arranged to scan said line in advance of said principal scanner, means for deriving auxiliary signals from said auxiliary scanner related to the tone values of picture elements seen by said auxiliary scanner, a first generator of oscillations of a characteristic related to white image signals, a second generator of oscillations of a different characteristic related to black image signals, means for passing oscillations of said generators to a circuit alternatively in accordance with said auxiliary signals, and means for regulating the scanning speed of said scanners in accordance with said principal and auxiliary signals.

16. In combination with variable speed line-by-line scanning apparatus for reconstituting an image from received picture signals, storage means, means for forming a single track record of image signals on said storage means at one instant, principal pick-up means for recovering said signals from said single track record at a later instant to provide printing signals, and auxiliary pick-up means for recovering said signals from said record at an intermediate instant to provide scanning speed signals.

17. In picture signaling apparatus, the combination which comprises signal storage means, means for forming a single track record of image signals on said storage means, means for recovering said image signals from said single track record at two separate later instants, and separate means for differently utilizing the signals recovered at said separate instants.

18. Signaling apparatus which comprises, a principal scanner disposed to scan successive elements of a single track record, an auxiliary scanner disposed to scan other elements of said single track record, means for deriving a principal signal from said principal scanner, means for deriving auxiliary signals from said auxiliary scanner, and means for regulating the speed of said scanners longitudinally of said record in accordance with both of said signals.

19. Signal receiving apparatus which comprises a cathode ray tube having means for projecting a cathode beam and a beam receiving element, a plurality of generators of oscillations of different frequencies, means for selectively actuating said generators by signals of different character, means for deflecting said cathode beam in a scanning direction at a speed dependent upon the frequency of whichever one of said

generators is actuated, and means for modulating said cathode beam under control of a particular one of said generators.

20. In an electro-optical image transmission system, means for scanning a field to set up an image current any instantaneous value of which corresponds to the light tone value of an elemental field area, means for prescanning said field along the elemental scanning path subsequently scanned by said first-mentioned scanning means, each element of said path instantaneously viewed by said prescanning means having a length much greater than the corresponding dimension of an element instantaneously viewed by said first-mentioned scanning means, and means under control of said prescanning means for controlling the rate of scanning by said first-mentioned scanning means.

21. Signaling apparatus which comprises variable speed means for scanning a portion of a field to be transmitted to derive principal signals therefrom, variable speed means for simultaneously scanning another portion of the same field to derive auxiliary signals therefrom, and means for varying the speed of said scanning means under the joint control of said principal and said auxiliary signals.

22. The method of scanning to set up an image current which comprises scanning the field along a chosen elemental strip path thereof, utilizing light received from the field as the result of said scanning to cause the value of a characteristic of a current to accord at each instant with the light-tone value of an elemental area of said path which is effective at that instant, maintaining a certain constant velocity of scanning while said characteristic of the resulting current is at a constant value corresponding to a certain tone value present in said field, and changing the velocity of scanning only when a point is reached defining the beginning along said path of a portion thereof from which said tone value is absent, the length of said portion along said path being large compared with the corresponding dimension of said instantaneously effective elemental area, but maintaining said first-named scanning speed over path portions from which said first-named tone value is absent, which portions are of length comparable with said instantaneously effective elemental area.

23. Apparatus for synthesizing a two-tone image from a signal consisting of portions having a common distinguishing characteristic representative of one of said tones and intervening blank portions indicative of the other of said tones which comprises a scanning element, an impression-receiving medium, means for selectively sweeping said scanning element over said medium at different speeds corresponding to said different tones under control of said blank portions and said distinguishable portions of said signal, respectively.

24. In an image signaling system, the combination with a variable speed means for scanning elemental areas of a field in succession to produce a principal image signal representative of the tone values of said elemental areas, of variable speed means for scanning other elemental areas of said field together as a group lying in advance of a respective one of said first-named areas to produce an auxiliary signal dependent upon tone values of said group, and means for varying the speed of said scanning means under control of said auxiliary signal.

25. In an image signaling means, the com-

5 bination of variable speed means for scanning successive areas of a field of view to be transmitted to derive image signals, means for causing said scanning means to travel at a comparatively low speed in scanning areas of one light characteristic and at a comparatively high speed in scanning areas of a different light characteristic, said speed-controlling means including means for initiating acceleration only when an area scanned is of said first-named light characteristic and at least a stipulated plurality of similar areas of said second-named light characteristic lie in advance thereof.

10 26. In an image signaling system, the combination with variable speed means for scanning a field to derive image signals, of means for causing said scanning means to travel at a comparatively low speed in scanning areas of one light characteristic independently of the extent of said areas and at a comparatively high speed in scanning areas of a different light characteristic of extent in excess of a stipulated amount.

15 27. An image-to-signal translating device which comprises a photoelectric cathode extended in the direction of a line of an image formed thereon, two separate differently-apertured electron-receiving anodes spaced apart on a line parallel with said first-named line, the spacing of said anodes and the aperture of one of said anodes being of the order of one elemental image area in length, the aperture of the

other of said anodes being of the order of a plurality of elemental image areas in length, means for directing electrons emitted from various points of said cathode in a beam of substantial width in the direction of said line to impinge on said anodes, means for deflecting said beam in the line of said anodes in a manner to permit electrons of said beam originating at a particular image point to impinge first upon said larger anode and subsequently upon said smaller anode, and means for deriving distinct and different signals from said separate anodes.

20 28. An image signaling system which comprises a principal scanner having an aperture arranged to scan a line of an image to be transmitted, an auxiliary scanner having an aperture substantially larger than said principal scanner aperture and arranged to scan said line in advance of said principal scanner, means for deriving principal signals from said principal scanner related to a light characteristic of areas seen singly by said principal scanner, means for deriving auxiliary signals from said auxiliary scanner related to a light characteristic of areas seen together by said auxiliary scanner, and means controlled by said auxiliary scanner signals for causing said principal scanner to pass comparatively rapidly over areas of one light characteristic and comparatively slowly over areas of another light characteristic.

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