

Nov. 10, 1942.

J. W. COX

2,301,374

FACSIMILE AND PICTURE SYSTEM WITHOUT SYNCHRONIZING UNITS

Filed Nov. 1, 1940

2 Sheets-Sheet 1

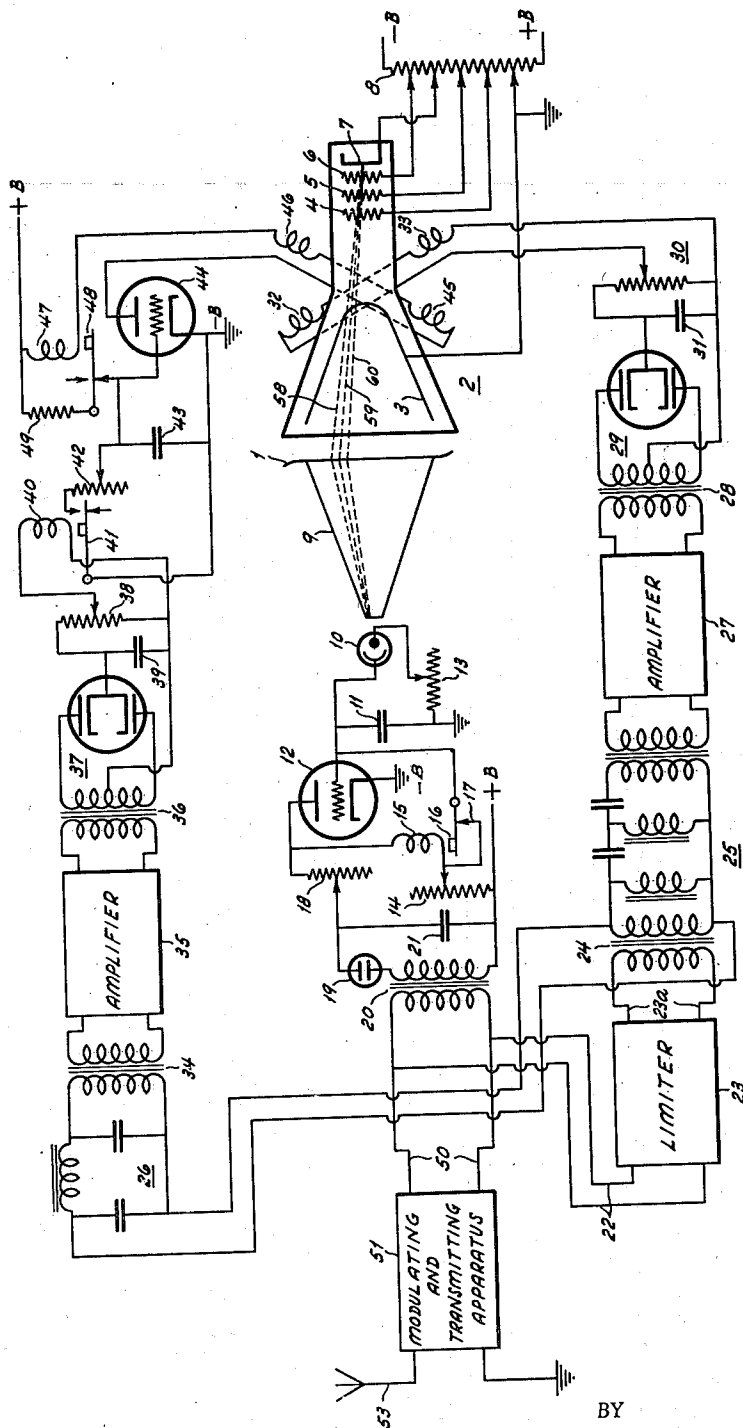


Fig. 1

INVENTOR.
JOHN W. COX

H.S. Grover
ATTORNEY

Nov. 10, 1942.

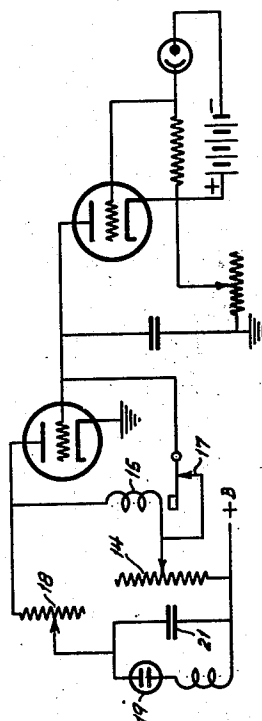
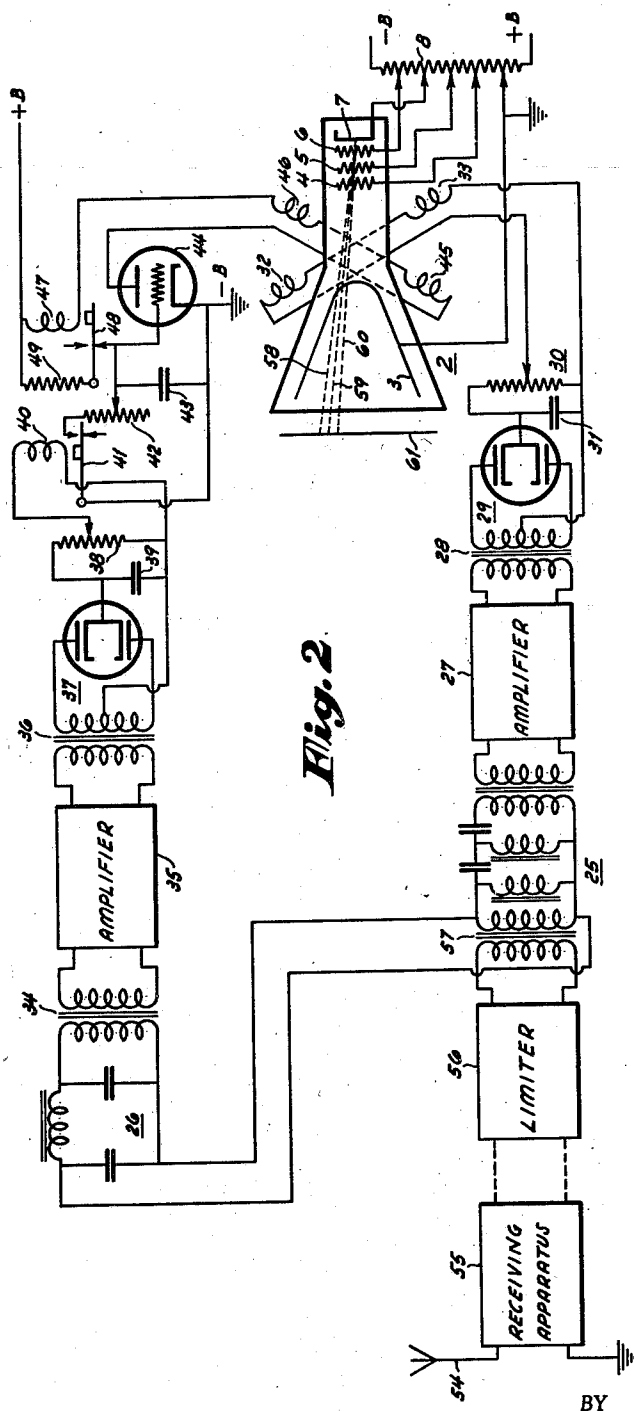
J. W. COX

2,301,374

FACSIMILE AND PICTURE SYSTEM WITHOUT SYNCHRONIZING UNITS

Filed Nov. 1, 1940.

2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,301,374

FACSIMILE AND PICTURE SYSTEM WITH-
OUT SYNCHRONIZING UNITSJohn W. Cox, Berkeley, Calif., assignor to Radio
Corporation of America, a corporation of Dela-
ware

Application November 1, 1940, Serial No. 363,806

8 Claims. (Cl. 178-6.7)

This invention relates to the production and recording of facsimile and picture signals without use of special mechanism for synchronizing the recorder with the transmission scanner.

It is an object of the invention to increase the speed of facsimile and picture transmission and reception by varying the line scanning rate with the shading of the line being scanned.

More specifically, an object is to scan black elements of a typewritten sheet at a relatively slow rate and white elements at a relatively high rate, and the reverse when desired.

Another object is to produce constant illumination at the recorder and to vary the shading by varying the scanning rate.

Another object is to produce signals of a predetermined frequency range for each line to be subject to be scanned and to control the rate of scanning by the variation of the frequency.

Another object is to produce signals of a predetermined frequency range for each line to be scanned, controlling the rate of scanning of the lines by the variation of frequency and shifting the scanning beam to the next line when the frequency reaches a predetermined value in said range.

Other objects will appear in the following description, reference being had to the drawings, in which:

Fig. 1 is a diagrammatic illustration of the circuits at the transmitter, certain old and well-known parts being shown in block diagram.

Fig. 2 is a diagrammatic illustration of the receiving and recording apparatus, certain well-known parts being shown in block diagram.

Fig. 3 illustrates a modified form of light control at the transmitter scanner.

The invention is not limited to any particular type of subject, but for purposes of explanation it will be assumed that the subject 1 being scanned in Fig. 1 is a translucent typewritten sheet or a positive film of the same. A cathode ray tube 2, for example Radiotron 903, is employed, which has a high-voltage anode 3, focusing anode 4, accelerating grid 5, control grid 6 and unipotential cathode 7. These elements may be supplied from the usual D. C. bleeder resistance 8. As customary, the high-voltage anode 3 is grounded instead of the negative terminal of the B-supply, though, of course, this may be changed if desired.

The beam of light from the cathode ray tube 2 is focused by an appropriate lens system indicated in diagrammatic form at 9 and is projected into a photo-electric cell 10 shunted across

condenser 11 in the grid circuit of vacuum tube 12. A variable controlling resistance 13 is included in this circuit across the condenser. The positive terminal of the B-supply of this tube is connected through adjustable resistance 14 and switch magnet coil 15 to the plate of the tube. The cathode and the negative terminal of the B-supply are grounded, as indicated in the drawing.

When the magnet 15 is not sufficiently energized, the armature 16 drops against switch contact 17, connected with the adjusting tap on resistance 14. Therefore, when this magnet releases the armature 16, condenser 11 is placed across the B-supply through the resistance 14, which charges it to its starting value.

The B-supply is connected to the plate of tube 12 through adjustable resistance 18 and a parallel circuit consisting, in one leg, of a neon tube 19 and the primary of transformer 20 and, in the other leg, condenser 21.

The secondary of transformer 20 is connected by lines 22 to a voltage or current limiting device 23, shown in block diagram. This limiter may be a tube limiter such as shown in my application, filed April 20, 1939, Serial No. 268,873, though any other form of voltage or current limiter may be used. The output lines 23a are connected to the terminals of the primary of transformer 24. The terminals of the secondary of this transformer are connected to high-pass filter 25, adapted to pass frequencies F₁ to F₂, and also to low-pass filter 26, adapted to pass only the lowest frequency, F₂.

The high-pass filter 25 is connected to an amplifier 27 having any desired number of stages of amplification. The output of the amplifier 27 is connected to the primary of transformer 28. The secondary of this transformer is connected to full-wave rectifier 29, which has load resistance 30 and a suitable filter, diagrammatically indicated by condenser 31. The horizontal deflecting coils 32, 33 of the cathode ray tube are adjustably connected to load resistance 30.

Low-pass filter 26 has its output connected through transformer 34 to a suitable amplifier 35, and the output of this amplifier is connected through transformer 36 to the full-wave rectifier 37, having load resistance 38 and filter condenser 39. Switch magnet coil 40 is adjustably connected across resistance 38. When this coil is energized, its armature 41 closes a circuit through adjustable resistance 42 across condenser 43 in the input circuit of vacuum tube 44.

The plate of tube 44 is connected through ver-

tical deflecting coils 45, 46 of the cathode ray tube and switch magnet coil 47 to the B-supply. When coil 47 is sufficiently de-energized to release its armature 48, the circuit is closed between the B-supply and resistance 49 to one terminal of grid condenser 43, the other terminal being connected to the cathode of the tube and to ground, which is the negative terminal of such supply. This charges the condenser to the starting value.

The secondary of transformer 20, which is the audio signal output, is connected through lines 50 to modulating and radio transmitting apparatus 51 or to a suitable wire or a cable link, if a wire telegraph system is employed. The radio transmitting apparatus 51 contains suitable amplifiers, rectifiers, modulating devices, carrier frequency generator, and other apparatus employed in radio transmitting stations for impressing signal modulations on a radio carrier. Any type of these devices may be used and hence the details are not shown, since their action is well known. Radiation may be had through any desired form of antenna 53.

The receiving apparatus in Fig. 2 consists of an antenna 54 of suitable design and receiving apparatus 55, which may consist of radio frequency amplifiers, a detector, and audio frequency amplifiers, as well as heterodynes and any other desired apparatus customarily used in receiving stations. The details of these have nothing to do with my invention and they may be of any design.

The extracted audio component of the signal is fed into limiter 56, which may be similar to the one at the transmitter. The purpose of these limiters, both at the transmitter and receiver, of course, is to limit the amplitude of the signal so that the signal pulses will all be of uniform amplitude and thus be free of amplitude modulation. The limiter output is connected to transformer 57 and the secondary of this transformer is connected to the deflecting coils of the cathode ray tube 2 through high and low frequency paths, containing high- and low-pass filters. All of the elements in these paths are similar to those of the transmitter in Fig. 1. They have been given similar reference characters and the connections will be understood without repeating the detailed description given in describing Fig. 1.

The vacuum tubes in the circuits of Figs. 1 and 2 have been shown with unipotential cathodes, though, of course, this is not a requirement. The heaters for these cathodes have not been illustrated, as they are well known in the art and it is obvious how they would be connected to a source of potential for heating the cathodes. If the high-potential anode is grounded as shown, the circuit, of course, must be well insulated from ground.

The operation of my improved facsimile system will now be described:

Referring to Fig. 1, let it be supposed that a typed paper sheet, or a translucent positive 1 of a typewritten sheet, is in position in respect to the cathode ray tube 2 and optical unit 9 and that condenser 11 is fully charged, which will be the starting point for scanning the first line. Magnet 15 will be sufficiently energized to hold its armature 16 and the B-supply voltage will thus be disconnected from the condenser 11 at contact 17. Vacuum tube 12 will now have relatively low mutual conductance and condenser 21 will charge relatively rapidly. When the break-

down point for neon tube 19 is reached, it will discharge through that tube and the primary of transformer 20. It will immediately start to recharge and neon tube 19 will cease to conduct current, as the voltage of its electrodes is now below the conducting point. The rate of charge and discharge of the condenser 21 thus produces an alternating current in transformer 20, as explained in my above-mentioned application. This frequency would be constant if the mutual conductance of tube 12 were constant, but this varies with the grid potential as the condenser gradually discharges through the photo-electric tube and resistance 13.

The rate of discharge through this circuit depends upon the intensity of the light passing into the cell from the cathode ray tube 2 through the optical focusing device 9. This light depends upon the translucency of that part of the letter 1 being scanned. If we suppose that the element or minute area being scanned on positive 1 is white, the discharge rate of condenser 11 will be relatively high and the frequency produced in transformer 20 will shift to a lower frequency at a correspondingly high rate. The alternating frequency in transformer 20 will always start out at some given frequency, say F_1 , and current of this frequency will pass through the limiter and the high-pass filter 25, after which it will be amplified and rectified, producing a given deflecting power in horizontal control magnets 32, 33. The design will be such that this will position the cathode beam 58 at the left-hand margin of the paper, but as soon as the frequency decreases by leakage of the charge of the condenser through the photocell, the amplitude of the alternating current passed through high-pass filter 25 and that of the resultant rectified current will be reduced. The deflecting power of magnets 32, 33 will then be reduced, which will swing the cathode beam 58 to the right.

If one assumes, for purposes of explanation, that all of the elements in the first line being scanned are white, condenser 11 will discharge at a relatively rapid rate and the decrease in amplitude of the alternating current passing through high-pass filter 25 and rectified at 30 will quickly decrease. This means that the cathode beam 58 will swing rapidly to the right and when it has reached the extreme right-hand position on the translucent subject 1, condenser 11 will be discharged to such an extent that the frequency will drop to F_2 , which will pass through low-pass filter 26. Current of this frequency, after amplification and rectification, produces sufficient energization of switch magnet 40 to raise its armature and close the circuit of condenser 43 through resistance 42. Condenser 43 then discharges to a slight extent and reduces the mutual conductance of vacuum tube 44. The plate current through vertical deflecting coils 45, 46 then decreases. This throws the cathode ray beam 58 down one scanning line, as indicated at 59. Current in magnet 15 is at this time sufficiently reduced to release armature 16, which instantly recharges condenser 11. This produces again the highest frequency in the oscillating circuit and the highest amplitude in the output of high-pass filter 25 and rectifier 30. Horizontal deflecting magnets 32, 33 now instantly swing the beam back to the left-hand side of the page 1. Thus current passes only momentarily through low-pass filter 26 and the charge on condenser 43 is

reduced only enough to drop the beam one line, as above stated.

While it will not be the case in usual practice, for purposes of explanation let it be assumed that the next line being scanned is wholly black. The condenser 11 will discharge as before through photo-electric cell 10 and lower the mutual conductance of tube 12 and, consequently, the frequency generated in the oscillating circuit. However, it will discharge at a lower rate. Therefore, the time required for the alternating current to pass from high frequency F_1 to low frequency F_2 will be greater than before. This means that the horizontal deflecting magnets 32, 33 will deflect the cathode beam in its new horizontal position at 59 from the left side of the page to the right at a slower rate. When the lowest frequency F_2 is reached, the cathode beam will be at the right-hand side of the page, as in the scanning of the previous line.

Current again passes through the low frequency filter 26, momentarily energizes switch magnet 40 and discharges condenser 43 an additional slight amount. This slightly reduces the plate current flowing through vertical deflecting magnets 45, 46 and deflects the cathode beam 59 to the next lower scanning line, as at 60. At this point magnet 15 no longer has sufficient current to retain its armature 16 and its switch contact 17 is closed. This immediately recharges condenser 11, stops passage of current through the low-pass filter 26 and switch magnet 40 and brings the frequency back to the high value F_1 . This causes the horizontal deflecting magnets 32, 33 to instantly swing the cathode beam over to the left-hand margin of the subject 1 at the horizontal level shown by beam 60.

If the next line is gray in shade, the transit time of frequency F_1 to frequency F_2 will be intermediate the transit time for white and black, but nevertheless the beam will start at the left-hand margin and end at the right-hand margin before it is shifted one line lower down by means of the next operation of switch magnet 40.

In view of the foregoing explanation, it will be apparent that the sheet 1 will be scanned at the transmitter from top to bottom at a rate varying with the transit time of the frequency from the high point to the low point. The rate of change, of course, in general will not be uniform, because, obviously, the line being scanned will not be all white, all black, or all gray. The shading will alternate between black and white in various portions of the line, depending upon the type in the line or the element of the picture being scanned. This will make the scanning rate variable throughout the length of the line.

The alternating frequency produced in transformer 20 also passes out through lines 50 to the modulating and transmitting apparatus and a radio wave is transmitted to the receiver, where it is received at 54 and 55, Fig. 1, limited at 56 and passed into either the high frequency path or the low frequency path, depending upon the frequency. The frequencies F_1 to F_2 will pass through high-pass filter 25, amplifier 27 and rectifier 30 to control the horizontal deflecting magnets 32, 33, which will swing the cathode ray 58 from left to right in unison with the travel of the cathode ray at the transmitter.

The cathode ray at the receiver, when the initial line is being scanned at the transmitter, will be at the top position shown at 58, because condenser 43 is fully charged and the current through vertical deflecting coils 45, 46 is of proper

value to hold the cathode beam in this position. When the lowest frequency F_2 is reached, current will pass through low-pass filter 26 and after rectification will operate switch magnet 40 to slightly discharge condenser 43, as previously described in connection with the transmitter. This will lower the cathode beam from position 58 to position 59 and thereafter to position 60 in unison with the horizontal position of the cathode at the transmitter, as previously described.

When the last line of the page has been scanned at the transmitter, the cathode rays will be at the bottom of the page at both the transmitter and receiver, and condenser 43 of both will be sufficiently discharged by the repeated momentary contacts made by the switch armatures 41 that switch magnets 47 will release their armatures 48 and engage their switch contacts, which will immediately recharge condensers 43 through resistance 49. This will swing the cathode rays back to the top of the page, ready for another sheet to be scanned at the transmitter and receiver.

With a positive 1 at the transmitter, a positive 61 will be produced at the receiver, because the cathode ray will travel at a fast rate over the white portions of the subject 1 and over the photographic film 61 at the recorder. This means that there will be minimum shading at the receiver when there is minimum shading at the transmitter and the shading of both will vary in unison. However, if desired, a negative may be scanned at the transmitter, which would make rapid transit time for black and slow transit time for white. This, obviously, would produce a negative at the receiver. However, it will usually not be desirable to operate the recorder in this way unless the sheet contains more black than white. It usually will be more advantageous to have rapid transit time of the frequency while scanning white.

If a negative is to be used at the transmitter, the scheme shown in Fig. 3 could be used, where reference characters similar to those of Fig. 1 indicate similar parts. With this arrangement it will be obvious that the discharge rate of condenser 11 will be high while light elements are being scanned and low while black elements are being scanned, due to the negative potential produced in resistance R. A negative at the transmitter in this modification would then operate in the same way as a positive in the arrangement of Fig. 1.

Electromagnetic relays have been shown in the drawing for simplicity of illustration, but it will be understood that the well-known forms of electron or ionic switching may be substituted therefor by employing grid control of tube relays.

It will be apparent that the invention is not limited to facsimile systems. It can be applied also to television, which differs from facsimile only in speed of scanning and switching. This can be secured by use of ionic or electronic switching instead of electromagnetic switching. Obviously, in this branch of the art, television tubes would be used for scanning, such as the 1849 or 1850 iconoscope and the 1800 or 1801 Kinescope, or other well-known types.

Obviously, light may be reflected from an opaque subject to the photocell for controlling the frequency of the oscillator, instead of passing it through a translucent subject as shown in the drawing. Various other modifications may be made in my improvement without departing from the spirit of the invention.

Having described my invention, what I claim is:

1. In picture transmission, a scanner, an oscillator, means for varying the frequency of the oscillator including a photo-electric cell, a cathode ray tube having horizontally and vertically deflecting field elements, means for projecting the cathode ray of said tube from the subject to said cell, a high-pass filter connected to said oscillator adapted to pass a predetermined band with an amplitude varying with the frequency, means for energizing said horizontally deflecting field element from the output of said high-pass filter, and means for varying the strength of the vertically deflecting field element after the frequency of the oscillator passes a predetermined limit.

2. In picture transmission, a scanner, an oscillator, means for varying the frequency of the oscillator including a photo-electric cell, a cathode ray tube having horizontally and vertically deflecting field elements, means for projecting the cathode ray of said tube from the subject to said cell, a high-pass filter connected to said oscillator adapted to pass a predetermined band at an amplitude varying with the frequency, means for rectifying the output of said filter, means for energizing said horizontally deflecting field element from the output of said rectifier, a low-pass filter connected to said oscillator adapted to pass a frequency outside said band, means for rectifying the output of said low-pass filter, and means controlled by the output of the second rectifier for varying the strength of the vertically deflecting field element.

3. In frequency-controlled scanners, an oscillator, means for cyclically varying the frequency of said oscillator, a cathode ray tube having horizontally and vertically deflecting field elements, a high-pass filter connected to said oscillator, for passing energizing current of a predetermined band of the oscillator frequencies to said horizontally deflecting field elements in amplitude varying with the frequency, means for energizing the vertically deflecting field elements, and means including a low-pass filter connected to said oscillator for altering the last-mentioned energization when a frequency below said band is generated by said oscillator.

4. In frequency-controlled scanners, an oscillator, means for cyclically varying the frequency of said oscillator, a cathode ray tube having horizontally and vertically deflecting field elements, a high-pass filter connected to said oscillator for passing energizing current of a predetermined frequency band to said horizontally deflecting

field elements in amplitude varying with the frequency, an impedance, means for energizing the vertically deflecting field elements through said impedance, and means for altering said impedance when a signal frequency outside said band is received from said oscillator.

5. In frequency-controlled scanners, an oscillator, means for cyclically varying the frequency of said oscillator, a cathode ray tube having horizontally and vertically deflecting field elements, a high-pass filter connected to said oscillator for passing energizing current of a predetermined frequency band to said horizontally deflecting field elements in amplitude varying with the frequency, an impedance, means for energizing the vertically deflecting field elements through said impedance, a low-pass filter connected to said oscillator, and means for altering said impedance by the current passing through said low-pass filter.

6. In frequency-controlled scanners, an oscillator, means for cyclically varying the frequency of said oscillator, a cathode ray tube having horizontally and vertically deflecting field elements, a high-pass filter connected to said oscillator for passing energizing current of a predetermined frequency band to said horizontally deflecting field elements in amplitude varying with the frequency, a vacuum tube, means for energizing the vertically deflecting field elements by a voltage varying with the transconductance of said tube, a low-pass filter connected to said oscillator for passing energizing current of a frequency below said band, and means for altering the transconductance of said tube by the current passing said low-pass filter.

7. In picture transmission, means for scanning a subject having elements of different light value, an oscillator, means for continually varying the frequency of said oscillator between an upper and a lower limit, means for scanning a line of the subject while the frequency is varied between said limits and means for changing the rate of variation of said frequency with the variation of the light values of the elements of said subject.

8. In picture transmission, means for scanning a subject having elements of different light value, an oscillator, means for continually varying the frequency of said oscillator between an upper and a lower limit, means for scanning a line of the subject while the frequency is varied between said limits and means for changing the rate of variation of said frequency with the variation of the light values of the elements of said line of the subject.

JOHN W. COX.