Oct. 5, 1948. W. G. H. FINCH 2,450,649

FACSIMILE SYNCHRONIZING SYSTEM

Filed Feb. 16, 1944. 4 Sheets-Sheet 1

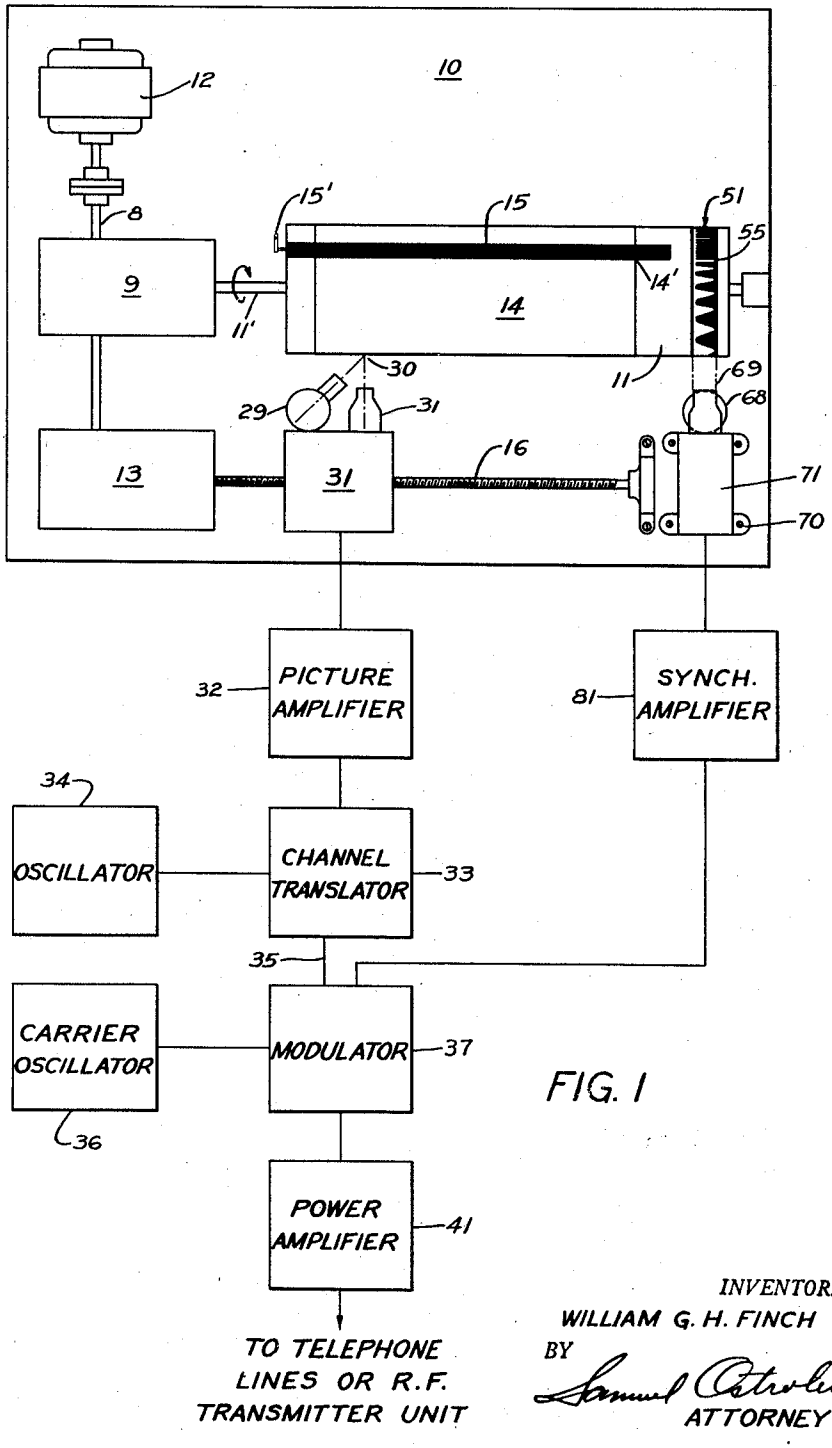


FIG. 1

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FACSIMILE SYNCHRONIZING SYSTEM

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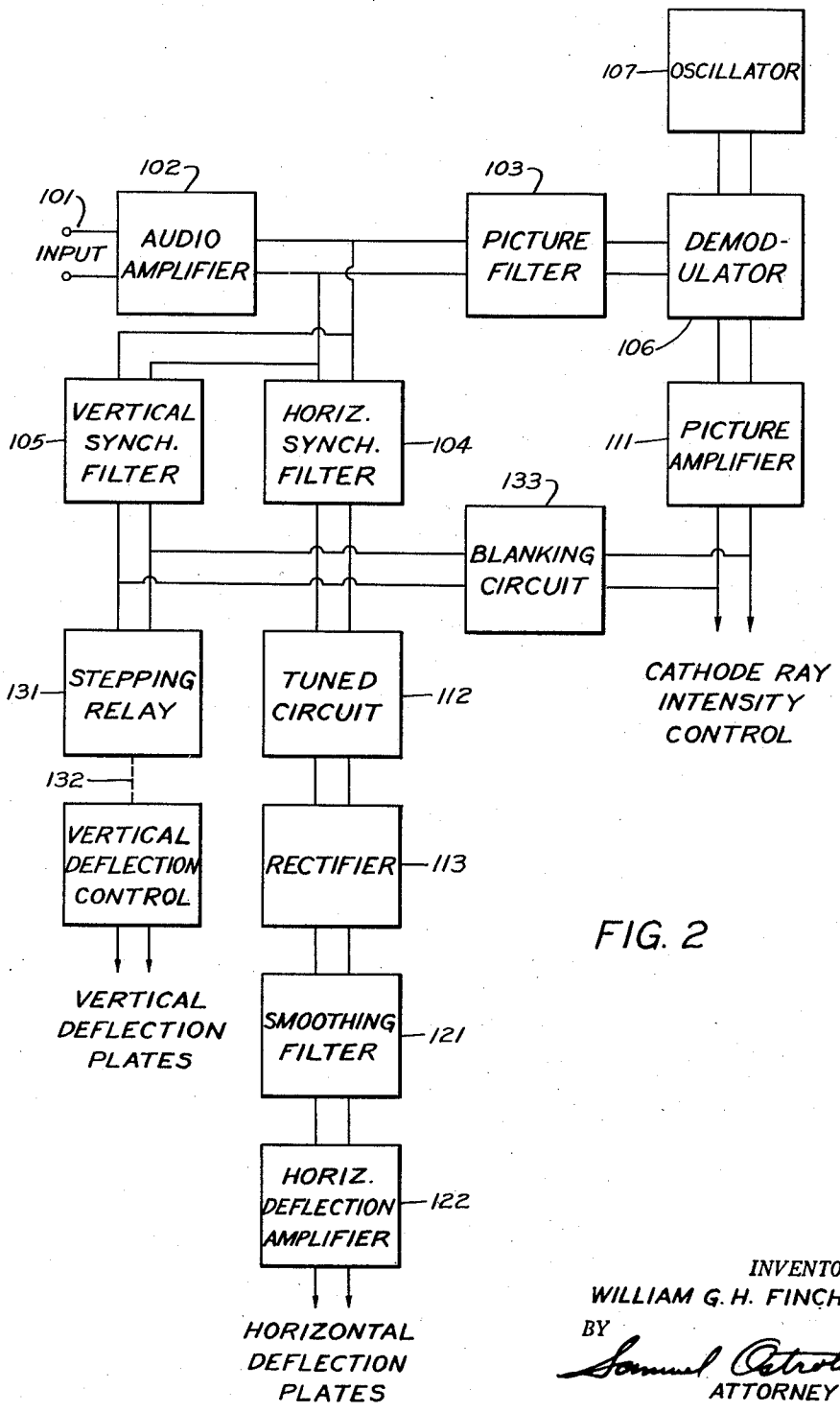


FIG. 2

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FACSIMILE SYNCHRONIZING SYSTEM

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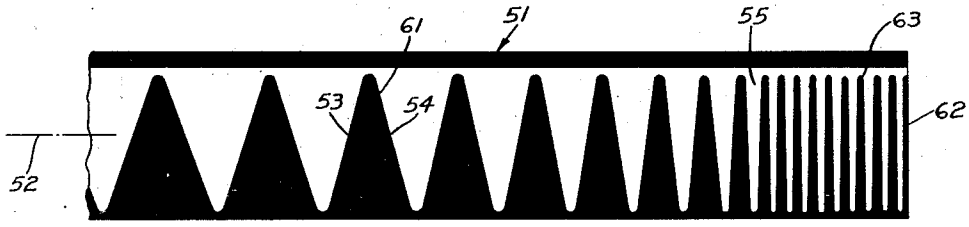


FIG. 3

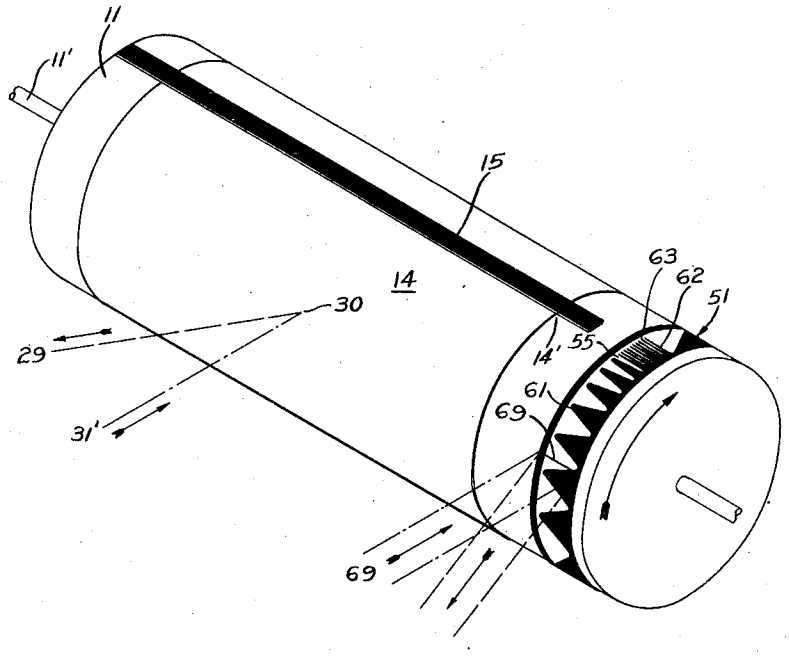


FIG. 4

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FACSIMILE SYNCHRONIZING SYSTEM

Filed Feb. 16, 1944 4 Sheets-Sheet 4

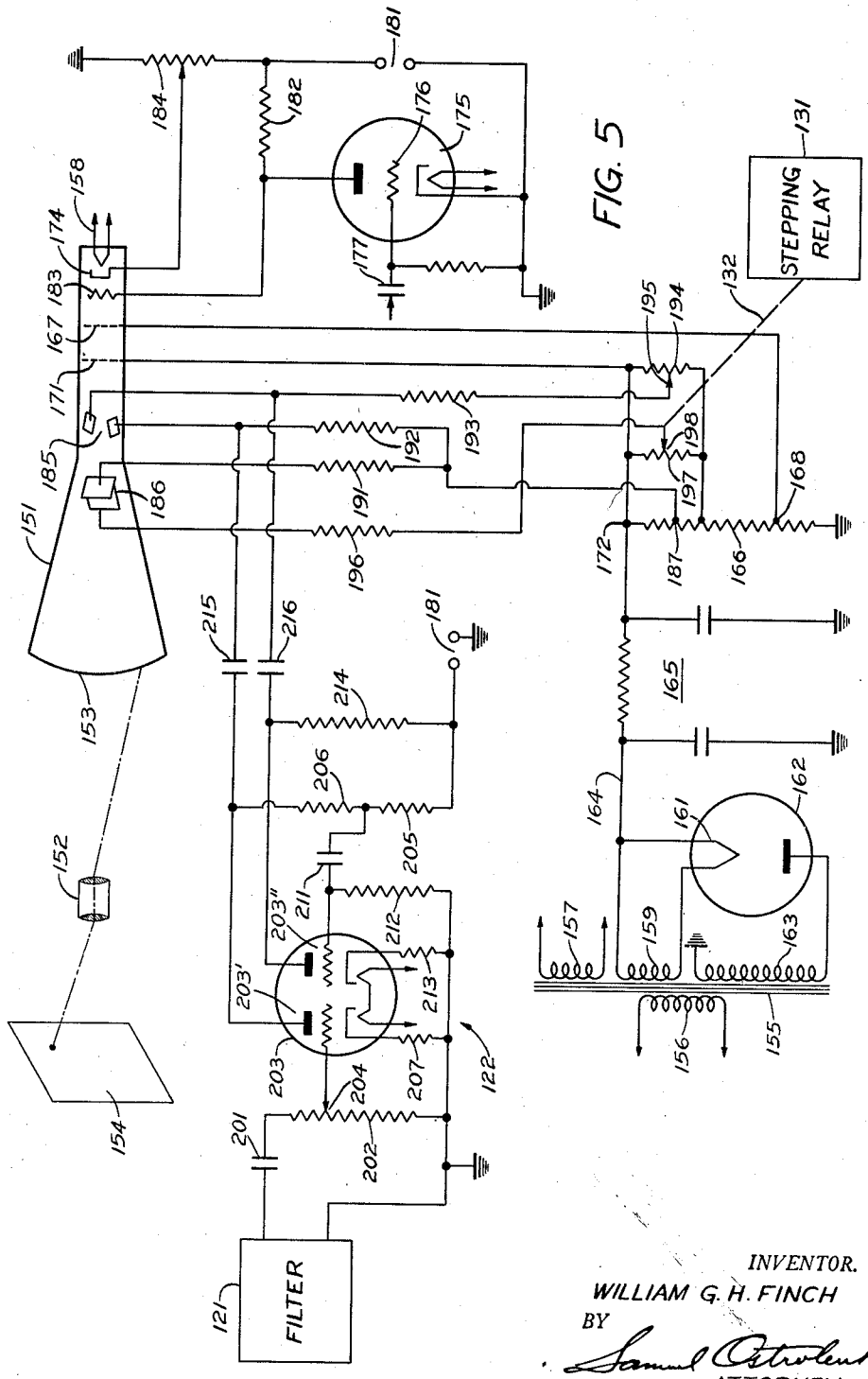


FIG. 5

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UNITED STATES PATENT OFFICE

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FACSIMILE SYNCHRONIZING SYSTEM

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Application February 16, 1944, Serial No. 522,601

10 Claims. (Cl. 178—69.5)

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My invention relates in general to the field of picture transmission and reception and more specifically concerns the utilization of cathode ray apparatus for picture recording.

In a facsimile system, an electro-optical scanning mechanism at the transmitter is used to generate electrical signals corresponding to the lights and shades of lines of a picture. These signals are transmitted by radio frequency currents or by telephone lines to a remote recorder whereat the signals are impressed upon a suitable recorder.

In order to make a photographic recording of the facsimile signals received from the transmitter, it has been the practice to modulate the intensity of a light beam and impress these signals upon an electro-optical film scanning mechanism somewhat similar to that utilized at the transmitter. Scanning, in general, was accomplished by suitably supporting the film upon a rotatable drum and producing a motion between the drum and the optical system such that the modulated light beam traced a helical path about the surface of the film.

As is well-known in the art, the primary problem presented by such mechanism was the need for a suitable synchronizing system so that scanning systems at the transmitter and recorder would operate at identical speeds and in the same phase.

The solution of the synchronizing problem has been accomplished by various complex electro-mechanical mechanisms which generally required that the recorder be driven in a "start-stop" manner or be driven by bulky synchronous motors.

My invention contemplates the elimination of electro-mechanical optical systems and the need for large driving motors and other complex synchronizing apparatus at the recorder, through the agency of a cathode-ray tube and its associated circuit elements.

In accordance with my novel invention, a cathode-ray tube fluorescent screen is utilized as the source of recording light. Photographic means are arranged so that the moving spot of light upon the cathode-ray screen will be continuously impressed upon a photographic plate, so that its position upon the plate is dependent at all times upon the position of the spot upon the cathode-ray screen.

The intensity of the cathode-ray spot is made at all times proportional to the intensity of the incoming picture signals so that the scanning of the cathode-ray fluorescent screen will produce upon a photographic plate an image representative of the picture transmitted. In order that the photographic recording be in all respects identical to the picture transmitted, it is, of course, essential that the cathode-ray spot on the fluorescent screen moves at the same speed and in the same phase as the light spot projected upon the image at the transmitter.

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In high-speed television transmission systems, the receiver is arranged to include two saw-toothed oscillators which generate signals for causing the electron beam in the cathode-ray tube to move horizontally a predetermined number of cycles while moving vertically in a similar manner at a different frequency. When the output of these oscillators are applied to the horizontal and vertical deflecting plates of the cathode-ray tube, a rectangular pattern is produced upon the screen which has a number of horizontal lines corresponding to the number of cycles of the horizontal saw-toothed oscillator which occur within one cycle of the vertical saw-toothed oscillator.

In conventional television systems the picture is composed of 551 horizontal lines flashed on the screen at the rate of 30 complete frames per second. In order to synchronize the television horizontal lines and frames with the signal generator at the transmitter, the signal generated at the transmitter is modulated with a series of synchronizing signals, namely, a horizontal synchronizing pulse at the end of each scanning line and a vertical synchronizing signal at the end of each frame.

These synchronizing impulses which occur at a comparatively high frequency are separated at the receiver and are applied to the horizontal and vertical saw-toothed oscillators in a manner which results in electronic synchronism between the oscillators at the transmitter and at the receiver.

The salient difference between ordinary facsimile transmission systems and television systems is that in facsimile it is generally necessary to send a single stationary picture and to maintain the picture transmission channel within a band of several thousand cycles per second, while in television, it is essential to transmit many frames per second and utilize a band of several megacycles per second.

Evidently, therefore, in cathode-ray facsimile transmission of a single picture, the vertical scanning frequency is merely one cycle over the period of time required to transmit the entire picture. Since this frequency may very well be

of the order of one cycle per minute it is clear that conventional synchronizing impulse means could not be used to stabilize an oscillator for generating a low frequency signal of this type. Similarly, the horizontal scanning in cathode-ray facsimile may be of a frequency as low as five cycles per second or less, and hence impulse synchronization of this oscillator is not possible.

In accordance with my invention, I propose to operate the horizontal and vertical deflection circuits of the receiving cathode-ray tubes by signals generated at the transmitter. These signals are generated directly by the transmitter scanning apparatus and accordingly are at all times in the proper phase relationship and at the proper frequency. These synchronizing signals directly cause the movement of the cathode-ray tube of fluorescent spot, and are free from the effects of static or other disturbances which would ordinarily result in a non-synchronous condition in a television recorder.

More specifically the electro-optical signal generating system at the transmitter produces a multiple signal comprising a picture signal of the usual type and a continuous synchronizing signal. This synchronizing signal is a variable frequency signal so generated that the frequency at any instant is proportional to the angular position of the drum relative to the scanning mechanism. This variable frequency synchronizing signal is transmitted to the receiver whereat a novel circuit translates this continuously varying frequency to a signal of correspondingly varying amplitude. This varying amplitude signal is impressed upon the cathode-ray horizontal deflecting circuit to cause the horizontal movement of the cathode-ray beam in a manner which corresponds identically to that of the light beam moving across the transmitting drum.

At the termination of each horizontal scanning line, the fluorescent spot on the cathode-ray screen is extinguished and returns to a position from which it may begin the scanning of the successive horizontal line. Simultaneously with the return of the fluorescent spot, the synchronizing signal transmitted from the scanning apparatus at the transmitter will cause a small vertical displacement of the spot. It is therefore evident that if the spot starts at one side of the cathode-ray screen, moves horizontally across at a uniform speed and then is rapidly returned to a position somewhat below the starting position, that proper scanning is established.

Since the picture signals received from the transmitter are at all times impressed upon the intensity control of the cathode-ray spot, the scanning of the screen will produce an image upon the photographic plate which will be identical with the picture at the transmitter.

It is important to recognize, of course, that the movement of the spot in a facsimile recording is comparatively slow and that therefore the screen of the cathode-ray tube will at no time show an image but instead will always show a slowly moving spot of variable intensity.

It is therefore an object of my invention to provide a facsimile system utilizing a cathode-ray tube at the recorder.

It is a further object of my invention to provide a cathode-ray facsimile transmission system wherein the electrical signals required to displace the cathode-ray fluorescent spot are generated at the transmitter.

Another object of my invention is to provide a facsimile transmitter with electro-optical means for generating a scanning signal of continuously variable frequency.

A still further object of my invention is to provide means for synchronizing cathode-ray horizontal and vertical deflection circuits at an extremely low frequency.

These and other objects of my invention will now become apparent from the following specification taken in connection with the accompanying drawings in which:

Figure 1 is a schematic representation of a facsimile transmitter.

Figure 2 is a schematic representation of a cathode-ray facsimile recorder.

Figure 3 is a developed view of the novel synchronizing strip used at the transmitter.

Figure 4 is a fragmentary view of the rotatable drum and shows the mounting of the synchronizing strip.

Figure 5 is a circuit diagram of the cathode-ray recorder.

Referring now more particularly to Figure 1, there is shown one modification of a transmitter mounted on base plate 10 to be used in connection with a cathode-ray facsimile system.

The transmitter comprises a rotatable drum 11 supported on shaft 11' which during operation, is continuously driven preferably by a constant speed motor 12. The drive of drum 11 is secured through shaft 8 and gear box 9. The speed of rotation of the drum 11 is, of course, determined by the type of transmission and the band width permissible for the transmission.

The image to be transmitted is secured to the rotatable drum 11 by a mounting bar 15, and its associated handle 15', as is well known in the art. Driven from the motor 12, is a rotatable helical feed screw 16, the angular speed of which is determined by the gear-ratio box 13.

An electro-optical scanning mechanism 31 is positioned adjacent the rotatable drum 11 and is removably coupled to the rotatable feed screw 16 so that during a scanning operation the optical system moves parallel to the axis of the drum.

Within the electro-optical system 31 is a conventional projection bulb and an optical system 31' for focusing a sharply defined light spot 30 upon the surface of the image 14 to be transmitted. Light reflected from the image 14 is impinged upon a suitable photo-sensitive device 29 within the scanning system 31, and accordingly, the intensity of the photo-electric current will be proportional to the lights and shades of the image.

In a transmitting operation, combined rotation of the drum 11 and lateral displacement of the electro-optical system 31 causes the light spot 30 to trace a helical path about the surface of the image 14.

The photo-electric currents thereby generated are impressed upon the grid circuit of a picture signal amplifier 32 for amplification to a suitable energy level.

As will be described later, it is necessary to transmit a synchronizing signal along with the picture signals. Since both of these signals may be within the same frequency band and since it is necessary at the receiver to selectively separate these signals, it is preferable to translate the picture signals to a frequency band removed from that of the synchronizing signals. Accordingly, the output of picture amplifier 32 is impressed upon a translating circuit 33 which comprises essentially a modulator utilizing a translating frequency generated in oscillator 34.

In general, commercial facsimile systems uti-

lize picture signals ranging from zero frequency to several thousand cycles. The signal emerging from channel translator **33** will cover a band of frequencies equal in width to the band generated in the electro-optical system **31**, but will have added to each frequency, an additional frequency corresponding to that of the oscillator **34**. For example, if the picture signal band ranges from zero frequency to three-thousand cycles, and if the frequency of oscillator **34** is three-thousand cycles, the translated band at the output **35** of channel translator **33** will cover a frequency range of three-thousand cycles to six-thousand cycles.

It is desirable in picture transmission system to transmit the output of channel translator **33** by causing these signals to modulate a low frequency carrier of the order of 8 to 10 thousand cycles per second. Accordingly, the output of channel translator **33** and a carrier frequency generated in oscillator **36** are impressed upon a conventional modulator circuit **37** to produce the desired carrier modulated signal. This modulated signal is in turn amplified to a suitable transmission level in power amplifier **41**.

Transmission may, of course, take place in any well known manner, as for example, over a telephone line or through the utilization of a radio frequency carrier. Such circuits are conventional and are not shown here.

In accordance with my novel facsimile transmission and recording system, a synchronizing strip **51** is securely mounted upon or engraved upon one end of the transmitting scanning drum **11**. This synchronizing strip **51** which is not at any time covered by the picture **14** comprises as is best shown in Figures 3 and 4, a picture of a continuously variable frequency wave having a constant amplitude.

This figure is constructed upon the strip **51** by dividing the axis **52** of the rectangular strip **51** into points such as **53** and **54**; the distance between which increases linearly as these points move away from the beginning of the strip **51**. Approximately ⅞ of the circumference of the drum **11** preferably is divided in this manner.

Between each pair of adjacent points such as **53** and **54**, a half cycle of a sine wave is drawn, and the area beneath one side of these sine waves such as **61** and the axis is blackened as shown.

Between the points **55** and the edge **62** of the synchronizing strip representing a distance of approximately ⅛ of the circumference of the drum **11**, a constant frequency, constant amplitude sine wave is drawn as shown. This constant frequency sine wave **63** is of a higher frequency than the highest frequency of the variable sine wave **61** covering the ⅞ of the drum **11**. As is shown in Figures 1 and 4, this strip is positioned along the edge of the drum such that the continuously variable frequency on the synchronizing strip begins at exactly the same point on the drum as the leading edge **14'** of the picture **14**.

The constant frequency range **63** along the synchronizing strip **51** is positioned approximately at the trailing edge of the picture **14**, and continues across that portion of the surface of the drum **11** covered by the mounting bar **15**.

As is illustrated in Figures 1 and 4, an additional electro-optical scanning system **71** is utilized in connection with my novel transmitter. This optical system is permanently fixed by screws **70** to the frame of the transmitter and is not in any way connected to the rotatable feed screw **16** as is the electro-optical system **31**. A

further difference between the two electro-optical systems is that optical system **71** projects a horizontal slit of light **69** upon the synchronizing strip **51**.

Light reflected from the entire horizontal strip **72** is selected by the photo-cell **68** of the electro-optical system **71**, and it will be evident that the currents generated by the photo-electric cell **68** will at all times be proportional to the white area covered by the light strip **69** on the synchronizing strip **51**. This in turn will be proportional to first the continuously variable sine waves **61**, and second, the constant frequency sine waves **63** on the synchronizing strip **51**. For best results it is preferable that motor **12** be governed at a constant speed.

As is evident from Figure 4, as the scanning operation of a single line of sheet **14** begins, the scanning by optical system **71** will begin at edge **55** of the synchronizing strip.

The length of the synchronizing strip between **55** and **62** may be made to correspond to the width of mounting bar **15**.

Referring now to Figure 1, the signal generated in the electro-optical system **71** is amplified by a synchronizing signal amplifier **81** and impressed upon the modulator **37** simultaneously with the picture signal. The frequency of these signals generated by the scanning of the synchronizing strip are preferably in a range below that of the picture translated signals as it comes out of the translator **33**. Hence, the signal output of the modulator **37** will be a multiple modulated wave comprising a sub-carrier modulation including a picture signal and a synchronizing signal modulation.

This multiple signal, in accordance with my invention, is the signal transmitted at all times to a recorder of the type schematically illustrated in Figure 2.

The received signals at recorder terminals **101**, Figure 2, is essentially that signal which appears at the output of power amplifier **41** of the transmitter. If the transmission occurred over a wired line, then the input at terminals **101** might be the junction to the transmission line; and if the transmission was accomplished by means of a radio frequency carrier, the input terminal **101** represents the output of a radio frequency amplifier and demodulator.

The signals reaching terminals **101** are first amplified in an audio-frequency amplifier **102**, the output of which is connected to three parallel channels comprising a picture filter **103**, a horizontal synchronizing filter **104**, and a vertical synchronizing filter **105**—the operation of which will now be described.

The picture filter **103** comprises essentially, a high pass filter **103** having a pass band tuned to the frequency band of the translated picture signal. This filter **103** is critically adjusted to discriminate against any signal of the type generated by electro-optical system **71**, Figure 1. The output of the picture filter is coupled into a demodulator **106** as is the output of an audio-frequency oscillator **107**.

The signals impressed upon the demodulator **106** act in the reverse manner of the channel translator **33** of the transmitting circuit of Fig. 1, and accordingly, the oscillator **107** is operative to produce an output consisting of the picture signals only.

Thus, the output circuit of the demodulator **106** is arranged so that the constant frequency of the oscillator **107** is subtracted from all the input sig-

nals from the picture filter 103, and therefore, it is evident that the input to the picture amplifier 111 is essentially that signal which appears in the picture amplifier 32 of the transmitter of Figure 1.

The output signal of the picture signal amplifier 111 is impressed, as will be described in greater detail later, upon the intensity control or control grid of a cathode-ray tube in order to cause the cathode beam to vary in intensity with the lights and shades of the picture signal.

The phase of the picture amplifier is arranged as desired so that the intensity of the cathode ray beam will vary in phase with the lights of the picture or 180° out of phase thereof in order that a positive or negative may be reproduced.

The horizontal synchronizing filter 104 connected across audio-amplifier 102 is a tuned circuit having a pass band over the frequencies which are generated by the variable frequency section on the synchronizing strip 51.

Accordingly, the highest frequency which may be passed is that frequency corresponding to the sine waves at the leading edge 55 of the strip, and the lowest frequency to be passed by filter 104 is that corresponding to the sine waves at the left edge of the variable frequency strip. This frequency range as previously described is selected and determined in part by the speed of the rotatable drum 11 at the transmitter.

Furthermore, the horizontal synchronizing filter 104 is tuned to discriminate against signals of the type impressed upon picture filter 103, namely, the translated picture band, and against signals of the frequency corresponding to the constant frequency portion between points 55 and 62 of the synchronizing strip 51.

Therefore the output of the horizontal synchronizing filter 104 will consist of a signal starting at a high frequency and linearly progressing to a low frequency once for each revolution of the drum 11 at the transmitter. Furthermore, the highest frequency will begin immediately as the scanning cycle at the transmitter begins, and the lowest frequency of the variable frequency signal will terminate immediately after the completion of the scanning cycle of the picture 14.

Since this frequency therefore represents at all times the linear circumferential distance covered by the scanning spot at the transmitter, the output of the horizontal synchronizing filter 104 may be utilized to directly cause the horizontal deflection of a cathode ray spot. Thus, the output of the filter 104 is impressed upon a tuned circuit 112 so that the variable frequency is operative along the linear slope of the circuit response characteristic. This circuit 112 may consist of a condenser and inductance having a resonant peak lower than the highest frequency of the variable frequency strip and may be resistance loaded so that the slope is not too steep and covers the frequency range required as described in Chapter III of Terman's Radio Enginering published in 1932 by McGraw-Hill Book Co. Inc.

By proper adjustment of condenser, inductance and by proper selection of the loading resistance, the linear rising response of the circuit 112 may be made to cover a frequency band which corresponds to a band somewhat wider but of the same frequency range as the lower and upper frequency limits of the output of horizontal synchronizing filter 104. It is, therefore, evident that upon the application of a signal (such as generated by the photo-electric cell 68 in the electro-optical scanning unit 71 as it passes over the variable frequency range of the synchronizing strip) the output of tuned circuit 112 will be of variable frequency as before, but of linearly varying amplitude—the amplitude being greater as the frequency decreases. To ensure a proper linear amplitude variation, an amplitude limiter circuit may be inserted between filter 104 and tuned circuit 112.

This signal of varying amplitude and frequency is impressed from the output of tuned circuit 112 upon a rectifier 113 and then upon a smoothing filter 121 designed to remove frequency components approximately fifteen times greater than the desired saw-tooth frequency.

Accordingly, the output of smoothing filter 121 will be a substantially saw-toothed wave having an amplitude which varies in accordance with the circumferential distance covered by the light spot 30 of scanning system 31 at the transmitter. This linearly rising wave is impressed upon the "push-pull" horizontal deflection amplifier 122 in which circuit it is amplified to a level sufficient to cause a linear horizontal deflection of a cathode ray beam. This circuit 122 is described in greater detail in connection with Figure 5.

It is important to note that the linearly rising saw-toothed wave will be generated immediately as the scanning of a single line at the transmitter drum 11 begins, and will continue over the entire variable frequency range of the synchronizing strip 51.

As the light slit 69 from electro-optical system 71 at the transmitter progresses beyond 55 onto the constant frequency range of the synchronizing strip 51, the generation of the saw-tooth ceases, and the vertical synchronizing filter 105 at the recorder, Figure 2, comes into operation.

As previously mentioned, the constant frequency range of the synchronizing strip 51 represents a comparatively high frequency when compared with the variable frequency produced over the major part of the cycle. Accordingly, the vertical synchronizing filter 105 is a tuned circuit critically adjusted so that the constant frequency generated at the transmitter will pass through the filter without attenuation while any other frequencies will be attenuated sharply. Accordingly, upon the receipt of a vertical synchronizing signal through audio-amplifier 102, the synchronizing filter 105 will pass a signal to the stepping relay 131.

This type of relay as is well understood in the art, comprises essentially, a coil and a movable armature such that upon energization of the coil, the armature is deflected against the normal bias of a spring to cause rotation of a shaft 132. This rotation is accomplished by means of an escapement mechanism and the amount of rotation obtained for each impressed signal is comparatively small.

When the relay coil is de-energized, the armature swings back to its original position and resets the escapement mechanism so that the following signal will cause another small rotational movement of shaft 132.

As illustrated in Figure 2, each energization of the stepping relay 131 will cause a small movement of shaft 132 which, as will be described in connection with Figure 5, will in turn cause a small displacement of a potentiometer movable arm which controls the vertical position of the cathode-ray beam.

Since during each small vertical movement of the cathode ray beam, the picture signal ceases, that is, the scanning spot at the transmitter

passes over the mounting bar 15, the cathode ray beam retraces its path from one extreme horizontal position to the other. It is essential that during this retrace, the cathode ray fluorescent spot be extinguished in order to avoid spurious light streaks upon the film.

Since the mounting bar 15 is black, the retrace, if the phase is adjusted such that the picture is negative, will be automatically extinguished. However, in order to ensure complete darkness of the cathode ray screen during the retrace period, the vertical synchronizing signals, may be employed as illustrated in Figure 2, to energize a blanking circuit 133 which injects a sharp biasing voltage into the picture signal channel, such that the fluorescent spot is extinguished.

The actual operation of the cathode ray facsimile recorder is best illustrated in Figure 5, considered in connection with the schematic circuit Figure 2.

As illustrated in Figure 5, a cathode ray tube 151 is conveniently disposed within a facsimile recorder and an optical system 152 is arranged to focus the screen 153 of cathode ray tube 151 upon a photographic plate 154. The optical system 152 and the plate 154 may be mounted in any convenient manner upon the frame of the facsimile recorder. For successful operation, the screen 153 of the cathode ray tube, the optical system 152 and the plate 154 must be enclosed in a suitable light-tight enclosure.

The high voltage circuits of the cathode ray tube 151 are operated in a conventional manner as illustrated. Thus the high tension transformer 155 has its primary 156 connected to a suitable source of alternating current.

A filament winding 157 is employed to energize the heater 158 of the cathode ray tube. A second filament winding 159 is utilized to energize the heater 161 of the high voltage rectifier 162.

The high tension winding 163 of the transformer 155 is grounded at one end and connected to the plate of the high voltage rectifier 162 at the other end. Thus, in the well known manner, the lead 164 is raised to a high potential of the order of several thousand volts as determined by the secondary 163.

A conventional resistance capacitance filter 165 is utilized for the high voltage direct current, and a bleeder resistance 166 is connected across the output thereof.

The focusing electrode 167 is connected to a tap 168 upon the bleeder resistance 166, and the high voltage accelerating anode 171 is connected to the high voltage terminal 172.

The picture amplifier schematically illustrated as 111 in Figure 2 is shown in Figure 5 as the amplifier tube 175. Thus the picture signals are coupled to the grid 176 of the amplifier 175 through condenser 177. The plate of amplifier tube 175 is connected to a suitable B+ source of low voltage direct current 181 through a load resistor 182.

The control grid 183 of the cathode ray tube 151 is directly coupled to the plate of amplifier tube 175 and accordingly the picture signals are impressed thereupon to modulate the intensity of the cathode ray beam coming from the cathode 174. The cathode of the tube 151 is biased to a positive potential by a tap on a potentiometer 184 connected between the low voltage B+ source 181 and ground. Accordingly, by an initial setting of this potentiometer, the cathode ray beam may be adjusted to the proper recording intensity so that picture signals impressed upon grid 183 will cause the spot focused upon screen 153 to properly vary in intensity over the complete range from black to white.

As illustrated in Figure 5, the horizontal and vertical deflection plates 185 and 186, respectively, are maintained at a comparatively high potential by joining them to taps on the high voltage bleeder resistor 166. Thus, as illustrated, one of each of the horizontal and vertical deflecting plates are joined to tap 187 of the high voltage bleeder through protective resistors 191 and 192 respectively. The second horizontal deflecting plate as illustrated is connected through protective resistor 193 to the variable point of a potentiometer 194 connected across the high voltage bleeder resistor 166.

Accordingly, by a proper adjustment of tap 195, the cathode ray spot may be adjusted so that its position is in the center of screen 153 when no deflecting voltage is applied to the horizontal deflecting circuit. The second plate of the vertical deflecting plates 186 is connected through protective resistor 196 to the movable tap 198 of a potentiometer 197 connected in the manner described for potentiometer 194. However, the movable tap 198 of the potentiometer 197 is controlled by shaft 132 of the stepping relay 131.

Prior to a picture transmission, the tap 198 is set manually to one end of the potentiometer 197. During the picture transmission, each vertical synchronizing signal as received through filter 105 of Figure 2, causes a small movement of tap 198 across the potentiometer 197 so that at the end of a transmission the tap will be at the opposite end of the potentiometer 197. It is evident, therefore, that the stepping relay 131 is adjusted to cause a complete cycle of movement of the tap 198 across the potentiometer 197 in as many steps as is determined by the number of horizontal scanning lines in the picture.

The horizontal deflection of the cathode ray spot as described in connection with Figure 2, is accomplished through the generation of a saw-toothed wave of voltage from a variable frequency signal. The output of the smoothing filter 121 as illustrated in Figure 5, is impressed upon a horizontal scanning amplifier 122 of the "push-pull" type. Thus, the signal which is saw-toothed in form is coupled through condenser 201 and through potentiometer 202 to the grid of the first triode element 203' of a conventional duplex triode tube 203.

The tap 204 on the potentiometer 202 is adjusted initially so that the extent of the horizontal sweep of the cathode ray beam is sufficient to cover the complete screen 153.

The plate of the first triode element 203' is energized from the low voltage direct current B+ source 181 through the series resistors 205 and 206, and the cathode of this first section is connected to ground through a resistor 207.

The saw-toothed voltage generated at the output of the first section 203' of the triode 203 is coupled to the second section 203'' through condenser 211 connected from the junction of resistors 205 and 206 to the grid of the second section 203''. The grid is joined to ground through resistor 212 and the cathode is connected to ground through resistor 213.

The plate of the second section 203'' of double triode 203 is connected to the direct current source 181 through load resistor 214. Accordingly, as is well understood in the art, the output between the plates of the triode sections within

tube 203 will comprise an amplified saw-toothed wave symmetrical in voltage. This saw-toothed output is applied to the horizontal deflecting plates 185 of cathode ray tube 151, directly through coupling condensers 215 and 216. The capacity of these condensers is chosen to suitably pass the saw-toothed wave of the frequency required for horizontal scanning in facsimile.

Due to the symmetry of the saw-toothed wave, as generated by the "push-pull" amplifier 203 shown, the cathode ray beam within tube 151 will be symmetrically deflected about the center so that the beam will start at one side of the tube and travel to the other side of the tube at which point the saw-toothed wave generator, namely, circuit 112 of Figure 2 will discharge and be ready for the following cycle, after the vertical synchronizing signal is received and utilized. Accordingly, it may be seen that in the operation of the novel cathode ray facsimile recorder, a cathode ray beam is caused to scan the screen 153 of a cathode ray tube 151 at a comparatively slow speed. The scanning signal required for the horizontal deflections are received directly from the transmitter and hence are in synchronism therewith, and the vertical deflection signals are received at the end of each scanning line to cause a vertical deflection equal in width to approximately one scanning line.

The moving spot on screen 153 is at all times focused sharply upon plate 154 and hence the spot correspondingly scans plate 154 of any well known light sensitive material suitably housed against external light exposure. The intensity of the fluorescent spot is governed by the incoming picture signal impressed upon control grid 183 of the cathode ray tube so that it is evident that helical scanning of an image at the facsimile transmitter may be converted into a photographic image upon plate 154 by the system described and illustrated.

At the completion of the scanning, the last operation of the stepping relay 131 may be employed to return 193 to its neutral position and at the same time present a new frame 154 for recording.

The chief advantage of such a cathode ray facsimile recorder is the lack of mechanically moving elements at the recorder and hence the attendant complex synchronizing problems are absent. Of course, other means may be utilized to transmit the horizontal deflecting signals and similarly other electronic means may be utilized to cause the stepping of the fluorescent spot in the vertical direction. In view therefore of the many modifications of this invention which will be apparent from consideration of this specification and these drawings, I wish that the scope of my invention be bound only by the appended claims.

I claim:

1. In a facsimile system, a transmitter, said transmitter comprising means for scanning a line of an image and generating corresponding picture currents and means operable during the scanning of said image line to generate a synchronizing signal having a characteristic varying linearly with the proportion of said image line scanned.

2. In a facsimile system, a transmitter, said transmitter comprising means for scanning a line of an image and generating corresponding picture currents and means operable during the scanning of said image line to generate a synchronizing signal having an instantaneous frequency proportional to the percentage of the image line scanned.

3. In a facsimile system, a transmitter, said transmitter comprising means for scanning a line of an image and generating corresponding picture currents and means operable during the scanning of said image line to generate a synchronizing signal having an instantaneous frequency proportional to the percentage of the image line scanned, and means for generating a second synchronizing signal at the termination of the scanning of said line.

4. In a facsimile system, a transmitter, said transmitter comprising means for scanning a line of an image and generating corresponding picture currents and means operable during the scanning of said image line to generate a synchronizing signal having an instantaneous frequency proportional to the percentage of the image line scanned, and means for generating a second synchronizing signal at the termination of the scanning of said line, said second mentioned synchronizing signal being a current of constant frequency.

5. In a facsimile system, a transmitter, said transmitter comprising means for scanning a line of an image and generating corresponding picture currents and means operable during the scanning of said image line to generate a synchronizing signal having an instantaneous frequency proportional to the percentage of the image line scanned, and means for generating a second synchronizing signal at the termination of the scanning of said line, said second mentioned synchronizing signal being a current of constant frequency, said first and second synchronizing signal generating means comprising an electro-optical scanning mechanism.

6. In a facsimile recorder, a cathode ray tube having an electron beam for generating a fluorescent spot and means for horizontally and vertically deflecting said electron beam, means for generating a horizontal saw-tooth deflection voltage comprising means for converting a constant amplitude variable frequency signal into a variable amplitude signal.

7. In a facsimile recorder, a cathode ray tube having an electron beam for generating a fluorescent spot and means for horizontally and vertically deflecting said electron beam, means for generating a horizontal saw-tooth deflection voltage comprising means for converting a constant amplitude variable frequency signal into a variable amplitude signal and means for deflecting said electron beam vertically at the end of each horizontal scanning cycle.

8. In a facsimile recorder, a cathode ray tube having an electron beam for generating a fluorescent spot and means for horizontally and vertically deflecting said electron beam, means for generating a horizontal saw-tooth deflection voltage comprising means for converting a constant amplitude variable frequency signal into a variable amplitude signal and means for deflecting said electron beam vertically at the end of each horizontal scanning cycle, said means comprising a relay operable at the end of each horizontal scanning cycle.

9. In a facsimile system, a recorder comprising a cathode ray tube having a fluorescent screen and an electron beam for generating a fluorescent spot on said screen, means for horizontally deflecting said electron beam comprising means for converting a received synchronizing signal of variable frequency into a saw-tooth

deflection voltage, means including a second received synchronizing signal for vertically deflecting said electron beam substantially the width of one scanning line at the end of each horizontal scanning cycle, and means for modulating the intensity of said electron beam with said picture signals.

10. In a facsimile system, a recorder comprising a cathode ray tube having a fluorescent screen and an electron beam for generating a fluorescent spot on said screen, means for horizontally deflecting said electron beam comprising means for converting a received synchronizing signal of variable frequency into a saw-tooth deflection voltage, means including a second received synchronizing signal for vertically deflecting said electron beam substantially the width of one scanning line at the end of each horizontal scanning cycle, and means for modulating the intensity of said electron beam with said picture signals, and means for photographically recording the movement of said fluorescent spot.

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