

April 27, 1943.

W. G. H. FINCH

2,317,850

ELECTRO-OPTICAL FACSIMILE SYNCHRONIZING SYSTEM

Filed Oct. 17, 1940

2 Sheets-Sheet 1

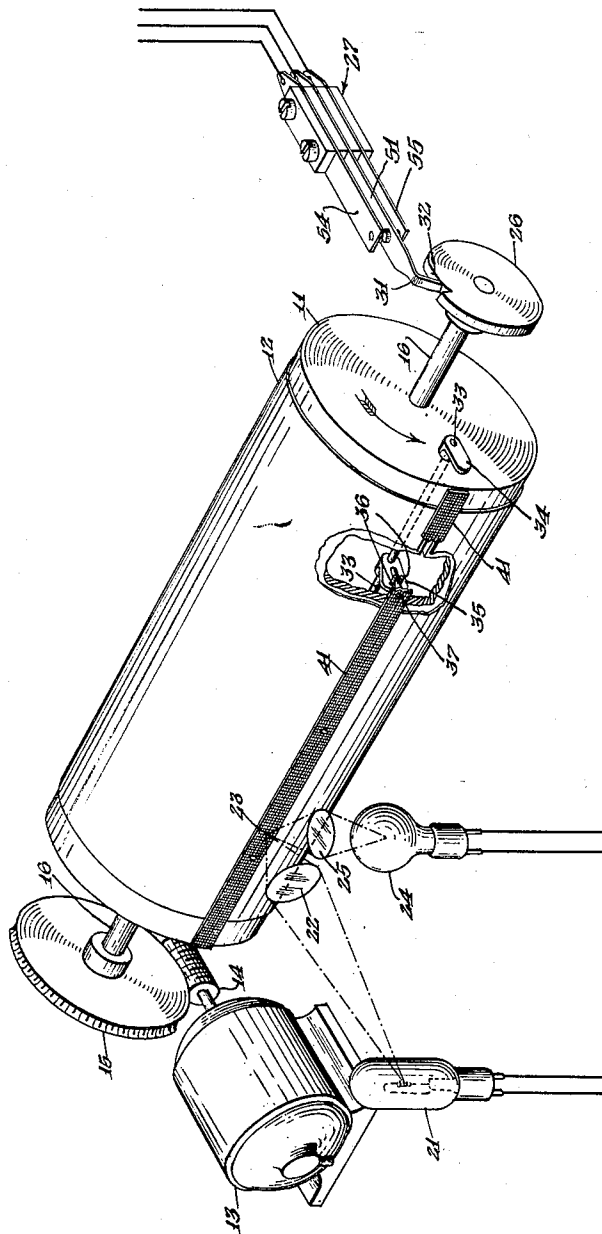


FIG. 1.

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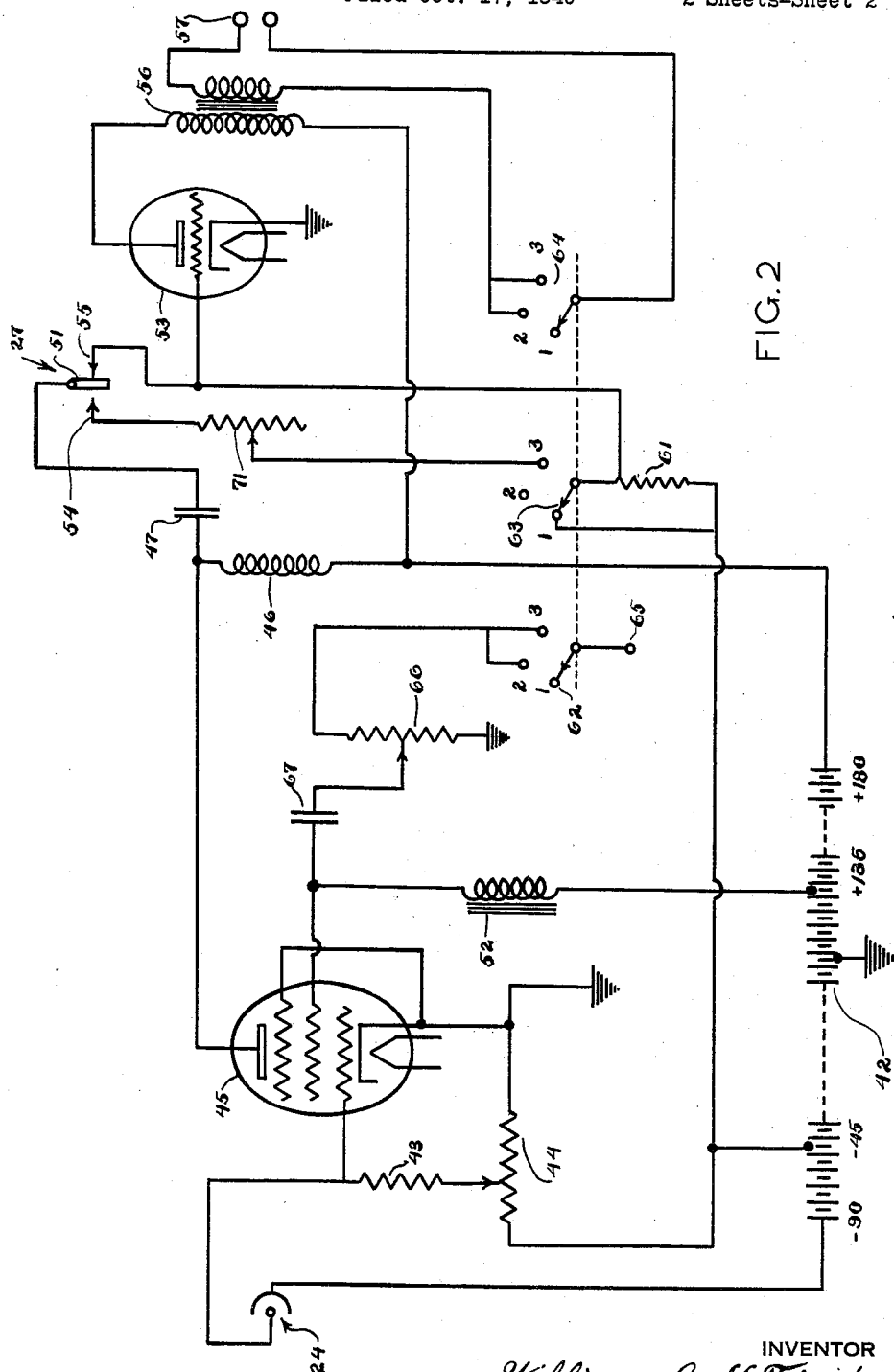


FIG. 2

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UNITED STATES PATENT OFFICE

2,317,850

ELECTRO-OPTICAL FACSIMILE SYNCHRONIZING SYSTEM

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Application October 17, 1940, Serial No. 361,480

7 Claims. (Cl. 178-7.1)

My invention relates in general to the art of facsimile transmission and reception and more specifically concerns a novel method for utilizing the transmission electro-optical apparatus for the generation of distinctive synchronizing signals.

In general, in facsimile transmission systems, the image to be transmitted is mounted in the field of a scanning member which breaks this image into elemental areas and translates the lights and shades of each of these elemental areas into corresponding electrical fluctuations. The scanning member may comprise conventional means for producing a concentrated spot of light upon the surface of the image to be transmitted and gathering the light reflected therefrom and bringing it to a focus upon the sensitive surface of a photoelectric cell, as illustrated in my application Serial No. 352,938.

The system employed for breaking an image into a plurality of elemental areas comprises, as is well known in the art, a method for scanning successive contiguous lines of the image. At the receiving apparatus, the electrical variations received are reconverted into lights and shades by means of a recording stylus or light beam. More specifically, the scanning process may consist of mounting the image upon a drum which is caused to rotate while there is relative axial movement between the drum and the scanning member. This, in effect, scans the image in a continuous helical line.

Means must necessarily be provided for maintaining the recording apparatus in synchronism with the transmission apparatus. In present day facsimile apparatus, synchronism is maintained by means of signals generated at the termination of each scanning excursion at the transmission apparatus and transmitted to the recording apparatus. The recording apparatus is caused to operate at a somewhat higher speed than the corresponding apparatus at the transmitter and is halted at the termination of each scanning cycle.

The initiation of the following cycle of the recording scanner is controlled directly by the synchronizing impulses generated at the transmission apparatus. Thus, the recorder operates in what is termed a "start-stop" fashion, as determined by the receipt of synchronizing impulses.

In present day facsimile apparatus it is conventional to employ a cam fixedly supported with respect to the drum at the transmitter which, with an associated switch, serves to generate an

impulse of distinctive character once during each revolution thereof. This impulse is generated in the period during which the scanning light beam is removed from the image itself, that is, when the scanning light beam traverses the image mounting means.

Impulses of a distinctive amplitude or a distinctive frequency may be employed, such as the type disclosed in my Patent No. 2,212,968. If an impulse of distinctive frequency is employed, the cam switch may be utilized to vary the frequency of a tone oscillator to that required for synchronization and if amplitude pulses are employed, the cam switch may be utilized to impress a signal of relatively great intensity upon the carrier wave. At the receiving apparatus, amplitude or frequency filters selectively operate the synchronizing mechanism and recording scanner.

The application of the cam switch to directly generate the synchronizing impulses has often resulted in improper synchronization inasmuch as mechanical switching inherently results in switching transients and other electrical faults. The occurrence of a transient signal prior to the actual synchronizing impulse results in a synchronizing signal in which there is no sharp line of demarcation to distinguish it from the carrier wave. Thus ragged edges at the received image have been a result of mechanical switching means for the generation of synchronizing impulses, and have been indicative of inaccurate synchronization.

I have discovered that I may generate synchronizing impulses of either distinct amplitude or frequency by means of the electro-optical scanning system at the transmitter, which do not present the limitations encountered with mechanical switching, as for instance, transient oscillations. My invention contemplates the utilization of that portion of the transmitting drum which is devoted to the fastening of the image. That is, I blacken or otherwise characteristically mark the member which fastens the image to the drum and employ this distinctive image in cooperation with the electro-optical scanning system, for the generation of synchronizing impulses.

If the image mounting means comprises a flat, narrow member disposed along the surface of the drum parallel to the axis thereof, as illustrated in my application No. 318,230, I may in one modification of my invention blacken this strip and arrange a synchronizing cam switch in the amplification circuit so that the level of

amplification is raised for the interval in which this black member passes under the scanning light beam.

In this manner, I produce a signal of relatively great amplitude for an interval determined by the peripheral velocity of the drum and the width of the black line, which may, of course, be formed by blackening one edge of the image rather than the fastening means.

If it is desired to generate synchronizing signals of a distinctive frequency by my novel system, I may draw a plurality of alternate black and white parallel contiguous lines along the image fastening means spaced so that the frequency of the light beam reflected therefrom will be equal to the synchronizing frequency desired when the peripheral velocity of the drum is at a predetermined value. With this type of synchronizing impulse, it is unnecessary to raise the level of this signal above the normal carrier level, and accordingly, the cam and its associated switch will be unnecessary, and will render this synchronizing system particularly advantageous in applications wherein switch wear presents a practical limitation to successful operation.

It is therefore an object of my invention to provide a novel method for maintaining facsimile transmitting and reception apparatus in synchronism.

It is another object of my invention to provide electrooptical means for generating synchronizing signals at facsimile transmission apparatus.

It is a further object of my invention to provide means on the field to be scanned for the generation of synchronizing signals of a distinctive character.

Another object of my invention is to provide means for impressing synchronizing signals of a distinctive amplitude or frequency upon the transmitted carrier wave by means of the electrooptical scanning member and associated switching means.

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

Figure 1 is a perspective view schematically illustrating the facsimile apparatus of my invention; and

Figure 2 is a schematic circuit diagram of the electrical apparatus required for the generation of synchronizing impulses.

The general method of facsimile transmission is schematically illustrated in Figure 1 wherein a drum 11 is utilized to carry the image 12 to be transmitted. The drum is caused to rotate under the influence of the source of motive power 13 through the worm 14 and the worm gear 15 which is fixedly supported upon the drum shaft 16.

The shaft 16 carries the drum in fixed relation therewith and is journaled in suitable bearings to allow free rotation thereof. Scanning means are provided by the schematically illustrated lamp 21, the rays of which are focussed to a point 23 upon the image 12 by means of the lens or lens system 22.

Light reflected from the spot 23 on the image surface is concentrated upon the photosensitive device 24 by means of another lens or optical system 25. The electrooptical system comprising lamp 21, photoelectrical cell 24 and their associated lens systems may be combined into a unitary structure which is displaced axially with respect to the drum by means of a feed screw mechanism coupled by suitable gearing to the

source of motive power 13. Thus the light spot 23 traces a helical path along the surface of the image 12.

It is desirable in present day facsimile apparatus to transmit a synchronizing impulse of the character previously described at the termination of each revolution of the image carrying drum. This has been accomplished in the facsimile systems heretofore employed by means of a switch cooperating with a cam mounted upon the drum shaft. In a preferred embodiment of my invention, I employ a cam 26 fastened to the drum shaft 16 for actuating a switch 27 which is incorporated in the facsimile amplifier circuit. The normal position of the switch, which is determined when the cam follower 31 rests upon the high or circular portion of the cam 26, is such that the facsimile amplifying apparatus is at the normal level required for signalling.

When the cam follower switch blade 31 is in the position illustrated in Figure 1, that is, in the notch 32 of the cam, the switch is oriented so that the level of amplification is raised above the normal level as will hereinafter be more completely described.

The drum 11 is of the type best illustrated and described in my application Serial No. 318,230 and is constructed so as to facilitate the mounting and removal of the image to be transmitted. A rod 33 passes through the drum and is pivotable in either direction by means of hand lever 34. Actuation of the hand lever 34 will cause corresponding actuation of a plurality of cranks 35 fastened to the rod 33. These cranks carry the guide pins 36 which in turn engage another pin 37 fastened to the strip of metal 41.

The rod 33 is normally biased so that the bar 41 is maintained in contact with the periphery of drum 11. Rotation of the hand lever 34 in one direction will raise a single edge of the bar 41 to permit the insertion of a corresponding edge of the image 12.

Actuation of the rod in the other direction will then lift the other edge of the bar 41 while maintaining the edge of the image which had previously been fastened to the drum in juxtaposition with the surface of the drum. This type of construction greatly facilitates the mounting of the sheet 12 which contains the image to be transmitted.

In one form of my invention, I blacken or otherwise distinctively color the outer surface of strip 41 in order to produce an impulse of distinctive character in the photoelectric circuit when traversed by the light spot 23. When arranged as illustrated, in Figure 1, the bar which has been blackened will pass under the light beam immediately following the actuation of switch 27 when cam follower 31 falls into the notch 32 of cam 26, and will recede therefrom prior to the movement of switch 27 to its normal position.

The application of this blackened strip to facsimile transmission will now be considered and reference is now made to Figure 2 wherein the photoelectric element 24 is shown with its associated amplifying and transmission circuits. Switch 27 is also indicated with the electrical connections thereto. The photoelectric cell cathode is joined to the negative terminal of a battery while the anode thereof is maintained at a positive potential in relation thereto.

Thus the anode is connected to a more positive terminal of battery block 42 through fixed resistor 43 and variable resistor 44. In addition, the anode of photoelectric cell 24 is also coupled

directly to the control grid of an amplifier 45 which is herein illustrated as a pentode. The control grid bias is obtained through resistors 43 and 44 which function as the load resistors for photoelectric cell 24 and the cathode of the pentode 45 is grounded with the suppressor grid thereof in the conventional manner. The variable resistor 44 in the plate circuit of the photoelectric cell permits the adjustment of the current intensity in the photoelectric circuit which corresponds with the white portion of the image.

The plate circuit of the pentode 45 is joined to a source of high potential through load impedance 46 and the output voltage appearing in the plate circuit is coupled through the coupling condenser 47 to the central member 51 of switch 27.

The signal is then coupled to the triode amplifier 53 through either of switch members 54 or 55, and the output of amplifier 53 is coupled by means of coupling transformer 56 to the transmitting means which are joined to the circuit illustrated by the terminals 57.

The control grid of amplifier 53 is negatively biased through resistor 61 and is, in addition, coupled to switch member 55 so that when switch member 51 is brought into contact with member 55 the signal coupled through condenser 47 is impressed upon the control grid of amplifier 53.

Three ganged, three-point switches are provided to effect control over the facsimile transmitter circuit as shown. Thus the switches 62, 63 and 64 when in position 1, as indicated in Figure 2, serve to open the output circuit to terminals 57 and serve to open the circuit from terminal 65 through potentiometer 66 and coupling condenser 67 to the screen grid of amplifier 45.

Therefore, it will be obvious that when the three ganged switches are in position 1, no signal will appear at output terminals 57. When the three ganged switches are in position 2, the output circuit to terminals 57 will be completed through switch 64 and the circuit from terminal 65 to the screen grid of pentode 45 will be completed through coupling condenser 52 by means of switch 62.

The position of switch 63 under these circumstances will be such that the output of pentode 45 may be impressed upon the control grid of vacuum tube 53 only when the switch member 51 is in contact with switch member 55. However, it may be seen from the corresponding numbering of the switch members in Figure 1 that switch members 55 and 51 will be in contact when the cam follower 31 is in the notch of cam 26 which is, as previously described, the period of synchronization.

During the normal period of picture transmission, when cam follower 21 is upon the raised or circular portion of cam 26, switch member 51 will complete the circuit through switch member 54, but ganged switch 63 will afford an open circuit from switch member 54. When the three ganged switches are oriented in position 3, it may be seen that switches 62 and 64 will maintain their former circuit arrangements inasmuch as switching contacts 2 and 3 are electrically interconnected. However, switch 63 will then afford an electrical circuit from switch member 54 through variable resistor 71 to the control grid of amplifier 53. Thus the signal appearing in the plate circuit of pentode 45 will be coupled to the control grid of amplifier 55 regardless of the position or orientation of switch member 51. The ganged switches, therefore, exercise a control over the

transmitted signal and if oriented in position 1, no signal is transmitted, in position 2, the synchronizing signals only appear at the output terminals, and in position 3, the picture and synchronizing signals appear at the output. Such selective operation may be desirable in test or experimental transmissions.

When switch 27 is normally oriented, that is, switch members 51 and 54 in electrical contact, the photoelectric signal is impressed upon the control grid of amplifier 53 through the variable resistor 71 which attenuates this signal in accordance with the value of variable resistor 71, whereas the photoelectric cell signal is coupled to the control grid of amplifier 53 without attenuation when switch members 51 and 55 are in contact during the synchronizing period.

It will now be obvious that the over-all voltage amplification will be greater when switch member 51 is in contact with switch member 55. During this period, the characteristic indication on the drum passes under the scanning light beam under the light spot within this time.

Pentode 45 may be employed as the modulator if the carrier frequency which is usually a locally generated audio frequency is impressed between terminal 65 and ground. The modulated carrier will then be the signal which appears in the plate circuit of pentode 45 and upon the control grid of amplifier 53.

Adjustments of potentiometer 66 will correspondingly vary the value of current which represents the black portions of the image. The function of the variable element is therefore substantially opposite to that of variable resistor 44 in the anode circuit of photosensitive element 24, which follows from the fact that the input and output voltages in a vacuum tube circuit are 180° displaced in phase. It will therefore be obvious that a proper manipulation of the variable resistors 44 and 66 will regulate the degree of contrast of the transmitted picture by electrical means, thereby affording control at the transmitter of the image to be recorded. Contrast control is particularly desirable when recording is performed upon electrochemically treated paper which does not inherently exhibit a linear characteristic.

It is to be pointed out that either a positive or a negative image may be transmitted. Thus if a negative image is transmitted, that is, if the intensity of the electrical variations are opposite to the light variations upon the image 12, the voltage level of the black line will be greater than the level of the picture signal inasmuch as resistor 71 attenuates the picture signal while not affecting the current which corresponds to the black line.

These distinct amplitude impulses may be employed at the facsimile receiving apparatus in cooperation with a start-stop system to effect proper synchronization. The increase in amplitude is obtained immediately after the switching operation effected by switch 27 when cam follower 31 enters the notch 32 of cam 26. The switching operation itself, however, has no effect upon the character of the synchronizing impulse generated inasmuch as this operation merely varies the amplification of a vacuum tube circuit by the injection of resistance prior to the actual pulse. Therefore the generation of synchronizing impulses by means of the blackened strip 41 is not accompanied by switching transients and other circuit irregularities.

If it is desired to employ synchronizing im-

pulses of a distinctive frequency in order that selection at the receiving circuit may be effected by means of frequency selective filters, the strip 41 may be covered with a series of alternate black and white lines, the spacing of which is determined by the frequency of the synchronizing impulse desired and the peripheral velocity of the drum 11.

Thus, if a synchronizing signal of 500 cycles per second is desired, and a peripheral drum velocity of 16" per second is employed, then approximately 31 lines per inch would be required along the face of strip 41 in order that the frequency of the current generated within the photoelectric cell be equal to 500 cycles per second.

The synchronizing impulse will then commence immediately as the spot 23 passes over the ruled strip 41 and will terminate when the strip 41 passes beyond the spot 23. Inasmuch as increased amplitude levels are not required when synchronizing impulses of a distinct frequency are transmitted, the switch 27 may be dispensed with as a means for increasing the amplification level and the output of pentode 45 may be coupled directly to the control grid of amplifier 53 of Figure 2.

The aforementioned figures of 31 lines per inch is consistent with the definition which is obtainable in the optical systems of facsimile apparatus. That is, it is well known that the light spot 23 may be less than 0.01" in diameter and therefore no difficulty is encountered in obtaining this distinctive frequency by photoelectric means.

Inasmuch as these alternate black and white lines may produce a photoelectric cell current rich in harmonics, if solid black and white alternate lines are used, these lines may be made to blend into each other, the light and shades varying in a substantially sinusoidal manner.

The receiving apparatus which may be employed with this type of synchronizing system is illustrated in my Patent No. 2,212,968. Here again the deleterious effects of switching transients do not enter to effect improper synchronization.

Many modifications of the specific disclosures hereinabove set forth may be made by those skilled in the art. Therefore I do not wish to be limited except by the appended claims.

I claim:

1. A facsimile transmitter comprising a rotatable drum and a picture field mounted upon said drum, electrooptical means for helically scanning said picture field and deriving a current fluctuating in accordance with the lights and shades of said field, means for amplifying said current, and means cooperating with said electro-optical scanning means for generating an electrical synchronizing signal of distinctive amplitude once during each drum revolution, said last mentioned cooperating means comprising a distinctively shaded band across said drum for impinging light on said electro-optical means at one end of the light intensity range to which said electro-optical means is affected in scanning said picture field, and switching means operative to increase the gain of said amplifier during the synchronizing period.

2. A facsimile transmitter comprising a rotatable drum, means for mounting a picture to be transmitted upon said drum, said mounting means comprising a blackened strip biased to juxtaposition with said drum, electrooptical means for helically scanning said picture and

deriving a current fluctuating in accordance with the lights and shades of said picture, means for amplifying said current, said blackened strip cooperating with said scanning system once during each revolution to generate a signal of amplitude equal to the maximum amplitude of said picture currents, and a switching means operative to increase the gain of said amplifier during the synchronizing period to produce a synchronizing signal which is invariably greater in amplitude than the maximum picture signal.

3. A facsimile transmitter comprising a rotatable drum, means for mounting a picture to be transmitted upon said drum, said mounting means comprising a blackened strip biased to juxtaposition with said drum, electrooptical means for helically scanning said picture and deriving a current fluctuating in accordance with the lights and shades of said picture, means for amplifying said current, said blackened strip cooperating with said scanning system and a switching means once during each drum revolution to generate an electrical synchronizing signal of an amplitude equal to the maximum amplitude of said picture currents, said switching means being in circuit with said amplifier and operative from a cam on said drum oriented with respect to said blackened strip to increase the gain of said amplifier during the synchronizing period for producing a synchronizing signal invariably greater in amplitude than the maximum picture signal.

4. A facsimile transmitter comprising a rotatable drum and a picture field mounted upon said drum, electro-optical means for helically scanning said picture field and deriving a current fluctuating in accordance with the lights and shades of said field, means for amplifying said current, and means cooperating with said scanning means for generating an electrical synchronizing signal of distinctive frequency once during each drum revolution, said last mentioned means comprising a band of alternate black and white lines across said drum.

5. A facsimile transmitter comprising a rotatable drum, means for mounting a picture to be transmitted upon said drum, said mounting means comprising a strip biased to juxtaposition with said drum and having a plurality of alternate black and white lines thereon, electrooptical means for helically scanning said picture and deriving a current fluctuating in accordance with the lights and shades of said picture, said strip cooperating with said scanning system once during each drum revolution to generate an electrical synchronizing signal of distinctive frequency.

6. A facsimile transmitter comprising a rotatable drum, means for mounting a picture to be transmitted upon said drum, said mounting means comprising a strip biased to juxtaposition with said drum and having a plurality of alternate black and white lines thereon, electro-optical means for helically scanning said picture and deriving a current fluctuating in accordance with the lights and shades of said picture, said strip cooperating with said scanning system once during each drum revolution to generate an electrical synchronizing signal of distinctive frequency, the spacing between said black and white lines being predetermined to correspond with the peripheral velocity of said drum for a given synchronizing frequency.

7. In a facsimile transmitter, a picture field, light sensitive means, scanning means for im-

pinging light from successive points on said picture field on said light sensitive means in scanning cycles; means interposed in said picture field between said scanning cycles for impinging light on said light sensitive means of an intensity at one of the limits of said image; an amplifier connected to said light sensitive means for

5 amplifying currents produced thereby as said image is scanned; and switching means operated simultaneously with the impinging of light from said interposed source on said light sensitive means for simultaneously increasing the gain of said amplifier.

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