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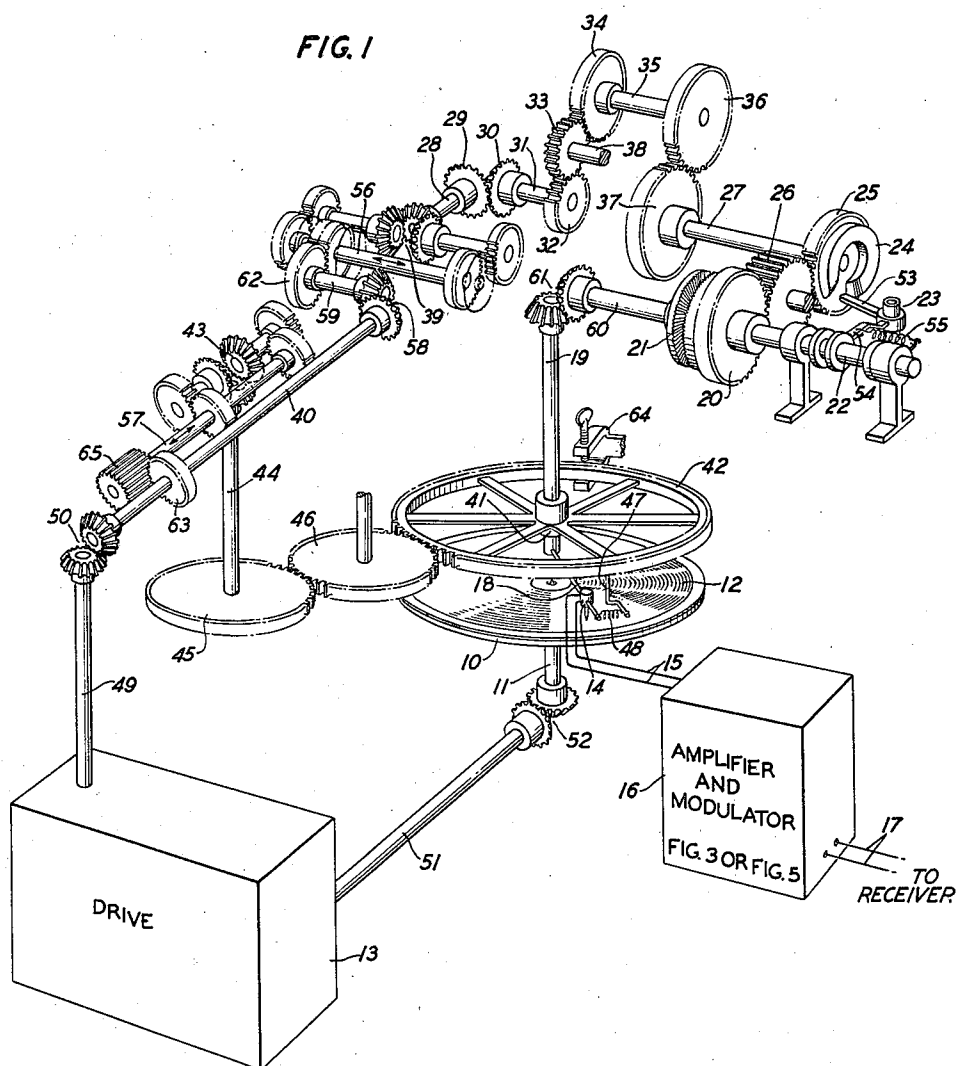
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2,218,211

TELEPHOTOGRAPHY

Filed March 3, 1939

4 Sheets-Sheet 1



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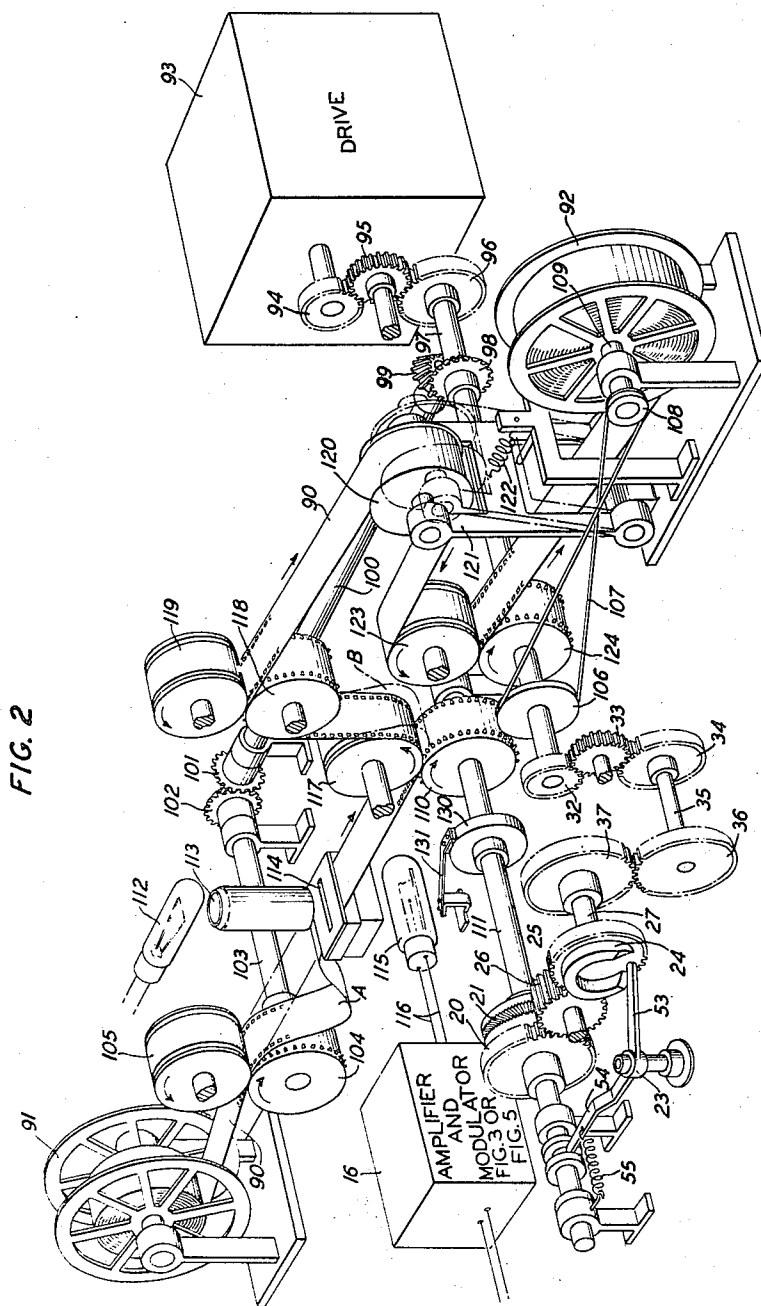
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TELEPHOTOGRAPHY

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4 Sheets-Sheet 2



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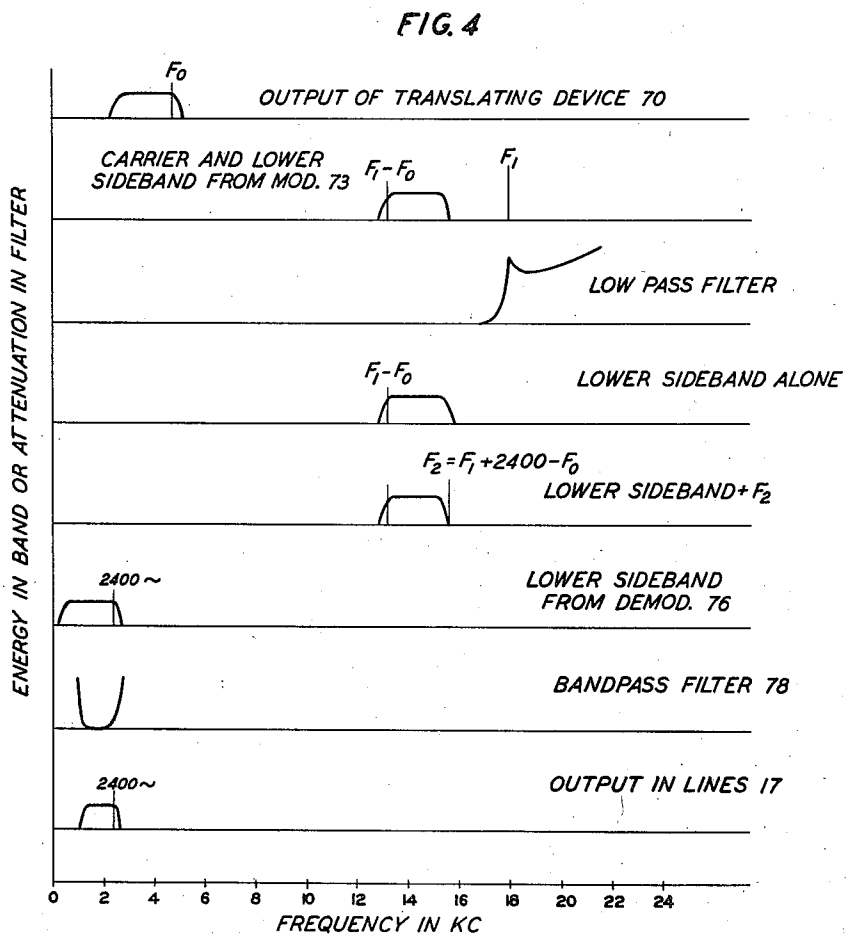
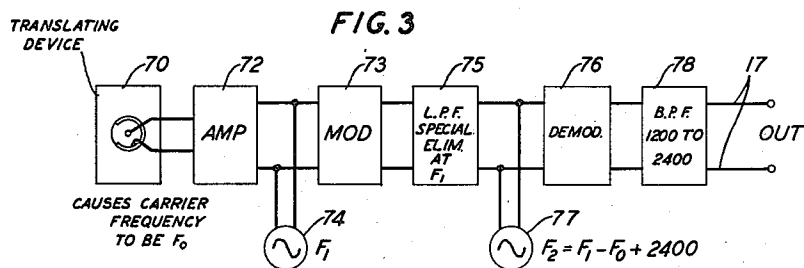
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4 Sheets-Sheet 3



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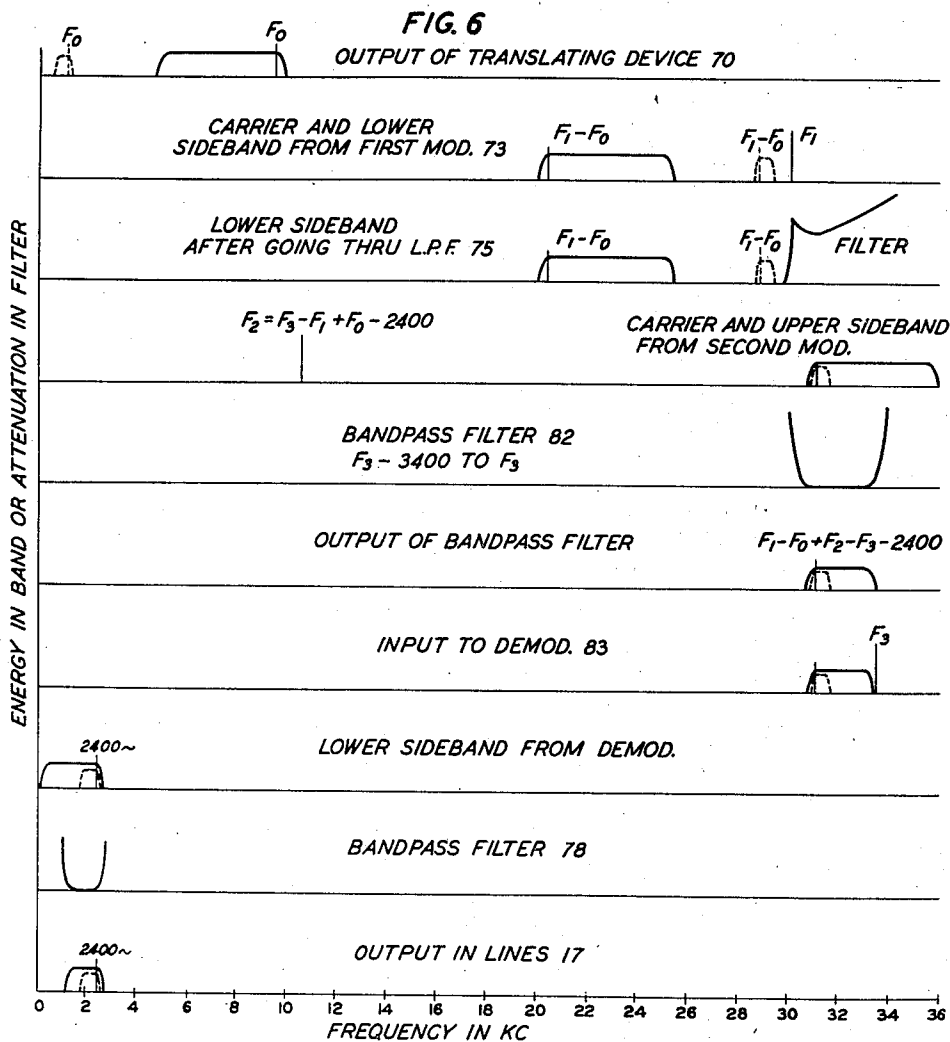
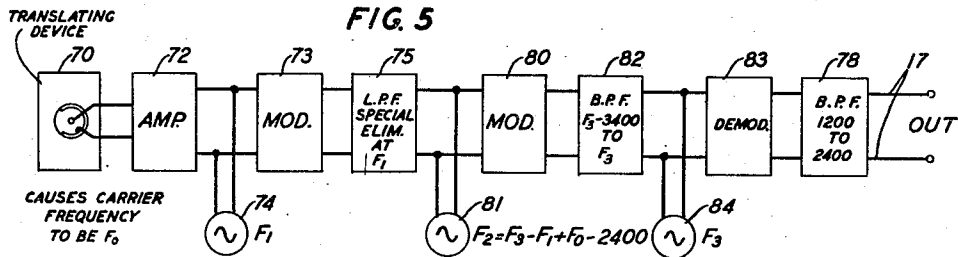
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4 Sheets-Sheet 4



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TELEPHOTOGRAPHY

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20 Claims. (Cl. 178—6.7)

This invention relates broadly to signaling and more specifically to means for storing signals from a telephotograph transmitting station upon a record and thereafter generating signals under the control of the record which are capable of reproducing a picture in a receiving system incapable of correctly reproducing the picture directly from the original signals.

An object of the invention is to provide means whereby transmission may be effected from a telephotograph transmitting machine to a telephotograph receiving machine having a different index of cooperation.

Another object of the invention is to provide means whereby transmission may be effected from a telephotograph transmitting machine operating at one speed to a telephotograph receiving machine operating at a different speed, both in the case where the two indexes of cooperation are equal and also in the case where they are not equal.

Other objects of the invention will be apparent from the following description and appended claims.

Features of the invention are novel types of signal recording and reproducing devices.

The index of cooperation of a telephotography system may be designated as the product of the pitch of the screw thread (i. e., threads per unit length), giving the device longitudinal motion, by the diameter of the drum (in the same units of length) on which the picture is placed. It is possible to send directly from a transmitting machine to a receiving machine having a different diameter drum provided the indexes of cooperation of the two machines are the same and their speeds in revolutions per minute are equal. If, however, a picture is sent from a machine with a certain pitch and diameter to another machine with, say, the same pitch but a different diameter, a distortion of the picture received will occur regardless of whether the speeds of the two machines in revolutions per minute are the same. Thus a square sent out by the first machine will appear as a rectangle on the second machine. This is because the relative dimensions will be changed in the process. Thus it is impractical to send directly from a transmitting machine to a receiving machine having a different index of cooperation, whether or not the drum speeds are the same. It is also impossible to transmit directly from a machine operating at one speed to a machine operating at a different speed (in revolutions per minute), even though the indexes of cooperation are equal.

One way of overcoming these difficulties is to receive the picture on a machine having the same index of cooperation as the transmitting machine and, after the picture has been developed, to transmit it from a different transmitting machine having the same index of cooperation and the same speed as the receiving system to which it is desired to send. However, this method has two major disadvantages, namely, loss of detail and loss of fidelity in tone reproduction. The first can be overcome by special apparatus but the second cannot.

Loss of detail occurs in two ways. If the scanning grain of the received picture is made to go in the same general direction that the scanning beam travels on the sending machine, there will be loss of detail unless the scanning beam of the sending machine follows exactly the scanning lines on the picture being sent. In practice this is almost impossible to accomplish with ordinary picture machines. It is possible to greatly widen the scanning line on the picture received by using a special receiving machine and then to similarly scan this wide line on the scanning machine and to so control the dimensions that the beam of light from the sending machine always falls directly on the line of the picture being sent. However, there still results a loss of detail caused by the finite size of the scanning spots but this loss is much less than in the case first mentioned.

Using an ordinary picture machine, the scanning lines on the received picture can be made to run at 90 degrees to the line of travel of the light beam in the sending machine. This method results in loss of detail due to the finite size of the scanning spots.

Loss of fidelity in tone reproduction occurs when pictures are retransmitted because the useful range of density of films used is limited. In addition, the characteristic of film density versus light is not a straight line even in the useful portion. Thus, each time a film is retransmitted or, for that matter, each time a negative is taken and another print is made, a certain loss in fidelity is obtained. This is inherent in the ordinary photographic process.

There is described below a method and apparatus which to a large extent reduces both of the above-mentioned difficulties. This method involves the making of a recording of the telephotograph signals, for example, upon a phonograph record or as a sound track record on a photographic film, and regenerating under control of this record a signal capable of reproducing the picture on the receiving machine without

geometric distortion. In this method, loss of detail is very small if a faithful record of the original signal transmission is made either on a high quality phonograph record or on a photographic film such as that ordinarily used for motion pictures. If the picture signal in the form of a carrier modulated in accordance with the light-tone values of the elemental areas of the picture is recorded on a film and then retransmitted, loss of accurate tone reproduction is small because the recording may be done with a medium density corresponding to zero input. Each half of any wave at the input then produces a variation above or below this medium density. Thus the best portion of the film characteristic may be utilized for the larger part of the used range. When the signal is transformed directly into a picture the worst parts of the film characteristic occupy an appreciable portion of the used range. Actually, when the method just mentioned of utilizing film storage of a picture signal is used, the harmonic content is very low for a useful range. Thus, for a range of input from 0 to 15 decibels below the maximum, which is approximately what is needed for picture transmission, harmonics are down at least 25 to 35 decibels. This is sufficiently far so that no effect whatever can be noticed in the pictures.

High quality vertical cut phonograph records give about the same results as film so far as harmonics are concerned but are better from the noise standpoint. However, noise is not an appreciable factor in the storage method employing either phonographs or films.

In order to understand the principles of operation of the translating and storing mechanisms which are fully described below, a few simple mathematical expressions showing how the index of cooperation affects picture systems are here given.

Assume that the translating record machine carries a cylindrical record and that recording is effected by a mechanism similar to that employed in ordinary telephotograph machines, where the two machines are operated at the same speed, the record cylinder being rotated and the recording carriage being moved longitudinally of the cylinder by means of a lead screw.

Let D_1 be the diameter of the translating cylinder;

p_1 the pitch of the translating machine;

D_2 the diameter of the receiving machine;

p_2 the pitch of the receiving machine.

If $p_1 D_1 = p_2 D_2$, a picture sent from the translating machine to the receiving machine will have no distortion due to changes in index of cooperation. If then the sending machine has the same index of cooperation as the translating machine, the reproduced picture on the receiving machine will be a duplicate of the original at the sending machine.

Assume now that the sending machine has a different index of cooperation than the receiving machine, such that $p_2 D_2 = K p_3 D_3$ where p_3 and D_3 are respectively the pitch and diameter of the sending machine.

Thus,

$$\frac{D_2}{K} = \frac{D_3 p_3}{p_2}$$

and

$$\frac{D_1}{K} = \frac{D_3 p_3}{p_1}$$

If something can now be done to have the

effect of multiplying D_1 by K when the picture is retransmitted, the effective indexes of cooperation of the translating machine and the receiving machine will be the same. This is the equivalent of multiplying the surface speed of the cylindrical record, i. e., the surface speed that would ordinarily be used in reading a record, or the speed of the film, if a film is used with a stationary reading element, by the factor K during the time the useful picture is transmitted therefrom, the surface speed being that of the needle, or equivalent element, with respect to the record. It will be apparent that it is not necessary to have the translating record in the form of a cylinder since by changing the surface speed of the record the effect of a change of index of cooperation may be obtained. It is not necessary to actually change the speed of the record because while the record is moving the reproducing pick-up device may be moved uniformly with respect to the record; or the record may be stationary while being read by the moving pick-up device. Broadly stated, what is necessary is a control of the relative movement between the record and pick-up device as compared with the relative movement between the record and the recording mechanism.

It will be seen that the index of cooperation is not dependent upon the revolutions per minute. If the speed in revolutions per minute of the transmitting machine is different from that of the receiving machine, this difference may likewise be compensated by further change in the surface speed of the record.

There are described below two specific forms of translating machines, one employing a phonographic record as the signal storage element and the other utilizing a continuous strip of photographic film therefor. It is obvious, however, that other types of translating machines are within the scope of this invention. In the use of these machines it is not sufficient merely to provide means for changing the relative speed between the record and pick-up device (assuming that the recording is effected with either the record or pick-up device stationary) because in transmitting without distortion from one system having one index of cooperation to another having a different index, there must be an unused portion of the drum on either the sending or receiving machine due to the difference in shapes of the "rolled-out" surface areas of a transmitting and receiving picture element. Thus, if the transmitting machine has a larger index of cooperation than the receiving machine, a portion of each elemental strip of the transmitting picture field (around the drum) must be discarded on the receiving machine. If, on the other hand, the receiving machine has the larger index of cooperation, the reproduction of the transmitter field at the receiver will not occupy the entire picture receiving surface. Each complete elemental line around the drum of the receiving machine corresponds to a definite length of record track on the translating machine. Since, in certain cases, part of the picture at the transmitting machine is not to be reproduced at the receiver, means are provided at the translating machine for retransmitting by reading (at reduced surface speed) only those portions of the lengths of the record which correspond to those parts of the elemental strips at the transmitter which it is desired to reproduce. To take care of those cases where the reproduction of the transmitter field cannot completely cover the receiving drum circumferentially, means are pro-

vided at the translating machine for retransmitting from each of all of the successive lengths of record track, each length being read at an enhanced rate, and for causing a pause in useful transmission after retransmission from each such length of the track.

The various features of the invention will be better understood from the following detailed description and the accompanying drawings in which:

Fig. 1 is a perspective view of a translating machine employing a record in the form of a phonographic disc;

Fig. 2 is a perspective view of a translating device employing a record in the form of a continuous film;

Fig. 3 is a block diagram of electrical equipment for modifying the retransmitted signal;

Fig. 4 is a diagrammatic showing illustrative of the circuit arrangement of Fig. 3;

Fig. 5 is a block diagram of a modified form of the electrical circuit arrangement of Fig. 3; and

Fig. 6 is a diagrammatic showing illustrating the operation of the circuit arrangement of Fig. 5.

Referring to the embodiment of the invention shown in Fig. 1, a turntable 10 mounted on a shaft 11 is provided for carrying a disc record 12 which has recorded thereupon, in the form of a continuous spiral groove, picture signals from a telephotographic transmitting station, preferably in the form of a modulated carrier, this recording having been effected in the usual manner by continuously rotating the record blank at uniform speed while a record cutter under control of the incoming currents is slowly moving radially of the disc, the disc being driven by any suitable driving mechanism. The turntable during the reproducing stage may thus be rotated by the driving mechanism 13 through the shaft 51 and gear assembly 52 at the same speed at which it was operated during recording. The pick-up device 14 may be of the type ordinarily employed for translating record variations into current variations. Through conductors 15 it controls either of the amplifier-modulator arrangements 16 or 16' shown in Figs. 3 and 5, respectively, the output of either of which is impressed upon the line 17 for transmission to the receiving machine.

The pick-up device 14 is slidable upon the rod 18 which is fixed to the lower end of shaft 19. Gear 20 drives shaft 19 through the clutch 21, shaft 60 and gear assembly 61 whenever this clutch is engaged, and is in turn driven through a series of gears and shafts, to be described below, by the driving mechanism 13. Gear 20 is carried by the slidable shaft 22, the longitudinal position of which is controlled by the reciprocating arm 23. One extremity 53 of arm 23 is positioned to be engaged by cam 24, unitary with gear 25, which drives gear 20 through the idler 26. The other extremity 54 of the reciprocating arm 23 causes the engagement and disengagement of the clutch 21 with the assistance of spring 55. Shaft 27 upon which gear 25 is fastened is driven by shaft 28 through gears 29 and 30, shaft 31, gears 32, 33 and 34, shaft 35 and gears 36 and 37. It is desired to make the revolutions per minute of the gear 25 and of the cam 24 the same as the revolutions per minute of the receiving drum at the particular receiver to which it is desired to transmit. To do this a number of gears 34 are provided, each of a different size, and that one is used during any

transmission which will give shaft 27 the proper speed. The idler gear 33 is mounted on a shaft 38. The shaft 28 in turn is driven in either direction desired by means of the reversing gear assembly 39 including gear shaft 56 which may be shifted longitudinally (by means not shown), which assembly is coupled to shaft 40 through gear 62, shaft 59 and gear assembly 58. The shaft 40 is driven by the driving mechanism 13 through shaft 49 and gear assembly 50. A gear 25 must be chosen from a set of such gears of different sizes such that the pick-up device 14 is given the proper speed relative to that of record 12 to suit the particular conditions.

Upon a collar 41 carried by shaft 19 is a wheel member 42 rotatable upon shaft 19. This member 42 is driven from the driving mechanism 13 through shaft 49, gear assembly 50, shaft 40, gear 63, gear 65, reversing gear assembly 43 including gear shaft 57 which may be shifted longitudinally (by means not shown), shaft 44, gear 45 and idler gear 46, which two last-mentioned gears may be changed to vary the speed of the wheel 42, if desired. Wheel 42 carries a downwardly projecting vertical member 47 supporting one end of spring 48 the other end of which is connected to rod 18. This spring is capable of drawing rod 18 back against the pin 47. The rod 18 rests against this pin when the clutch 21 is disengaged. Thus, the starting point for the pick-up during each period of useful transmission is determined, this being the period during which a line of the reproduced picture is being formed. The purpose in having the stop pin 47 movable, by being mounted on the wheel 42, is to take care of the case where the revolutions per minute of the turntable 10 are different from the revolutions per minute of the sending picture machine or of the receiving machine or both. Thus if one 360-degree trace on the record should correspond to more or less than one scanned line of the picture field at the transmitter and the stop pin 47 were stationary, the needle in the pick-up device 14 would return to a point at the end of each cycle of operation which would not correspond at all to the edge of the picture on the transmitting drum. The clamp 64 takes care of the special case where the revolutions per minute of the sending machine happen to be exactly the same as the revolutions per minute of the turntable and of the receiving machine. When the clamp 64 is used, the reversing gears 43 are completely disengaged by shifting the shaft 57 to its extreme right-hand position.

It will be obvious from the above description that in the operation of this mechanism pick-up device 14 is caused to have relative motion with respect to the record 12. Assume, for example, that pick-up device 14 is moving clockwise when viewed from above. This movement is effected by virtue of engagement of clutch 21 which in turn is controlled by the cam member 24 and the arm 23. When the arm rides off the cam the clutch is disengaged and spring 48 quickly draws the arm 18 to element 47 thus very rapidly moving the needle over a portion of the record. The time taken for this movement is negligibly small and does not interfere with the reproduction of the picture. During this movement of the pick-up device 14 the wheel member 42 is being rotated to such a position that the pick-up device 14 will be in the proper position with respect to the record so that the useful retransmission for the next line period will begin on the correct place on the record. Gear 25 and cam 24 must

travel at the same revolutions per minute as the receiving picture machine as they must start the pick-up 14 in motion at a time corresponding to the same angular position of the drum of the receiving picture machine for each line. When the toothed clutch 21 engages, the pick-up 14 is given the required motion relative to the record.

The reversing gear assemblies 39 and 43 are provided, as it may be necessary to give the pick-up 14 a motion either with or against that of the record; and also it may be necessary to move the wheel 42 in either a clockwise or counter-clockwise direction with respect to the turntable. The reversing gear mechanisms 39 and 43 may be caused to operate the shafts 28 and 44, respectively in either direction by suitable means (not shown) for shifting longitudinally the shafts 56 and 57.

Consider, for example, the case when the receiver has the larger index of cooperation so that the reproduced picture will not reach entirely around the receiving drum. This means that there will be a period of time between successive line reading periods when no useful signal is transmitted. In other words, a length of record track corresponding to a full line of the transmitted picture is read with clutch 21 engaged and then there is a short period during which nothing useful is transmitted. During this short period the clutch 21 is disengaged. The clutch is then engaged at the instant recording of the next line on the receiving drum should begin. Then the second line is transmitted, and so forth.

When the transmitting machine has the larger index of cooperation, a circumferential elemental line at the transmitter is too long to be reproduced in its entirety on the receiving drum and must, therefore, be left out at the receiver. In this case, when one complete revolution of the receiving drum is completed, the stylus 14 will not yet have completed the reading of the record track corresponding to one elemental line at the transmitter. (Assuming that the picture at the transmitter just fills the transmitting drum circumferentially so that on the record there are no gaps between the lengths of track corresponding to adjacent elemental lines at the transmitter.) At this instant the clutch 21 is disengaged by reason of the break in cam surface 24 momentarily permitting pin 53 to fall therein. Arm 18 is released and spring 48 quickly pulls arm 18 back to stop 47. Arm 18 then starts to move again and to read the track corresponding to the next elemental line. This process is repeated for all of the elemental lines.

Gear 25 must have the same revolutions per minute as the receiving drum. Its speed is therefore fixed for a given retransmission. But the ratio of gear 25 to gear 20 controls the speed of the reading stylus 14 which will be different for operation with different receivers having different indexes of cooperation. To take care of this, different gears 25 having different numbers of teeth are provided (a corresponding set of idlers 26 may be used). However, it will not in general be sufficient merely to select gear 25, since the speed of shaft 27 must conform to that of the receiving drum and, being driven from drive 13, could not be changed without changing a gear ratio in the driving gear chain. This is taken care of by providing gears 32, 33, 34, 36 and 37 and having a set of some one contacting pair of these gears (33 and 34, for example) from which the proper selection can be made to give shaft 27 the proper speed.

When it is desired to transmit from a transmit-

ter to a receiver having the same index of cooperation but the speeds of the two drums in revolutions per minute are different, some translating device is necessary as otherwise one line of the received picture would contain more or less than a line of the transmitted picture and consequently the received picture would not conform to the transmitted picture. As the indexes of cooperation are the same, the clutch 21 is never disengaged. A closed ring element is therefore substituted for cam 24 and the movement of the wheel 42 is made the same as the movement of the pick-up device 14 which is the same or opposite in direction to that of the turntable as the situation demands, and at whatever speed, with respect to that of the turntable, is necessary. In this case there is no need to pass quickly over certain portions of the record. The pick-up will be at such speed that an entire elemental line of signals is received at the receiving station during one revolution of the receiver drum.

Having the relative speed of the pick-up to the record different from the speed of the record during recording with a stationary needle, as is done during reading of the record by moving the pick-up device with respect to the moving record, will, of course, result in having the frequencies of everything transmitted different from the frequencies received at the translating machine from the transmitter. Consider the change in the frequency of the picture carrier. It will be necessary to change this picture carrier frequency back to its proper value, assumed in this case to be 2400 cycles by way of example, before it reaches the receiver and preferably before sending it out on the line, as otherwise it would not operate the receiving machine properly. For this purpose, an amplifier and modulator shown schematically by the block 16 in Fig. 1 and shown in detail in Fig. 3 or Fig. 5 may be used.

Referring now to Figs. 3 and 5, block diagrams of amplifier-modulator systems suitable for insertion between the translating device shown in Fig. 1 (represented by a block 70 in Figs. 3 and 5) and the output lines 17 are shown. As pointed out above, the translating device causes a change in all frequencies in proportion to the change in relative speed of the pick-up 14 to the record 12 with respect to the surface speed of recording in the case of the phonograph device shown in Fig. 1. If this relative speed is greater during reading than during recording it will widen out the whole frequency band proportionately and vice versa. It is necessary to modify the frequency band sent out from the translating device so that the new carrier will be 2400 cycles. It is also desirable to transmit only the lower side-band (assuming that the receiving device uses the lower side-band). In the arrangement in Fig. 3 a simple circuit arrangement is shown which will work when the band sent out from the translating device is less than 3600 cycles wide. The arrangement shown in Fig. 5 will operate for any band width from the translating device.

In the arrangement shown in Fig. 3, waves from the translating device 70 pass first through an amplifier 72 and then are modulated by a modulator 73, the moderately high carrier frequency F_1 being generated by a suitable oscillator 74. These modulated waves then pass through a low-pass filter 75 which eliminates the frequency F_1 and all frequencies above it. After passing through this filter, the resultant waves are modulated again by the device 76 with a variable frequency F_2 from a suitable oscillator 77.

The lowest side-band of this modulation is passed through a band-pass filter 78 corresponding to the sending telephotograph filter. It passes the band from 1200 to 2400 cycles.

Reference will now be made to Fig. 4 which shows a frequency chart showing graphically the various steps in the operation of the system represented by the block diagram of Fig. 3. A band from 2400 to approximately 5000 cycles with the carrier at 4800 is assumed. This corresponds to a reading speed double the recording speed (during useful transmission) and assumes also a band of 1200 to 2400 cycles from the original sending picture machine after modulation on a 2400-cycle carrier. The next step going from top to bottom on the diagram of Fig. 4 shows the carrier frequency F_1 at 18 kilocycles and the lower side-band out of the modulator. There will also be an upper side-band and some of the original band at this point, but this has no significance and is not shown. The action of the low-pass filter is next shown, which cuts off F_1 and the upper side-band, leaving the lower side-band. The frequency F_2 which is exactly 2400 cycles away from what corresponds to the carrier frequency in this lower side-band, is then placed on the line. This is represented in Fig. 4 under the label "lower side-band + F_2 ". The next step represents the lower side-band produced by the demodulator 76, along with the carrier which is now at 2400 cycles. This is then passed through a 1200- to 2400-cycle band-pass filter and at the output the band is the desired width.

This process could be used also in systems using carrier and lower side-band transmission other than those in which a frequency change is due, in whole or part, to the above-described action of the translating machine.

The limitation of the system shown in Figs. 3 and 4 is, however, that if the original band is wider than 3600 cycles it will overlap the second frequency F_2 , so that the upper portion of this side-band will produce frequencies higher than 1200 cycles. These in turn will appear in the lower side-band from the demodulator and cause unwanted products to fall in the band from 1200 to 2400 cycles. Thus if the original band is wider than 3600 cycles a somewhat more complex system should be used.

A system suitable for use with an original band width greater than 3600 cycles is shown in Fig. 5. Referring now to this figure, a system is shown in which three stages of frequency changing apparatus are used instead of two. In Fig. 5, the output of the low-pass filter 75 (all parts of the system to the left of the filter 75 being similar to corresponding parts in the system of Fig. 3) is impressed upon a modulator 80 which receives oscillations from a suitable oscillator 81 operating at a frequency F_2 which is equal to

$$F_3 - F_1 + F_0 - 2400$$

F_0 being the frequency of the carrier of the signals in the output of the translating device 70, and F_3 the frequency of the oscillator 84 which supplies the carrier for the demodulator 83 into which the waves of the band-pass filter 82 are fed from the modulator 80. The band-pass filter 78 is the same as in Fig. 3.

Referring to Fig. 6 and taking the diagrams in order from the top to the bottom, it will be noted that the original output of the translating device is shown as consisting of a band from 4800 to about 10,000 cycles with the carrier at 9600 cycles.

This is modulated by a frequency F_1 of 30 kilocycles and the lower side-band now appears as 20 kilocycles to 25.2 kilocycles with the original carrier transposed to 20.4 kilocycles. The low-pass filter 75 then cuts off frequency F_1 and the upper side-band. The variable frequency F_2 is now introduced which causes the original carrier to appear as an upper side-band at exactly 31 kilocycles. This is just 2400 cycles away from F_3 which is 33.4 kilocycles. This upper side-band is then passed through a band-pass filter 82 passing from frequency F_3 down to 30 kilocycles. This causes the upper sideband from the second modulator to be no wider than about 2800 cycles. Thus no matter how wide the original band is, in this case 4800 cycles, there is no danger of the extreme edges of the original band modulating with the final carrier F_3 to produce unwanted products above 1200 cycles. At the output of the demodulator 83 a band of about 200 to 2600 cycles with the carrier of 2400 cycles is obtained as a lower side-band. This is then passed through the band-pass filter 78 and the final output is 1200 to 2400 cycles which is carried over the output lines 17 to the receiving system.

In the case where a comparatively narrow band of signals is sent from the translating machine due to a relatively slow reading speed, the action of the system is substantially the same as in the case where a wider band of signals is sent from the translating machine. Assume that the output of the translating device consists of a band from 600 to about 1300 cycles with the carrier at 1200 cycles. Employing the apparatus shown in Figs. 5 and 6, the frequency transformations occur in the same manner as in the case shown by the full lines, the frequencies and frequency bands where a narrow band of signals is employed being represented by dotted lines in the diagrams in this figure. F_1 is, as before, 30 kilocycles so the lower side-band now appears as 28.7 kilocycles to 29.4 kilocycles with the carrier at 28.8 kilocycles. F_1 is then cut off by filter 75 and F_2 is set at 2.2 kilocycles in accordance with the formula. The upper side-band from modulator 80 then falls within the pass-band of filter 82 as shown with the original carrier now transposed to 31 kilocycles. This is then demodulated by the demodulator 83 and the lower side-band only is passed by the band-pass filter 78. The original carrier is now transposed to 2400 cycles and the side-band falls from about 1800 to 2500 cycles.

A narrow band such as discussed above may also be transferred by the arrangement of Figs. 3 and 4 in the same manner as shown for the wider band. Carrier F_2 would have to be set in accordance with the formula so as to cause the lower side-band from demodulator 76 to fall in the proper position.

Fig. 2 shows another embodiment of the invention which may be used as a translating device between receiving and transmitting systems having different indexes of cooperation or different drum speeds, or both. It will be immediately recognized that certain of the elements shown in Fig. 1 correspond to elements of Fig. 2. Many of these corresponding elements have been given the same numbers in these two figures. A close similarity also exists with respect to the methods of operation of the two embodiments.

In the system shown in Fig. 2, a film 90 containing a track record of the incoming currents representative of the picture to be transmitted is reeled on a suitable reel 91, is fed therefrom by

a system of driving members, to be described below, and is then wound on a second reel 92. The track is made on the film 90 by recording the image currents corresponding to successively traced elemental strips or lines of the picture on the transmitting drum. The tracks are made in accordance with the usual sound-track-on-film procedure. The film may be developed, fixed, washed and dried in a well-known manner.

The film is unwound, and given an initial uniform speed, by the driving mechanism 93 acting through gears 94, 95, 96, shaft 97, gears 98 and 99, shaft 100, gears 101 and 102, shaft 103, and driving sprocket wheel 104. The sprocket wheel 104 may pull the film 90 from the reel 91 at any desired speed with respect to that at which the original recording was made but these two speeds are usually made the same, as this relationship is the one which would ordinarily be chosen. An idler wheel 105 is mounted on the opposite side of the film from the driving sprocket wheel 104.

The film 90 is reeled on the reel 92 at the same speed as it is unreel from the reel 91 by means of the pulley 106 mounted on the shaft 97 which pulley is connected by a belt 107 to a pulley 108 mounted on the shaft 109 which carries the reel 92. The sprocket wheel 124 mounted on the shaft 97 supplies a positive drive to the film 90.

Between these two positive drives is an intermittent drive consisting of the sprocket wheel 110 which is mounted on the shaft 111 upon which one part of the clutch 21 is mounted. The shaft 111 receives power intermittently (depending upon the engagement or disengagement of the clutch 21) through the driving mechanism 93, gears 94, 95 and 96, shaft 97, gears 32, 33 and 34, shaft 35, gears 36 and 37, shaft 27, gears 25, 26 and 20, and clutch 21 to the shaft 111. The cam 24 mounted on the gear 25 is similar in design and method of operation to the corresponding cam bearing the same reference character in Fig. 1. Moreover, the gear trains 32 to 37, inclusive, and the action of the cam 24 in causing the engagement and disengagement of the clutch 21 are similar to the corresponding mechanisms shown and described above with reference to Fig. 1.

Reproduction is made from the sound track by means of an optical system comprising a suitable source of illumination 112, and a suitable lens system 113 for focussing a bright slit of light upon the film 90 through a slit aperture 114, light from the illuminated strip on the film being impressed upon a photocell pick-up device 115. Leads 116 connect the pick-up device 115 to the amplifier-modulator device 16 similar to one or the other of those described above in connection with Fig. 1.

The film 90 in its passage between reel 91 and reel 92 passes between the driving sprocket wheel 104 and the idler 105, under the slit aperture 114 for reproduction from the film, between the intermittent driving sprocket wheel 110 and an idler wheel 117, between sprocket wheel 118 and idler wheel 119 over wheel 120 which is mounted on a swinging support 121, over idler wheel 123 and between this idler and the driving sprocket wheel 124 to the reel 92 which is turned by means of the pulley 106 connected by the belt 107 to the pulley 108. Spring 122 always pulls the support for wheel 120 to the right to take up slack in the film between wheel 120 and the nearest positively driven sprocket (110 or 104, as the case may be). Sprockets 104 and 124 run at the same speed but the speed given the film at the inter-

mittent drive 110 may be adjusted by changing the dimensions of the gear 25 carrying the cam 24 to give the desired surface speed, as pointed out above in connection with Fig. 1, during part of the time.

As in the case of Fig. 1, the speed of gear 25 is fixed for a given retransmission since this gear must have the same revolutions per minute as the receiving drum. But the ratio of the teeth in gear 25 to gear 20 determines the speed at which the film is read which will be different for different receivers having different indexes of cooperation. Therefore, different gears 25 are provided having different numbers of teeth, from which the proper one can be selected. A corresponding set of idlers 26 of different diameter can be used. As different receiving machines have different revolutions per minute while drive 93 is preferably kept at the same revolutions per minute for all receivers, the revolutions per minute of shafts 97 and 100 may be changed by changing the gear ratio in the trains 94, 95 and 96. These gears must be arranged so that the speed of film at sprockets 104 and 124 causes one complete picture element to pass through for each revolution of the receiving machine. Gears 32, 33 and 34 are then arranged to cause gear 25 to have the same revolutions per minute as the receiving machine.

The operation of the arrangement of Fig. 2 will be better understood by considering the cases where the index of cooperation of the receiving machine is larger and smaller, respectively, than that at the transmitting machine, the revolutions per minute of both being the same and the speed of movement of the film at sprocket 104 being that at which recording took place. The effect of having different number of revolutions per minute at the receiver than at the transmitter will then be apparent.

When the index of cooperation at the receiver is greater than at the transmitter, the reproduced picture (assuming the original picture occupies all of the drum at the transmitter) will not entirely cover the receiving drum in the circumferential direction. A gear 34 of proper size to give shaft 27 the same revolutions per minute as the receiving machine is chosen. The beginning of the track on the film may be set at slot 114. As the reading must proceed at a more rapid rate than the film is driven by sprocket 104, a loop A is left. A gear 25 (with corresponding idler 26) of proper size to give the desired reading speed is chosen and put in place so that the cam 24 will be angularly positioned to engage arm 53 just beyond the break in the cam surface. The receiving drum will be oriented for the commencement of reproduction of an elemental strip. The drive 93 will start the rotation of shaft 111 at the instant the receiving cylinder starts, by any well-known means (not shown) for insuring simultaneous starting of rotating elements located at separated points. There should be no slack in the film except at A but wheel 120 should be in its right-hand position so that a loop can form at B, as explained below.

When shaft 111 starts, reading begins. Loop A decreases in size as the reading proceeds; loop B increases in size, however, since sprocket 110 is moving somewhat faster than sprockets 104 and 124. At the instant that the point on the film is reached corresponding to the end of the first elemental strip of the picture and the beginning of the second, the film should stop and

remain stationary during the rest of the period of rotation of the receiving drum (and gear 25 which has the same speed). This is taken care of by the break in the surface of cam 24, which causes clutch 21 to disengage and remain disengaged for the required time. The sprocket wheel 110 is held stationary by the action of a brake 131 pressing against a friction wheel 130 which is fixedly mounted on shaft 111. The brake exerts a pressure on the wheel 130 which is sufficient to hold the wheel 110 stationary when the clutch 21 is disengaged but which is not enough to prevent the wheel 110 from turning when the clutch is engaged. When clutch 21 disengages, the slack in loop B is taken up by sprocket 124 and in the meantime a new loop is formed at A. At the beginning of the next picture element on the receiving drum, the clutch 21 again engages and the process is repeated.

The operation of the embodiment of the invention shown in Fig. 2, when the index of cooperation at the receiver is less than that at the transmitter, is as follows:

The whole receiving drum is now to be used for less than the whole picture at the transmitter, so that a portion of each section of film track corresponding to an elemental strip of the original picture is to be left out and the reading of the portion to be retransmitted is to be slower than the recording speed. The machine is set with wheel 120 pulled back toward the right.

Reading of the useful part of the film should be begun with no loop formed at A. Clutch 21 is now engaged and sprocket drive wheel 110 moves more slowly than drive wheels 104 and 124, so that a loop slowly forms at A and wheel 120 slowly moves toward the left, thus extending spring 122. When reading of the part of the track to be retransmitted to form the first elemental line of the picture reproduction has been completed the clutch 21 is disengaged, and remains disengaged for the period corresponding to the unused portion of the transmitting picture. As soon as clutch 21 is disengaged the loop that has formed at A is removed by action of the spring 122, which pulls wheel 120 to the right. The brake 131 is not sufficient to prevent this action. These steps are then repeated for each successive elemental strip of the picture.

In general, in the examples of operating conditions given above, with respect to each of the two illustrated embodiments of the invention, the speed in revolutions per minute of the receiving machine was taken as the same as that of the transmitting machine. If the angular speeds of the two drums are different it will be necessary to choose a surface speed of record reading different from that when the speeds are the same. If, for example, the speed of the receiving drum is twice that of the transmitting drum, the surface speed of reading must be made twice as great as when the speeds are the same. This will be taken care of by proper choice of gears 25 and 34, and in the case of the machine using film, by also changing the speed of driving sprockets 104 and 124. This may be done by a proper selection of gear 96, a set of which gears are provided for this purpose. If, for example, the angular speed of the receiving drum is twice that of the transmitting drum the sprockets 104 and 124 are given twice the speed that they would have if the speeds of the two picture machines were the same.

The arrangement shown in Fig. 2 also changes the frequencies of everything transmitted due to

the change of speed of the film and the same amplifier-modulator circuits are necessary as were in the case of Fig. 1. The amplifier-modulator arrangements shown in Fig. 3 and Fig. 5 would be used for Fig. 2 in the same cases that they would be used in connection with Fig. 1.

While two embodiments of the invention have been illustrated and described, it is to be understood that the invention in certain of its aspects is not limited to these forms or to the two types of records used therein.

What is claimed is:

1. Translating means for receiving from a picture transmitting apparatus picture current produced by scanning a picture in parallel elemental strips, means for recording said current, and means for reading said record and for generating picture current under control of said reading suitable for controlling the reproduction of said picture upon a picture receiving apparatus having an index of cooperation different from that of said transmitting apparatus, said last-mentioned means comprising means capable of being adjusted at will either to cause the reading at uniform rate of a portion only of each of successive lengths of the track on said record which correspond respectively to elemental strips of the picture field at the transmitting apparatus or to cause the reading of all of each of such successive lengths of track, each at uniform rate.

2. Translating means for receiving from a picture transmitting apparatus picture current produced by scanning a picture in parallel elemental strips, means for recording said current, and means for reading said record and for generating picture current under control of said reading suitable for controlling the reproduction of said picture upon a picture receiving apparatus having an index of cooperation different from that of said transmitting apparatus, said last-mentioned means comprising means capable of being adjusted at will either to cause the reading at uniform rate of a portion only of each of successive lengths of the track on said record which corresponds respectively to elemental strips of the picture field at the transmitting apparatus or to cause the reading of all of each of such successive lengths of track, each at the same uniform rate and in a period less than the total reading time for all of said successive lengths of track divided by the number of said successive tracks, so read.

3. Translating means for receiving from a picture transmitting apparatus picture current produced by scanning a picture in parallel elemental strips, means for recording said current, and means for reading said record and for generating picture current under control of said reading suitable for controlling the reproduction of said picture upon a picture receiving apparatus having an index of cooperation different from that of said transmitting apparatus, said last-mentioned means comprising means for successively reading lengths of the track on said record, each corresponding to at least a portion of an elemental line of the picture field at said transmitting apparatus, the reading of all the tracks being at the same uniform rate and in equal periods separated by periods during which no useful reading is done.

4. Translating means for receiving from a picture transmitting apparatus picture current produced by scanning a picture in parallel elemental strips, means for recording said current, and means for reading said record and for generating

picture current under control of said reading suitable for controlling the reproduction of said picture upon a picture receiving apparatus having an index of cooperation different from that of said transmitting apparatus, said last-mentioned means comprising means for reading in succession lengths of the track on said record corresponding to successively scanned elemental strips of the picture field at said transmitting apparatus, the reading of all such tracks being at the same uniform rate and in periods separated by periods during which no useful reading is done.

5. The combination with means for reading a linear record of electric current variations, of means including rotating driving means for said record for automatically causing uniform relative movement between said reading means and said record during recurrent periods and more rapid relative movement between said periods.

6. The combination with a record turntable, of record reading means, means for rotating said table about its axis and for simultaneously moving said reading means in the direction of a record trace, and means for automatically periodically stopping said reading means without changing the speed of said turntable while a record is being read.

7. The combination with translating means for reading a record of variations corresponding to a signal and for translating said record variations into electric current variations, of means for producing during each of a plurality of equal successive periods of time, first one relative movement between said record and said translating means along a record trace and then a different relative movement along said trace.

8. The combination with translating means for reading a circular disk record of variations corresponding to a signal and for translating said record variations into electric current variations, of means for producing during each of a plurality of equal successive periods of time, first one relative movement between said disk record and said translating means along a record trace and then a different relative movement along said trace.

9. In the art of electro-optical image-production, the combination with translating means for reading a film track record of current variations produced by scanning a field in parallel elemental strips in succession for translating said record variations into electric current variations, of means for producing during each of a plurality of equal successive periods of time during the reading of said record, first a relative movement between said film track record and said translating means along a record trace at one speed and then a relative movement long said trace at a different speed.

10. In the art of electro-optical image-production, the combination of a translating means for reading a record of current variations produced by scanning a field in parallel elemental strips in succession of driving means for moving said record at a uniform rate, and means under control of said driving means for periodically abruptly changing the relative position of said translating means with respect to the record traced on said record while said record is being read.

11. In the art of electro-optical image-production, the combination with a translating means for reading a record of variations produced by scanning a field in parallel elemental strips in succession and setting up waves corresponding

to the variations of said record, of means for imparting motion to said record while it is being read, and means under control of said last-mentioned means for imparting motion to said translating means while it is reading said record.

12. In combination, a pick-up device for reading a record of received variations in image current which current varies in accordance with light-tone values of successively scanned elemental areas of a picture or field of view, means for producing relative movement between said record and said pick-up device such that the reading will proceed at a rate different from the recording, and means for periodically abruptly modifying said relative movement while said record is being read.

13. The combination with a translating means for reading a record of variations corresponding to a signal, of means for producing relative movement between said record and said translating means, and means under control of said last-mentioned means for changing said relative movement.

14. The combination with a record of signal variations, of translating means for reading said record and translating said recorded variations into electric current variations, of means for producing during each of a plurality of equal successive periods of time, first one relative movement between said translating means along a record traced at a predetermined speed, and then a relatively quick movement along said trace compared with the first relative movement therealong.

15. In combination, a turntable having a record thereon of signal variations, means for rotating said turntable at a predetermined speed, a pick-up device associated with said record member, means for rotating said pick-up device at a predetermined speed to produce relative movement with respect to said record member, and means for periodically abruptly causing the movement of said pick-up device with respect to said record member to be different from said first-mentioned relative movement.

16. A translating means for use in a picture transmitting system wherein the transmitting device and the receiving device have different indexes of cooperation comprising a record member carrying a record corresponding to the successively traced elemental areas of the picture at the transmitting station, a pick-up device associated with said record, means for causing relative movement between said pick-up device and said record member at a surface speed dependent upon the speed of scanning at the receiving station, and means for periodically producing an enhanced relative movement between the pick-up device and the record member in order that each line of the reproduced picture at the receiving station may start at the proper position with respect to the other lines.

17. In combination in an electro-optical image producing system, a film having thereon a track record of current variations produced by scanning a field in parallel elemental strips in succession, an electro-optical pick-up device, means for moving said film past said pick-up device at a predetermined speed for a period of time corresponding to a useful line of a picture being transmitted from a transmitting station to a receiving station through a translating station containing said film record, and means acting at the end of transmission of said line for changing said film

speed with respect to said electro-optical pick-up device.

18. A translating means for use in a picture transmitting system wherein the transmitting drum and the receiving drum have different indexes of cooperation comprising a film track record, said record corresponding to successively traced elemental areas of the picture at the transmitting station, two reels for said film, positive driving means for unreeling said film from one reel at a speed which is the same as that at which the film track record thereon was recorded, a second positive driving means for reeling said film on the other reel at the same speed, an intermittent driving means for driving said film at a speed dependent upon the receiving drum speed, means for starting said intermittent drive at a time corresponding to the beginning of each transmission of a useful line of the picture being translated to the receiving drum and for stopping said intermittent drive at the end of transmission of each useful line, and an electro-optical pick-up device for reading the track record on said film, said pick-up device being located between said first positive drive and said intermittent drive.

19. The method of transmitting pictures by means of modulated carrier current between picture transmitting and receiving apparatus having different indexes of cooperation, which comprises recording the picture current produced at the transmitting apparatus in the form of a linear record, reading said record to produce picture current for transmission to said receiving appa-

ratus, said reading being effected in periods during each of which a portion of the record corresponding to an elemental strip of the reproduced picture is read, said recording and reading being at such speeds that the band of frequency components of the resulting current is expanded or compressed and the position of the carrier in the frequency spectrum is changed with respect to the corresponding band and carrier received from the transmitting apparatus, and acting upon said last-mentioned current before application to said receiving apparatus to produce a current therefrom having a band of frequency components of substantially the width of the frequency component band of the current from said transmitting apparatus and including a carrier component of the same frequency as that of said original current.

20. The method of signal transmission which comprises producing a signal current, recording said current, reading said record at a rate different from the recording rate to set up signaling current, the frequency components of which constitute a band of different width from that of the original signal current and which occupies a different position in the frequency spectrum, and acting electrically upon said second signal current to produce a third signal current having a frequency component band of about the same width and occupying about the same position in the frequency spectrum as that of said first current.

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