XR 1,751,584

March 25, 1930. C. W. HANSELL 1,751,584

PICTURE TRANSMISSION

Filed Aug. 13, 1927 3 Sheets-Sheet 1

Fig. 1

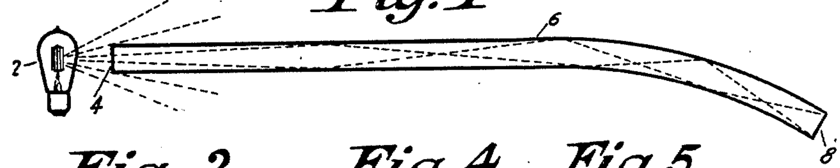


Fig. 2

Fig. 4

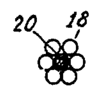


Fig. 5

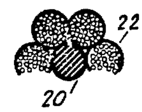


Fig. 6

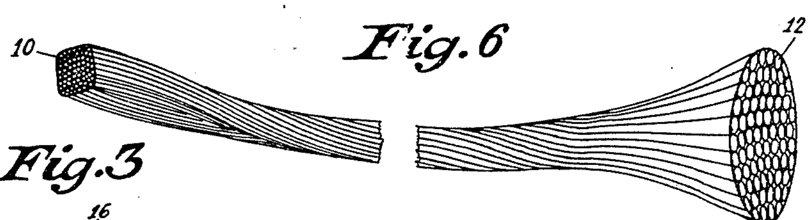


Fig. 3

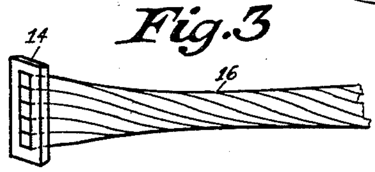
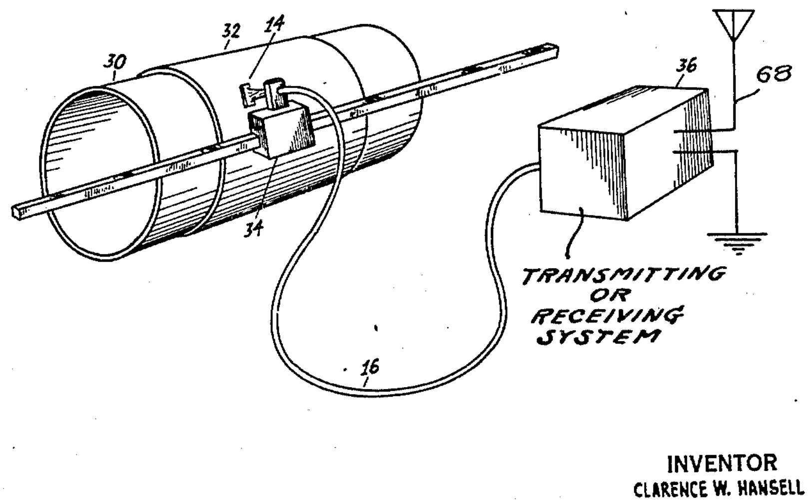


Fig. 7



INVENTOR
CLARENCE W. HANSELL
BY Ira J. Adams
ATTORNEY

Corr. (British) 275,501 350/96 (B)

March 25, 1930. C. W. HANSELL 1,751,584

PICTURE TRANSMISSION

Filed Aug. 13, 1927 3 Sheets-Sheet 2

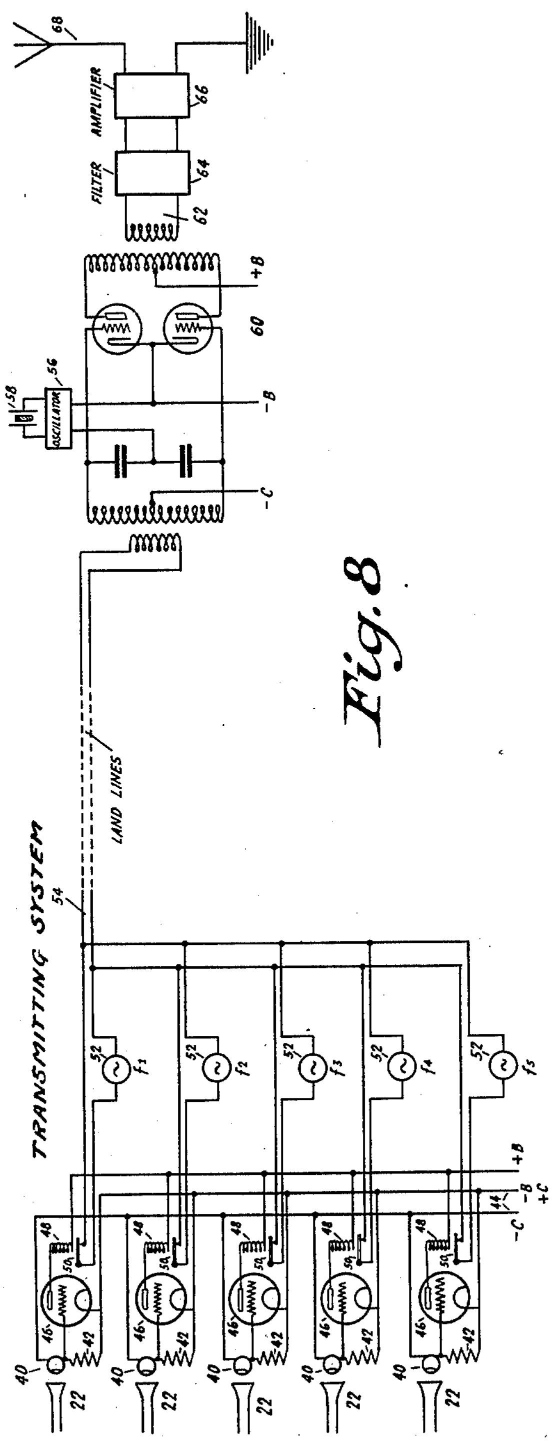


Fig. 8

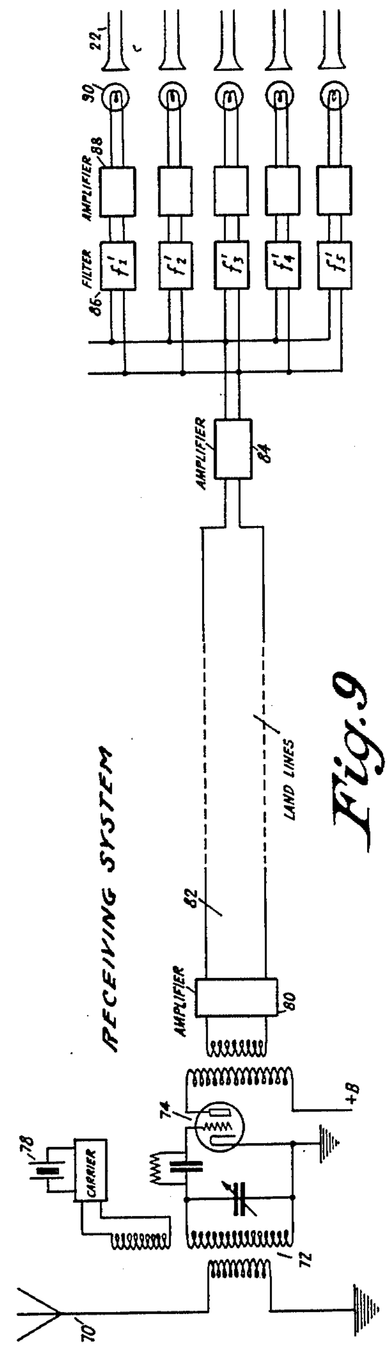


Fig. 9

INVENTOR
CLARENCE W. HANSELL
BY
Ira J. Adams
ATTORNEY

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PICTURE TRANSMISSION

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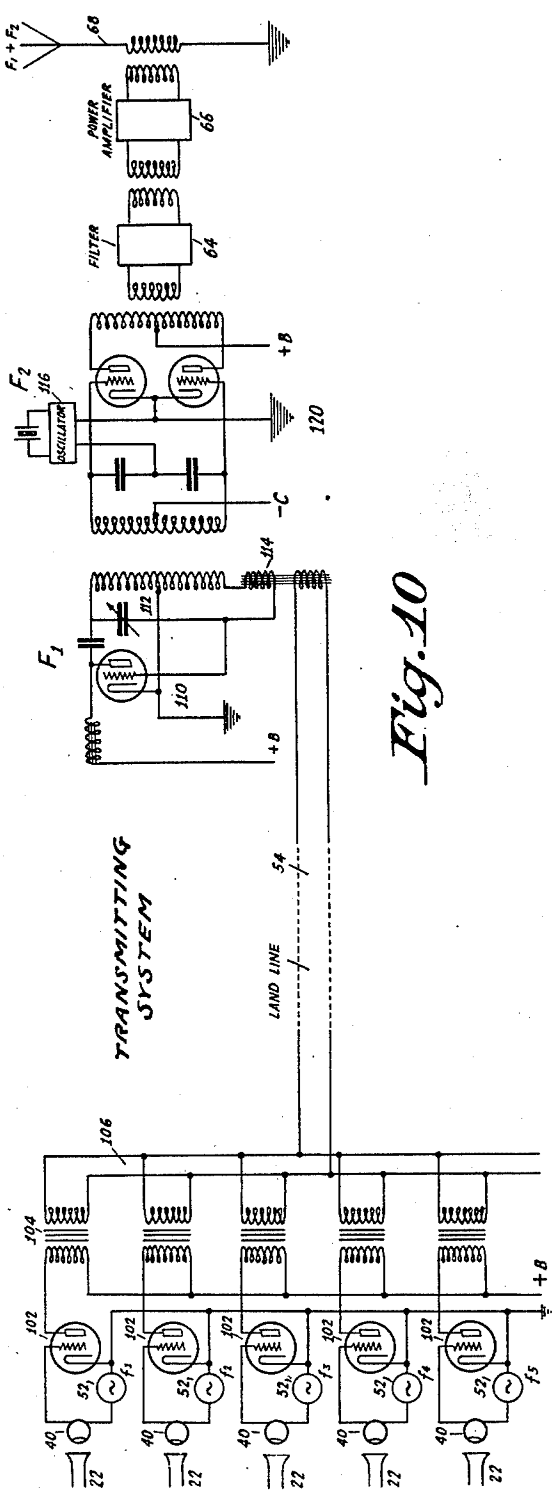

Fig. 10

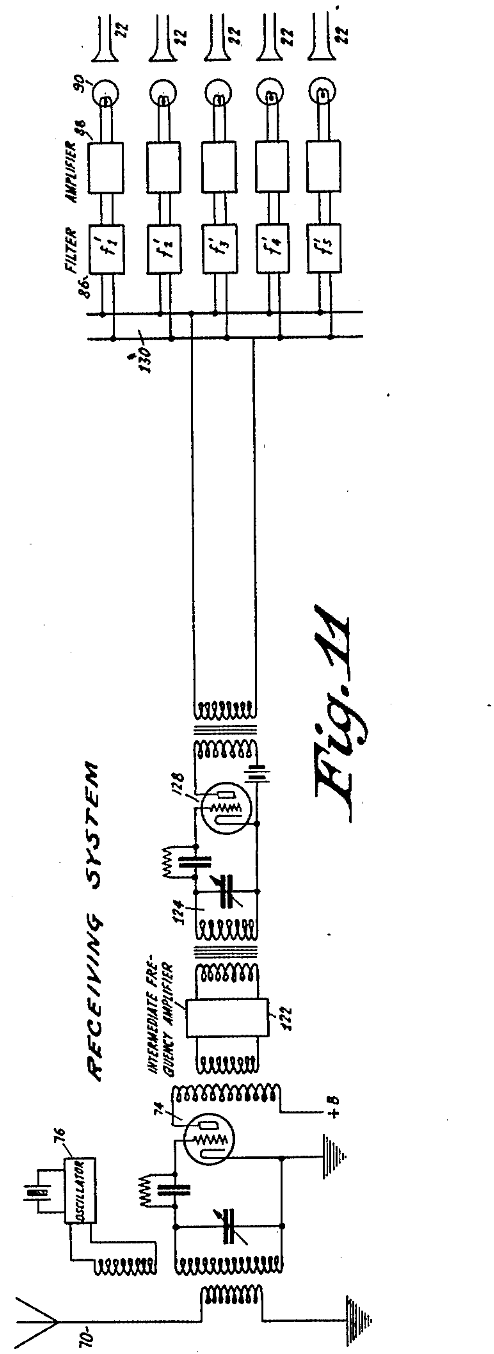

Fig. 11

INVENTOR
CLARENCE W. HANSELL
BY
Ira J. Adams
ATTORNEY

Patented Mar. 25, 1930 **1,751,584**

UNITED STATES PATENT OFFICE

CLARENCE W. HANSELL, OF ROCKY POINT, NEW YORK, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

PICTURE TRANSMISSION

Application filed August 13, 1927. Serial No. 212,803.

This invention relates to picture transmission, and includes methods which may or may not involve the intermediate use of electrical energy.

It is an object of my invention to make possible the transmission of radiant energy in a curved path, and this I do by employing a conductor composed of transparent substance having a large critical refraction angle, such as quartz, and bending the conductor to follow the desired path.

It is a further object of my invention to control the concentration of energization, that is, to make possible a change in intensity as well as a change in direction of radiant energy during its transmission, and this I do by suitably varying the cross section of the quartz conductor.

It is a further object of my invention to make a conductor for radiant energy which shall be relatively flexible, which I do by building up a cable out of so many relatively fine strands of quartz that the resultant cable is sufficiently flexible for the purpose desired.

Such a cable is not merely suitable for conducting radiant energy but also for transmitting and reproducing radiant energy of varying intensities, for each strand is insulated from the adjacent strands, and therefore the intensity does not average. In effect, then, the cable becomes a picture transfer cable, which may be applied to a wide range of uses. For example, such a cable may be used for transferring the reading of instruments from inaccessible to accessible locations, as the reading of a gasoline gage from the gas tank to the dash board of an automobile. Or it may be used by surgeons for examining inaccessible internal parts of the body, or by mechanics to examine invisible interiors of complicated castings, or in war time as a flexible periscope.

I shall more particularly describe the use of such a cable in connection with picture transmission over great distances through the intermediate use of electrical waves. In such picture transmission it is customary to have movable means to scan the picture to be reproduced, and the resultant picture consists of the integral of a large number of such scanning movements. To transfer the light from the scanning means to a photo-electric cell has proved troublesome, and for this purpose my invention is especially applicable.

The time for transmission of a complete picture depends upon the total number of scanning movements necessary to integrate the picture, and to reduce the necessary number of scanning movements is a further object of my invention. This I propose to do by utilizing a multiple scanning means, and a plurality of photo-electric cells arranged to control a multiplex transmitter. For simultaneously scanning a plurality of adjacent points my picture transfer cable is especially useful, for at each end the strands may be separated and positioned as desired, and the flexibility of the intermediate cable permits movement of the scanning means, or if the scanning means are stationary and the picture is moved, the cable permits of picture transmission from closely adjacent points to separated photo-sensitive cells located out of the normal direct path of the radiant energy, in a very convenient manner.

To increase the speed of intelligence transmission efforts are being made to employ facsimile reproduction instead of telegraphic code. For this purpose my multiple scanning device is well applicable, for the ends of the cable strands may be arranged to simultaneously scan a plurality of adjacent points superposed transversely of the direction of a line of print, and so may transmit a complete line with a single passage, which eliminates many of the difficulties of exact synchronizing, as well as greatly increases the speed of operation. In simplest form only five scanning points are needed to reproduce a line of lettering, and a multiplex transmitter with five signal channels is quite feasible.

Such facsimile transmission leads to relative secrecy of signalling, for only stations properly equipped will be able to decode the transmitted signals. Furthermore, by the use of my special cable the relative order of the scanning lines may be mixed up as desired at the transmitter, and only if the receiver has its reproducing means similarly relatively transposed will the facsimile be properly reproduced. The electrical system used may be wired or wireless, and the signalling may be by make and break or by modulation, and if by modulation, it may be amplitude or frequency modulation.

For printing the received signals I prefer to use photographic printing means arranged very similarly to the transmitting means except that in place of the photo-electric cells there are light sources independently responsive to the electrical signals received over the various signal channels, and light from each of these sources is impressed upon the separated ends of the strands of a quartz cable. The other end of the cable is formed into a multiple printing means which is placed in transverse juxtaposition to a light sensitive surface on which the facsimile is printed.

The invention is described more in detail in the following specification which is accompanied by drawings in which—

Figure 1 shows a conductor of transparent material characterized by a large critical angle of refraction;

Figure 2 indicates a cable composed of a large number of strands of such material;

Figure 3 represents the scanning end of a cable used for facsimile transmission;

Figure 4 is a cross section of such a cable having a flexible core;

Figure 5 is a cross section of a cable as in Figure 4 wherein each strand is itself a cable;

Figure 6 shows how the terminae may be formed into convenient shapes of desired cross section area;

Figure 7 schematically indicates both a scanning arrangement at a transmitter, and a printing arrangement at a receiver;

Figure 8 is a wiring diagram for a transmitter;

Figure 9 is a wiring diagram for a receiver;

Figure 10 is a transmitter for frequency modulation; and

Figure 11 is a receiver for frequency modulated signals.

Referring to Figure 1 it is seen that radiant energy from a source 2 is impressed on a transversely cut end of a conductor 6. This conductor is preferably made of fused quartz but may be made of glass, though with less satisfaction, or of any transparent substance having a large critical angle of refraction, so that the rays of radiant energy are refracted, somewhat as indicated by the dotted lines in the figure. If the curvature is not made too sharp the radiant energy is entirely confined and is emitted at the other end 8. Radiant heat energy is transferred as well as light energy, and experimentally, the remote end of such a rod may be used to ignite paper even though the conductor is quite cool along its surface, and may be held without any sensation of heat.

The radiant energy in such a conductor is mixed up and averaged out at the far end. If it is desired to transmit radiant energy of varying intensities and to reproduce equivalent energies at another point a cable may be formed, as is indicated in Figure 2. If the cable is used for picture transfer it is obvious that the fineness of detail will depend upon the cross section area of the individual strands. The cable may be twisted, but for picture transfer the strands should keep their relative position. Such a cable constitutes a simple means for looking around corners and complicated curves, and is very useful when circumstances are such that reflecting prisms or mirrors cannot well be used. As has already been mentioned, it may be used for transferring the readings of gages, or for any number of inspection purposes.

I intend more particularly to employ the cable for picture and facsimile transmission. Figure 3 indicates a cable intended for multiple scanning where a five channel multiplex signal system is to be used. There is a scanning head 14 within which there are clamped the ends of five parts of the quartz cable 16.

For increasing flexibility a core of more flexible material may be used as indicated in Figure 4, the quartz conductors 18 being wound upon a core 20. Also each of the conductors 18 may itself be a cable composed of a large number of fine quartz threads which may be arranged indiscriminately, as indicated by the cables 22 formed upon the core 20 in Figure 5.

In Figure 6 there is shown a conductor the end 10 of which has been formed into a desirable shape for scanning a line of a picture, while the other end 12 has been enlarged to permit the light picked up at the end 10 to be impressed upon a greater area of a photoelectric cell. A similar conductor is useful at the receiving end, for the large end 12 may be exposed to a fluctuating light source, while the light is then greatly intensified and reproduced at as small an area as desired for the photographic printing.

Referring to Figure 7 there is a drum 30 on which a picture 32 is fixed. The drum may be transparent, and illuminated from within. The cable 16 terminates at one end in a scanning head 14 which is reciprocated longtudinally of the drum 30 by a reciprocating carriage 34. Mechanism is provided so that at each reciprocation of the carriage 34 the drum 30 is rotated a distance equivalent to the spacing between the lines of type, in the case of facsimile transmission, but in the case of picture transmission the rotation is equivalent to the effective width of the scanning head 14.

It is thought not necessary to describe the mechanical details, nor the method of synchronizing the transmitter and the receiver by means of synchronizing signals at the end of each line or other equivalent methods, as these are not new with me, and satisfactory means are known in the art. One mechanical arrangement which is quite suitable is described in a patent application of R. H. Ranger, Serial No. 128,720, filed August 12th, 1926.

The cable 16 leads to an enclosure 36, within which there are located photo-electric cells and associated circuits which are further described in connection with Figures 8 and 10.

In Figure 8, the five ends of the quartz cable, numbered 22, are suitably enlarged and conveniently separated, and each is placed in juxtaposition to a photo-electric cell 40. The cell is in series with a resistance 42, and thence, by way of the conductor 44, with a source of constant electromotive force C. As the resistance of the cell 40 is altered according to the light sensitization impressed thereon the potential at a point between the cell 40 and the constant resistance 42 fluctuates, and this potential fluctutation is impressed on the grid of an electron emission tube 46. There are five such tubes, and the anode circuits of these tubes are provided with relay coils 48 which influence armatures 50 to make and break the circuits of the alternating current sources 52, which each have different frequencies, indicated by f_1, f_2, f_3, f_4, and f_5, each representing a separate signal channel. The alternating current sources may be miniature rotary converters, or rotary frequency changers energized from a single alternating current line.

The complex wave representing the sum at any instant of the waves of frequency f_1, f_2, etc., is transferred over a line 54, which may be a long land line leading from the transmitter to the receiver, in the case of wire transmission, or from an urban office to a suburban transmission station, in the case of radio transmission.

At the radio transmitting station there is a source of carrier frequency 56, which preferably is crystal controlled by a crystal 58. The carrier energy is supplied symmetrically to a push-pull modulator 60, as shown in the wiring diagram, and in consequence of this the carrier is eliminated from the output 62, and only the two side bands and the original modulating frequencies are produced. A filter 64 is arranged preferably as a high pass filter with cut-off at the carrier frequency, so that the modulating frequencies and the lower side band are eliminated. The upper side band is amplified by a power amplifier 66, the output from which is radiated by means of an antenna system 68, the exact form of which will depend on considerations such as frequency and directivity.

The transmitter has been described in simple form, and it is clear that the use of relays such as 48, 50 is probably only good for facsimile transmission, because such relays do not reproduce the varying shades of light characteristic of a picture, that is, they either make or break, according as the picture is dark or light. In the case of picture transmission it is preferably to obtain modulation rather than make or break, and to do this we may amplify the energy output from each tube 46 and use it to modulate energy of frequencies f_1, f_2, etc., or we may use the simple direct modulation scheme shown in the left hand portion of Figure 10. The modulation of these land line frequencies will then be reproduced in the side band finally transmitted from the antenna system 68.

Figure 9 indicates a receiving circuit in simple form. The signals are picked up on an antenna 70 and are transferred through a coupling 72 to a rectifying tube 74. A heterodyning current is supplied from a source 76, which preferably is crystal controlled by a crystal 78, and combined with the incoming wave by means of the coupling 72 and the rectifying tube 74. The heterodyning frequency may equal the carrier frequency at the transmitter, in which case the beat frequencies will equal the frequencies f_1, f_2, etc. To so do is convenient, but not necessary, for if the heterodyne frequency is different the beat frequencies will be f_1', f_2', etc., which will differ from each other by the same amounts as the frequencies f_1, f_2, etc.

The complex low frequency wave may be amplified by an amplifier 80 and then conveyed over a land line 82 to a reproducing means located wherever convenient. In the case of wire transmission the line will be the line 82, connected to the line 54 in Figure 8. At the end of the line there may be an amplifier 84, the output of which is coupled to filters 86 each of which is adjusted to select one of the frequencies f_1', f_2', etc. The output of the filters 86 may be amplified by amplifiers 88, and then used either indirectly, or directly, as shown, to energize light sources 90. These are exposed to the ends 22 of a picture transfer cable such as was used at the transmitting station.

Referring again to Figure 7, the light energies from the sources 90 are conveyed by the cable 16 to a reproducing head 14 which is reciprocated by a carriage 34 across a photo sensitive surface 32 mounted upon a drum 30. It is clear that if the reciprocations of carriage 34 at the transmitter and at the receiver occur even relatively crudely in synchronism the facsimile will be reproduced with sufficient fidelity.

Another arrangement for transmission is indicated in Figure 10, in which it is seen that the ends 22 of the strands of a light cable are positioned before light sensitive cells 40, as in Figure 8. The cells, instead of being connected in series with a direct current source, are in series with alternating current sources 52, having frequencies f_1, f_2, etc. Each cell being essentially a variable resistance this arrangement results directly in amplitude modulation of the alternating energies. The modulated signal energies are preferably amplified in the amplifying tubes 102, the output from which is coupled by means of the transformers 104 to a common bus 106 to which a land line 54 is connected.

As so far described this arrangement provides a complex signalling wave the component energies of which are modulated rather than completely cut off, and the land line 54 may be connected to a carrier suppression modulator such as was described in connection with Figure 8. However, in some cases it may be desirable to use frequency modulation, rather than amplitude modulation, and in such a case the signal energy from the land line 54 in either Figure 8 or 10 is led to a frequency wobbler.

This has been shown in Figure 10, wherein the oscillator 110 has for part of the reactance of its resonant circuit 112 the radio frequency winding of a magnetic wobbler 114. The land line 54 is connected to the saturation winding of the wobbler. The frequency F_1 of the frequency modulated oscillator 110 may be a transmission frequency, or it may be an intermediate frequency which is then used to modulate energy of a higher frequency F_2 generated in a constant frequency oscillator 116. The energy from this oscillator is coupled symmetrically through radio frequency condensers to a push-pull modulator stage 120. The frequency modulated energy of intermediate frequency is used to modulate high frequency energy, and of the two resulting side bands the filter 64 selects one, which may then be amplified in a power amplifier 66 and radiated from an antenna system 68. The side band is constant in amplitude because the intermediate frequency energy is constant in amplitude, while the mean frequency F_1 plus F_2 is quite uniform because of the stability of the high frequency oscillator 116, which preferably is crystal controlled.

A receiver for frequency modulated signals has been shown in Figure 11, in which the energy picked up by the antenna system 70 is coupled to the input circuit of a combining tube 74, to which there is also coupled an oscillator 76. The local oscillator may supply energy of frequency F_2, in which case there will result a beat frequency equal to the transmission intermediate frequency F_1, but this is not an essential condition. The intermediate frequency energy is amplified in an amplifier 122, the output from which is coupled to an analyzing circuit 124. This is a resonant circuit the frequency of which is adjusted to lie to one side of the operating range of intermediate frequency supplied to it, in order to change the frequency modulation of the intermediate frequency energy to amplitude modulation. The amplitude modulated energy is rectified by a detector tube 128, the output from which is a complex wave made up of the component signals on the channels of frequencies f_1, f_2, etc. This energy is supplied to a bus 130, from which the signals are separated by the filters 86, and amplified, if necessary, in amplifiers 88, the output from which is led to suitable luminous devices 90. The resulting modulated light energy is directed towards the ends 22 of a light cable 16, as has already been described in connection with Figure 7.

The systems described are relatively secret because an intercepting receiver will have to exactly duplicate the actual receiver employed. Even with make and break signalling, as is shown in Figure 8, ordinary receivers will be unable to multiplex and unable to decode the equivalent dots and dashes of a single scanning line. The secrecy may be further increased by rearranging the relative order of the scanning lines in a similar manner at both the transmitter and the receiver.

It is clear that the arrangement disclosed herein may be used on land lines as well as with radio systems. Any convenient number of signal channels may be employed. Any type of multiplex transmitter and receiver may be utilized, whether employing frequency or amplitude modulation, and I shall therefore use the term modulation broadly, intending it to include both.

I claim:

1. In combination, a source of radiant energy, a device located out of the normal direct path of said radiant energy for response thereto, and means to convey said energy from the source to the device comprising a flexible quartz conductor capable of being moved relatively thereto, said conductor having transversely cut ends located in juxtaposition to the source and the device.

2. In combination, a surface to be scanned, scanning means including one end of a relatively flexible strand of quartz, means provided by said flexibility for permitting movement of said scanning means relative to said surface, photo-electric means responsive to the light intensity of said surface, and means comprising the aforesaid strand of quartz to convey the light from the surface to the photo-electric means.

3. In combination, a surface to be scanned, scanning means including one end of a relatively flexible quartz cable having a plurality of strands of quartz for scanning a predetermined number of unit areas of said surface, means provided by said flexibility of cable for permitting relative motion between said scanning means and said surface, photo-electric means responsive to the light intensity of

said surface, and means comprising the aforesaid quartz cable to convey the light from the surface to the photo-electric means.

4. In combination, a surface to be scanned, scanning means including one end of a relatively flexible quartz cable having a plurality of strands of quartz, means to move said scanning means over said surface, a plurality of photo-electric cells responsive to the light intensity of the portions of said surface scanned by the strands of said cable, and means comprising the aforesaid cable to convey the light from said surface portions to the cells.

5. In combination, a surface to be scanned, scanning means including one end of a relatively flexible quartz cable having a plurality of strands of quartz, means to move said scanning means over said surface, a plurality of separated photo-electric cells responsive to the light intensity of the portions of said surface scanned by the strands of said cable, and means comprising the aforesaid cable to convey the light from said surface portions to the cells, the strands of said cable being spread apart at one end and positioned separately adjacent the cells.

6. A picture transmission system comprising multiple scanning means, a plurality of photo-electric cells, a plurality of quartz conductors for conveying light from the multiple scanning means to the cells, a multiplex transmitter having a plurality of signal channels, and means controlled by the cells for signalling on the several channels in accordance with the light intensities impressed on the multiple scanning means.

7. A facsimile transmission system comprising a plurality of photo-electric cells, a plurality of strands of quartz one set of ends of which are superposed transversely of a line of print for scanning the line in a single scanning movement and the other ends of which are conveniently separated and increased in area for cooperation with the plurality of photo-electric cells, and a multiplex transmission system the several signal channels of which are independently controlled by said cells.

8. In combination, a light sensitive surface to be printed, printing means including one end of a relatively flexible strand of quartz, means provided by the flexibility of said quartz strand for permitting movement of said printing means over said surface, a luminous source responsive to received electrical signals, and means comprising the aforesaid strand of quartz to convey light from the source to the printing means.

9. In combination, a light sensitive surface to be printed, printing means including one end of a relatively flexible quartz cable having a plurality of strands of quartz for printing a plurality of unit areas on said surface simultaneously, means to move the printing means over said surface and means provided by the flexibility of said cable for permitting said movement of the said printing means relative to said surface, a luminous source responsive to received electrical signals, and means comprising the aforesaid quartz cable to convey light from the source to the surface.

10. In combination, a light sensitive surface to be printed, multiple printing means including one end of a relatively flexible quartz cable having a plurality of strands of quartz, means to move said printing means over said surface, a plurality of luminous sources each independently responsive to received electrical signals, and means comprising the aforesaid cable to independently convey light from each of said sources to the printing means.

11. In combination, a light sensitive surface to be printed, a relatively flexible quartz cable formed of a plurality of strands separated at one end, printing means including the other ends of the strands of the quartz cable arranged in superposition, means to move said printing means over said surface, a plurality of separated luminous sources each independently responsive to received electrical signals, and means comprising the strands of the aforesaid quartz cable to convey light from each of said sources to the printing means, the separated ends of the strands of said cable being positioned adjacent the separated luminous sources.

12. In a picture transmission system, a reproducer comprising a plurality of variable light sources, a plurality of strands of quartz one set of ends of which are positioned transversely of the direction of printing and the other ends of which are conveniently separated and increased in area for cooperation with the plurality of variable light sources, and a multiplex receiving system for independently controlling the light emission from each of said sources.

13. In a facsimile transmission system, a reproducer comprising a plurality of variable light sources, a plurality of strands of quartz one set of ends of which are superposed transversely of the direction of a line of print for photo printing the line in a single passage and the other ends of which are conveniently separated and increased in area for cooperation with the plurality of variable light sources, and a multiplex receiving system for independently controlling the light emission from each of said sources.

14. In combination, a surface to be scanned, a light responsive relay, and a flexible member of greater refractive boundary than the surrounding medium for conveying impressions of the light intensity on said surface to said relay, and means provided by the flexibility of said member for permitting relative motions between said surface and member for successively causing responses

from said relay proportionate to the successive light intensities forming the entirety of said surface.

15. The combination of a source of light, a relatively long flexible light conveying element having a sharp light confining boundary throughout its length for distributing light from said source, a surface responsive to light and means provided by the flexibility of said element for permitting movement thereof relative to said surface for causing said light to influence the same, and means for effecting relative movement of the said cable to said surface.

16. The combination of a source of light, a plurality of flexible conducting rods adjacent said source for picking up the light therefrom and distributing the same at a point remote therefrom in a predetermined manner, a light sensitive record surface at the end of said rods remote from said source, and means provided by said flexibility of rods and the plurality thereof for respectively permitting relative motion between said rods and said surface and influencing said light sensitive surface at a plurality of points simultaneously.

17. A system for increasing the speed of picture transmission by multiplexing which includes means for simultaneously scanning a plurality of adjacent points located transversely of the direction of scanning, a plurality of elongated flexible light conveying elements for conveying the light from each of said points along predetermined paths, a photo-electric element at the end of each of said light conveying elements, means for simultaneously transmitting a plurality of independent signals over carriers of different frequencies, and means provided by said photo-electric elements for simultaneously modulating each of said carriers in accordance with the intensity of light and shadow conveyed through each of said light conducting elements for influencing said cells.

CLARENCE W. HANSELL.