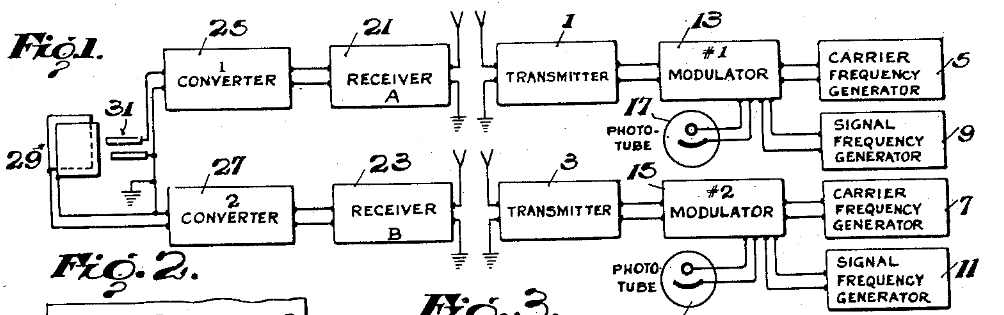
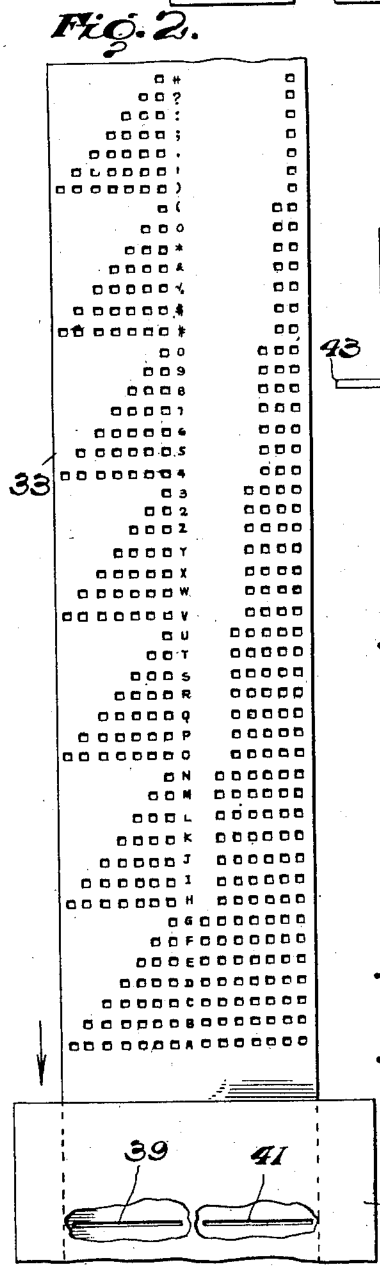
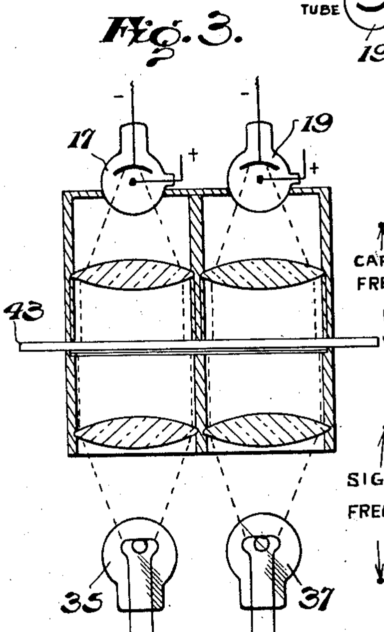
March 3, 1942. J. T. McNANEY 2,275,017

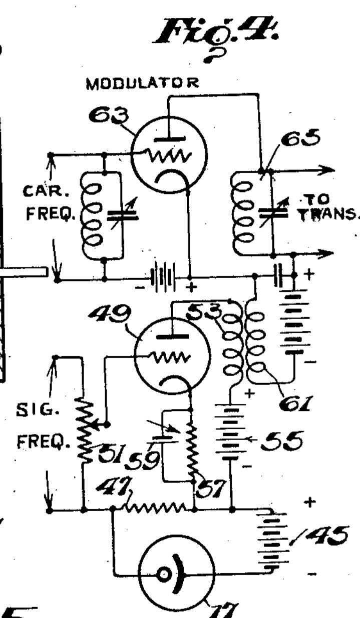
SIGNALING SYSTEM

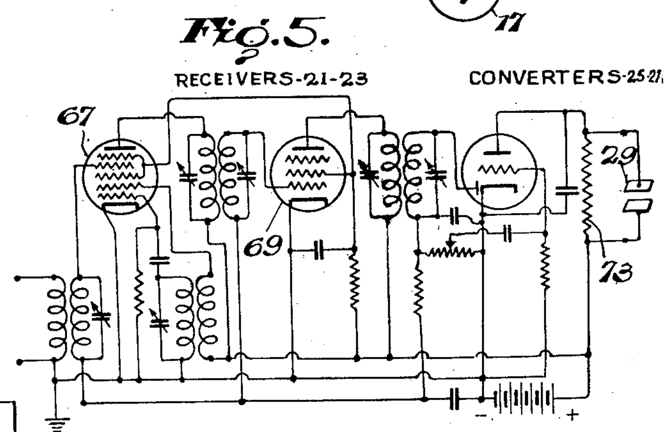
Filed June 18, 1940 2 Sheets-Sheet 1











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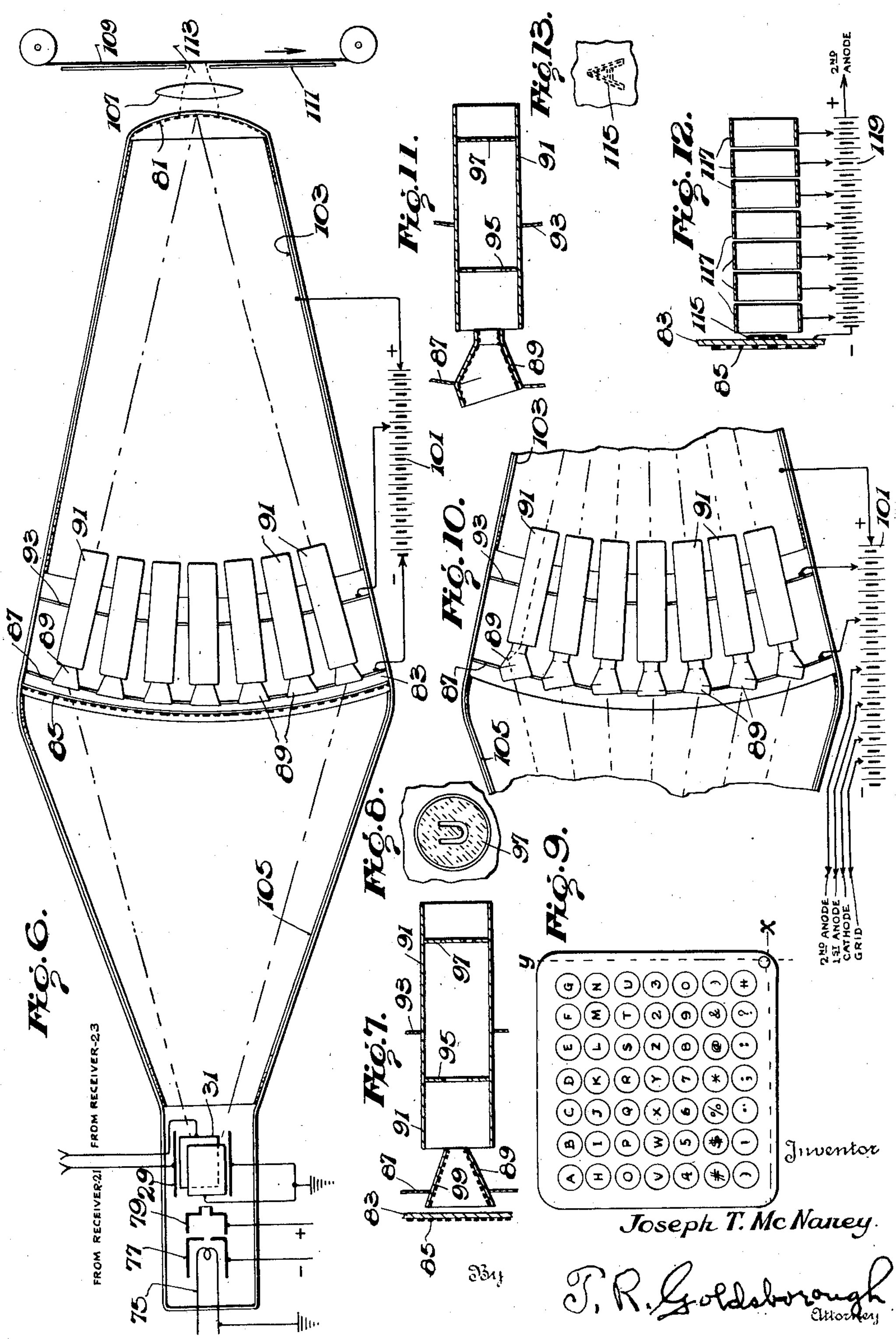
March 3, 1942 J. T. McNANEY 2,275,017

SIGNALING SYSTEM

Filed June 18, 1940 2 Sheets-Sheet 2



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2,275,017

SIGNALING SYSTEM

Joseph T. McNaney, Baltimore, Md.

Application June 18, 1940, Serial No. 341,196

7 Claims. (Cl. 178—15)

My invention relates to signaling systems and it has a particular relation to high speed systems of the type wherein a perforated tape or the like is utilized at the transmitter and means at the receiver are utilized for making a permanent record of a received message.

Heretofore, in systems of the general type to which my invention pertains, the limitation upon the speed of transmission and reception has been largely mechanical. That is to say, referring for example to teletype systems, the inertia of the moving parts at the receiver prevents ultra high speed and in printing telegraphs the same limitation appears.

It is, accordingly, an object of my invention to provide a signaling system wherein the speed of transmission and reception is substantially unlimited, within reason, and a permanent record of the message is formed.

Another object of my invention is to provide a system of the type described that shall be substantially unaffected by static.

Another object of my invention is to provide, in a signalling system of the type referred to, receiving apparatus that shall enable the making of a photographic record of an incoming message.

Another object of my invention is to provide a novel receiving tube wherein incoming electrical impulses representing message-characters may be translated into light and the light therefrom is of such nature that it may be utilized for the purpose of making a photographic record.

A still further and more specific object of my invention is to provide a novel receiving tube of the cathode ray type that shall be capable of translating incoming electrical impulses representing characters of a message into visible replicas of the said characters, which replicas may be utilized for photographic recording.

The novel features of my invention are set forth with particularity in the appended claims; the invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawings, wherein:

Figure 1 is a diagramamtic view, highly conventionalized, of a signaling system embodying my invention,

Figure 2 is a view of a perforated tape of the type utilized in the transmitting portion of my system,

Figure 3 is a view partly in section exemplifying the manner in which the perforated tape is utilized for the purpose of providing a plurality of groups of electrical impulses, each group of impulses being representative of a message-character,

Figure 4 is a circuit diagram exemplifying the utilization of photo-electric currents for the purpose of controlling the modulation of a transmitter.

Figure 5 is a circuit diagram of a receiver utilized in my system,

Figure 6 is a conventionalized view, partly in section, of my novel cathode ray translating tube and exemplifying the manner in which the tube is employed for the purpose of photographically recording an incoming message,

Figure 7 is a view in vertical section of a gun-element of the cathode ray tube shown in Figure 6,

Figure 8 is an enlarged view of one of the diaphragms in the element shown in Figure 7,

Figure 9 is a view in vertical elevation of the electron gun asesmbly exemplified by Figure 6, looking into the tube from the recording end thereof,

Figure 10 is a fragmentary view, partly in section and partly in vertical elevation, exemplifying an alternative form of my cathode ray tube.

Figure 11 is an enlarged sectionalized view of one of the electron guns shown in Figure 10,

Figure 12 is a fragmentary view in vertical section exemplifying an alternative embodiment of my invention, and

Figure 13 is an enlarged elevational view of a portion of the apparatus shown in Figure 12.

In accordance with my invention, I provide means for transmitting two modulated carrier waves by wire or radio, the said waves being utilized at the receiving end of the system for determining the momentary angles of deflection of a locally generated cathode ray, the coordinates of the position of the ray in turn determining a particular character of a transmitted message. More specifically, referring now to Figure 1 of the drawings, at the transmitting end of the system, I provide two radio transmitters 1 and 3, two carrier frequency generators 5 and 7, two signal frequency generators 9 and 11, and two modulators 13 and 15, the percentage of modulation in each modulator being determined, simultaneously, by the output from two photo electric cells 17 and 19. At the receiving end, it being understood that the two transmitters send on different carrier frequencies, I provide two receivers 21 and 23 permanently tuned to the carrier frequencies and two converters 25 and 27 for changing the incoming signals to D. C. potentials, which potentials are simultaneously impressed across pairs of deflecting plates 29 and 31 in a cathode ray receiving tube.

For the purpose of providing message modulated light for the two transmitting photo-electric cells, 17 and 19 I provide, as shown in Figures 2 and 3, a perforated tape 33 that is caused to advance between the photo electric cells and a pair of light sources 35 and 37, the light falling on the photo tubes being limited by two slots 39 and 41 in a mask 43 interposed between the said tubes and the light sources.

Referring still to Figure 2, it will be noted that the tape carries a plurality of paired groups of perforations disposed at each side of the center thereof, the groups extending transversely of the tape in alignment with the respective slots in the mask, whereby, when the tape is caused to advance between the light sources and the photo tubes the amount of light reaching each tube is determined by the number of perforations momentarily interposed between it and its individual light source. It will also be noticed that the several transverse slots in the mask are narrower than any perforation through the tape, considered in the direction of the travel thereof, whereby each group of the said perforations dwells for a short space of time before the slot corresponding to it. The slots in the actual apparatus are much narrower than shown in the drawings.

In Figure 2, I have made no attempt to exemplify an actual message but have shown instead the manner in which the transverse paired groups of perforations may be so designed as to the relative number of perforations per group that 49 separate and distinct characters may be transmitted. It may be pre-punched by any suitable device.

The manner in which each one of the two photo electric cells is utilized in the transmitter to modulate a carrier wave is exemplified by the transmitter diagram of Figure 4. The space current path in a photo tube is connected in series with a source 45 of potential and a biasing resistor 47, which resistor is included in the input circuit of a thermionic tube 49 in series with an additional adjustable resistor across which a modulating frequency at constant amplitude is impressed. The modulating frequency, for example, may be within the audible range, such as one thousand cycles or the like, and it is preferably the same for both photo tubes. The anode circuit of the thermionic tube includes the primary coil 53 of a transformer, a source 55 of potential and a self-bias resistor 57 shunted by a by-pass condenser 59.

The secondary coil 61 of the transformer is included in the anode circuit of a modulator tube 63, in series with an impedance device such as a tuned circuit 65. The carrier frequency is impressed upon the input circuit of the modulator tube 63 from an oscillator (not shown) and appears across the impedence device, modulated by the signal frequency which is introduced into the anode circuit thereof from the secondary winding of the transformer.

The percentage of modulation of the carrier frequency depends upon the amplitude of the signal frequency supplied to the anode circuit from the photo-cell-controlled tube 49; the said signal frequency amplitude, in turn, is a function of the negative bias applied to the grid of the tube 49 and the strength of the input thereto from the signal frequency generator.

It will be noted from inspection of Figure 4, that the direction of current flow through the photo tube and the resistor 47 is such that increased current produces a more negative potential upon the grid of the thermionic tube 49 connected thereto lessening amplification therein. In the operation of the apparatus, when no light through the perforated tape reaches the photo electric cell, the resistor 51 across which the signal frequency is impressed is so adjusted that the normal self-bias applied to the grid from the cathode resistor 57 is just sufficient to permit 100% modulation of the carrier frequency in the modulator tube. Obviously, when light falls upon the cathode of the photo electric cell, the bias applied to the tube becomes more negative, thus lessening the percentage of modulation. The amount of modulation of the carrier of each transmitter from maximum, or 100%, toward zero is controlled in seven discreet steps depending upon the number of perforations in the group of perforations that momentarily permits light to reach the corresponding photo cell.

Referring once more to Figure 2 of the drawings, it will be noted that the paired groups of perforations allocated, respectively, to each of the forty-nine characters are so chosen that the light simultaneously reaching the two photo tubes differs, the amount of difference depending upon the particular character momentarily being transmitted. For example, the paired groups of perforations representing the character "A" are equal. Thus, when "A" is being transmitted, each photo-cell receives the same amount of light, this amount being the greatest of the seven different amounts controlled by the perforations, and the percentage of modulation of each carrier will be changed from 100% to the lowest of the seven predetermined amounts. Again, if the character "G" is being transmitted, it will be noted that one unit of light reaches one of the photo-tubes while seven units of light reach the other tube. In that event, one carrier is modulated at the highest percentage of the seven predetermined amounts eblow 100% while the other carrier is modulated at the lowest of the seven predetermined percentages.

Each character is represented by analogous dissimilar paired groups of perforations. This feature of my invention is very important because, as will be clear to those familiar with mathematics, each character may be denoted by X—Y coordinates. As an example, referring also to Figure 9, "A" could be represented by —7X, 7Y; "G" by —X, 7Y; "T" by —2X, 5Y, and so on with the remaining characters, each character thus being capable of being represented by a definite locus in a plane. The manner in which I take further advantage of the geometric relation between the perforation-groups and of the consequent geometric relation of the percentages of modulation of the two carrier waves, in the receiver, will be apparent hereinafter.

Referring now to Figures 1 and 5 of the drawings, two modulated carrier waves are received by two separate radio receivers 21 and 23 tuned, respectively, thereto and two D. C. potentials are derived therefrom by two converters 25, 27. The amplitudes of the D. C. potentials are proportional to the percentages of modulation of the two carriers. It is to be understood, of course, that the carrier waves may be transmitted either by radio or over line wires or the equivalent.

As shown in Figure 5 of the drawings, the receiver and converters are conventional in design comprising a detector 67 and ampilfier and a thermionic tube 71 having an auxiliary diode circuit on which the detected and amplified signal is impressed. The last mentioned tube functions in a manner well known to those skilled in the art and provides, across a resistor 73 included in the output circuit thereof, a D. C. potential proportional to the amplitude of modulation of the incoming carrier wave. Inasmuch as each receiver is provided with AVC, the 100% modulated portions of the several carriers, corresponding to darkness at the transmitting photo cells, may be kept at a definite level which will serve as the upper limit of a gauge or a voltage. The varying momentary "drops" from this constant level will be voltages that represent the coordinates of a message character as hereinbefore explained.

For the purpose of making use of the voltages representing character coordinates, I prefer to utilize a composite cathode ray tube of novel design exemplified by Figure 6 of the drawings. Such a tube has at one end thereof a thermionic cathode 75, a grid 77, an electron gun 79 and two pairs of deflecting plates 29 and 31. At the extreme opposite end of the tube the interior surface carries a layer 81 of fluorescent material such as Willemite or the like. At the position intermediate the two ends of the tube is disposed a transparent screen 83 coated, on the side facing the deflecting plates, with a layer 85 of fluorescent material. Opposite the side of the screen facing the fluorescent end of the composite tube, which screen may be curved as shown in the drawings, is mounted a metallic supporting element 87 provided with forty-nine conical cups 89 having their larger openings exposed to the partition bearing the fluorescent material and their smaller openings pointing toward the open ends of an equivalent number of electron guns 91 carried and electrically connected together by a second metallic supporting element. The cups and the electron guns corresponding thereto are arranged, substantially as shown in Figure 9, in seven rows, each row comprising seven cup-gun combinations. The cups and guns, therefor, have definite X—Y coordinates as explained in connection with the description of my transmitting tape.

Preferably, the composite tube takes substantially the form of a double cone with the fluorescent screen interposed at the junction of the bases thereof and the electron guns mounted in that portion, the end of which carries the fluorescent screen. Each of the guns, which may be made from nickel or an analogous material, is provided as shown in Figure 7 with one or more electron-limiting perforated diaphragms 95, 97, the opening in the diaphragm 97 nearest the fluorescent screen in each gun corresponding in contour to a message-character. It will also be noted from an inspection of Figure 6 that the guns are trained upon the center of the fluorescent screen.

The interior surface of each of the cups has a coating 99 material, such as a caesium compound which, when exposed to light from the central fluorescent screen, emits photo electrons and the cups 89 are maintained at a negative potential with respect to the guns 91. The potential may be derived from any suitable source such as a battery 101, the most positive point in the source being connected to a focusing anode 103 mounted within the tube. The portion of the tube, extending toward the deflecting plates, is also supplied with an interior focusing anode 105 which is maintained at a high positive potential with respect to the thermionic cathode 7.

In the operation of the receiving tube, potentials determined by the light received by the several transmitting photo-cells, as the tape moves before them, are impressed from the two-receiver converters, respectively, across the several pairs of deflecting plates. When these two potentials are equal and maximum, corresponding to the no-signal condition, the cathode ray assumes a position designated 0 in Fig. 9. If now the letter "A" is transmitted and received, the modulation of each carrier is reduced seven units, and the ray is deflected to a position on the main fluorescent screen in front of the cup-gun combination wherein the diaphragm 97 has an opening conforming in contour to that letter. Such position might be represented by the notation —7X, 7Y . . . Analogous dissimilar pairs of potentials, each less than the maximum corresponding to 100% modulation at the transmitter, cause proportional deflections of the cathode ray which ray dwells on the proper spot on the screen for the space of time required for a row of perforations to travel between the photo-cells and the light sources in the transmitter.

Light emitted by the main fluorescent screen 85, at any given position of the deflected ray, falls upon the interior surface of the conical cup 89 allocated to that position and causes the emission of photo-electrons that are accelerated through the corresponding gun 91 to ultimately impinge upon the small fluorescent screen 81 at the recording end of the tube. As the stream of electrons emerges from the gun, it has a cross section corresponding to the contour of the character-perforation in the interior gun-diaphragm. For example, if the gun-diaphragm is provided with a U-shaped perforation, as shown in Figure 8, only those electrons corresponding to the U will pass therethrough and will be shot against the fluorescent screen 81 at the extreme end of the tube and thereat will be reconverted into a visible image of the said character for the purpose of recording the said character.

A lens system 107 is provided which focuses light from the fluorescent screen onto a moving strip 109 of photo-sensitive material. A diaphragm 111 having an opening 113 therethrough may be interposed between the lens system and the moving light sensitive material. Obviously, the entire apparatus may be enclosed in a light-tight housing to prevent the light-sensitive material from receiving any light other than that transmitted to it from the fluorescent screen by way of the lens system. The specific arrangement of the housing and other details of the film advancing mechanism form no part of my present invention and, for that reason, they have not been illustrated.

The film or other light-sensitive material is given continuous motion past the opening in the mask, the rate of travel being commensurate with the rate of travel of the perforated tape of the transmitter. By this, I mean that the linear speed of the record-receiving material should be such that an unexposed portion thereof is moved into place during the instant of time consumed by the cathode ray in moving from one point on the fluorescent screen to another.

Because of the fact that the cathode ray itself is devoid of inertia the speed of transmission is limited only by the rate at which the transmitting tape may be caused to move past the transmitting photo cells, the photo-sensitivity of the record receiving material and the maximum speed at which the said material may be caused to pass through the apparatus. My research into these problems has led me to the conclusion that the ultimate speed obtainable by my improved system is much greater than with any other system heretofore utilized, although at this time I am unable to state with certainty the maximum number of words per minute the system is capable of handling.

Instead of converting the cathode ray into light and reconverting the light into an electron stream to represent a character of a message, it lies within the scope of my invention to utilize the deflected cathode ray itself, reinforced by secondary electrons, for that purpose. Referring to Figures 10 and 11, when employing the cathode ray direct the central fluorescent screen **83**—**85** is omitted and the cups **89** are provided with an inner coating of material that freely emits secondary electrons when under bombardment by the ray. A suitable coating is aluminum oxide.

In order to more efficiently make use of the cathode ray, the cups are focused, so to speak, upon the opening of the gun **79** in the cathode-ray generating portion of the composite tube; the construction of the small guns trained on the fluorescent screen is the same as that shown in Figures 6 and 7.

When receiving a signal by means of the alternative embodiment of my invention, the cathode ray, as it dwells within the opening of particular cup **89** corresponding to a message-character being momentarily received, causes the emission of secondary electrons. Such secondary electrons, together with electrons from the ray itself, are accelerated through the small gun **91** associated with the cup because of the positive potential applied thereto. The contour of the electron stream is determined by the perforation in the diaphragm **97** near the end of the small gun and the modified stream, under the influence of the potential of the focusing anode, strikes the fluorescent screen in the end of the tube to provide a visible image of the character.

It also lies within the scope of my invention to omit the perforated diaphragm in the small guns and to control the cross-section of each minor stream of electrons directly at its source. That modification is exemplified by Figs. 12 and 13 of the drawings and comprises the partition **83** carrying the main fluorescent screen **85** as exemplified by Figure 6. I dispense, however, with the cups carrying photo-emissive material and, instead, deposit such material on the surface of the partition, facing the small electron guns, in the form of a character **115** itself. The characters electrically interconnected in order that they may be maintained at a negative potential with respect to the associated electron guns. For that purpose, the surface of the partition may be provided with a substantially transparent metallic coating of gold or silver by the well known sputtering process before the characters are formed thereon. The coating is too thin to illustrate.

Because of the fact that the electron stream at its origin, has the proper cross section to represent a message character, the small guns **91** may each be a plain cylinder devoid of diaphragms or they may be constituted by a plurality of rings **117**, as shown in Figure 12. When rings are used, a potential gradient is maintained along the common axis thereof by connecting them to successively more positive points on a voltage source **119** the negative terminal of which is connected to the conductive layer on which the characters are formed.

From the foregoing description of my invention it will be seen that it offers practically unlimited possibilities insofar as rapidity of transmission and reception are concerned. Transients, such as static, will affect both receivers to substantially the same degree and, consequently they will give rise to equal decrements of potential across the pairs of deflecting plates. Even if strong, static will only urge the cathode ray diagonally of the screen toward the zero position thereon corresponding to 100% modulation. If, as a result of static, therefore, a character is omitted from the recorded message it may easily be interpolated by reference to a chart such as shown in Figure 9. The appearance of any recorded character itself cannot be marred by interference, because the ray must dwell for an appreciable length of time on a given portion of the screen to give rise to a photographic representation of the character.

No synchronization of the transmitter and the receiver is necessary as in other well known systems because the transmitter tape does not have to run at the same speed as the film.

The receiver being free of moving parts and electrical contacts is less likely to give trouble, at the same time being more reliable.

The high speeds possible will permit greater use of expensive land lines and submarine cables.

A signaling system of this type has possibilities for secret signaling.

Although I have shown and described a few specific embodiments of my invention, many other modifications thereof will be apparent to those skilled in the art to which it pertains. My invention, therefore, is not to be limited except by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In a signaling system, means for generating and for transmitting two carrier waves, means for simultaneously and individually modulating said waves to predetermined percentages in accordance with a message-character, two receiving devices for individually receiving said modulated waves, means connected to each receiving device for deriving two unidirectional potentials proportional, respectively, to the percentages of modulation of the received waves, a cathode ray tube provided with two independent ray-deflecting systems at one end, a fluorescent screen at the opposite end, means interposed between the ray-deflecting systems and the screen for deriving a plurality of minor electron streams from the cathode ray, and means for simultaneously impressing said unidirectional potentials upon said systems, respectively, to thereby control the deflection of the cathode ray over said interposed means.

2. In a signaling system, means for generating and for transmitting two carrier waves, means for simultaneously and individually modulating said waves at a constant frequency, means for controlling the percentages of modulation, respectively, in accordance with a message-character, two receiving devices for individually receiving said modulated waves, means connected to each receiving device for providing an unidirectional potential proportional to the percentage of

modulation of the wave received thereby, a cathode ray tube having a target adapted to provide secondary electrons in response to the cathode ray, and independent ray deflecting systems for causing the ray to move over the target, means for simultaneously impressing said potentials upon said systems, respectively, to thereby determine the coordinates of the point of impact of the ray upon the target, and means for making a record of the loci of the successive points of impact of the ray upon the target.

3. The invention set forth in claim 1, wherein the modulating means cause the two carrier waves to be modulated in definite, predetermined steps.

4. The method of signal transmission which comprises generating two carrier waves having different constant frequencies, causing each wave to be modulated at a substantially constant lower frequency, causing the percentage of modulation of each wave to differentially vary in predetermined steps, the relative percentage of modulation of the two waves corresponding to a definite message-character, and causing said waves to simultaneously travel to a remotely disposed receiver.

5. The method of signaling which comprises generating and transmitting two modulated carrier waves simultaneously, causing the percentage of modulation of said waves to differentially change in accordance with a message character, deriving two unidirectional potentials from said waves proportional, respectively, to the percentages of modulation thereof at any given instant, generating a cathode ray, utilizing said potentials to control the angular deflection of said ray, and making a record of the coordinates corresponding to each deflection thereof.

6. The method of signaling which comprises generating and transmitting two modulated carrier waves simultaneously, causing the percentage of modulation of said waves to differentially change in accordance with a message-character, deriving two unidirectional potentials from said waves proportional, respectively, to the percentages of modulation thereof at any given instant, generating a cathode ray, utilizing said potentials to control the angular deflection of said ray, deriving a stream of secondary electrons from the ray, utilizing the secondary electrons to energize a fluorescent screen and making a photographic record of the instantaneous appearance of said screen.

7. The method of signaling which comprises generating and transmitting two modulated carrier waves simultaneously, causing the percentage of modulating of said waves to differentially change in accordance with a message-character, deriving two unidirectional potentials from said waves proportional, respectively, to the percentages of modulation thereof at any given instant, generating a cathode ray, utilizing said potentials to control the angular deflection of said ray, causing the ray to control the generation of a stream of secondary electrons proportional in section to the angular deflection of the cathode ray, and deriving a photo-chemical effect proportional to the cross-section of the secondary electron stream.

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