

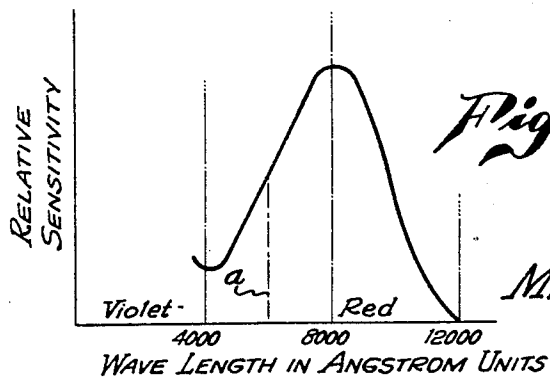
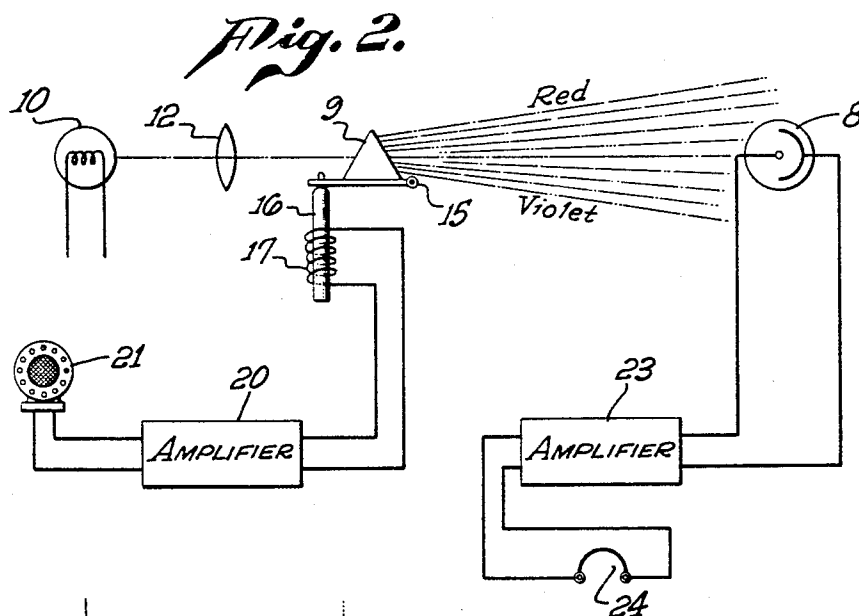
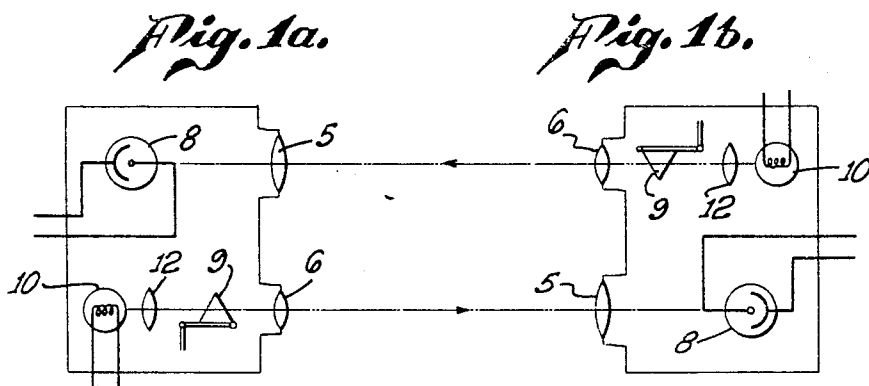
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FREQUENCY MODULATION LIGHT BEAM TRANSMISSION

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FREQUENCY MODULATION LIGHT BEAM TRANSMISSION

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This invention relates to signal communication systems and particularly to a communication system utilizing light waves as the transmission medium.

Light beam transmission systems are well-known in the art, an early system of this type being shown in Bell Patent No. 235,199 of December 7, 1880. During recent years, there have been many improvements to such systems, a modern light beam transmission system being disclosed and claimed in copending applications, Ser. No. 551,125, filed August 25, 1944, and Ser. No. 554,246, filed September 15, 1944. Although the improvements embodied in these recent systems are directed to new elements and their combination, they all utilize amplitude modulation of the light beam, that is, the light beam is modulated by varying its intensity or quanta, which variations are impressed on a receiving photo-sensitive device, such as a photoelectric cell. The output of the cell thus varies in accordance with the variations in intensity or quanta of the light beam received thereon.

The present invention uses the visible light spectrum as the transmitting medium as in the prior systems, but utilizes a type of modulation known in radio communication as "frequency modulation." The visible light spectrum is divided up into its various color components which are projected to the receiving unit at a constant intensity. The signal to be transmitted modulates the colored light beam by varying its position, such as by vibrating the beam in accordance with the amplitude of the signal to be transmitted. To detect these variations, a photoelectric cell, such as an RCA No. 923, having a particular color response characteristic, is used as a discriminator. As the color of the light impressed on the cell varies, the output of the cell varies accordingly. For instance, when the red end of the spectrum impinges upon the cell, maximum output is obtained, and when the blue end of the spectrum is impressed on the cell, minimum output is obtained. Thus, the system is arranged so that the light dividing element, such as a prism, shifts the beam impinging on the cell from the blue or violet end of the spectrum to the red end for the increasing amplitudes, and vice versa for decreasing amplitudes. In this manner, not only is a light beam communication system provided, but one which requires a special type of receiver for the detection of the signals. Thus, secret communication may be easily provided between units of the present invention.

The principal object of the invention, there-

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fore, is to facilitate communication by means of visible light waves.

Another object of the invention is to provide an improved system of light beam communication between two points.

A further object of the invention is to provide a light beam communication system wherein modulation and detection is obtained by frequency modulation.

A still further object of the invention is to provide an improved light beam communication system wherein signal modulation is produced by varying the color of the light transmitted and/or received.

A still further object of the invention is to provide a secret light beam communication system.

Although the novel features which are believed to be characteristic of this invention will be pointed out with particularity in the appended claims, the manner of its organization and the mode of its operation will be better understood by referring to the following description read in conjunction with the accompanying drawings forming a part hereof, in which:

Figs. 1a and 1b are diagrammatic views showing two units of a complete two-way communication system embodying the invention.

Fig. 2 is a circuit diagram of a complete one-way unit of a communication system embodying the invention, and

Fig. 3 is a graph showing the frequency response characteristic of the receiving photoelectric cell used in the invention.

Referring now to Figs. 1a and 1b, the units shown in each figure being identical, light receiving or collecting lenses 5 are shown aligned with light transmitting lenses 6 in the front of each of the units. The projecting lenses 6 are shown positioned so as to project light to the receiving lenses 5 when the units are properly aligned for communication. Behind each of the transmitting lenses 5 are photocells 8 upon which the light collected by the lenses 5 is projected. Behind each of the projection lenses 6 are prisms 9, light sources 10, and lenses 12 for concentrating light from the lamps 10 on the prisms 9.

The prisms 9 may be mounted in any suitable manner for oscillation, such as being pivoted at a point 15 and attached to an armature 16 of an electromagnet 17. (See Fig. 2.) The electromagnet is connected to the output of an amplifier 20 which is fed by a microphone or other signal pickup device 21. The photoelectric cell 8 is connected to an amplifier 23, the output of

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which is impressed upon a pair of earphones 24 or other sound reproducer.

As will be noted in Fig. 2, white light from the lamp 10 is divided into its component parts by the prism 9 so that the red end of the spectrum is at one side of the projected beam, and the violet or blue end is at the other side of the beam. The photoelectric cell positioned at a distance from the prism will see only a small section of the entire beam and thus will have impressed thereon substantially monochromatic light. Thus, as the prism 9 is rotated about the pivot 15, light of different colors will be impressed on the cell 8. This may be accomplished by projecting the entire spectrum into space as shown in Fig. 2 or with the arrangement of Figs. 1a and 1b, where only a narrow portion of the beam is actually projected through the projection lens 6 for impression on the cell 8. The prisms 9 are of a size and shape to provide the optimum spread of the spectrum depending on the average distance between stations, the illustrations being diagrammatic.

Detection is accomplished by utilizing the frequency response characteristic of a photoelectric cell whose output varies with the color of the light impressed thereon, the cell thus serving as a discriminator. For instance, the type RCA No. 923 photocell has a characteristic such as shown in Fig. 3, wherein the sensitivity is peaked at substantially 8000 angstrom units or at the red end of the spectrum and falls to substantially zero at 4000 angstrom units at the blue end of the spectrum, and at 12,000 angstrom units. Thus, since the visible spectrum lies substantially between 4000 and 8000 angstrom units, maximum output from the cell 8 would be obtained during projection and reception of the red end of the spectrum, and a minimum output would be obtained when the blue end of the spectrum is projected on the cell.

As shown in Fig. 3, the no signal or zero position of the beam as impressed on the cell is shown at *a*, which is a light frequency midway on the straight portion of the cell characteristic. As the varied colored beam is vibrated about this zero position, the different colors or frequencies are impressed on the cell and the output of the cell will vary along the left-hand side of the response characteristic. Thus, the color received by the cell varies in accordance with the amplitude and sense of the signal and consequently the output of the cell will vary accordingly, while the rate of color variation will be in accordance with the frequency of the signal. Since only a photoelectric cell with a characteristic such as shown in Fig. 3 will provide the proper detecting relationship, secret communication may be provided.

Although the prism 9 has been shown pivoted at one edge or corner and driven by an electromagnet for purposes of illustration, any other suitable method of obtaining vibration of the spectrum is also satisfactory, such as by fixedly mounting the prism and varying the angle of projection of the white light thereon by a galvanometer as disclosed in the above-mentioned copending application, Ser. No. 554,246, filed September 15, 1944.

I claim as my invention:

1. In a light beam transmission system, a source of white light, means for obtaining a complete spectrum of said light, and means for varying the position of said spectrum in accordance with the amplitude of the signal to be trans-

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mitted, said last mentioned means also varying the rate of change in position of said spectrum in accordance with the frequency of said signal.

2. A light communication system comprising a source of white light, means for dividing said light into its complete spectrum, a single photoelectric cell upon which different sections of said spectrum are projected in accordance with the angle of projection of said spectrum, and means for varying the angle of projection of said colored spectrum in accordance with the amplitude of a signal to be transmitted, and the rate of change between projection angles in accordance with the frequency of said signal being transmitted.

3. In a light beam transmission system comprising a source of white light, means for dividing said white light into its complete spectrum, means for varying the position of said spectrum in space in accordance with the amplitude of a signal to be transmitted, and a single photosensitive device on which portions of said spectrum are impressed in accordance with the position of said spectrum in space, the output of said cell varying in accordance with the color of the portion of the spectrum impressed thereon, said color being in accordance with the amplitude of said signal and the rate of change between colors being dependent upon the frequency of said signal.

4. A light beam transmission system in accordance with claim 3 in which said first mentioned means is a refracting prism and said second mentioned means is an electromagnetic device having an armature connected to said prism.

5. The method of signaling between two points comprising generating light waves of a plurality of frequencies, projecting said waves from one point to a second point, varying the position of said light waves at said second point in accordance with the amplitude of a signal being transmitted between said points and detecting said light waves at said second point, each frequency received corresponding to a different amplitude of said signal, the rate of change of said received light frequencies corresponding to the frequency of said signal.

6. The method of signaling between two points comprising generating a light spectrum containing all light frequencies, vibrating said spectrum in accordance with a signal being transmitted, and translating said spectrum into electrical currents, the amplitude of said electrical currents varying in accordance with the frequency of the spectrum being translated and the frequency of the electrical currents varying in accordance with the rate of change between frequencies of said light spectrum.

7. The method of transmitting a signal between two points by light waves comprising generating a complete light spectrum, vibrating said spectrum in accordance with a signal to be transmitted, projecting said bands into space and translating said bands into electrical currents, the rate of change of said spectrum corresponding to the frequency of said signal and the portion of the spectrum being translated at any instance corresponding to the amplitude of said signal.

8. A signaling system comprising a sending station and a receiving station, means for obtaining a progressive band of light frequencies, means for projecting said light frequencies from said sending station to said receiving station, means for translating said light frequencies into electrical currents, the amplitude of said currents varying with the frequency of said light impressed thereon, and means for varying the rate of change

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between light frequencies impressed on said translating means in accordance with the frequency of a signal being transmitted between said stations.

9. A signaling system in accordance with claim 8 in which said first mentioned means includes a prism for obtaining a spectrum of white light and said last mentioned means comprising a single photoelectric cell having a varying light frequency response characteristic.

10. A signaling system comprising a sending station and a receiving station, a light source at said sending station, a single light sensitive device at said receiving station, optical means for dividing light from said source into its component frequencies arranged in a progressive order, means for projecting said components from said sending station to said light sensitive device at said receiving station, and means for varying the particular component impressed at any instant on said light sensitive device in accordance with the amplitude and frequency of a signal, the ampli-

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tude being determined by the component being impressed on said light sensitive device and the frequency being determined by the rate of change between components being impressed on said light sensitive device.

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REFERENCES CITED

10 The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
15 2,193,606	Ulrey	Mar. 12, 1940
2,271,980	Kellogg	Feb. 3, 1942
2,014,174	Francis	Sept. 10, 1935

88/14
179/100.3
179/100.3

FOREIGN PATENTS

Number	Country	Date
498,146	Great Britain	Jan. 4, 1939
489,357	Great Britain	Oct. 20, 1936

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250/7x