Nov. 21, 1944. L. A. SMITH 2,363,270

FACSIMILE TELEGRAPH SYSTEM

Filed Oct. 3, 1942 2 Sheets-Sheet 1

FIG. 1

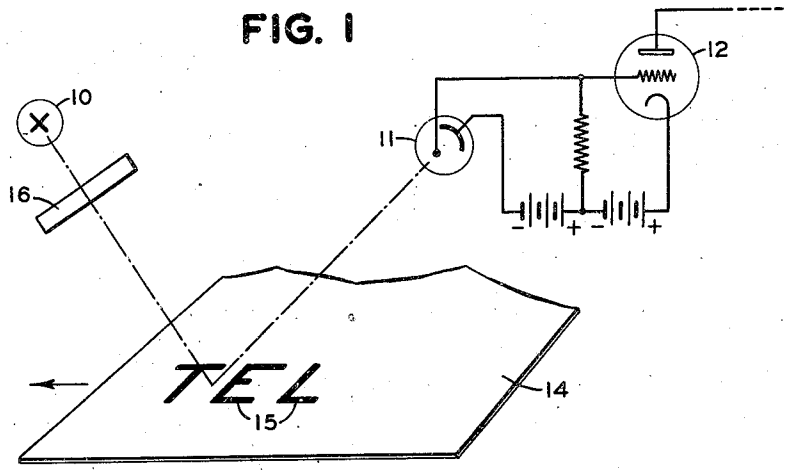


FIG. 2

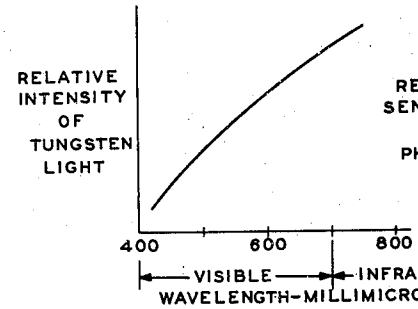


FIG. 3

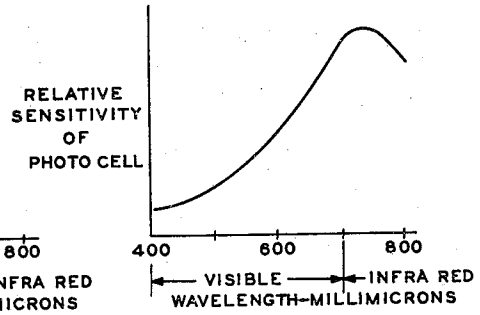


FIG. 4

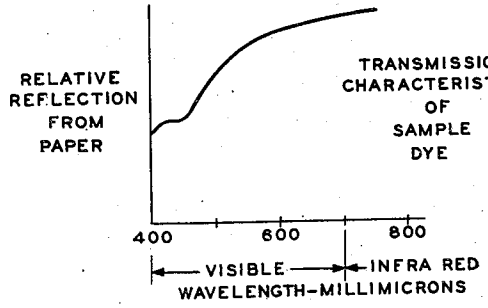
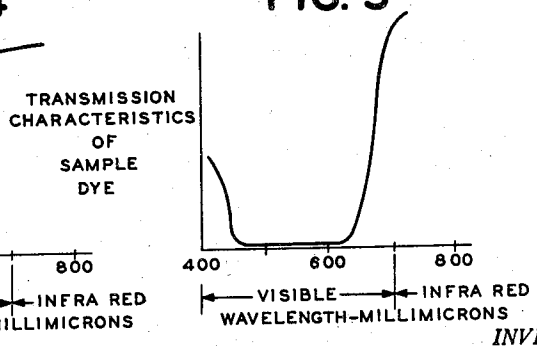


FIG. 5



INVENTOR
L. A. SMITH

BY M J Reynolds
ATTORNEY

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FIG. 10

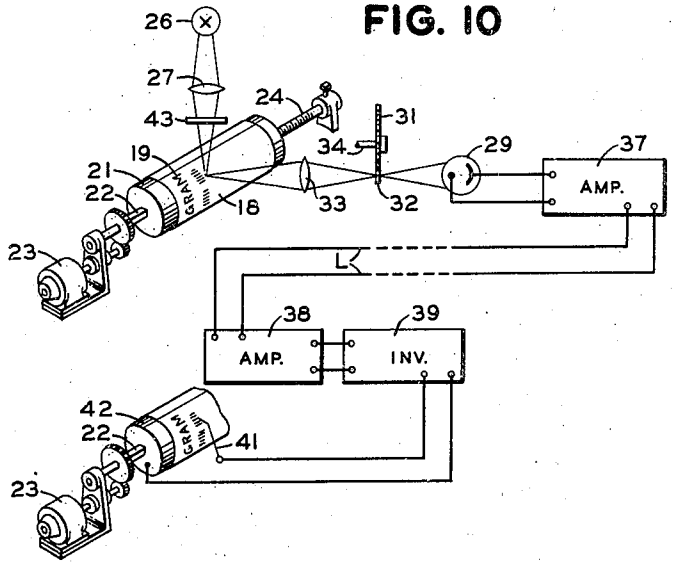


FIG. 6

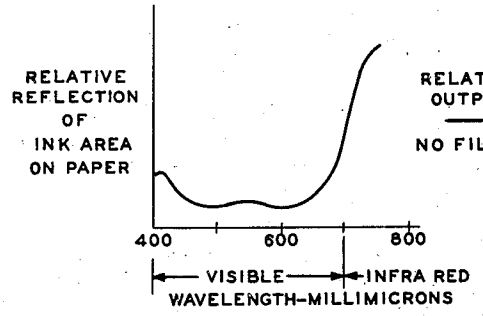


FIG. 7

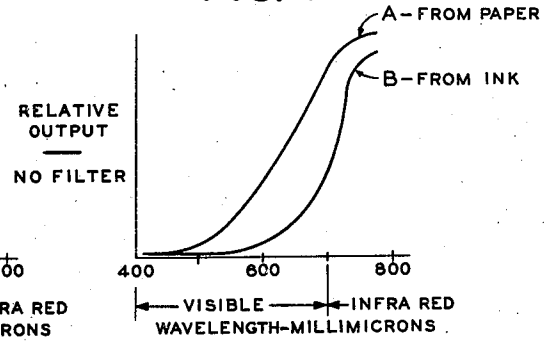


FIG. 8

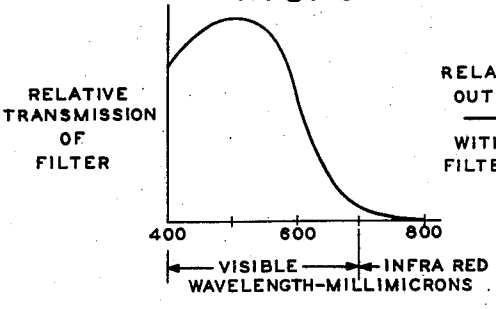
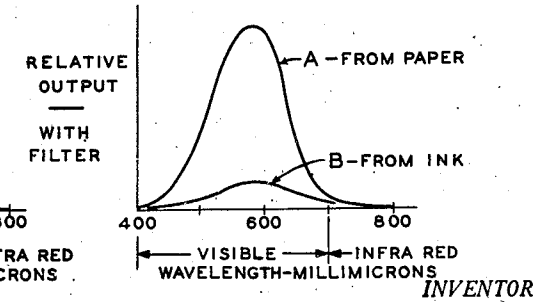


FIG. 9



INVENTOR
L. A. SMITH
BY M. J. Reynolds
ATTORNEY

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UNITED STATES PATENT OFFICE

2,363,270

FACSIMILE TELEGRAPH SYSTEM

Leonard A. Smith, Nutley, N. J., assignor to The Western Union Telegraph Company, New York, N. Y., a corporation of New York

Application October 3, 1942, Serial No. 460,604

4 Claims. (Cl. 178—6.6)

The present invention relates to photoelectric scanning systems, and more particularly to an improved system for deriving the maximum useful response from a photocell employed in a facsimile telegraph scanner.

A major difficulty encountered in providing facsimile communication service to the general public with facsimile telegraph equipment employing a photosensitive cell at the transmitter is that little or no control may be had over the writing medium employed by a prospective patron of such a service when inscribing a message. Special writing materials may be provided by the concern offering the service for the patron's use, but business reasons make it preferable to encourage the patron to use his own writing materials. This applies to typewriter ribbons, mimeograph inks, special drawing inks, writing inks, and pencils.

One important object of the present invention is to make it unnecessary to offer special writing materials to prospective patrons of a facsimile communication service. Facsimile communication service to the public is thereby rendered more flexible in that it will suit the more varied needs of prospective patrons.

In carrying out the invention, the optical arrangement, which illuminates the subject matter to be transmitted and which collects light transmitted through or reflected from the sheet or support bearing this subject matter, is provided with a device having selective radiant energy transmission properties, thereby providing an improved result which will be pointed out in the description of two illustrative embodiments appearing hereinafter.

Another object of this invention is to provide for improving the useful response of a photoelectric tube or cell exposed to variations in radiant energy impinging thereon by selectively reducing the total amount of radiant energy incident on the photocell or tube.

Still another object of the invention is to provide improved response of a photoelectric cell or tube by removing components of radiant energy impinging on the photocell or tube to which the photocell or tube is most responsive.

Other and more specific objects of the invention are defined by the terms of the appended claims and will be apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation of an optical scanning system utilizing the present invention;

Figs. 2 to 9 are curves illustrating the results obtained by a photoelectric scanning system having the several components thereof selected for the accomplishment of the purpose of the invention; and

Fig. 10 is a diagrammatic representation of a facsimile telegraph system in which the present invention may be advantageously employed.

The principle of the invention and its application to a pickup system useful in a facsimile telegraph scanner or other signal generating device will be explained with reference to Fig. 1 and the curves of Figs. 2 to 9. In Fig. 1, 10 designates a source of radiant energy, preferably luminous, and 11 designates a radiation sensitive device having more or less selective sensitivity to portions of the radiant energy lying within the spectrum emitted by the source 10. The radiation sensitive device 11 may be any of the well known types of photo or radiation sensitive cells or tubes heretofore proposed in the art and will be referred to hereinafter as a photocell. The source 10 is usually a tungsten filament lamp which has a "white" light output composed of the various colors of the visible spectrum plus invisible components extending into the infra-red region. The term "light" will be used hereinafter as synonymous with the total radiation from the source 10, and the source 10 will be referred to as the light source. The photocell 11 is sensitive to these different colored components which make up the scanning light and is employed to translate the reflected light into electrical energy in the form of signals appearing in the output circuit of an amplifier 12.

A light source of the tungsten filament type has its maximum energy in the invisible infra-red region, as shown by the curve of Fig. 2 of the drawings. In Figs. 2 to 9, the curves are plotted with wave lengths in millimicrons as abscissae and with relative values of light intensity as ordinates. The approximate limits of the visible portion of the spectrum are indicated for each curve. Fig. 3 shows the responsiveness to various wave lengths of the total spectrum of the light source 10 of the type of photocell normally employed. A caesium cell was selected for illustrative purposes as such a cell is usually used in pickup devices. A sheet of paper 14 bearing markings 15, such as characters of a message for transmission by the facsimile process, is arranged so that relative movement between the source 10 and the sheet 14 is produced in any known manner whereby light from the source 10 is projected successively onto elemental areas of

the sheet 14. In areas of the sheet 14 which do not contain markings 15 the light is reflected onto the photocell throughout the entire frequency range of light from an ideal uniform source assumed to be substituted for the practical source 10, as shown by the curve of Fig. 4 of the drawings. This curve of relative reflection assumes equal intensity of all components in the light source.

Assuming that the subject matter for transmission by the facsimile process is composed of black characters on white paper, the result of the scanning process may be described in the following terms. When the incident light falls on the unmarked background of the sheet 14, a high percentage of this incident light is reflected from the paper and collected by the photocell 11, causing a relatively large change in the output of the amplifier 12, from the minimum incident light condition. If the relative movement between the sheet 14 and the light source 10 causes the light to be incident on a black area forming a part of one of the markings 15, a large portion of the light is absorbed by the black area and only a small percentage is reflected onto the photocell. Since the output of the photocell is dependent upon the amount of light directed onto its collecting element, and the quantity of light reflected from the black area is small, the change in the output of the amplifier 12 is small in comparison to the minimum incident light condition. Where writing or printing materials, such as black India ink, black lead pencil, black printer's ink or black typewriter ribbon, are provided for the purpose of inscribing or otherwise marking a message sheet, a pickup system of the kind shown in Fig. 1 produces signals in facsimile in the output circuit of the photocell and hence in the output circuit of the amplifier 12 in the manner just described.

If the subject matter to be transmitted consists of a colored ink on the reflective surface of a paper sheet and this colored ink has the property of absorbing only a relatively small portion of the incident light, the electrical output of the photocell, when the light is incident on one of the characters of the subject matter, will not differ greatly from the electrical output of the photocell when the light is incident on the reflective surface of the paper sheet. The resulting record produced at a recorder supplied with signals generated by the photocell 11 will not have sufficient contrast between the two levels.

Many substances such as fountain pen inks derive their characteristic color from dye stuffs. To the eye, a character written, or printed or otherwise impressed on the reflective surface of a paper sheet with such inks may appear to be quite dark as compared to the paper background because a large proportion of the visible light falling on the character is absorbed and only a small proportion of the visible light corresponding to the characteristic color of the dye is reflected to affect the eye. The infra-red content of the incident light, even if it is reflected from the area in question, is not visible and therefore does not affect the eye.

Substantially all known dye stuffs have the property of freely transmitting wave lengths corresponding to the invisible infra-red rays which will be reflected by the paper underneath the dye marking, and will be retransmitted back through the dye marking to be incident on the radiation sensitive portion of a photocell. If the visible components of the incident light are neglected and only the infra-red components considered, it will be found that there is very little difference in the total energy contained in the light reflected from unmarked areas of the paper sheet and areas of visually dark characters produced by the dye.

It should be pointed out that ink normally consists of a vehicle being merely a means of retaining the dye stuff in a form suitable for writing or printing purposes. In general, the radiant energy absorption characteristics of the vehicle used may be neglected and the dye stuff considered as the controlling factor. Color as is well known is the result of a selective absorption and reflection of light rays. A writing fluid composed of a dye stuff and a vehicle which produces a visible record of some definite color reflects a large percentage of the light rays of this color. In addition, however, the reflected light contains a very large percentage of infra-red rays present in the incident light. As previously pointed out, these infra-red rays are reflected from the paper underneath the ink with little or no absorption by the dye stuff contained therein. In accordance with the invention, a selectively absorbent screen or filter 16 is placed either, as shown, in the light path from the source 10 to the sheet 14 or, if desired, in the light path from the sheet 14 to the photocell 11.

Fig. 5 shows the light transmission characteristics of a typical dye stuff and Fig. 6 the reflection characteristic of an area written on ordinary paper with an ink employing this dye. These curves assume equal intensity of all component parts of the incident light used in obtaining the characteristics. A purple dye was used when obtaining the curves of Figs. 5 and 6, and the curve of Fig. 4 was obtained by using a sheet of ordinary paper which may be readily obtained. However, it will be understood that the underlying principle of the invention herein and illustrated by the curves of Figs. 2 to 9 is applicable to dyes of all colors and to any type of paper providing the effect of visual components is considered.

The output energy of the amplifier 12 controlled by the photocell 11 will depend upon the magnitude of the components of different wave lengths contained in the light incident on the sheet 14, the percentage of these various components contained in the reflected light, and the relative sensitivity of the photocell to the various components. Therefore, a combination of the curves of Figs. 2, 3 and 4 will produce the curve A of Fig. 7 which shows the distribution of energy produced in the output of the photocell by light, using the paper selected by way of example from which the curve of Fig. 4 was obtained. Similarly, a combination of Figs. 2, 3 and 6 will produce the curve B of Fig. 7 for the distribution of power resulting from light reflected from the character 15.

The ratio of the areas under the curves A and B of Fig. 7 will be an indication of the relationship between the power outputs of areas of paper background and the markings 15, respectively.

It will be seen that in the longer wave region in the neighborhood of the infra-red portion of the spectrum, there is a fairly large percentage of power both for the paper background and the character. The large amount of power due to the longer wave lengths in the infra-red region reflected from the paper through the markings 15 is detrimental, since they greatly reduce the ratios of power of the two cases, a high ra-

tio being desirable. By introducing the selective optical filter 16 in the beam of light which scans the message, the longer wave lengths in the infra-red region of the spectrum can be greatly reduced. The removal of the infra-red portion of the spectrum will reduce the total power output, since there will be less total light available for affecting the photocell, but the percentage reduction in power will be far greater for the markings 15 than for the areas of paper background.

Fig. 8 shows the transmission characteristic of a typical optical filter suitable for producing the results of this invention. It should be understood that the curve of Fig. 8 shows the transmission characteristic of a filter selected by way of example and that other filters may be employed which result in producing the desired high ratio between the power outputs of the cell. Curves A and B of Fig. 9 show the result obtained when the optical filter having the transmission charateristic of Fig. 8 is introduced at any point in the light path between the light 10 and photocell 11. These curves are for the same combination of dye characters impressed on the paper used in obtaining the curve of Fig. 7 without a filter. It will be noted that, although the total area under each curve is considerably less for the case covered by Fig. 9 than for that of Fig. 7, the ratio of the output powers for the character and the plain background of the sheet 14 is greatly increased. The reduction in total power is of no consequence, as it can easily be offset by increased amplification of the electrical output of the system in the amplifier 12, or by any other known means.

The choice of the optical filter 16 for use in a pickup system employing the present invention will depend upon the characteristic of the color content of the light reflected from areas covered with the particular color of the ink being considered. Where, as will normally be the case, a different color may be used for each different piece of subject matter, such as signatures by different persons using fountain pen ink, the color of which is not under control of the person who is to transmit a facsimile of the written matter, a filter may be selected which operates to eliminate the infra-red or other unabsorbable content of the light and permits transmission of the remaining absorbable content of the light to be incident on ink of substantially any color. This also applies where both the absorbable and the unabsorbable components are incident on the ink and the filter is interposed in the path of both these components after reflection. Also, the invention is applicable to characters on a transparency which are impressed or written thereon by colored inks. In this case, the infra-red or other unabsorbable component may be prevented from passing through the ink and the transparency or the unabsorbable component may be removed after it has passed through the transparency by a filter selected in accordance with this invention.

Referring to Fig. 10, which illustrates a facsimile telegraph system embodying the invention, a message sheet 18 having a message or other subject matter 19 written, stamped or printed thereon with any kind of ink is mounted upon a drum 21 which is rotated through a suitable driving connection 22 by a motor 23. Screw means 24 are provided for advancing the message sheet bearing drum 21 axially as it rotates so that the entire field will be covered by light from a suitable source 26. If desired, the light from this source may be concentrated by a lens 27 upon the surface of the message sheet 18. The light incident on the sheet is reflected therefrom into a light sensitive device such as the photocell 29, the latter being suitably supported in a housing or the like (not shown) at a proper distance from the outer periphery of the drum 21. The spot of light projected upon the surface of the drum by the lens 27 is caused to traverse the drum in a longitudinal direction as the drum rotates by reason of the axial movement imparted by the screw means 24. In this manner the spot of light will follow a helical path as the drum 21 is rotated, thus producing a scanning action.

The foregoing method of obtaining a scanning movement as well as various other methods of scanning a given field are well known, and it will be understood that any of the known methods of scanning may be employed in practising the invention.

The light which is incident upon the photocell 29 is interrupted by a shutter or light chopper 31, which may, as illustrated, be a disc, having a series of equally spaced openings or notches 32 adjacent its outer edge. Where the reflected beam is to be interrupted as shown, a lens 33 serves to bring the reflected light beam to a focus substantially in the plane of the disc 31 so that it may pass through the openings 32 in succession. The disc 31 is secured upon a rotatable shaft 34 which is driven in any suitable manner, either from the motor 23 or a separate source of mechanical power. The number of openings in the chopper disc and the speed of rotation of the shaft may vary within wide limits, depending upon the desired rate of scanning, the constants of the communication circuit employed between stations and other factors. The output appearing across the terminals of the photocell 29 is supplied to the amplifier 37 for transmission over the line conductors L or any other desired communication channel to the receiving amplifier 38. The output of the amplifier 38 is inverted by a signal inverting device 39 so that a positive reproduction of the original subject matter 19 may be obtained by employing a recording stylus 41. One output terminal of the inverter 39 is connected to the stylus 41, the other terminal being connected to the scanning drum 42 of the receiver which serves as a conductive platen. The scanning mechanism of the recorder is shown as being similar to that of the recorder. Any recording instrumentality may be substituted for the stylus 41, and where a photographic recording is obtained, the inverter 39 may be omitted.

A selective optical filter 43, similar in all respects to the filter 16 of Fig. 1, is shown as being located in the light beam which is incident on the message sheet 18. However, as pointed out above, this filter may be located at any point between the message sheet and the photocell 29.

In operation of the facsimile system disclosed in Fig. 10, that portion of the total light flux emitted by the light source 26 which will not be absorbed by the ink composing the characters 19 of the subject matter to be transmitted is absorbed by the selective filter 43. Therefore, the ratio of the power output of the photocell when the background of the sheet 18 is scanned is considerably in excess of the power output from the photocell when the subject matter 19 is scanned,

and therefore the ratio of these two power outputs is greatly increased.

While the invention has been described in connection with picture transmission and reception, it is applicable to other systems in which simlar operating conditions are present. The nature of the invention will be determined from the foregoing, and the scope thereof is defined in the appended claims.

What is claimed is:

1. A system for deriving electrical signals from markings upon a surface of a member having radiation directing properties comprising a source of radiation, a radiation sensitive device, means to produce relative movement between said surface and said device, means to direct a beam of radiation from said source upon said directive surface, means to direct radiation from said reflective surface to said radiation sensitive device, and a selectively absorbent filter positioned between said source and said device, said source, said filter, and said device having the respective characteristics of emitting rays of maximum intensity, maximum absorption and maximum sensitivity in a common region of the spectrum whereby the response of said device will be, primarily, in accordance with the relative absorption characteristics of said surface and said markings thereon, in the remaining portion of the spectrum of said source.

2. A photoelectric scanner for a facsimile telegraph system for generating signals in accordance with markings upon a surface in which the radiation absorption characteristics of said markings and said surface are similar in one portion of the spectrum and dissimilar in other portions of the spectrum comprising a source of radiation, a radiation sensitive device, means to direct radiation from said source upon a sheet having subject matter inscribed thereon in ink for transmission by a facsimile telegraph process, means to direct radiation from successive areas of said sheet upon said radiation sensitive device, and a filter positioned between said source and said device, said filter having high absorption characteristics in said region of the spectrum of said source in which said surface and markings have similar absorption characteristics and said filter having low absorption characteristics in that portion of the spectrum of said source in which the surface and markings have dissimilar absorption characteristics whereby the response of said radiation device will be, primarily, in accordance with the relative absorption characteristics of said surface and said markings in that portion of the spectrum in which said characteristics are dissimilar.

3. An optical scanning system for deriving electrical signals representative of markings in ink upon a surface of a member having reflective properties comprising a source of radiation of both visible and invisible wave length components, a radiation sensitive device responsive to both said visible and invisible wave length components, means to direct a beam of radiation from said source upon said reflective surface, means for direct radiation from said reflective surface to said radiation sensitive device, and a selectively absorbent filter positioned between said source and said device having high absorption characteristics of the invisible wave length components radiating from said source, whereby the response of said device will be, primarily, in accordance with the relative absorption characteristics of said markings and said surface in the visible portion of the spectrum.

4. A photoelectric scanner for a facsimile telegraph system comprising a source of radiation in both the visible and infra-red portions of the spectrum, a radiation sensitive device responsive to radiations in both said visible and infra-red portions of the spectrum, means to direct radiation from said source upon a sheet having subject matter inscribed thereon in ink for transmission by a facsimile telegraph process, means to direct radiation from said sheet upon said radiation sensitive device, and a filter disposed between said source and said radiation sensitive device and having a high absorption characteristic in the infrared portion of the spectrum whereby the response of said device to light reflected from said surface will be substantially independent of the infrared radiation from said source.

LEONARD A. SMITH.