Dec. 30, 1952 M. LANGE 2,623,432

MEANS FOR AUTOMATIC COLOR SELECTION

Filed Jan. 21, 1950 4 Sheets-Sheet 1

FIG. 1

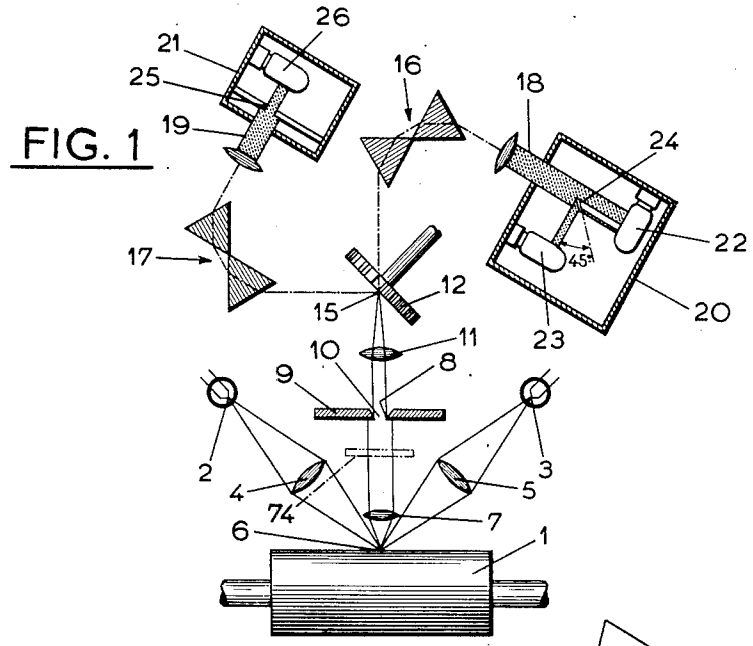
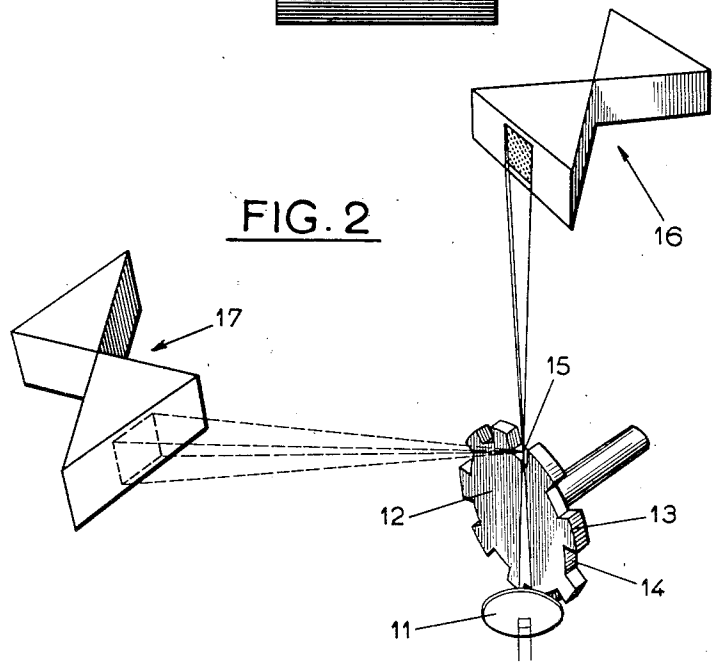


FIG. 2



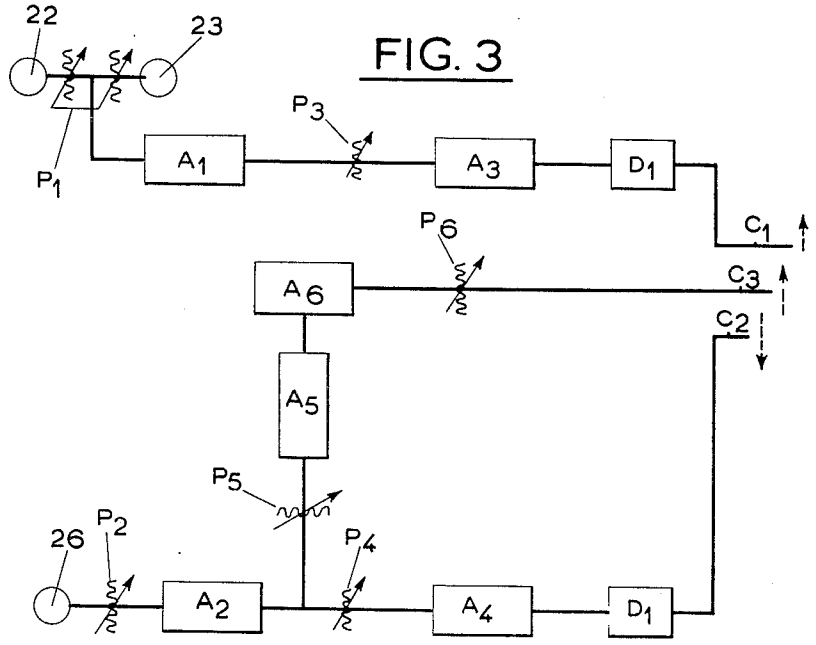
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MEANS FOR AUTOMATIC COLOR SELECTION

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FIG. 3



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MEANS FOR AUTOMATIC COLOR SELECTION

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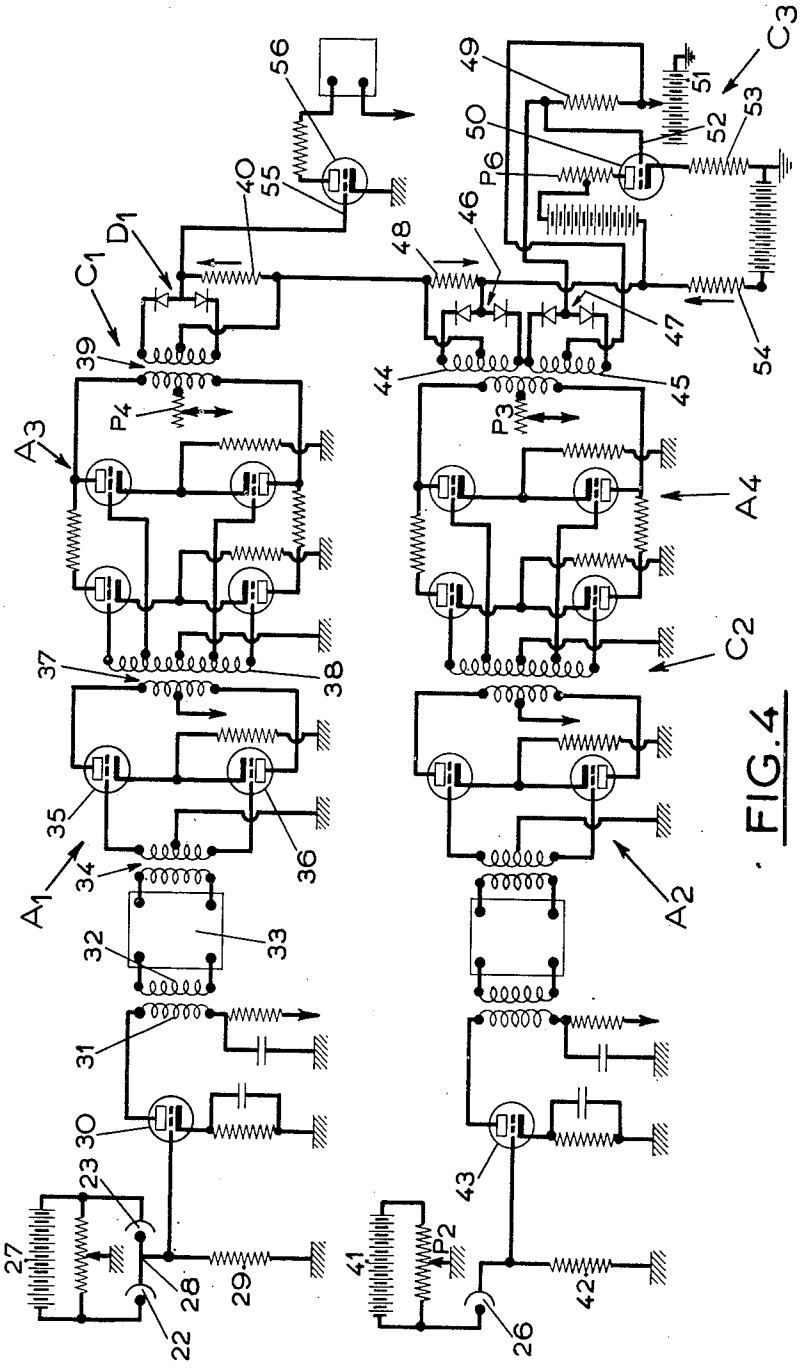


FIG. 4

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Dec. 30, 1952 M. LANGE 2,623,432

MEANS FOR AUTOMATIC COLOR SELECTION

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FIG.5

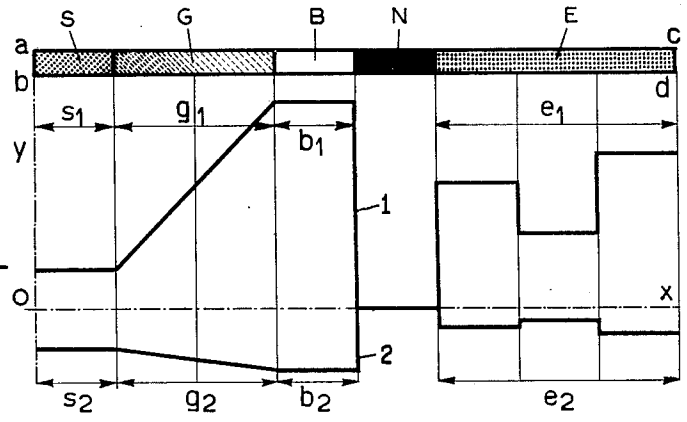


FIG.6

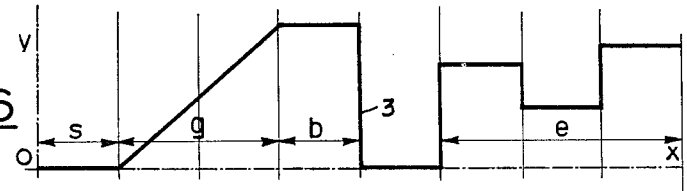


FIG.7

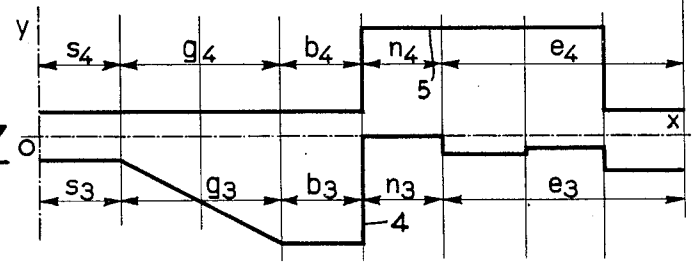


FIG.8

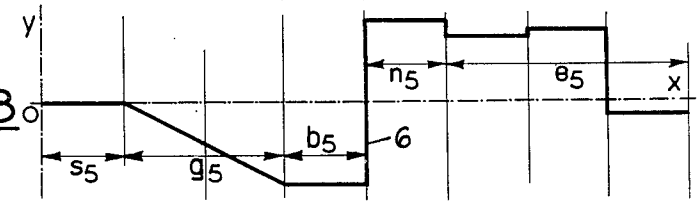
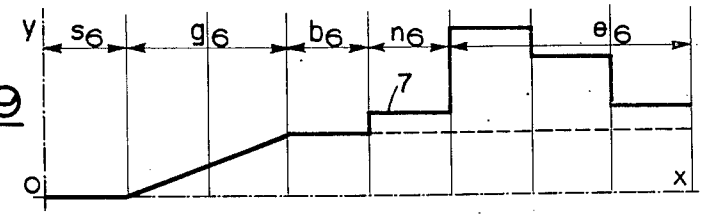


FIG.9



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Patented Dec. 30, 1952

2,623,432

UNITED STATES PATENT OFFICE

2,623,432

MEANS FOR AUTOMATIC COLOR SELECTION

Maurice Lange, Issy-les-Moulineaux, France

Application January 21, 1950, Serial No. 139,813
In France January 27, 1949

3 Claims. (Cl. 88—14)

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The present invention relates to means for selecting colors, and more particularly to an apparatus for detecting or sorting any particular color, made up of at least one band of wavelength of the spectrum, even from mixtures of said particular color with a greater or less extent of other colors of other wave-lengths, the detection or sorting being made automatically with a great accuracy.

An object of this invention therefore is to provide means for automatic selection of colors.

Another object is to provide means for selecting proportionally the shading in a given color and for eliminating undesired other colors.

A further object of this invention is to provide means enabling an accurate separation of similar colors to be obtained automatically.

The invention may be carried out either by transparency or by reflection of colored beams; it may be used for a considerable number of various applications, such as colorimetric analysis of liquids or analysis of opaque documents or objects; it is applicable also to the control of weaving looms or knitting machines, to the sorting out of colored pieces, to the reproduction of polychromic documents by means of a printing weft usable to prepare printing surfaces on paper or fabrics, etc. While a number of possible applications have been indicated hereabove, it may be understood that such applications have been given by way of example only, to illustrate the wide variety of uses of the invention.

In order that a desired color and the shading of this desired color be selected with accuracy, it is necessary that the complete color spectrum of the desired color be analyzed, since experiments have shown that pure colors are very rare in practice and that, in the spectrum of a red color, for instance, a variable amount of blue, green or yellow rays may be present.

A color selecting apparatus in accordance with the present invention comprises in combination: means for lighting a scanned area of an object; means for directing alternately and sequently the light beam arriving from said scanned area in two different directions by dividing said light beam in a first partial light beam and a second partial light beam; first light dispersing means in the path of said first partial light beam; second light dispersing means in the path of said second partial light beam; first photoelectric means responsive to the spectrum from said first light dispersing means; second photoelectric means responsive to the spectrum from said second light dispersing means; a first electrical circuit controlled by said first photoelectrical means and adapted to generate an output potential; a second electrical circuit controlled by said second photoelectric means and adapted to generate an output potential; and means for applying said output potentials simultaneously to a receiving means.

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The color selecting or analyzing device is associated with photoelectric means of well-known type, comprising a pair of photocells one of which receives the selected portion in the first spectrum and the second of which receives the remaining portion of the first spectrum and a third photocell which receives the selected portion in the second spectrum, and three electrical relay means controlling the intensity of a direct current in three respective circuits which control together an output amplifier, the first circuit being controlled by the pair of photocells, the second circuit being controlled by the third photocell, and the third circuit being controlled through the second one and supplying a direct current the minimum value of which may be adjusted suitably.

Generally speaking, the present invention is practiced by automatically selecting a desired predetermined shade among a plurality of colors and shadings by the following steps: the desired shade is marked by a zero method used in conjunction with a pair of photoelectric cells oppositely connected and responsive to the spectrum from the scanning beam, and all colors and shades different from the desired shade are given different levels, preferably in such a way that the levels of the white and light shades are lowered and the levels of those undesired colors and shades which normally are lower than the level corresponding to the sum of the shadings forming the desired shade are raised.

In other words, in accordance with the present invention, for the selection of any predetermined desired shade, all other shades are eliminated from the working zone of the receiving means by raising their levels above the level of the desired color and of its shadings; this is obtained for instance by such an action on the analyzing photoelectric cells that they feed a mirror galvanometer, the mirror of which reflects a light beam or pencil which is operative only within a given angle corresponding to the sum of the shadings of the desired colors, while the angular displacements beyond this operative angle project the reflected light beam outwardly from the operative field of the registering or metering apparatus.

The invention will be best understood from the following description of an illustrative embodiment thereof, taken in a descriptive sense only without any limitative intention, and with reference to the accompanying sheets of drawings, wherein:

Fig. 1 diagrammatically shows the optical analyzing device for scanning a colored object to be selected, this device being associated with the photoelectric cells of the controlling device for a mirror oscillograph;

Fig. 2 is a perspective view illustrating the device for occulting and reflecting the light beam arising from a scanned area in the object, together with the light dispersing means on which the direct and the reflected beams, respectively, are caused to impinge;

Fig. 3 diagrammatically shows an electrical circuit for combining the signals from the photoelectric cells and for controlling an oscillograph, the mirror of which transmits light signals to the registering or reproducing device;

Fig. 4 is a wiring diagram for the circuit of Fig. 3;

Fig. 5 is a diagram showing the variations of the first output voltage and of the second output voltage from the pair of oppositely arranged photoelectric cells receiving the first light beam, after amplification and rectification, in the respective cases of a desired shade, of its shadings up to pure white, and of other undesired colors, including pure black;

Fig. 6 is a similar representation showing the variations of a third output voltage resulting from the algebraic summation of said first and said second output voltages;

Fig. 7 is a similar diagram showing the variations of a fourth output voltage and of a fifth output voltage both resulting from the third photoelectric cell receiving a selected portion of the second light beam;

Fig. 8 is a similar diagram showing the variations of a sixth output voltage resulting from the algebraic summation of said fourth and fifth output voltage;

Fig. 9 illustrates the variations of a seventh output voltage resulting from the algebraic summation from said third and sixth output voltage.

For the sake of convenience and simplicity, the invention will be described as applied to the scanning of an opaque flexible document mounted on a cylinder as used in telephotographic arrangements, but it is to be clearly understood that numerous modifications and changes could be made to this illustrative embodiment without departing from the scope of the present invention.

The document to be analyzed is spread on a cylinder 1 (Fig. 1) which may be rotated about its axis and displaced lengthwise thereto by any well-known means.

By means of one or several light sources, such as the lamps 2 and 3, and of lenses 4, 5, respectively, a light image 6 having a predetermined area is formed on the cylinder 1, the total illuminating light having as white a characteristic as possible. The colored light arising from the illuminated area 6 is received by the lens objective 7 which gives an enlarged image 8 of the area 6 on a fixed screen 9 provided with a square aperture or a small diaphragm 10. As the cylinder 1 rotates while sliding axially, the complete surface of the document passes through the illuminated area 6, and thus the various successive images 8 correspond to the total area of the scanned document. At each instant, a certain amount of more or less colored light passes through the diaphragm 10, this light coming from that area of the document which corresponds to the area 6.

A lens 11, positioned beyond the diaphragm 10, focuses the light of the beam passing through the diaphragm 10 upon the periphery of a disc 12. This disc is angularly positioned at 45° with respect to the incident light beam and, on its periphery, comprises teeth 13 (Fig. 2) and recesses or notches 14 having the same angular length as the teeth 13. The teeth and the notches are substantially rectangular in shape. The solid portions or teeth of the disc 12 are made reflective by a silver, aluminum or like deposit. However, a transparent disc could be used having a reflective layer on one surface with transparent portions acting in the same manner as the notches 14 in the disc 12.

On account of the angular position of the disc 12, the total amount of light arising by the scanned document and passing through the diaphragm 10 is utilized; simultaneously the light beams are interrupted periodically. Whenever the light beam arising from the scanning area passes through a notch 14, it continues on its straight path, and when a reflective tooth 13 is introduced in its path, the light beam is deflected by 90° with respect to its former direction. It is to be noted that with interruptor discs of conventional design, only 50% of the incident light is utilized, since only the light passing through the notches is made operative. On the contrary, the total amount of light is operative when using a disc in accordance with this invention.

The disc 12 is rotated at a suitable constant speed, enabling for instance 3000 occultations per second to be obtained, by any convenient means, and simultaneously the cylinder 1 is rotated and translated. The light beam which is focused at the point 15 is thus subjected to periodic reflections at 90°, and therefore a direct beam and a reflected beam are obtained, formed of equispaced light signals having an equal duration. The direct beam and the reflected beam are analyzed by a pair of prisms 6 and a pair of prisms 17, respectively. The issuing spectra 18 and 19, respectively, pass through openings in associated light-tight boxes 20 and 21. The box 20 encloses a pair of photoelectric cells 22 and 23, the color characteristics of which are chosen as panchromatic as possible. 24 designates a little mirror the reflective surface of which is displaced by 45° with respect to the general axis of the spectrum beam 18. The position of this mirror 24 may be adjusted to enable the mirror to reflect any predetermined portion of the spectrum 18. A plurality of mirrors similar to 24, or larger mirrors, may be used for specific purposes, as for selecting a complex color, e. g. a brown tint, and a suitable conventional supporting means for these mirrors may comprise slides and an electromagnet for magnetically maintaining the mirror or mirrors 24 in the desired position.

That portion of the spectrum 18 which has been reflected by the mirror 24 is applied to the photoelectric cell 23, while the remaining portion of the spectrum 18 reaches to the photoelectric cell 22.

An adjustable diaphragm 25 is provided within the box 21 in the path of the spectrum 19 to cause a predetermined portion of this, generally the same portion as the portion reflected by

mirror or mirrors 24, to be applied to a photoelectric cell 26, the characteristics of which are chosen as panchromatic as possible.

The photoelectric cells 22, 23 and 26 control associated circuits the outputs of which are applied to a common valve or tube for controlling an oscillograph (Figs. 3 and 4).

The first circuit C_1 is controlled by the photoelectric cells 22 and 23, which, as already stated, are inverted electrically with respect to each other; the circuit C_2 is controlled by the photoelectric cell 26; finally, the circuit C_3 supplies a direct current and is controlled by the circuit C_2. The arrangement is such that the potentials at the outputs of the circuits C_1 and C_3 are caused to be of like polarity which is opposed to that of the output potential from the circuit C_2.

Potentiometric means diagrammatically illustrated at P_1, P_2, P_3, P_4, P_5, P_6 are used to adjust the output potentials in the circuits C_1, C_2 and C_3 to convenient values; the adjustments are effected preferably in such a manner that, for the desired shade to be selected, the output potential from the circuit C_1 is made nil; in the same conditions, the circuits C_2 and C_3 are set to have equal output potentials of opposite polarities, whereby the sum of the potentials applied to the control device for the oscillograph from the circuits C_2 and C_3 also equals zero; thus, the mirror of the oscillograph keeps its angular position so long as the image 6 stays on an area of the document having the color to be selected.

Figure 4 is a more detailed wiring diagram of the arrangement shown in Fig. 3.

Referring to this Fig. 4, the circuit C_1 comprises the photoelectric cells 22 and 23. These photocells 22 and 23 are connected in series with each other; they are balanced by means of a potentiometer P_1 and fed by a direct current supply source, illustrated as a battery 27 for the sake of simplicity. The common tapping between the photoelectric cells 22 and 23 is grounded through a high value resistance 29, and is connected to the control grid of an amplifying tube 30, the anode circuit of which includes a coupling transformer 31. The secondary winding 32 of the transformer 31 feeds a filter circuit 33 of well-known type adapted to suppress any undesired alternative components, such as ground noise, humming, and so on. The filter circuit 33 also connects the secondary winding 32 with a symmetrically arranged amplifying stage through a coupling transformer 34. The anodes of the tubes 35 and 36 in this amplifying stage feed the adjacent ends of the primary winding of a transformer 37 in push-pull. The secondary 38 of this transformer 37 comprises taps from which the control grids of a balanced amplifier A_3 of well-known type are supplied respectively; the amplifier A_3 comprises a conventional compensating arrangement whereby some distortion may be corrected.

Through an output transformer 39, the tubes in the amplifier A_3 supply a rectifying unit D_1 connected across a load resistance 40. With such an arrangement, when the light fluxes received by the photoelectric cells 22 and 23 have been balanced at the instants where the desired tint to be selected is scanned in the original document, no potential is present across the resistance 40. When unbalance exists, however, for instance when a shaded tint is scanned, a given current, which is proportional to the intensity of the shading, will pass through the resistance 40, thus producing a given potential drop in this resistance.

The circuit C_2 includes the photoelectric cell 26, a supply circuit comprising a potentiometer P_2 and a direct supply source 41. This circuit generates a potential in the load resistance 42 and this potential is applied to the control grid of an amplifying tube 43 which is the first stage in an assembly having elements similar to the circuit C_1. The output transformer in the amplifying stage A_4 for the circuit C_2 comprises a pair of secondary windings 44 and 45, respectively, which feed rectifying units 46, 47, respectively. The rectifying unit 46 furnishes a given voltage drop across the load resistance 48 when the photoelectric cell 26 receives a light flux, the polarity of this voltage drop being opposite to that of the voltage drop present across the load resistance 40. As a result the potential difference at the terminals of the resistance 48 will have a polarity opposite to that of the potential difference present at the terminals of the load resistance 40 for the circuit C_1.

As already stated, the other secondary winding 45 of the output transformer in the circuit C_2 feeds a rectifying unit 47 equipped with a load resistance 49, which represents the potentiometric means P_5 illustrated in Fig. 3. The load resistance 49 is inserted in the grid circuit of a direct amplifying tube 50, acting as the assemblies A_5—A_6 in Fig. 3. Further the control grid of the amplifying tube 50 is biassed negatively with respect to its cathode, by means of an independent bias source illustrated as a battery 51.

The potential difference present at the terminals of the resistance 49 has a polarity opposite to that of the fixed bias supplied by the battery 51. When the rectified current amounts to a given value, the potential of the grid 52 in the tube 50 becomes zero with respect to that of the cathode of the tube 50, and thus a relatively considerable plate current is produced which passes through the resistances 53 and 54 inserted in the cathode circuit of this tube, whereby a potential drop occurs across resistance 54. The potential difference obtained in this way is added to the potential differences present at the terminals of the resistances 48 and 40, respectively. Consequently, the grid 55 of the tube 56 receives a potential which depends simultaneously, first on the output of circuit C_1, the input of which is constituted by the photoelectric cells 22 and 23, further on the potential difference produced by the compensating circuit fed by the photoelectric cell 26, and finally on the potential difference present across the resistance 54.

The plate current generated in the tube 56 feeds a mirror galvanometer, the deflection of which is thus proportional to the applied potential.

In order that the setting up of the circuits C_1, C_2 and C_3 be understood more clearly, reference will be made now to the curves of Figs. 5 to 9 inclusive. In these figures, it has been assumed that the light image 6 scans a rectangular strip *a, b, c, d*. In practice, in the embodiment shown and described, a helical strip having a much lesser width is scanned, since the original document is spread over the cylinder 1 which is rotated at constant speed while axially sliding at an uniform rate. Thus the strip *abcd* may be con-

sidered as being a representation of a helical strip extending from *ab* to *cd*.

In the figures, S designates the tint or shade which it is desired to select, G a portion of the document in which the desired tint is fading progressively from S up to pure white B; the white area B is followed by a black area N, and then by a plurality of variously colored areas having colors different from the desired color S and indicated generally by E.

In Fig. 5, the tracing above the line Ox indicates the variations of a first voltage or potential present across the resistance 40 and produced by the photoelectric cell 22 only, after amplification and rectification. The diagram shows that said first voltage or potential has a constant value and may be represented by an horizontal line extending along s_1, that is, extending as long as the desired color S is scanned. Then the fading is represented by an increasing potential, as shown by the line which extends across g_1. When the white area is scanned a further horizontal line b_1 is obtained. For the black area N, no potential is present across the resistance 40; further the various colors different from the color S to be selected produce a tracing e_1 corresponding to potentials which may be either greater or lower than each of the various potentials corresponding to g_1 (various shades of the preselected color), depending upon the respective color. Thus a single photoelectric cell 22 is unable to select the desired tint S.

In the same Fig. 5, those portions of the tracing which are drawn below the line Ox indicate the variations of a second voltage or potential given from the photoelectric cell 23 inversely connected with respect to the cell 22. A broken line s_2, g_2, b_2, e_2 is thus obtained and the potentiometric means P_1 is adjusted in such a manner that for the area corresponding to the desired shade S potentials having the same value, but of opposite polarities, be obtained.

Under such conditions the photoelectric cells 22 and 23 produce a total output potential or third voltage which is represented by the tracing of Fig. 6. It may be seen from this representation that the circuit C_1 is insufficient to give a suitable selection, since some of the colors E to be suppressed produce output potentials comprised between the values corresponding to the portions *s* and *b* respectively, whereas a black area, when scanned, produces no output potential, as is the case for the desired color S.

Referring now to Fig. 7, the curve above the line Ox represents the output potentials applied by the circuit C_3 to the resistance 54, and the potentials obtained from the circuit C_2 through the resistance 48 are illustrated by the curve below the line Ox. The potentiometric means P_2, P_4, P_5, P_6 in the circuits C_2 and C_3 are adjusted in such a manner that the circuit C_3 always gives a potential having the same polarity as the potential given by the circuit C_1, and the minimum value of which is equal to that of the circuit C_2 when the desired tint S is scanned, but is oppositely polarized. When the strip *abcd* is scanned, the circuit C_2 generates a fourth voltage or potential varying in accordance with the various colors and tints in said strip, as represented by the broken line s_3, g_3, b_3, n_3, e_3, and the circuit C_3 produces also a fifth varying voltage or potential represented by the broken line s_4, g_4, b_4, n_4, e_4.

Fig. 8 shows the resultant potentials obtained at the output of the circuits C_2 and C_3, which are represented by the curve s_5, g_5, b_5, n_5, e_5.

Similarly the Fig. 9 illustrates the output potential from the three circuits together, this final potential being represented by the broken line s_6, g_6, b_6, n_6, e_6, from which it may be seen that the desired tint S produces a zero resulting potential, which progressively increases as the tint S fades out, up to a maximum constant value corresponding to pure white. For black areas and areas having colors different from the desired tint, the potentials produced have a higher value than the potential corresponding to pure white.

Thus, the cooperating circuits C_2 and C_3 cause the slope of the line *g* to be reduced and the potentials corresponding to black and undesired colored areas to be made greater than the potential produced by a white area. As a result, the mirror of the oscillograph will swing through a given angle comprised between zero for the desired color and a maximum for pure white, while the colors to be eliminated will impart a greater angular displacement to the mirror; in this manner, the reflected beam corresponding to the undesired colors is deflected angularly beyond the above-mentioned operative maximum and beyond the operative range of the receiving or metering apparatus.

Obviously, many changes and variations could be made to the exemplary embodiment described without departing from the general scope of the present invention. Thus, as previously stated, a plurality of mirrors could be used for selecting a given tint in the spectrum which controls the pair of photoelectric cells 22—23; this would be the case, for instance, for a red-violine or brown tint which comprises two distinct portions of the spectrum; in such an instance, two mirrors 24 would be employed.

Also the photoelectric cell 26 could be suppressed and then the circuit C_2 could be controlled by the photoelectric cell 23; with such an arrangement, however, the accuracy of selection of the apparatus would be lesser, since the described arrangement enables to select a portion of the spectrum to energize the photoelectric cell 26 which is slightly different from the portion which acts on the photoelectric cell 23; experiments have revealed that such a possibility offers many practical advantages in most cases.

It is to be clearly understood, on the other hand, that a selecting arrangement in accordance with the present invention may be used for controlling any known device adapted for use in some different type of system.

Having thus described my invention what is claimed as new and desired to be secured by Letters Patent, is:

1. An apparatus for selecting colors and distinguishing among the shadings of a desired color, comprising, in combination, scanning means producing a beam of light emanating from a scanned area of an object, optical means alternately directing said beam over two different paths, first light dispersing means in one of said paths producing a first spectrum, first and second photoelectric means in said first path, first adjustable optical means in said first path directing the portion of said first spectrum corresponding to said desired color toward said first photoelectric means and directing the remainder of said first spectrum toward said second photoelectric means, thereby causing the production of a first output voltage by said first photoelectric means and of a second output voltage by said second photoelectric means, said portion of said output being that part of the spectrum which corresponds to

a desired color, a first comparison circuit algebraically summing said first and said second output voltages, thereby producing a third voltage, second light dispersing means in said second path producing a second spectrum, third photoelectric means in said second path, second adjustable optical means in said second path directing the portion of said second spectrum which corresponds sensibly to said desired color towards said third photoelectric means thereby causing the production of a fourth output voltage, D.-C. amplifier means comprising an electron tube provided with a control grid, biasing means for said control grid including a source of direct current, circuit means including said source and said third photoelectric means biasing said amplifier means beyond cut-off upon said fourth voltage being due to the scanning of an area comprising said desired color, said amplifier means thus producing an output in the form of a fifth voltage having a substantially constant value as long as said scanned area contains said desired color, a second comparison circuit algebraically summing said fifth voltage with said fourth voltage, thereby producing a sixth voltage, a third comparison circuit algebraically summing said sixth voltage with said third voltage, thereby producing a seventh voltage, and measuring apparatus responsive to said seventh voltage.

2. An apparatus according to claim 1, wherein said measuring apparatus is arranged to give a maximum reading in response to a seventh voltage due to the scanning of a white area and a maximum reading in response to a seventh voltage due to the scanning of an area of said desired color reading.

3. Apparatus for detecting a desired color and distinguishing among the shades of said desired color, comprising means for successively scanning areas of an object, means for resolving the light emanating from said scanned areas into its spectral components, means for producing a first voltage proportional to the quantity of said desired color present in the spectrum of said

scanned areas, means for producing a second voltage proportional to the quantity of the remaining colors of the spectrum of said scanned areas other than said desired color, means for algebraically summing said first voltage and said second voltage to produce a third voltage of a magnitude indicative of shadings different from said desired color except for the color black, means for producing a fourth voltage proportional to the quantity of said desired color, means for producing a fifth voltage in dependence upon said fourth voltage, means for maintaining said fifth voltage at a substantially constant value when said desired color is present in the spectrum of said scanned areas, means for changing said fifth voltage from said constant value when said desired color is absent from said scanned areas, means for algebraically summing said fourth and fifth voltages to produce a sixth voltage for differentiating the presence of the color black from said desired color, and means for algebraically summing said third and sixth voltages to thereby produce a seventh voltage indicative of the shadings different from said desired color.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,849,544	Howey	Mar. 15, 1932
1,999,023	Sharp et al.	Apr. 23, 1935
2,162,529	Dawson et al.	June 13, 1939
2,287,322	Nelson	June 23, 1942
2,359,734	Hood	Oct. 10, 1944
2,382,439	Osborn	Aug. 14, 1945
2,442,910	Thomson	June 8, 1948

FOREIGN PATENTS

Number	Country	Date
687,405	Germany	Jan. 29, 1940