upon relatively low light intensities reflected from the sample. The white standard, which is the reference for the reflectance value measurement, represents the condition of 100 percent reflectance, a maximum intensity of reflected light. Noise in the system, on the other hand, is generally kept to a relatively low value, but nevertheless may comprise a significant portion of light intensities reflected from different samples. Thus, noise in the system will introduce greater errors in the measurement of those colors with respect to which the human eye has the increased resolution.

Although prior systems compensate for electrical noise in the system, there is no suggestion in any of the prior art of compensating color measurements for noise due to stray light. Stray light may enter the system despite difficult, complex and costly attempts to block its entrance. Such stray light may exist in the optical paths from several sources, including light derived from the primary source of illumination which finds its way to the photosensitive device, bypassing both the color and white standard target. It is possible to measure electronic noise by taking a reading on the electrical output of the system with the light input totally blocked, but such a measurement would not account for noise generated by the photosensitive surface in the presence of received radiant energy, nor would it account fot stray light in the system.

Still another disadvantage of prior systems is the time required for a single measurement encompassing the entire optical spectrum. It is not uncommon for such systems to require as much as two full minutes for a single measurement employing 20–30 sample points of the color spectrum being measured.

In an article entitled "The Growing Range of Mulitchannel Detection", in the January, 1971, issue of *Optical Spectra*, G. G. Olson described systems of multichannel spectrophotometry employing improved detectors in the form of television camera tubes, such as silicon vidicon and other tubes containing internal image intensification with conventional photocathode front ends. An optical mulitchannel analyzer that has been built by SSR Instruments of Santa Monica, California, is described in an article entitled "Optical Multichannel Analyzer" by F. W. Karasek in the January, 1972, issue of *Research/Development*, pages 47–50, and in an article entitled "Applications of an Optical Multichannel Analyzer" by G. G. Olson in the February, 1972, issue of *American Laboratory*. As described in these articles, the SSR instrument employs electronic spectral scanning performed within the vidicon tube and further employs the face of the vidicon tube to image both background and signal channels so as to allow background and random noise to be substracted subtracted the signal. The background and random noise includes camera tube dark current, shot noise and resistor thermal noise. However, this method of noise compensation employs different areas on the face of the photo-sensitive surface and does not account for difference in noise generated or received by the different surface areas, particularly where different optical paths are involved. Further, the arrangement of the SSR instrument does not compensate for stray light that occurs in the optical path of the signal, for stray light emanating from the primary source of radiation that illuminates the target, nor for stray light in the reflectance measurement system.

According, it is an object of the present invention to provide methods and apparatus for measurement of color that avoid or substantially minimize the abovementioned problems.

SUMMARY OF THE INVENTION

In carrying out principles of the present invention in accordance with an exemplary embodiment thereof, improvement in noise elimination is accomplished by subtracting from the several intensity measurements an intensity measurement representing energy transmitted from a black body. According to one aspect of the invention, reflectance measurements for color are made by comparing the reflections from a color sample over its spectrum with reflections from each of a white standard and a black body over corresponding spectra. Problems of matching plural radiant energy collecting paths are minimized by use of a path that is common to all of the measurements over substantially the entire length of the transmission. In a specific arrangement, a mirror is moved to sequentially view each of three targets whose reflectance is employed in the measurement. Energy is reflected from the mirror along a single optical path to a radiant energy-sensitive device at which intensities are changed to electrical quantities.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a color measuring system embodying principles of the present invention;

FIG. **2** is a schematic representation of significant mechanical, optical and electrical components of a color measuring system embodying principles of the present invention;

FIG. **3** is a view of optical components, the diffusisng sphere and polychrometer of a preferred form of the invention;

FIGS. **4** and **5** are cross-sectional views showing details of the diffusing sphere of FIG. **3**;

FIG. **6** shows the diffusing system mirror and part of its support; and

FIG. **7** illustrates an embodiment of the invention employing a vidicon sensor.

DETAILED DESCRIPTION

The general arrangement of a color measuring system employing principles of the present invention is illustrated in block form in FIG. **1**, wherein a diffusing sphere **10** having a plurality of target ports and a source of illumination is operated under control of a port selector **12** to sequentially view the several targets positioned at the target ports. The mirror transmits light reflected from the targets in sequence to a polychrometer **14** which spectrally disperses the transmitted light and causes the spectra to impinge upon the surface of a sensor **16** which may take the form of an array of light-sensitive elements or the face of an electronic image tube. The image upon the sensor surface is scanned and sampled. The resulting electrical signals represent measured intensities of impinging light and are fed to storage and computation apparatus indicated generally at **18**. The storage and computation, the scanning or readout of the sensor surfaace, surface, the selection of a target to be viewed by means of the port selector, are all under synchronized control of a timing and control circuit **20** which is basically timed from a crystal clock **22**. The storage and computation equipment **18** performs the required arithmetic operation of subtracting