REFLECTANCE MEASURING APPARATUS INCLUDING A CYLINDER-SHAPED LIGHT CONDUCTING DEVICE BETWEEN THE MEASURING APERTURE AND THE SPECIMEN

FIELD OF THE INVENTION

The invention relates to a reflectance measuring apparatus having a measuring aperture for placement on the specimen to be measured. The apparatus includes a light source for illuminating the specimen and a receiving optic which detects the radiation reflected from the specimen within a predetermined aperture.

BACKGROUND OF THE INVENTION

Reflectance measuring apparatus measure the proportion of the radiation reflected from a specimen to the radiation reflected from a comparison specimen under the same conditions. For this purpose, the specimen is placed on a circularly-shaped measurement opening in many such apparatus so that the specimen is received by the measuring apparatus in a precisely defined position. Often, this measuring aperture is arranged in a so-called Ulbricht sphere by means of which the specimen is diffusibly illuminated.

With some reflectance apparatus, a so-called measuring head having all parts necessary for the measurement in the direct vicinity of the specimen is separated from the remainder of the apparatus and is connected to the latter only via a cable. In these apparatus, the measuring aperture can be brought to the specimen which is an advantage especially for large and heavy specimens. Such a reflectance measurement apparatus is described, for example, in the article entitled "Diode Array Spectrometer: an Optimised Design" by H. H. Schlemmer and M. Mächler, J. Phys. E: Sci-Instrum., Volume 18, pages 913 to 919, 1985.

The measurement opening must not exceed a specific diameter so that the measuring apparatus or the measuring head is not too large. However, since the measuring aperture must be large with respect to the surface structure of the specimen in order to obtain measurement results which are independent of which part of the specimen is by chance applied to the measuring aperture, only specimens with a sufficiently small surface structure can be reliably measured for a predetermined diameter of the measuring aperture. This is especially then a disadvantage when specimens having a large surface structure are to be measured only from time to time.

Further, an enlargement of the measurement surface on the specimen cannot be obtained by arranging the specimen in a correspondingly large spacing from the measuring aperture because not only does the illumination of the specimen become so weak that the reflected radiation is no longer adequate for measuring but also because the angular distribution of the rays incident on the measurement surface of the specimen is so changed even with small distance changes that the measurement values and therefore also the color range change considerably.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a reflectance measuring apparatus which can also adequately and reproducibly measure specimens having relatively large surface structure notwithstanding a small measuring aperture.

According to a feature of the reflectance measuring apparatus of the invention, a light-conducting device which is at least approximately cylindrically shaped is placed or is placeable upon the measuring aperture. The axis of the light-conducting device is perpendicular to and disposed centrally on the surface of the measuring aperture and has a diameter and length which is selected so that the aperture of the receiving optic is at least not substantially changed and the end of the light-conducting device lying opposite the measuring aperture is provided as an enlarged measuring aperture for the specimen.

In an especially advantageous embodiment of the invention, the light-conducting device comprises a cylindrically-shaped tube which is mirrored on its inner surface. If the following conditions are present: (a) the inner diameter of the tube is, for example, greater than the diameter of the measurement surface in the measuring aperture by a factor of 1.41; and, (b) the tube is so long that at its end facing away from the measuring aperture, the aperture angle detected by the receiving optic almost touches the inner diameter; then the specimen surface detected at the end of the tube for the measurement is twice as large as when the specimen is placed directly on the measuring aperture.

According to another embodiment of the invention, the end of the tube facing the specimen can be provided closed off by a window.

In another advantageous embodiment of the invention, the light-conducting device comprises a solid, light-transmitting cylindrical part made of glass or plastic. In this case, the enlargement factor of the measurement surface is smaller by a factor of the index of refraction of the glass or plastic or the length of the light-conducting device must be increased with respect to the tube by a factor of the index of refraction. This can even be advantageous in order to reach a measurement surface on which the conventional measuring head cannot be applied because of spatial reasons.

If quantitative deviations in the color values computed from the reflectance values are permitted, then the light-conducting device can be made shorter or longer than in the embodiments discussed above. Even deviations from the cylindrical shape are possible provided that they are not too large. Furthermore, the measurement surfaces must not necessarily have circularly-shaped cross sections.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the drawings wherein:

FIG. **1** is a side elevation view, in section, of a reflectance measuring apparatus having an Ulbricht sphere for diffusibly illuminating the specimen and a cylindrically-shaped tube disposed ahead of the measuring aperture; and,

FIG. **2** is a side elevation view, in section, of the measuring part of a reflectance measuring apparatus having directed illumination of the specimen and a massive light conductor ahead of the measuring aperture.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

In FIG. **1**, reference numeral **1** identifies an Ulbricht sphere which has a measuring aperture **11***m* on which a specimen to be measured can be placed in the usual