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(71)出願人 000005201
富士写真フイルム株式会社
神奈川県南足柄市中沼210番地

(72)発明者 町田 誠
神奈川県南足柄市中沼210番地 富士写真フイルム株式会社内

(74)代理人 100080159
弁理士 渡辺 望稔

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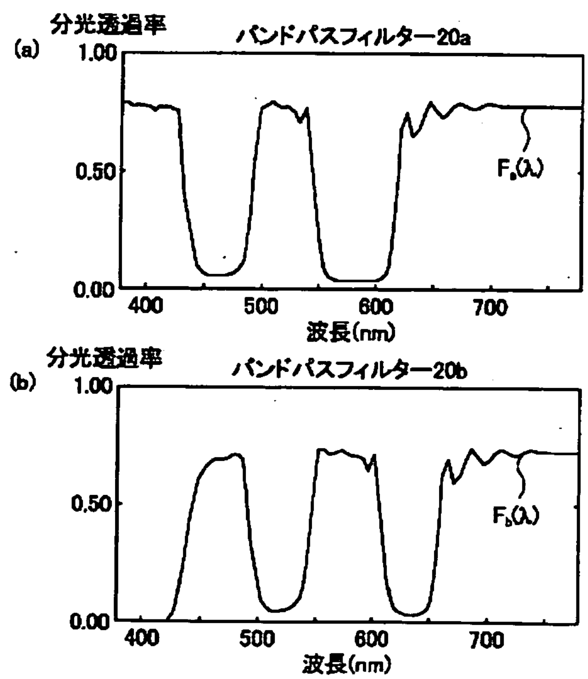
(54)【発明の名称】 分光反射率画像の取得方法、撮影装置および分光反射率画像取得システム

(57)【要約】

【課題】複数の分光感度帯域を有する感光材料等の感光素子を用いて画像を撮影し、この撮影した画像から分光反射率画像を取得する際、小型軽量で簡便なカメラ等の撮像装置を用い、従来のマルチバンド画像を撮影する際に比べて、少ない撮影回数で被写体を撮影して、分光反射率画像を取得することを目的とする。

【解決手段】複数の分光感度帯域の各々を多分割した複数の分割波長帯域の中から、分光感度帯域毎に１つずつ選ばれた複数の分割波長帯域を、撮影の際の撮影光の通過波長帯域とするバンドパスフィルター２０ａ、２０ｂを、分光感度帯域のすべての分割波長帯域が１度ずつ選択されるように用意し、この用意されたバンドパスフィルター２０ａ、２０ｂ毎に、同一被写体を撮影して画像を取得し、この撮影した画像から分光反射率画像を取得する。



ステムを提供することを目的とする。

【０００６】

【課題を解決するための手段】上記目的を達成するために、本発明は、分光波長上に複数の分光感度帯域を有する感光素子を用いて被写体を撮影し、この撮影した画像から分光反射率画像を取得する分光反射率画像の取得方法であって、前記複数の分光感度帯域の各々を多分割した複数の分割波長帯域の中から前記分光感度帯域毎に１つずつ選ばれた複数の分割波長帯域を撮影の際の撮影光の通過波長帯域とするフィルターが、前記分光感度帯域の前記分割波長帯域のすべてが１度ずつ選ばれるように複数用意されており、このフィルターを取り替えながら、同一被写体を撮影し、撮影した画像から分光反射率画像を取得することを特徴とする分光反射率画像の取得方法を提供するものである。

【０００７】ここで、前記感光素子を用いて得られる画像の濃度値と撮影の際の露光量との対応関係を予め定めた参照テーブルを用いて、前記撮影された画像の濃度値から前記撮影の際の露光量を求めることによって、前記分光反射率画像を取得するのが好ましい。また、前記感光素子は、３個以上の分光感度帯域を有する写真用感光材料であるのが好ましい。

【０００８】また、上記目的は、分光波長上に複数の分光感度帯域を有する感光素子を用いて画像を撮影する撮影装置であって、前記複数の分光感度帯域の各々を多分割した複数の分割波長帯域の中から前記分光感度帯域毎に１つずつ選ばれた複数の分割波長帯域を、前記撮影の際の撮影光の通過波長帯域とするフィルターを有し、このフィルターが、前記分光感度帯域のすべての分割波長帯域が１度ずつ選ばれるように、複数用意されていることを特徴とする撮影装置によって達成される。

【０００９】また、上記目的は、分光波長上に複数の分光感度帯域を有する感光素子を用いて被写体を撮影する撮影装置と、撮影した画像から分光反射率画像を取得する処理装置とを備える分光反射率画像取得システムであって、前記撮影装置は、前記複数の分光感度帯域の各々を多分割した複数の分割波長帯域の中から前記分光感度帯域毎に１つずつ選ばれた複数の分割波長帯域を撮影の際の撮影光の通過波長帯域とするフィルターが、前記分光感度帯域のすべての分割波長帯域が１度ずつ選ばれるように複数用意され、前記処理装置は、前記感光素子を用いて得られる画像の濃度値と露光量との対応関係を定めた参照テーブルと、この参照テーブルを用いて、前記フィルターを取り替えながら前記撮影装置で同一被写体を撮影した画像から、撮影の際の露光量を求め、この露光量から分光反射率を算出する分光反射率算出部とを有することを特徴とする分光反射率画像取得システムによって達成される。

【００１０】

【発明の実施の形態】以下、本発明の分光反射率画像の取得方法、撮影装置および分光反射率画像取得システムについて、添付の図面に示される好適実施形態を基に詳細に説明する。

【００１１】図１には、本発明の好適実施形態である分光反射率画像取得システム１０が示される。分光反射率画像取得システム１０は、カメラ１２と、処理装置１４とを有して構成される。

【００１２】カメラ１２は、撮影レンズ１６を介して結像された被写体の像を赤（Ｒ）、緑（Ｇ）および青（Ｂ）の光で感光するＲ、Ｇ、Ｂの感光感度帯域を有する写真用フィルム１８に記録する撮影装置で、本発明における感光材料（感光素子）を用いて記録する本発明に係る撮影装置の一例である。撮影レンズ１６の前面にはバンドパスフィルター２０が配置される。

【００１３】バンドパスフィルター２０は、後述するように、フィルム１８の３つの分光感度帯域Z_B、Z_G、Z_R（図４参照）の各々を２分割した２つの分割波長帯域の中から、分光感度帯域Z_B、Z_G、Z_R毎に分割波長帯域を１つずつ選択し、この選択された３つの分割波長帯域を撮影の際の撮影光の通過波長帯域とするものであり、分割波長帯域が１度ずつ選択されるように、異なる分割波長帯域が選択された２つのバンドパスフィルター２０ａ、２０ｂによって構成される。そして、被写体の撮影は、２つのバンドパスフィルター２０ａ、２０ｂを取り替えながら行われる。撮影されたフィルム１８は現像されて、同一の被写体を２つのバンドパスフィルター２０ａ、２０ｂを用いて撮影した２つの画像が形成される。画像の形成されたフィルム１８は、処理装置１４のフィルムを読み取るスキャナ部２２に送られる。

【００１４】処理装置１４のスキャナ部２２は、フィルム１８上の画像を担持する透過光を結像させてＣＣＤ撮像素子等によって読み取り、規格等によって予め定められたＲ、ＧおよびＢの３原色の分光波長に基づいた画像の画素毎の濃度信号D_R、D_GおよびD_Bを得る部位である。ここで、スキャナ部２２で読み取られる画像は、バンドパスフィルター２０ａ、２０ｂを用いて同一被写体を撮影した２つの画像であるので、濃度信号D_R、D_GおよびD_Bは、この２つの画像の画素毎の信号となる。ここで、スキャナ部２２は、公知のスキャナ読取装置が用いられる。得られた濃度画像信号D_R、D_GおよびD_Bは対数露光量変換部２３に送られる。

【００１５】対数露光量変換部２３は、送られてきた濃度画像信号D_R、D_GおよびD_Bを用い、３次元ＬＵＴ（ルックアップテーブル、参照テーブル）２４を参照して、濃度画像信号D_R、D_GおよびD_Bに対応する対数露光量信号$\mathrm{Log}E_R$、$\mathrm{Log}E_G$、$\mathrm{Log}E_B$に変換する部位である。なお、３次元ＬＵＴ（ルックアップテーブル）２４の作成方法については後述する。

【００１６】対数露光量変換部２３では、スキャナ部２２から送られてきた濃度画像信号D_R、D_GおよびD_B

があったが、本実施形態ではバンドパスフィルター２０ａ、２０ｂを取り替えて２回の撮影で済む。

【００２６】なお、バンドパスフィルター２０ａは、例えば、図７（ａ）に示すように、４６０（ｎｍ）を中心とし半値幅を略６０ｎｍとする帯域を非透過帯域（反射帯域）とするバンドストップ型の干渉フィルターａ$_1$と、５７０（ｎｍ）を中心とし半値幅を略８０ｎｍとする帯域を非透過帯域（反射帯域）とするバンドストップ型の干渉フィルターａ$_2$とを重ねることによって得られる。干渉フィルターａ$_1$、ａ$_2$の重ね合わせの際、バンドパスフィルター２０ａ、２０ｂに干渉縞が発生しないように、インデックスマッチングオイルをフィルター面に塗り、あるいは、干渉フィルターａ$_1$、ａ$_2$の間に所定間隔の空隙を設けるのが好ましい。このようなバンドストップ型の干渉フィルターは、基板上に屈折率の異なる誘電体を真空蒸着させることによって作製され、例えば、光伸光学工業株式会社製バンドストップフィルターや富士写真光機株式会社製バンドリフレクションフィルターが挙げられる。

【００２７】同様に、バンドパスフィルター２０ｂは、図７（ｂ）に示すような透明基板に染料を用いて作成したフィルターｂ$_1$と上記バンドストップ型の干渉フィルターｂ$_2$、ｂ$_3$とを用い、これらを重ねて得られる。

【００２８】このようなバンドパスフィルター２０ａおよび２０ｂを用いて撮影されたフィルム１８の画像は、スキャナ部２２において、読み取られ（ステップ１０２）、２つの撮影画像各々の画素毎の濃度画像信号D_R、D_GおよびD_Bが得られる。さらに、濃度画像信号D_R、D_GおよびD_Bは、対数露光量変換部２３において、３次元ＬＵＴ２４を用いて、対数露光量$LogE_R$、$LogE_G$、$LogE_B$に変換される（ステップ１０４）。ここで、３次元ＬＵＴ２４は以下のように作成される。すなわち、レーザー露光装置、例えば富士写真フイルム社製ＰＨＩＳＵＬを用いて、Ｒ、ＧおよびＢの光の強度をそれぞれ９段階に制御してフィルム１８あるいは、フィルム１８と同等の分光感度特性を有する感光材料に光を照射し、9^3（７２９）個の画像を作成する。そして、この作成された画像をスキャナ部２２で読み取って、9^3（７２９）個の濃度画像信号D_R、D_GおよびD_Bを得、9^3（７２９）個の濃度画像信号D_R、D_GおよびD_Bを３次元座標（D_R，D_G, D_B）におけるサンプル点とする。一方、上記レーザー露光装置において、Ｒ、ＧおよびＢの光を９段階に制御した際の、9^3個の光の露光量を対数化した対数露光量$LogE_R$、$LogE_G$、$LogE_B$を求め、先に求めた9^3（７２９）個のサンプル点と対応させて、３次元ＬＵＴ２４を作成する（ステップ１０６）。このような３次元ＬＵＴ２４の作成は、被写体の撮影の前に予め行われるものであってもよい。

【００２９】濃度画像信号D_R、D_GおよびD_Bが、３次元ＬＵＴ２４のサンプル点に該当するものであれば、この３次元ＬＵＴ２４上のサンプル点に対応する対数露光量$LogE_R$、$LogE_G$、$LogE_B$を取り出し、濃度画像信号D_R、D_GおよびD_Bが、３次元ＬＵＴ２４のサンプル点に該当しない場合、サンプル点による内挿補間を用いて対応する対数露光量$LogE_R$、$LogE_G$、$LogE_B$を算出する。このような対数露光量の算出は、読み取られた２つの画像について画素毎に行われる。

【００３０】次に、分光反射率の算出が行われる（ステップ１０８）。すなわち、ステップ１０６において算出された対数露光量$LogE_R$、$LogE_G$、$LogE_B$から、露光量E_R、E_G、E_Bを求め、一方において、基準白色板を所定の照明光の下で被写体として上記感光材料に撮影した際の撮影光の露光量E_wを予め求め、この露光量E_wを用いて、上記露光量E_R、E_G、E_Bを正規化し、基準白色板に対する相対露光量S_{in}（ｉ＝ａまたはｂ、ｎ＝１～３）を求め、この値を分光反射率の値とする。

【００３１】ここで求められる相対露光量S_{in}は、公知の下記式（１）で定められるフィルム１８の受ける相対露光量S_{in}'に対応するものである。

【数１】

$$S'_{in}=\frac{\int_{vis}R(\lambda)\cdot P(\lambda)\cdot F_i(\lambda)\cdot S_n(\lambda)d\lambda}{\int_{vis}P(\lambda)\cdot W(\lambda)\cdot F_i(\lambda)\cdot S_n(\lambda)d\lambda} \quad (1)$$

$$(i=a,b\ ,\ n=1,2,3)$$

その際、Ｒ（λ）は、被写体の分光反射率分布であり、Ｐ（λ）は、照明光の分光強度分布であり、F_i（λ）は、バンドパスフィルター２０ａあるいは２０ｂの分光透過率分布であり、S_n（λ）は、フィルム１８の分光感度分布であり、Ｗ（λ）は、基準白色板の分光反射率分布である。

【００３２】なお、式（１）の分母の積分値は、上記基準白色板の露光量E_wに対応し、式（１）の分子の積分値は、露光量E_R、E_G、E_Bに対応する。従って、露光量E_wを用いて、露光量E_R、E_G、E_Bを正規化するので、相対露光量S_{in}は、式（１）で定められるフィルム１８の受ける相対露光量S_{in}'と対応する。一方、上述したように分光感度帯域Z_B、Z_G、Z_Rを分割する分光透過率分布F_i（λ）と分光感度分布S_n（λ）との積によってできる分光特性が、図６に示すように、比較的急峻なピークを構成するので、分光反射率分布Ｒ（λ）は６つの相対露光量S_{in}に略対応する。従って、分光反射率分布Ｒ（λ）は、相対露光量S_{in}と対応する。

【００３３】求められた相対露光量S_{in}の値は、対応するバンドパスフィルター２０ａ、２０ｂの通過波長領域

である。

【００４２】

【発明の効果】以上、詳細に説明したように、感光素子の分光感度帯域を多分割するバンドパスフィルターを用いるので、小型軽量で簡便なカメラ等の撮影装置を用いることができる。しかも、分光反射率分布の推定算出精度を落とすことなく、従来の方法でマルチバンド画像を撮影する際に比べて、少ない撮影回数で被写体を撮影して分光反射率画像を取得することができる。

【図面の簡単な説明】

【図１】　本発明の分光反射率画像の取得方法を実施する本発明の分光反射率画像取得システムの構成の一例を示す構成図である。

【図２】　本発明の分光反射率画像の取得方法の流れの一例を示すフローチャートである。

【図３】　本発明における感光素子の一例である写真用フィルムを説明する図である。

【図４】　図３に示すフィルムの分光感度分布の一例を示す図である。

【図５】　（ａ）および（ｂ）は、本発明におけるバンドパスフィルターの分光透過率分布の一例を示す図である。

【図６】　図４に示す分光感度分布と図５（ａ）および（ｂ）に示す分光透過率分布によってできる分光特性を示す図である。

【図７】　（ａ）および（ｂ）は、図５（ａ）および（ｂ）に示す分光透過率分布を有するバンドパスフィルターの合成方法を示す図である。

【図８】（ａ）～（ｄ）は、本発明の方法によって得られた分光反射率の値を分光波長を横軸にしてプロットしたグラフである。

【符号の説明】

１０　分光反射率画像取得システム

１２　カメラ

１４　処理装置

１６　撮影レンズ

１８　フィルム

２０ａ，２０ｂ　バンドパスフィルター

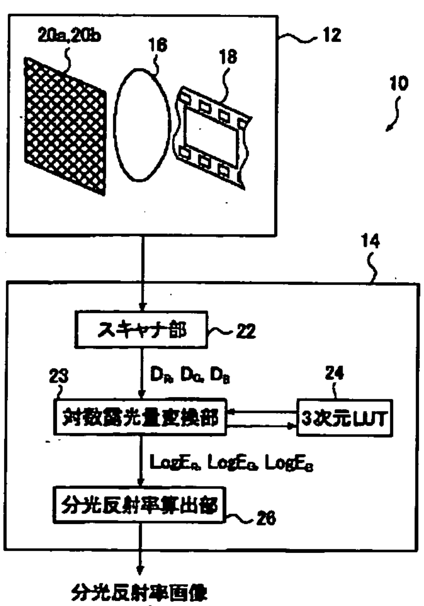
２２　スキャナ部

２３　対数露光量変換部

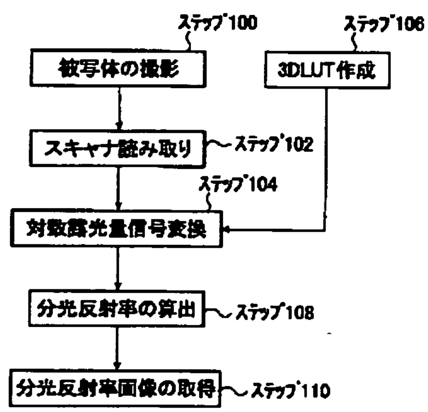
２４　３次元ＬＵＴ

２６　分光反射率算出部

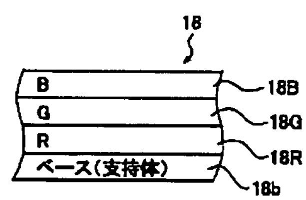
【図１】



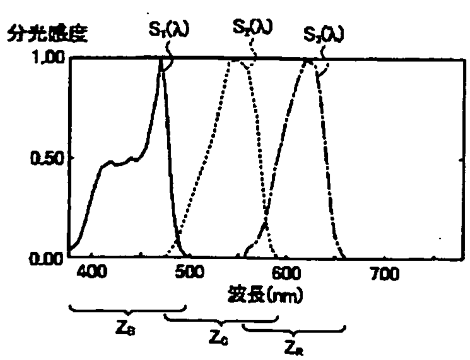
【図２】



【図３】



【図４】



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CLAIMS

[Claim(s)]
[Claim 1] A photographic subject is photoed using the light-sensitive element which has two or more spectral sensitivity bands on part light wave length. It is the acquisition approach of the spectral-reflectance image which acquires a spectral-reflectance image from this photoed image. The filter made into the passage wavelength band of the photography light in the case of photography of two or more division wavelength bands chosen one [at a time] for said every spectral sensitivity band from two or more division wavelength bands which carried out hyperfractionation of each of two or more of said spectral sensitivity bands The acquisition approach of the spectral-reflectance image which photos the same photographic subject and is characterized by acquiring a spectral-reflectance image from the photoed image while two or more preparation is carried out so that said all division wavelength bands of said spectral sensitivity band may be chosen by a unit of 1 time, and exchanging this filter.
[Claim 2] The acquisition approach of the spectral-reflectance image according to claim 1 characterized by acquiring said spectral-reflectance image using the reference table which defined beforehand the correspondence relation between the concentration value of the image obtained using said light-sensitive element, and the light exposure in the case of photography by calculating the light exposure in the case of said photography from the concentration value of said photoed image.
[Claim 3] Said light-sensitive element is the acquisition approach of the spectral-reflectance image according to claim 1 or 2 which is the sensitive material for photographs which has three or more spectral sensitivity bands.
[Claim 4] It is photography equipment which photos an image using the light-sensitive element which has two or more spectral sensitivity bands on part light wave length. Two or more division wavelength bands chosen one [at a time] for said every spectral sensitivity band from two or more division wavelength bands which carried out hyperfractionation of each of two or more of said spectral sensitivity bands Photography equipment with which it has the filter made into the passage wavelength band of the photography light in the case of said photography, and this filter is characterized by carrying out two or more preparation so that all the division wavelength bands of said spectral sensitivity band may be chosen by a unit of 1 time.
[Claim 5] The photography equipment which photos a photographic subject using the light-sensitive element which has two or more spectral sensitivity bands on part light wave length, It is a spectral-reflectance image acquisition system equipped with the processor which acquires a spectral-reflectance image from the photoed image. Said photography equipment The filter made into the passage wavelength band of the photography light in the case of photography of two or more division wavelength bands chosen one [at a time] for said every spectral sensitivity band from two or more division wavelength bands which carried out hyperfractionation of each of two or more of said spectral sensitivity bands Two or more preparation is carried out so that all the division wavelength bands of said spectral sensitivity band may be chosen by a unit of 1 time. Said processor The reference table which defined the correspondence relation of the concentration value of an image and light exposure which are obtained using said light-sensitive element, The spectral-reflectance image acquisition system characterized by having the spectral-reflectance calculation section which calculates the light exposure in the case of photography, and computes a spectral reflectance from this light exposure using this reference table from the image which photoed the same photographic subject with said photography equipment while exchanging said filter.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention photos an image using light-sensitive elements, such as photosensitive material which has two or more spectral sensitivity bands, and relates to the acquisition approach of the spectral-reflectance image which acquires a spectral-reflectance image from this photoed image, photography equipment, and a spectral-reflectance image acquisition system.
[0002]
[Description of the Prior Art] Color photography is recording the color information on a photographic subject as an image, R, G, and B, of three channels today using the sensitive film for color photography which has the sensitive material (light-sensitive element) of R, G, and B exposed with the light of red (R), green (G), and blue (B). However, in color photography, since the color information on a photographic subject is based on three colors, even if it searches for spectral-reflectance distribution of the photoed photographic subject using the spectral sensitivity characteristic of the sensitive material of R, G, and B, it cannot pass over spectral-reflectance distribution to be expressed by three points in a part light wave length band, and it cannot presume spectral-reflectance distribution correctly.
[0003] There is the approach of computing spectral-reflectance distribution by acquiring the multi-band image which photoed the same photographic subject whose wavelength fields differ on the other hand, using a CCD camera as an approach of acquiring spectral-reflectance distribution by at least four or more channels. For example, in the field of fine-arts handicrafts, such as pictures, in order to perform faithful reappearance of a color, the above-mentioned multi-band image is used and arrangement preservation etc. is performed. Furthermore, spectral-reflectance distribution of a photography photographic subject is searched for for every pixel, the spectral-reflectance image which has spectral-reflectance distribution of a photography photographic subject for every pixel is obtained from the above-mentioned multi-band image, and arrangement preservation etc. is performed. Here, changing 16 times, for example changing the band pass filter which makes a steep peak wave a filter property one by one, a multi-band image photos the same photographic subject, and is acquired by obtaining 16 monochrome photography images, for example.
[0004]
[Problem(s) to be Solved by the Invention] however, the camera which photos a multi-band image -- the above -- a steep peak wave -- a filter shape -- carrying out -- moreover -- a peak wave -- a spectrum -- since the adjustable filter which can be freely shifted on wavelength was used, the camera itself could not become large, it could not become complicated and could not carry easily, and also there was a problem that actuation of the band pass filter at the time of photography became complicated. Furthermore, since the same photographic subject had to be photoed and exposure time took two or more times in all, for example, no less than 16 times, for the number of channels, the photographic subject also had the problem that it was restricted to a static image.
[0005] Then, this invention photos an image using light-sensitive elements, such as sensitive material which has two or more spectral sensitivity bands. In case a spectral-reflectance image is acquired from this photoed image, compared with the time of photoing the conventional multi-band image using image pick-up equipments, such as a simple camera, by the small light weight, a photographic subject is photoed by the small count of photography. It aims at offering the acquisition approach of the spectral-reflectance image which acquires a spectral-reflectance image, photography equipment, and a spectral-reflectance image acquisition system.
[0006]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention photos a photographic subject using the light-sensitive element which has two or more spectral sensitivity bands on part light wave length. It is the acquisition approach of the spectral-reflectance image which acquires a spectral-reflectance image from this photoed image. The filter made into the passage wavelength band of the photography light in the case of photography of two or more division wavelength bands chosen one [at a time] for said every spectral sensitivity band from two or more division wavelength bands which carried out hyperfractionation of each of two or more of said spectral sensitivity bands Two or more preparation is carried out so that said all division wavelength bands of said spectral sensitivity band may be chosen by a unit of 1 time, exchanging this filter, the same photographic subject is photoed and the acquisition approach of the

spectral-reflectance image characterized by acquiring a spectral-reflectance image from the photoed image is offered.
[0007] It is desirable to acquire said spectral-reflectance image by calculating the light exposure in the case of said photography from the concentration value of said photoed image using the reference table which defined beforehand the correspondence relation between the concentration value of the image obtained using said light-sensitive element, and the light exposure in the case of photography here. Moreover, as for said light-sensitive element, it is desirable that it is the sensitive material for photographs which has three or more spectral sensitivity bands.
[0008] Moreover, the above-mentioned purpose is photography equipment which photos an image using the light-sensitive element which has two or more spectral sensitivity bands on part light wave length. Two or more division wavelength bands chosen one [at a time] for said every spectral sensitivity band from two or more division wavelength bands which carried out hyperfractionation of each of two or more of said spectral sensitivity bands It has the filter made into the passage wavelength band of the photography light in the case of said photography, and this filter is attained by the photography equipment characterized by carrying out two or more preparation so that all the division wavelength bands of said spectral sensitivity band may be chosen by a unit of 1 time.
[0009] Moreover, the photography equipment with which the above-mentioned purpose photos a photographic subject using the light-sensitive element which has two or more spectral sensitivity bands on part light wave length, It is a spectral-reflectance image acquisition system equipped with the processor which acquires a spectral-reflectance image from the photoed image. Said photography equipment The filter made into the passage wavelength band of the photography light in the case of photography of two or more division wavelength bands chosen one [at a time] for said every spectral sensitivity band from two or more division wavelength bands which carried out hyperfractionation of each of two or more of said spectral sensitivity bands Two or more preparation is carried out so that all the division wavelength bands of said spectral sensitivity band may be chosen by a unit of 1 time. Said processor The reference table which defined the correspondence relation of the concentration value of an image and light exposure which are obtained using said light-sensitive element, Using this reference table from the image which photoed the same photographic subject with said photography equipment while exchanging said filter The light exposure in the case of photography is calculated, and it is attained by the spectral-reflectance image acquisition system characterized by having the spectral-reflectance calculation section which computes a spectral reflectance from this light exposure.
[0010]
[Embodiment of the Invention] Hereafter, the acquisition approach of the spectral-reflectance image of this invention, photography equipment, and a spectral-reflectance image acquisition system are explained to a detail based on the suitable operation gestalt shown in an attached drawing.
[0011] The spectral-reflectance image acquisition system 10 which is the suitable operation gestalt of this invention is shown in drawing 1 . The spectral-reflectance image acquisition system 10 has a camera 12 and a processor 14, and is constituted.
[0012] A camera 12 is photography equipment recorded on the photographic film 18 which has the sensitization sensibility band of R, G, and B which expose the image of the photographic subject by which image formation was carried out through the taking lens 16 with the light of red (R), green (G), and blue (B), and is an example of the photography equipment concerning this invention recorded using the sensitive material (light-sensitive element) in this invention. A band pass filter 20 is arranged in the front face of a taking lens 16.

[0013] A band pass filter 20 so that it may mention later Three spectral sensitivity bands ZB of a film 18, Out of two division wavelength bands which divided each of ZG and ZR (refer to drawing 4) into two the spectral sensitivity band ZB, ZG, and ZR every — so that every one division wavelength band is chosen, these three selected division wavelength bands may be made into the passage wavelength band of the photography light in the case of photography and a division wavelength band may be chosen by a unit of 1 time It is constituted by two band pass filters 20a and 20b with which a different division wavelength band was chosen. And photography of a photographic subject is performed, exchanging two band pass filters 20a and 20b. The photoed film 18 is developed and two images which photoed the same photographic subject using two band pass filters 20a and 20b are formed. The film 18 with which the image was formed is sent to the scanner section 22 which reads the film of a processor 14.
[0014] the spectrum of R, G, and B which the scanner section 22 of a processor 14 made carry out image formation of the transmitted light which supports the image on a film 18, read it by the CCD image sensor etc., and were beforehand defined by specification etc. in three primary colors — the concentration signal DR for every pixel of an image based on wavelength, and DG And DB It is the part to obtain. Here, since it is two images which photoed the same photographic subject using band pass filters 20a and 20b, the image read in the scanner section 22 is the concentration signal DR and DG. And DB It becomes a signal for every pixel of these two images. Here, a scanner reader with the well-known scanner section 22 is used. the acquired concentration picture signal DR and DG And DB a logarithm — it is sent to the light exposure transducer 23.
[0015] a logarithm — the concentration picture signal DR with which the light exposure transducer 23 has been sent, and DG And DB using — three-dimension LUT (a look-up table, reference table)24 — referring to -

-- the concentration picture signal DR and DG And DB The number light exposure signals LogER, LogEG, and LogEB of matched pairs It is the part to change. In addition, about the creation approach of three-dimension LUT (look-up table)24, it mentions later.
[0016] a logarithm -- the concentration picture signal DR sent from the scanner section 22 in the light exposure transducer 23, and DG And DB if it is a thing applicable to the sample point of three-dimension LUT24 -- this sample point -- the number light exposure LogER, LogEG, and LogEB of matched pairs It takes out. the concentration picture signal DR sent from the scanner section 22 on the other hand, and DG And DB The concentration picture signal DR sent from the scanner section 22 when it does not correspond to the sample point of three-dimension LUT24, DG And DB Two or more sample points of three-dimension LUT24 which encloses the three-dimension coordinate point (DR, DG, and DB) formed on a three-dimension coordinate are taken out. Interpolation interpolation is used using this sample point, and they are the concentration picture signal DR and DG. And DB The number light exposure LogER, LogEG, and LogEB of matched pairs It computes. such a logarithm -- calculation of light exposure is performed for every pixel of two images corresponding to two band pass filters 20a and 20b read in the scanner section 22. the computed logarithm -- light exposure LogER, LogEG, and LogEB It is sent to the spectral-reflectance calculation section 26.
[0017] Prepare the spectral-reflectance calculation section 26 beforehand, and it asks the sensitive material which has the spectral sensitivity characteristic equivalent to a film 18 or a film 18 for the light exposure Ew of the photography light at the time of photoing a reference white plate as a photographic subject. a logarithm -- the logarithm sent from the light exposure transducer 23 -- light exposure LogER, LogEG, and LogEB from -- light exposure ER, EG, and EB While asking The above-mentioned light exposure Ew It uses and they are light exposure ER, EG, and EB. It normalizes and the relative light exposure to a reference white plate is calculated for every pixel. here -- a logarithm -- light exposure LogER, LogEG, and LogEB The relative light exposure of a total of six pieces is obtained from two images corresponding to band pass filters 20a and 20b. That is, relative light exposure turns into the relative light exposure Sb1, Sb2, and Sb3 of the image photoed through the relative light exposure Sa1, Sa2, and Sa3 of an image and band pass filter 20b which were photoed through band pass filter 20a. This relative light exposure is henceforth set to Sin.(i=a or b, n=1-3).
[0018] furthermore, the spectral-reflectance calculation section 26 the value of the relative light exposure Sin as relative light exposure to the central value of the passage wavelength field of the corresponding band pass filters 20a and 20b Presumed calculation of the spectral-reflectance distribution R (lambda) is carried out using linear interpolation from the point which plotted in the graph which makes an axis of abscissa wavelength and makes an axis of ordinate relative light exposure, and was plotted by this graph. Or presumed calculation of the smooth spectral-reflectance distribution R (lambda) is carried out using the curve fitting by high order interpolation of a cubic spline function etc., all pixels are followed in this presumed calculation, and a spectral-reflectance image is acquired. The configuration of the spectral-reflectance image acquisition system 10 is explained as mentioned above.
[0019] Next, it is explained based on the flow shown in drawing 2 , using as an example the approach enforced in the acquisition approach of the spectral-reflectance image of this invention using the spectral-reflectance image acquisition system 10.
[0020] First, in a camera 12, a film 18 is made to expose the photography light of the photographic subject which penetrated band pass filter 20a, a film 18 is exposed, and a photographic subject is photoed. Next, it exchanges from band pass filter 20a to band pass filter 20b, and the same photographic subject is photoed similarly (step 100).
[0021] Here, a film 18 is three spectral sensitivity bands ZB as are shown in drawing 3 , and the laminating of the blue sensitive layer 18B, green sensitive layer 18G, and red sensitive layer 18R mainly carried out one by one from the upper layer on film base 18b and shown in drawing 4 , and ZG. And ZR It has and the spectral sensitivity distribution in each band has become the spectral sensitivity distribution S1 (lambda), S2, and (lambda) S3 (lambda). Here, the spectral sensitivity distribution illustrated by drawing 4 is an example of spectral sensitivity distribution of the negative color film by Fuji Photo Film Co., Ltd.
[0022] On the other hand, band pass filter 20a is the spectral sensitivity band ZB. It divides into two and is the spectral sensitivity band ZB. The photography light of the division wavelength band by the side of short wavelength is made to penetrate. Spectral sensitivity band ZG It divides into two and is the spectral sensitivity band ZG. The photography light of the division wavelength band by the side of short wavelength is made to penetrate. Furthermore, spectral sensitivity band ZR It divides into two and is the spectral sensitivity band ZR. It is the band pass filter which has the spectral transmittance distribution Fa (lambda) which makes the photography light of the division wavelength band by the side of short wavelength penetrate as shown in drawing 5 (a).
[0023] On the other hand, band pass filter 20b is the spectral sensitivity band ZB. It divides into two and is the spectral sensitivity band ZB. The photography light of the division wavelength band by the side of long wavelength is made to penetrate. Spectral sensitivity band ZG It divides into two and is the spectral sensitivity band ZG. The photography light of the division wavelength band by the side of long wavelength is made to penetrate. furthermore, spectral sensitivity band ZR 2 -- dividing -- spectral sensitivity band ZR a long wave -- it is the band pass filter which has the spectral transmittance distribution Fb (lambda) which makes the photography light of the division wavelength band by the side of merit penetrate as shown in drawing 5 (b).

[0024] Therefore, the spectral characteristic as shown in drawing 6 can be formed by combining band pass filters 20a and 20b and a film 18.
[0025] Namely, since a film 18 receives and exposes the photography light of a photographic subject which passed band pass filters 20a and 20b The spectral transmittance distribution Fa (lambda) of band pass filter 20a or 20b, and Fb (lambda), The spectral characteristic made by the product of the spectral sensitivity distribution S1 (lambda) of a film 18, S2, and (lambda) S3 (lambda) serves as spectral distribution with six comparatively steep peaks as shown in drawing 6 . Consequently, in case the conventional multi-band image is photoed, compared with the case where it carries out changing the band pass filter which makes a steep peak wave a filter property one by one, the photography image based on the spectral characteristic which has three comparatively steep peaks by one photography can be obtained. Therefore, although the band pass filter which makes a steep peak wave a filter property conventionally needed to be photoed whenever [the] with exchange 6 times when the photography image based on the six spectral characteristics was obtained, band pass filters 20a and 20b are exchanged, and it ends with this operation gestalt by two photography.
[0026] In addition, band pass filter 20a is the interference filter a1 of the band stop mold which makes the band which considers half-value width as 60nm of abbreviation a core [460 (nm)] a nontransparent band (reflective band) as shown in drawing 7 (a). Interference filter a2 of the band stop mold which makes the band which considers half-value width as 80nm of abbreviation a core [570 (nm)] a nontransparent band (reflective band) It is obtained by piling up. Interference filters a1 and a2 In the case of superposition, index matching oil is applied to a filter side so that an interference fringe may not occur in band pass filters 20a and 20b, or it is an interference filter a1 and a2. It is desirable to prepare the opening of predetermined spacing in between. The interference filter of such a band stop mold is produced by carrying out vacuum deposition of the dielectric with which refractive indexes differ on a substrate, for example, the band stop filter by optical Nobumitsu study industrial incorporated company and the band reflection filter by Fuji photograph light machine incorporated company are mentioned.
[0027] Similarly, band pass filter 20b is the filter b1 which used and created the color to the transparence substrate as shown in drawing 7 (b). The interference filter b2 of the above-mentioned band stop mold, and b3 It uses and these can be obtained in piles.
[0028] the image of the film 18 photoed using such band pass filters 20a and 20b is read in the scanner section 22 — having (step 102) — the concentration picture signal DR for every two pixels of each photography image, and DG And DB It is obtained. furthermore, the concentration picture signal DR and DG And DB a logarithm — the light exposure transducer 23 — setting — three-dimension LUT24 — using — a logarithm — light exposure LogER, LogEG, and LogEB It is changed (step 104). Here, three-dimension LUT24 is created as follows. That is, light is irradiated at the sensitive material which controls the luminous intensity of R, G, and B to nine steps, respectively, and has the spectral sensitivity characteristic equivalent to a film 18 or a film 18 using PHISUL by the laser aligner Co., Ltd., for example, Fuji Photo Film, and the image of 93 (729) individuals is created. And this created image is read in the scanner section 22, and it is 93. The concentration picture signal DR of an individual (729), and DG And DB It obtains and is 93. The concentration picture signal DR of an individual (729), and DG And DB It considers as the sample point in a three-dimension coordinate (DR, DG, and DB). 93 at the time of on the other hand controlling the light of R, G, and B to nine steps in the above-mentioned laser aligner the logarithm which logarithm-ized light exposure of the light of an individual — light exposure LogER, LogEG, and LogEB It is made to correspond with the sample point of 93 individual (729) for which it asked for and asked previously, and three-dimension LUT24 is created (step 106). Creation of such three-dimension LUT24 may be beforehand performed before photography of a photographic subject.
[0029] The concentration picture signal DR and DG And DB If it corresponds to the sample point of three-dimension LUT24 At the sample point on this three-dimension LUT24, the number light exposure LogER of matched pairs LogEG and LogEB It takes out and they are the concentration picture signal DR and DG. And DB When it does not correspond to the sample point of three-dimension LUT24, the interpolation interpolation with a sample point is used, and it is the number light exposure LogER, LogEG, and LogEB of matched pairs. It computes. such a logarithm — calculation of light exposure is performed for every pixel about two read images.

[0030] Next, calculation of a spectral reflectance is performed (step 108). namely, the logarithm computed in step 106 — light exposure LogER, LogEG, and LogEB from — light exposure ER, EG, and EB Ask and it sets to one side. Light exposure Ew of the photography light at the time of photoing a reference white plate to the above-mentioned sensitive material as a photographic subject under the predetermined illumination light It asks beforehand. This light exposure Ew It uses and they are the above-mentioned light exposure ER, EG, and EB. It normalizes, and the relative light exposure Sin (i=a or b, n=1-3) to a reference white plate is calculated, and let this value be the value of a spectral reflectance.
[0031] The relative light exposure Sin calculated here corresponds to relative light exposure Sin' which the film 18 defined by the well-known following formula (1) receives.
[Equation 1]

$$S'_{in}=\frac{\int_{vis} R(\lambda)\cdot P(\lambda)\cdot F_i(\lambda)\cdot S_n(\lambda)d\lambda}{\int_{vis} P(\lambda)\cdot W(\lambda)\cdot F_i(\lambda)\cdot S_n(\lambda)d\lambda} \qquad (1)$$

(i=a,b , n=1,2,3)

that time — R (lambda) — spectral-reflectance distribution of a photographic subject — it is — P (lambda) — the spectrum of the illumination light — Fi (lambda) is spectral transmittance distribution of band pass filter 20a or 20b, it is intensity distribution and W (lambda) is [Sn (lambda) is spectral sensitivity distribution of a film 18, and] spectral-reflectance distribution of a reference white plate.

[0032] In addition, the integral value of the denominator of a formula (1) is the light exposure Ew of the above-mentioned reference white plate. Corresponding, the integral value of the molecule of a formula (1) is light exposure ER, EG, and EB. It corresponds. Therefore, light exposure Ew It uses and they are light exposure ER, EG, and EB. Since it normalizes, the relative light exposure Sin corresponds with relative light exposure Sin' which the film 18 defined by the formula (1) receives. On the other hand, as mentioned above, they are the spectral sensitivity band ZB, ZG, and ZR. Since the spectral characteristic made by the product of the spectral transmittance distribution Fi (lambda) and the spectral sensitivity distribution Sn (lambda) to divide constitutes a comparatively steep peak as shown in drawing 6 , the spectral-reflectance distribution R (lambda) is six relative light exposure Sin. Abbreviation correspondence is carried out. Therefore, the spectral-reflectance distribution R (lambda) corresponds with the relative light exposure Sin.

[0033] The value of the calculated relative light exposure Sin as relative light exposure to the central value of the passage wavelength field of the corresponding band pass filters 20a and 20b Linear interpolation is performed based on the point which plotted in the graph which makes an axis of abscissa part light wave length, and was plotted by this graph, and presumed calculation of the spectral-reflectance distribution R (lambda) is carried out. Or the curve fitting by high order interpolation of a cubic spline function etc. is used, and presumed calculation of the smooth spectral-reflectance distribution R (lambda) is carried out. Such spectral-reflectance distribution R (lambda) is searched for for every pixel of the image which photoed the photographic subject, and the spectral-reflectance image of a photographic subject is acquired (step 110). Moreover, principal component analysis may be performed to a spectral-reflectance image, and you may ask for the spectral-reflectance image which expressed spectral-reflectance distribution of each pixel with the linear combination of two or more principal component vectors.

[0034] In this way, the called-for spectral-reflectance image can predict the photography image which will be obtained when a photograph is taken with image pick-up equipment with the designed spectral sensitivity distribution using the spectral sensitivity distribution and the spectral-reflectance distribution of a photographic subject which could use for the design of spectral sensitivity distribution of image pick-up equipments, such as a digital still camera which used the CCD image sensor, for example, were designed, and the illumination light. Moreover, it can use also for the design of spectral sensitivity distribution of sensitive material, such as a film. Furthermore, the image reproducing the vanity in different illumination light can also be created.

[0035] In addition, although the band pass filter which divides the spectral sensitivity band of a film 18 into two was used with this operation gestalt, division of a spectral sensitivity band is not restricted comparatively for 2 minutes, but may perform a spectral sensitivity band more than trichotomy. In case every one division wavelength band is chosen for every spectral sensitivity band with this operation gestalt from the division wavelength bands which divided the spectral sensitivity band into two, moreover, band pass filter 20a Among spectral sensitivity bands, although band pass filter 20b chooses the division wavelength band by the side of long wavelength among spectral sensitivity bands, respectively, the division wavelength band by the side of short wavelength In this invention, especially the selection approach of a division wavelength band is not restricted that, as for a band pass filter, a division wavelength band should just be chosen so that all the division wavelength bands of a spectral sensitivity band may be chosen by a unit of 1 time.

[0036] Moreover, this operation gestalt is three spectral sensitivity bands ZB, ZG, and ZR. Although it is the example which used as the light-sensitive element the film 18 which it has, in this invention, a light-sensitive element may be a sensitive material which it is not restricted to a photographic film but is exposed to infrared radiation, ultraviolet rays, etc. that what is necessary is just the light-sensitive element which is not limited to three spectral sensitivity bands, but has at least two or more spectral sensitivity bands. Furthermore, the light-sensitive element in this invention may be a color image sensor which made the color filter and the CCD image sensor the set.

[0037] (Example) The band pass filter which, on the other hand, has the spectral transmittance distribution shown in drawing 5 (a) and (b) as the above-mentioned band pass filters 20a and 20b was prepared using the negative color film by Fuji Photo Film Co., Ltd. and REALA which have the spectral transmittance distribution shown in drawing 5 as a light-sensitive element. Therefore, the spectral characteristic as shown in drawing 6 from band pass filters 20a and 20b and the above-mentioned negative film is formed.

[0038] While the spectral-reflectance distribution which consists of 24 patches (six-step four trains) exchanged band pass filters 20a and 20b by using the known Macbeth chart as a photographic subject using such band pass filters 20a and 20b and a negative film, a photograph was taken twice with the camera 12. three-dimension LUT after a photography image's being read by the scanner section 22 shown in drawing 1 and considering as a concentration signal -- a logarithm -- by changing into a light exposure signal, the light exposure corresponding to the six spectral characteristics was obtained for every patch, and six relative light exposure Sin was obtained for every patch of the Macbeth chart. And the axis of abscissa was plotted in the graph made into wavelength as relative light exposure to the central value of the passage wavelength field of the band pass filters 20a and 20b corresponding to this relative light exposure Sin for the value of these six relative light exposure Sin. Drawing 8 (a) - (d) shows the result of every train of the Macbeth chart. In addition, spectral-reflectance distribution of the patch for every train of the Macbeth chart is displayed on drawing 8 (a) - (d) by the continuous line, the broken line, or the chain line with six plotted relative light exposure Sin.

[0039] the plotted relative light exposure Sin being plotted from drawing 8 (a) - (d) near the spectral-reflectance distribution of the Macbeth chart expressed by the continuous line, the broken line, or the chain line (O, **, **, x, **, +), for example, using the curve fitting by high order interpolation of a cubic spline function etc. -- spectral-reflectance distribution of the Macbeth chart -- abbreviation -- it turns out that presumed calculation of the near spectral-reflectance distribution R (lambda) can be carried out. In this way, when the colorimetry value was calculated using the acquired spectral-reflectance distribution, the average color difference with the Macbeth chart was set to 3.9. On the other hand, by the approach of photoing the conventional multi-band image, when the colorimetry value was calculated using the spectral-reflectance image which photoed the image of the Macbeth chart with exchange 6 times, and was obtained in the band pass filter, it turned out that the average color difference with the Macbeth chart is 3.2, and the color difference acquired in this example is the color difference and the abbreviation EQC which are obtained by the conventional approach.

[0040] Therefore, by the conventional approach, what needed to photo the same photographic subject 6 times while exchanging the band pass filter can be substituted for 2 times at this example, maintaining the presumed calculation precision of a spectral reflectance on a par with the former. And since a band pass filter can be managed with two, it becomes unnecessary to use a large-sized adjustable filter like before, and a photograph can be taken using image pick-up equipments, such as a simple camera, by the small light weight.

[0041] As mentioned above, although the acquisition approach of the spectral-reflectance image of this invention, photography equipment, and a spectral-reflectance image acquisition system were explained to the detail, this invention of various kinds of amelioration and modification being made is natural in the range which limitation is carried out to neither the above-mentioned operation gestalt nor an example, and does not deviate from the summary of this invention.

[0042]

[Effect of the Invention] As mentioned above, since the band pass filter which carries out hyperfractionation of the spectral sensitivity band of a light-sensitive element is used as explained to the detail, photography equipments, such as a simple camera, can be used by the small light weight. And without dropping the presumed calculation precision of spectral-reflectance distribution, compared with the time of photoing a multi-band image by the conventional approach, a photographic subject can be photoed by the small count of photography, and a spectral-reflectance image can be acquired.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing an example of the spectral-reflectance image acquisition structure of a system of this invention which enforces the acquisition approach of the spectral-reflectance image of this invention.
[Drawing 2] It is the flow chart which shows an example of the flow of the acquisition approach of the spectral-reflectance image of this invention.
[Drawing 3] It is drawing explaining the photographic film which is an example of the light-sensitive element in this invention.
[Drawing 4] It is drawing showing an example of spectral sensitivity distribution of the film shown in drawing 3 .
[Drawing 5] (a) And (b) is drawing showing an example of spectral transmittance distribution of the band pass filter in this invention.
[Drawing 6] It is drawing showing the spectral characteristic made according to the spectral transmittance distribution shown in the spectral sensitivity distribution shown in drawing 4 , drawing 5 (a), and (b).
[Drawing 7] (a) And (b) is drawing showing the synthetic approach of a band pass filter of having the spectral transmittance distribution shown in drawing 5 (a) and (b).
[Drawing 8] (a) - (d) is the graph which set the axis of abscissa as the value of the spectral reflectance obtained by the approach of this invention, and plotted part light wave length.
[Description of Notations]
10 Spectral-Reflectance Image Acquisition System
12 Camera
14 Processor
16 Taking Lens
18 Film
20a, 20b Band pass filter
22 Scanner Section
23 Logarithm — Light Exposure Transducer
24 Three-Dimension LUT
26 Spectral-Reflectance Calculation Section

[Translation done.]

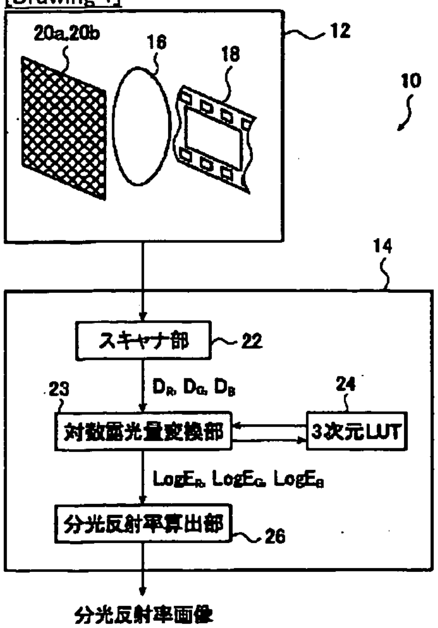
* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

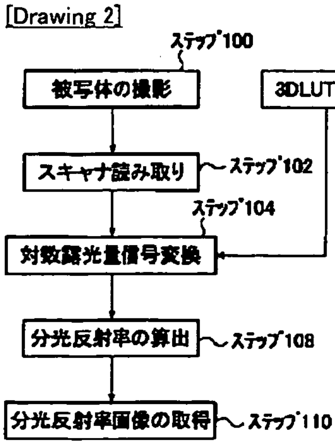
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

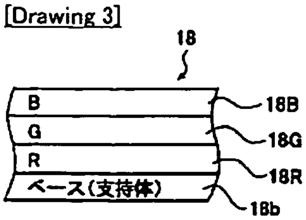
[Drawing 1]



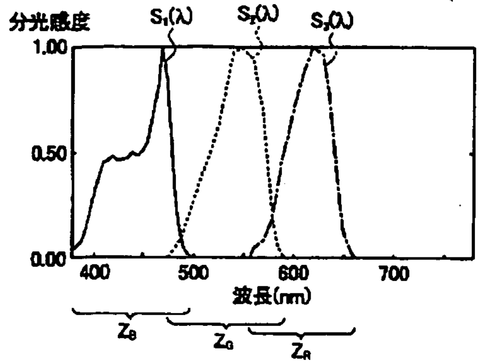
[Drawing 2]



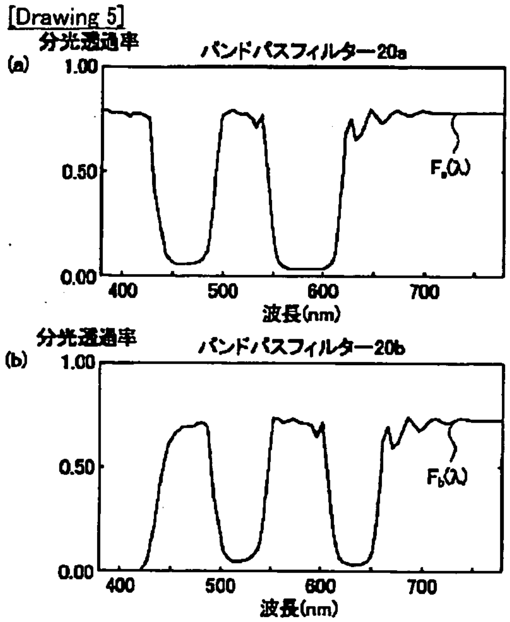
[Drawing 3]



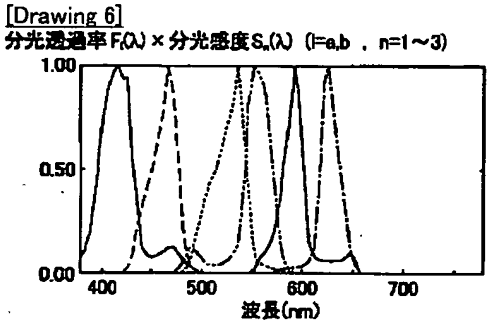
[Drawing 4]



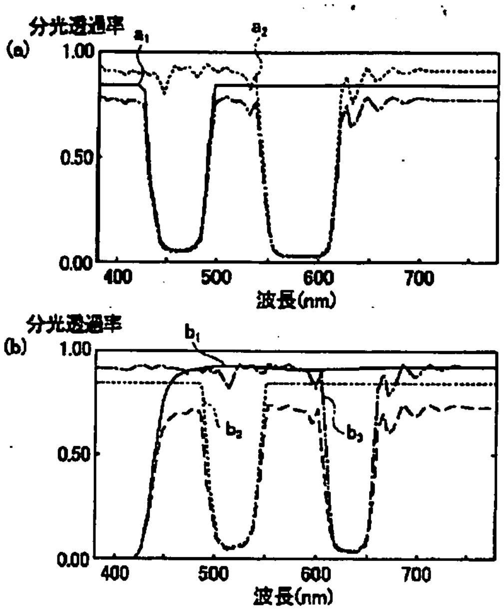
[Drawing 5]



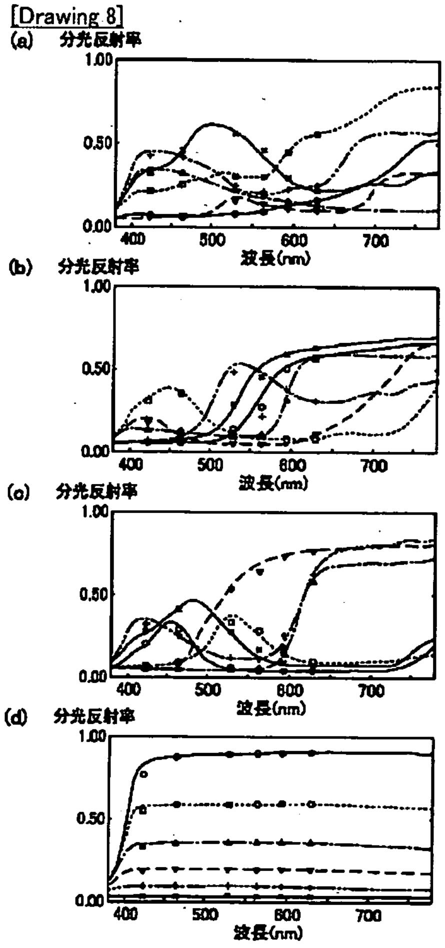
[Drawing 6]



[Drawing 7]



[Drawing 8]



[Translation done.]