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Kidd et al.

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[54] **LIGHT SOURCE MEASURING APPARATUS**

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[52] **U.S. Cl.** **250/226;** 356/189

[51] **Int. Cl.**[2] **G01J 3/50**

[58] **Field of Search** 250/226, 214; 356/173, 356/175, 176, 177, 186, 188, 189

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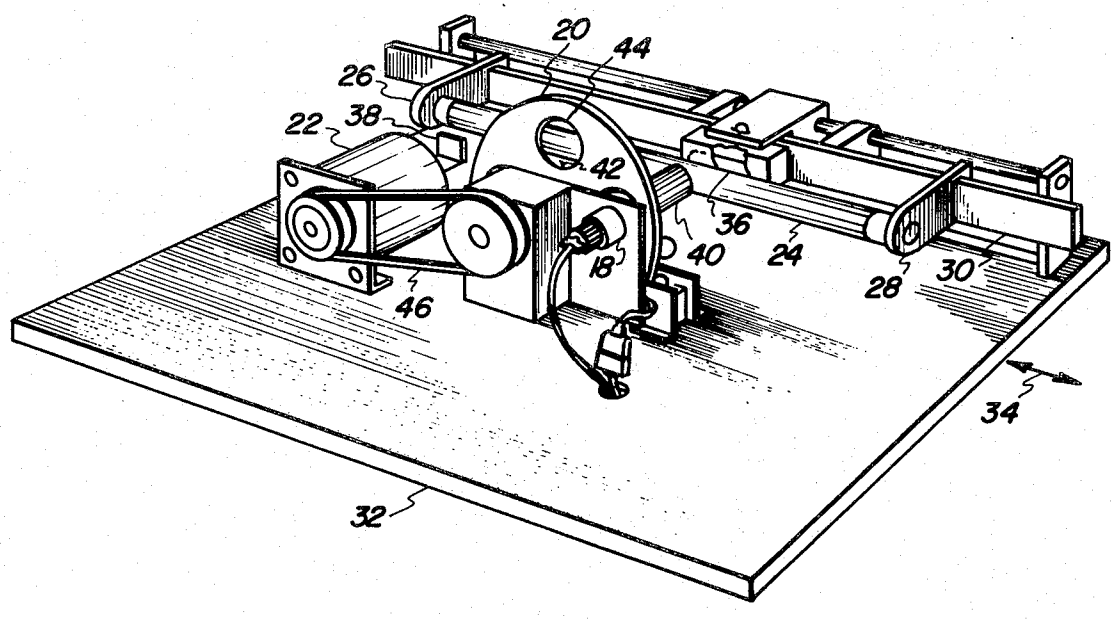
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[57] **ABSTRACT**

An apparatus in which the spectral characteristics of a light source are determined. The light rays from the light source are filtered and the intensity of each of the respective filtered light rays measured. These measured characteristics are recorded indicating the peak irradiance values which may be compared to evaluate the color balance of the light source.

The foregoing abstract is neither intended to define the invention disclosed in the specification, nor is it intended to be limiting as to the scope of the invention in any way.

9 Claims, 4 Drawing Figures



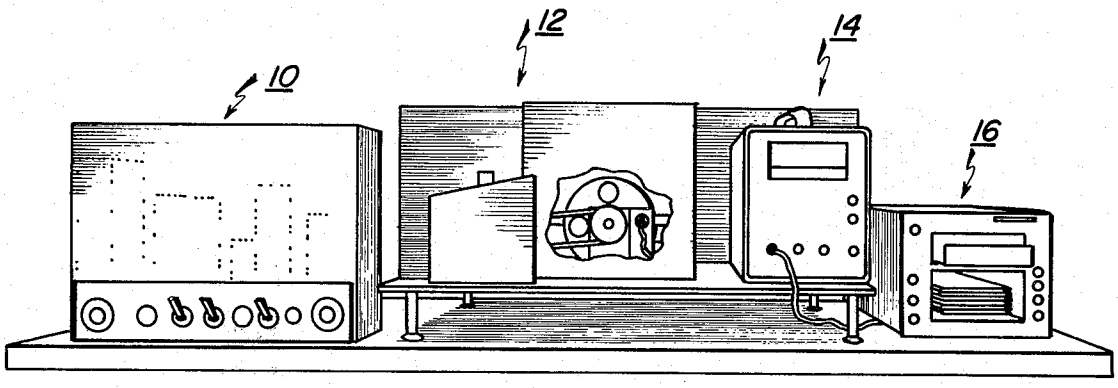


FIG. 1

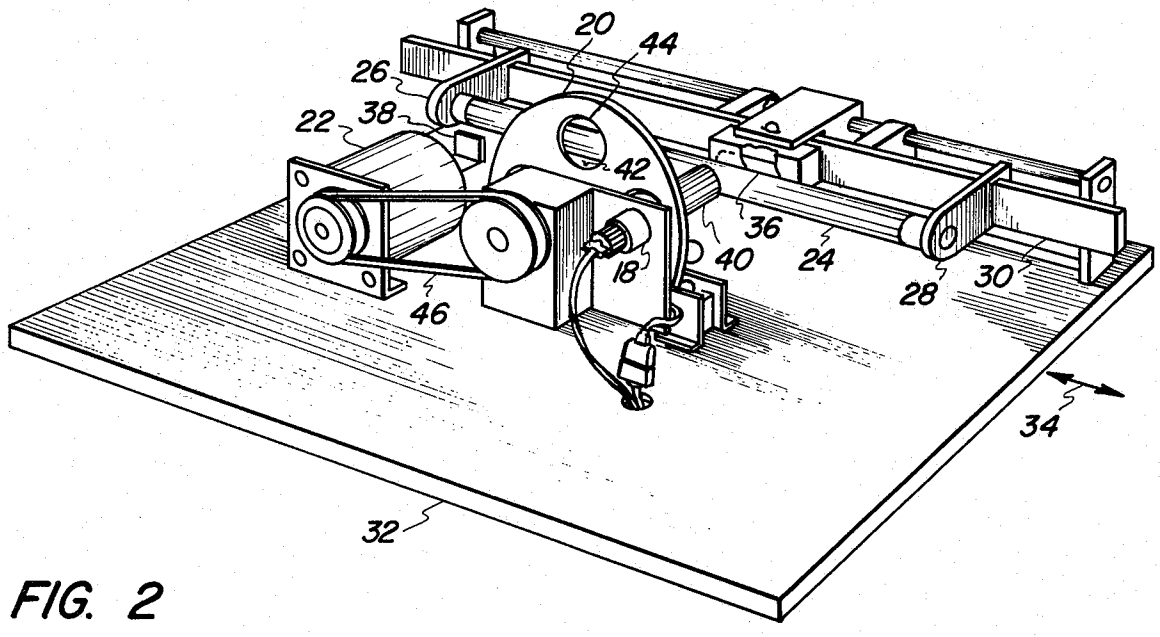


FIG. 2

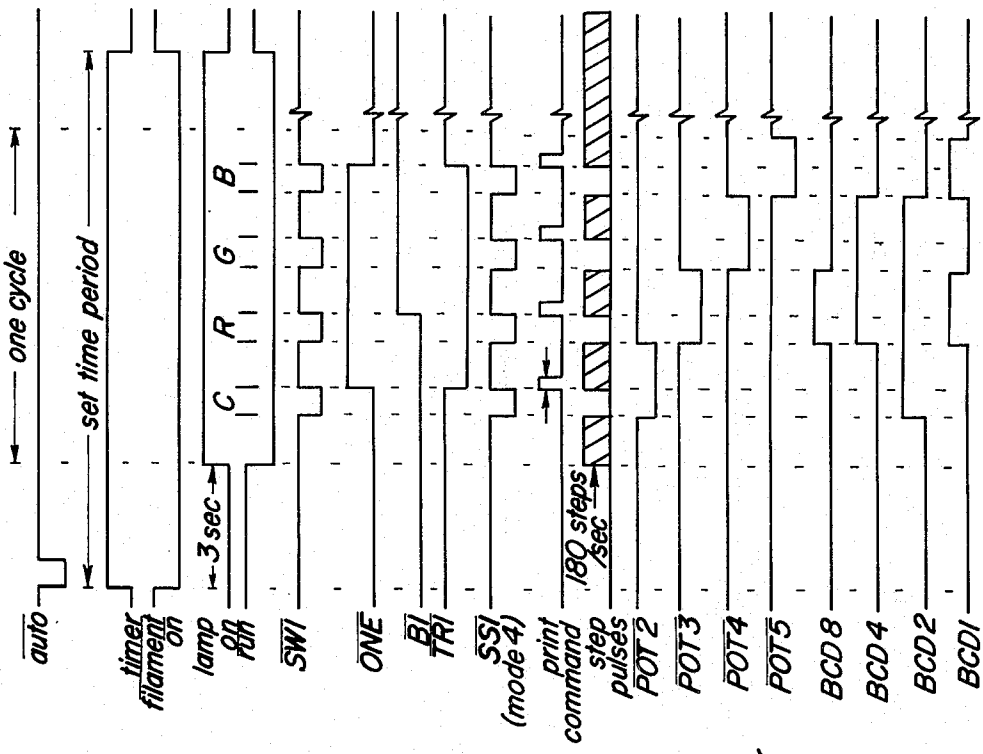

one cycle
set time period
auto
timer filament on
lamp on run
3 sec
C
R
G
B
SWI
ONE
BI TRI
SSI (mode 4)
print command
step pulses
180 steps /sec
POT 2
POT 3
POT 4
POT 5
BCD 8
BCD 4
BCD 2
BCD 1

FIG. 4

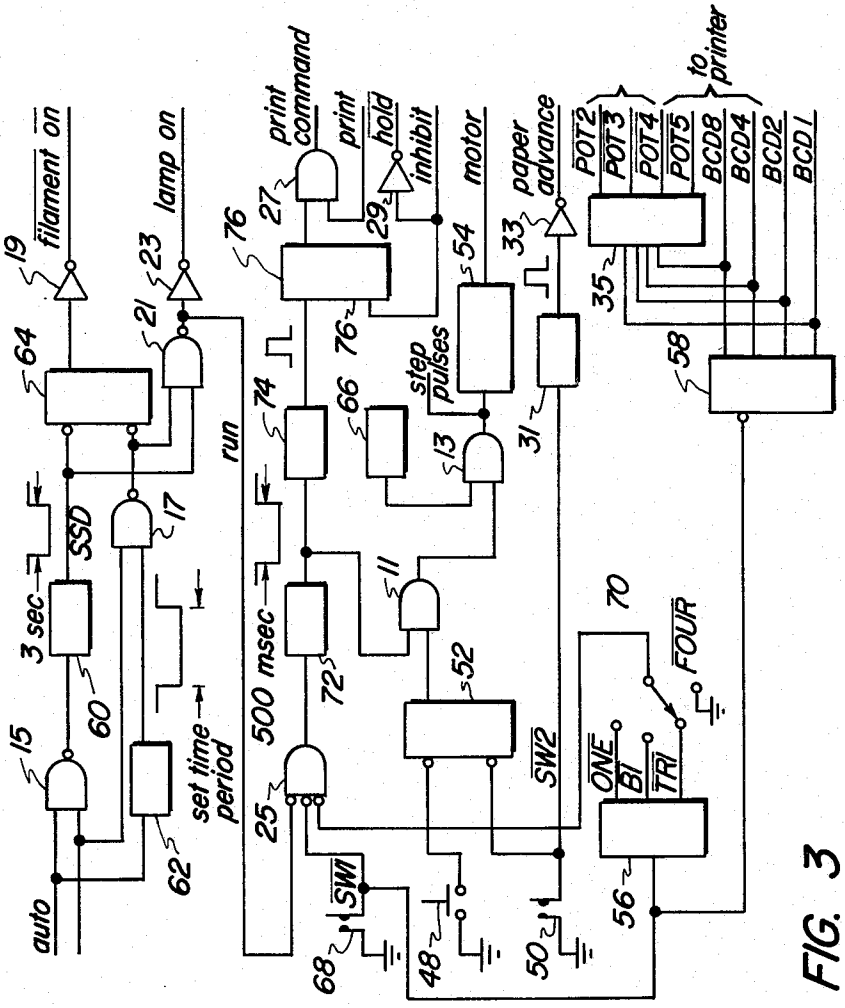

auto
filament on
lamp on
run
3 sec
SSD
set time period
500 msec
print command
print hold
inhibit
motor
paper advance
step pulses
SWI
SW2
ONE
BI
TRI
FOUR
to printer
POT 2
POT 3
POT 4
POT 5
BCD 8
BCD 4
BCD 2
BCD 1

FIG. 3

LIGHT SOURCE MEASURING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates generally to scan lamps employed in multi-color electrophotographic printing machines, and more particularly concerns an apparatus for determining the spectral characteristics of the scan lamp.

In the process of multi-color electrophotographic printing, a plurality of single color light images are produced from a multi-color original document. The light images are created by illuminating the original document and filtering the light rays reflected therefrom. The filtered light rays irradiate a charged photoconductive surface to form a single color electrostatic latent image. This single color electrostatic latent image is developed with toner particles complementary in color thereto. Thereafter, the toner particles are transferred to a sheet of support material. The foregoing process is repeated a plurality of cycles wherein each successive toner powder image is deposited, in superimposed registration with the prior one, on the sheet of support material. It is evident that in multi-color electrophotographic printing, the spectral characteristics of the scan lamp are of particular importance.

Hereinbefore, scan lamps have been predominantly utilized in black and white copiers and have been of a single phosphor type. These lamps produce a broad band emission continium with related mercury lines. However, with the advent of multi-color electrophotographic printing, a multi-phosphored lamp is required. In order to qualify a multi-phosphor lamp, a measurement technique has to be developed to quantify and characterize the lamp parameters. The radiometric and sensitometric requirements of color electrophotography are significantly more stringent than that of black and white systems.

Scan lamps employed in color electrophotographic printing machines are of the bi-phosphor or tri-phosphor type. The apparatus of the present invention is intended to measure the characteristics of the lamp and provide a means of incoming inspection therefore. The significant parameters determined by the apparatus of the present invention are the irradiance variation over the length of the light source and the minimum peak irradiance thereof.

Accordingly, it is a primary object of the present invention to develop an apparatus for determining the spectral characteristics of a light source employed in a multi-color electrophotographic printing machine.

SUMMARY OF THE INVENTION

Briefly stated, and in accordance with the present invention, there is provided an apparatus for determining the spectral characteristics of a light source.

Pursuant to the present invention, the apparatus includes a plurality of filters mounted indexably on a frame. Successive filters are interposed between the light source and the means for measuring the spectral characteristics of the light source. Means are provided for recording the measured spectral characteristics. The spectral characteristics are recorded with each successive filter being interposed between the light source and the measuring means.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will become apparent upon reading the following detailed description and upon reference to the drawings, in which:

FIG. 1 is a schematic perspective view depicting the apparatus of the present invention therein;

FIG. 2 is a schematic perspective view illustrating the mechanical portions of the FIG. 1 apparatus;

FIG. 3 is a schematic diagram illustrating the electrical circuitry of the present invention; and

FIG. 4 is a timing diagram for the FIG. 3 circuit diagram.

While the present invention will be described in connection with a preferred embodiment, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

With continued reference to the drawings, wherein like reference numerals have been used throughout to designate like elements, FIG. 1 illustrates a perspective view of the apparatus of the present invention adapted to determine the spectral characteristics of a light source. Although the apparatus of the present invention is particularly well adapted for use with a light source employed in a multi-color electrophotographic printing machine, it should become evident from the following description that it is equally well suited for use in a wide variety of light sources and is not necessarily limited in its use to the particular embodiment shown herein.

As shown in FIG. 1, the apparatus of the present invention includes electrical circuitry or control logic **10**, a mechanical fixture **12** arranged to support light source **24** (FIG. 2) and filter the light rays therefrom, measuring means **14** for determining the irradiance characteristics of light source **24**, and recording means or printer **16**. The apparatus automatically and rapidly measures the characteristics of a light source, i.e., a bi-phosphor or tri-phosphor lamp. The measuring means or radiometer **14**, i.e., a solid state light meter, is calibrated to read in microwatts/centimeter^2 of light energy. The electrical signal indicative of the amount of light energy is an analog signal transmitted from a photosensor **18** (FIG. 2). This signal is connected to a digital panel meter which provides a digital read-out and a binary coded decimal output used to drive external equipment. Three decades of binary coded decimals (8–4–2–1) and the numeric 1,000 are provided along with "PRINT" and "HOLD" signals. The "PRINT" output line is used to provide a signal when the conversion of the analog signal to a digital signal is complete. The "PRINT" signal is active when the binary coded decimal output lines carry valid data. The "HOLD" input line maintains the last reading on the display and the binary coded decimal output terminals by inhibiting any further analog to digital conversion. Recording means **16** is a digital recorder, preferably, of the type made by Hewlett-Packard, Model No. 5055A and prints a maximum of ten columns of data at a maximum speed of ten lines per second. The data input is parallel entry binary coded decimals (± 8–4–2–1). For printer

operations, a "PRINT COMMAND" input signal is needed. Upon receipt of the "PRINT COMMAND" an "INHIBIT" output signal is sent. Following the "INHIBIT" signal the recorder prints the characteristics which correspond to the binary coded decimal data input. Control logic **10** employs a combination of diode-transister logic and transister-transister logic. The logic polarity is positive with a "1" or high represented by a plus 5 volts and a "0" represented by 0 volts. A logic board controls the operation of the overall system. The logic diagram is shown in FIG. **3.** It indexes filter **20** (Filter 2), and, in the proper mode, turns light source **24** on and off as well as providing the proper signals to measuring means **14** and recording means **16.** Further, it provides the binary coded decimal signals to the recorder to print the characteristics, red (R), green (G), blue (B) and cyan (C). Control logic **10** also includes a translator module which is a printed circuit board with logic capabilities for stepping a motor in increments of 1.8°. It energizes the stepping motor when triggered by stepping pulses which have to be a 10 to 15 volt negative charge or voltage with a minimum pulse width of 50 microseconds. The indexing means or stepping motor **22** is a precision stepping motor which makes 200 steps per shaft revolution. For DC stepping applications, the motor is preferably rated at 3 DC volts, 4 amperes per winding and 85 oz.-inches or torque. The system has five power supplies all contained in control logic **10.** There is a 5 volt, DC regulated supply for the logic boards, two 12 volt supplies for the translater module and relays and a 6.3 volts DC supply to gate the triac and a double secondary variable filament transformer rated at a maximum of 6.3 volts. A linear reactor essentially operating as a variable inductor is used to supply constant current to light source **24.** The four current ranges for which the linear reactor can be set are a maximum of 0.7 amperes, 720 volt maximum; 1.5 amperes maximum, 360 volts maximum; 3.0 amperes maximum, 180 volts maximum; and 6.0 amperes maximum, 90 volts maximum. The 3.0 ampere maximum range is utilized to test the bi-phosphor and tri-phosphor lamps employed in multi-color electrophotographic printing machines.

Referring now to FIG. **2,** the basic features of the mechanical fixture are described therein. Lamp **24** is mounted on brackets **26** and **28** which, in turn, are mounted slidably on bar **30.** Bar **30** is secured movably to frame **32.** Bracket **26** and **28** include lamp sockets which can be rotated to align the aperture of lamp **24** with photosensor **18.** Brackets **26** and **28** are mounted movably on bar **30** and can be adjusted for lamps ranging in size from 9 to 24 inches in length. Indicia marks are etched on bar **30** to denote the centerline and the 2, 4, 5, 6, 7 and 8 inch points on either side thereof. As hereinbefore indicated, bar **30** is mounted movably on frame **32** and may be moved on suitable bearings in the direction of arrow **34.** Lamp guide **38** is provided to align lamp aperture. This is achieved by rotating lamp **24** until the aperture therein is centered in lamp guide **38.** Collimator **40** provides a nearly parallel beam of light rays from lamp **24** which are transmitted to photosensor **18.** Filter wheel **20** contains four 1 ½ inch diameter filters **42** mounted in a substantially opaque disc **44.** These filters **42** may be removed from disc **44** by taking out a retaining ring on the back side of disc **44.** Five magnets are disposed on disc **44,** four to denote each filter position and one to denote the home position. Each filter position is determined by a magnetic relay which detects the magnets thereon. The position of each relay is adjusted such that filter wheel **20** stops with the respective filter **42** in line with photosensor **18.** The home relay is also adjustable. A cover is mounted over filter wheel **20** and timing belt **46.** This cover is kept on during operation to remove ambient light and function as a safety factor.

Referring now to FIGS. **3** and **4,** there is shown a logic diagram for control electronics **10** (FIG. **3**) and a timing diagram (FIG. **4**) associated therewith. System operation is initialized by resetting filter wheel **20** to the home position. Depressing reset button **48** allows filter wheel **20** to rotate until the home position is detected by the home magnetic relay **50.** The reset signal sets a flip-flop **52** which in turn gates the step pulses to translator module **54** through AND gates **11** and **13.** Translator module **54** drives a motor **22** which rotates filter wheel **20** to the home position, the signal SW2 clears flip-flop **52** which disables the step pulses. The SW2 signal also clears mode counter **56** and character counter **58.** In addition, signal SW2 passes through time delay logic **31** and invertor **33** to advance the paper of printer **16.** Lamp testing is initiated by toggling the run switch to AUTO. The AUTO signal triggers a single shot timer **60** through NAND gate **15,** and a uni-junction timer **62.** Single shot timer **60** is set for a three second pulse while the timing circuit is controlled by a timer potentiometer in the main control box. Switching the run switch to the continuous operation overrides the timer. The signal SSD for NAND gate **17** sets run flip-flop **64** the output of which is gated to invertor **19.** This activates the FILAMENT ON signal which applies power to the lamp filaments and the linear reactor. When the signal from single shot timer **60** terminates, lamp **24** is energized by a signal from NAND gate **21** and inverter **23** which opens a relay across the lamp with the signal LAMP ON. At the same time, RUN is actuated which gates the step pulses to translator module **54** through AND gates **25, 11** and **13,** and single shot timer **72.** The step pulses are derived from oscillator **66** which is set to oscillate at approximately **180** hertz. When translator module **54** receives the step pulses, filter wheel **20** rotates until the proper filter **42** is detected by the filter magnetic relay **68.** The proper filter position is determined by the mode selected. There are four different modes which determine at what position filter wheel **20** stops. These modes are determined by switching to one of the outputs of mode counter **56.** When the correct filter position is reached, single shot timer **72** is triggered by signal SW1 from filter read relay **68.** Single shot timer **72** provides a 500 millisecond pulse which disables the step pulses for this amount of time. During this time, one filter **42** of filter wheel **20** is positioned in line with photosensor **18** and a light reading is taken. When the signal from single shot timer **72** is expired, a PRINT COMMAND signal is sent to printer **16.** This is achieved by triggering single shot timer **74** at the trailing edge of the pulse from single shot timer **72.** Single shot timer **74** sets the print flip-flop **76** which, in turn, enables the print signal recorder **16** through AND gate **27** via the print command input line. When the PRINT COMMAND signal is received by recorder **16,** it transmits an INHIBIT signal and a HOLD signal through invertor **29,** which holds the digital display on radiometer **14** and also clears print flip-flop **76.** Relay **68,** in addi-

tion to triggering single shot timer **72** and toggling the mode counter **56** also toggles character counter **58.** Character counter **58** generates the proper binary coded decimal signal which corresponds to the characters red (R), green (G), blue (B) and cyan (C). These signals are also gated through REGISTER **35** in such a manner as to switch one of the four channels on printer **16,** i.e., through the corresponding potentiometer (POT **2,** POT **3,** POT **4,** or POT **5**). Therefore, at the end of the 500 millisecond volt time, printer **16** prints the final numbers on the digital display and also prints the key characters relating to the filter position. The above procedure is repeated for each filter position as filter wheel **20** is indexed in one of four modes. Hence, for each cycle or one revolution of filter wheel **20,** one, two, three, or four irradiance readings are taken. This can be determined by mode selector **70.** Each set of readings is separated by a blank space. This is accomplished by the home relay **50** which, once every cycle, triggers the time delay, which, in turn, provides a pulse to advance the paper one space on recorder **16.** The system is in automatic operation until the signal time expires. This clears run flip-flop **64** which turns off the power to lamp **24** and disables the step pulses.

Thus, the system rapidly characterizes the peak phosphor irradiance of a fluorescent lamp. The system has the capability of one, two, three, or four filter interrogation of the peak radiance by means of indexing the filter wheel **20** in the proper mode. The apparatus can mechanically accept lamps ranging from 9 to 24 inches in length with standard diameters ranging from ½ to 1 ½ inches. The system has a lighted length measure capability obtained by a traversing bar which positions the lamp on axial center line. Measurements can be performed up to **8** inches off center. Arrangement is provided for mechanically aligning the lamp apertures.

In recapitulation, the system comprises a filter wheel driven by a stepping motor. A light meter radiometer is utilized for making irradiance measurements and a recorder is provided for producing a digital read-out of those irradiance measurements. Additionally, a computer may be employed to interface with the system and automatically store the irradiance measurements. A stepping motor indexes the filter wheel stopping at the desired filter or filters for approximately 500 milliseconds. During this dwell time, an irradiance reading is taken by the radiometer. This reading is then printed on paper by a digital recorder. In this manner, each rotation of the filter wheel will yield one or more irradiance values. Successive rotation of the filter wheel yields successive printed irradiance values, which, in turn, can be visually scanned for peak irradiance. System color balance can be determined by the appropriate ratios of irradiance values.

It is, therefore, apparent that there has been provided in accordance with this invention, an apparatus that fully satisfies the objects, aims and advantages set forth above. While this invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations as fall within the spirit and broad scope of the appended claims.

What is claimed is:

1. An apparatus for determining the spectral characteristics of an elongated, substantially tubular apertured light source, including:
- a frame;
- means for measuring the spectral characteristics of the light source;
- at least one filter mounted on said frame and interposed between the light source and said measuring means;
- collimator means interposed between said filter and the light source for providing a substantially parallel beam of filtered light rays to said measuring means;
- means, operatively associated with said measuring means, for recording the spectral characteristics of the light source;
- guide means for rotatably aligning the aperture of the light source with said collimator means; and
- means for mounting the light source in a substantially horizontal position with the longitudinal axis thereof substantially normal to the longitudinal axis of said measuring means.

2. An apparatus as recited in claim **1,** wherein said filter includes:
- an opaque disc having a plurality of apertures therein; and
- a plurality of filters mounted in the apertures of said disc.

3. An apparatus as recited in claim **2,** further including means for indexing said disc so that successive filters are interposed between said measuring means and the light source.

4. An apparatus as recited in claim **3,** further including first circuit means for regulating said indexing means so that the filter is interposed between said measuring means and the light source.

5. An apparatus as recited in claim **4,** wherein said measuring means includes:
- a photosensor for detecting the intensity of the light rays transmitted through said filter, said photosensor being adapted to generate an analog signal indicative of the intensity of light rays transmitted thereto; and
- second circuit means, responsive to the analog signal generated by said photosensor, for producing a digital signal corresponding thereto.

6. An apparatus as recited in claim **5,** wherein said recording means includes a digital recorder, responsive to the digital signal produced by said second circuit means, for printing the digital signal.

7. An apparatus as recited in claim **6,** wherein said indexing means includes a stepping motor.

8. An apparatus as recited in claim **7,** further including third circuit means adapted to control the energization of the light source.

9. An apparatus as recited in claim **8,** wherein said plurality of filters include:
- a cyan filter;
- a blue filter;
- a green filter; and
- a red filter.

* * * * *