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TUESDAY, OCTOBER 25, 2016
CITY COUNCIL REVISED AGENDA
6:00 PM

I. Call to Order.

II. Pledge of Allegiance/Invocation (Chairman Freeman).

III. Minute Approval.

IV. Special Presentation.

"Mayor's Proclamation for Domestic Violence Awareness Month"
Councilwoman Carol Berz and the Family Justice Center

V. **Ordinances – Final Reading:**

POLICE

a. An ordinance to amend Chattanooga City Code, Part II, Chapter 5, Article III, to amend Sections 5-47, 5-48, and 5-78 relative to beer in motion picture theaters. **(Sponsored by Councilman Grohn) (Deferred from 10/18/2016)**

PUBLIC WORKS AND TRANSPORTATION

Transportation

b. MR-2016-120 James Havron (Abandonment). An ordinance closing and abandoning a portion of the right-of-way located at the 300 block of Mixson Street and the 300 block of Peak Street, detailed on the attached map, subject to certain conditions. **(District 1) (Recommended for approval by Transportation)**

c. MR-2016-133 Susan L. Fogo (Abandonment). An ordinance closing and abandoning an alley off of the 500 block of West 21st Street, detailed on the attached map, to facilitate future development, subject to certain conditions. **(District 7) (Recommended for approval by Transportation)**

VI. **Ordinances – First Reading:**

PLANNING

a. An ordinance to amend Chattanooga City Code, Part II, Chapter 38, Zoning Ordinance, and Chapter 11, Businesses, Trades, and Occupations, relating to Short-Term Vacation Rentals within any zones allowing residential use and providing terms and conditions for the issuance of Short-Term Vacation Rental Certificates. **(Deferred from 10/18/2016)**

VII. **Resolutions:**

ECONOMIC AND COMMUNITY DEVELOPMENT

a. A resolution to make certain findings relating to the Riverview Housing Associates, LP Project, to delegate certain authority to the Chattanooga Housing Authority and to authorize the Mayor to enter into and execute an agreement for payments in lieu of ad valorem taxes for the acquisition and renovation of the Jaycee Tower located at 500 West M.L. King Boulevard for use as a multi-family housing facility for low income elderly tenants pursuant to Tennessee Code Annotated Section 13-20-104.

PLANNING

b. 2016-159 Libby Stamey/JHR Northgate, LLC/Flashbacks Bar and Grill, LLC (Special Exceptions Permit). A resolution approving a Special Exceptions Permit for use of a late night entertainment facility located at 1966 Northpoint Boulevard, Suite 126, Hixson, TN 37343, more particularly described in the attached documents. **(District 3) (Added by permission of Chairman Freeman) (Deferred from 10/18/2016)**

PUBLIC WORKS AND TRANSPORTATION

Transportation

c. A resolution authorizing the Administrator for the Department of Transportation to amend an agreement previously established under Resolution No. 28354 with CDM relative to Contract No. T-14-039, for professional services associated with evaluation of and design services for the rehabilitation or replacement of the Standifer Gap Road Bridge, for an increased amount of $80,000.00, for a revised contract amount of $353,195.00. **(District 6)**

VIII. Departmental Reports:

a) Police.
b) Fire.
c) Economic and Community Development.
d) Youth and Family Development.
e) Transportation.
f) Public Works.
g) Finance.
h) IT.
i) **Human Resources.**
j) General Services.

IX. Purchases.

X. Other Business.

XI. Committee Reports.

XII. Agenda Session for Tuesday, November 1, 2016.

XIII. Recognition of Persons Wishing to Address the Council on Non-Agenda Matters.

XIV. Adjournment.

TUESDAY, NOVEMBER 1, 2016
CITY COUNCIL AGENDA
6:00 PM

1. Call to Order.

2. Pledge of Allegiance/Invocation (Councilman Hakeem).

3. Minute Approval.

4. Special Presentation.

5. **Ordinances – Final Reading:**

PLANNING

a. An ordinance to amend Chattanooga City Code, Part II, Chapter 38, Zoning Ordinance, and Chapter 11, Businesses, Trades, and Occupations, relating to Short-Term Vacation Rentals within any zones allowing residential use and providing terms and conditions for the issuance of Short-Term Vacation Rental Certificates.

6. **Ordinances – First Reading: (None)**

7. **Resolutions:**

GENERAL SERVICES

a. A resolution to amend Resolution No. 28696 authorizing the Mayor to execute an amended and restated land lease agreement with SBA Structures, LLC, in substantially the form attached, for a cellular tower at 8429 Sanders Road, identified as a portion of Tax Map No. 140-141, for a term of five (5) years commencing on February 1, 2018, with the option to renew for three (3) additional and successive five (5) year renewal terms with the last additional renewal term expiring on January 31, 2038, with lease execution subject to negotiated access agreement to delete the requirement for a negotiated access agreement. **(District 4)**

b. A resolution authorizing the Mayor to execute an agreement to exercise option to renew between the City of Chattanooga and Tennessee River Soccer Company d/b/a the North River Soccer Association, subject to the use agreement, the property located at 4500 Access Road South of the Norfolk Southern right-of-way, Tax Map No. 119H-A-003.01, for an additional one (1) year term, with two (2) remaining options to renew. **(District 2)**

HUMAN RESOURCES

c. A resolution authorizing the appointment of Catherine Vogel as a special police officer (unarmed) for the Department of Public Works to do special duty as prescribed herein, subject to certain conditions.

MAYOR'S OFFICE

d. A resolution to confirm the Mayor's appointments of Mark Harrison, Robert Payne, and Eric Sines to the Wastewater Regulations and Appeals Board. **(Revised)**

PUBLIC WORKS AND TRANSPORTATION

Public Works

e. A resolution authorizing the Administrator for the Department of Public Works to award Consent Decree Contract No. W-12-016-202 to P. F. Moon and Company, Inc. of West Point, Georgia, CITICO CSOTF and pump station improvements, in the amount of $2,313,000.00, with a contingency amount of $230,000.00, for an amount not to exceed $2,543,000.00, subject to SRF loan approval. **(District 9)** **(Consent Decree)**

Transportation

f. A resolution authorizing Brian Orr to use temporarily the right-of-way located at 4117 Wilkesview Drive for the purpose of building a driveway, as shown on the maps attached hereto and made a part hereof by reference, subject to certain conditions. **(District 5)**

g. A resolution authorizing Tennessee Awning Company % Lincoln Christensen on behalf of property owner, Reginald Ruff, to use temporarily the right-of-way located at 45 E. Main Street for the purpose of installing an awning, as shown on the maps attached hereto and made a part hereof by reference, subject to certain conditions. **(District 8)**

YOUTH AND FAMILY DEVELOPMENT

h. A resolution authorizing the Department of Youth and Family Development to donate pottery equipment located at the John A. Patten Youth and Family Development Center to Scenic City Clay Arts, with an estimated value of $4,500.00.

8. Departmental Reports:

a) **Police.**
b) Fire.
c) Economic and Community Development.
d) Youth and Family Development.
e) Transportation.
f) Public Works.
g) Finance.
h) IT.

i) Human Resources.
j) General Services.

9. Purchases.

10. Other Business.

11. Committee Reports.

12. Agenda Session for Tuesday, November 8, 2016.

13. Recognition of Persons Wishing to Address the Council on Non-Agenda Matters.

14. Adjournment.

Proposed City Council Purchases 10-25-16							
DEPARTMENT REQUISITION NO.	ITEM DESCRIPTION	BIDS REQUESTED	BIDS RETURNED	LOWEST/BEST BIDDER	COST	FUND NAME	NOTES
R 144517 Public Works	Effluent Monitoring Instrument Demonstration & Purchase Waste Resources Division	–	–	ZAPS Technologies P.O. Box 2332 Corvallis, OR 97339-2332	Not to Exceed $76,724	Interceptor Sewer Operations	Demonstration and purchase of one (1) ZAPS Technologies LiquID Model 2000 Effluent Monitoring Instrument. The subject instrument will be installed for a ninety (90) day demonstration at a total cost of $13,692. Following satisfactory performance of the instrument, it can be purchased for $63,032 for a total of $76,724. The instrument is under patent #7,411,668 and sole sourced. TCA 6-56-304.6 allows for this single source purchase from ZAPS Technologies to be exempted from the usual advertising and bidding procedures.

City of Chattanooga

Mayor Andy Berke

October 14, 2016

Mr. Justin Holland, Administrator
Public Works Department
Development Resource Center
1250 Market Street – Suite 2100
Chattanooga, TN 37402

Subject: 144517 – Effluent Monitoring Instrument Demonstration and Purchase – Waste Resources Division – Public Works Department

Dear Mr. Holland:

Council approval is recommended for the demonstration and purchase of one Effluent Monitoring Instrument for the Waste Resources Division of the Public Works Department. The ZAPS Technologies LiquID Model 2000 is the instrument to be installed in the liquid effluent stream at Moccasin Bend Wastewater Treatment Plant to provide monitoring of six chemical/biological parameters on a real-time basis. Real-time monitoring is intended to assist plant operators in responding to changing conditions and avoid NPDES permit violations.

The subject instrument will be installed for a ninety (90) day demonstration at a total cost of $13,692 including packaging, shipping, start-up and training. Following satisfactory performance during the demonstration period, the instrument can be purchased for $70,532 minus a credit of $7500 from the amount paid for the demonstration. Therefore, the total cost of both demonstration and subsequent purchase would be $76,724. Waste Resources recommends the demonstration before purchase approach to verify performance of the instrument.

ZAPS Technologies optical monitoring is protected by US Patent #7,411,668. Hence, ZAPS Technologies is the sole source for the subject instrument. TCA 6-56-304.2 allows single source purchases to be exempted from the usual advertising and bidding procedures.

I concur with Public Works' recommendation to award this demonstration and purchase to ZAP Technologies in the amount of $76,724.

Respectfully,

Bonnie Woodward
Director of Purchasing

Commercial proposal
Ref. : PR1609-0510

Ref. customer : Chattanooga (Purchase)
Date : 09/23/2016
Validity ending date : 11/22/2016
Customer code : CU1608-0129

From:

ZAPS Technologies Inc.
AR / AP: P.O. Box 2332, Corvallis OR, 97339-2332
Ship To: 2121 NE Jack London St, Corvallis, OR 97330

Phone: 866-390-9387 - Fax: 541-207-1236
Email: sales@zapstechnologies.com
Web: www.zapstechnologies.com

To:

City of Chattanooga
Charles Thomas
City of Chattanooga WWTP
455 Moccasin Bend Rd
Chattanooga, Tennessee, 37405

- Budgetary proposal for purchase of LiquID Station Model 2000.
- Up to 75% of rental/project payments may be applied towards the purchase of the LiquID Station.
- If the station is moved to a new location additional commissioning fees with a maximum of $5,000 may be required.
- Please include Ref Order number from top right of this document as well as a signed copy of this proposal when issuing a PO or payment.
- If Tax Exempt provide Tax Exempt Certificate so taxes are not collected otherwise taxes will be included on the invoice.
- Shipping: FOB ZAPS Technologies.
- Full Terms and Conditions can be found online at http://www.zapstechnologies.com/support/terms-and-conditions

Amount in US Dollars currency

Description	U.P. (net)	Qty	Reduc.	Total (net of tax)
LID2000 - LiquID Model 2000 Waste Water Icludes 5 standard parameters at no additional cost	65,000.00	1		65,000.00
8080-1 - Wireless Cell Modem Kit (Sprint Provider) Includes Antenna and Coax Cable Includes 1 year modem service	1,920.00	1		1,920.00
8506 - COD Standard Parameter	2,000.00	1	Offered	0.00
8502 - cBOD Standard Parameter	2,000.00	1	Offered	0.00
8527 - Ammonia Gas - NH3 Standard Parameter	2,000.00	1	Offered	0.00
8521 - TSS Standard Parameter	2,000.00	1	Offered	0.00
8513 - Nitrate + Nitrite Standard Parameter	2,000.00	1	Offered	0.00
8509 - E.coli Additional Parameter	2,000.00	1		2,000.00
8308 - Packaging Packaging, US	650.00	1		650.00
Shipping_Cost - Shipping Cost	962.00	1		962.00

Commercial proposal
Ref. : PR1609-0510

Ref. customer : Chattanooga (Purchase)
Date : 09/23/2016
Validity ending date : 11/22/2016
Customer code : CU1608-0129

Availability delay:	6 weeks after PO received	Total (net of tax)	70,532.00
Payment terms:	30 days		
Payment type:	Purchase Order		

Written acceptance, company stamp, date and signature

Commercial proposal
Ref. : PR1609-0511

Ref. customer : Chattanooga (90 Day)
Date : 09/23/2016
Validity ending date : 11/22/2016
Customer code : CU1608-0129

From:

ZAPS Technologies Inc.
AR / AP: P.O. Box 2332, Corvallis OR, 97339-2332
Ship To: 2121 NE Jack London St, Corvallis, OR 97330

Phone: 866-390-9387 - Fax: 541-207-1236
Email: sales@zapstechnologies.com
Web: www.zapstechnologies.com

To:

City of Chattanooga
Charles Thomas
City of Chattanooga WWTP
455 Moccasin Bend Rd
Chattanooga, Tennessee, 37405

- Budgetary proposal for **90 day** project using LiquID Station, project begins 2 weeks after delivery or when the first data is reported by the LiquID Station, whichever occurs sooner.
- A ZAPS Project Agreement required to be completed prior to the initiation of this project.
- After **90 day** project this converts to monthly rental invoiced each month at **$3,446.**
- Up to 75% of rental/project payments may be applied towards the purchase of the LiquID Station. The purchase price of the listed configuration is **$68,920**. If purchased ZAPS Technologies will include 1 year standard warranty from date of purchase.
- Customer must return equipment if not purchased, rent continued, or other financial arrangement made (save crate to avoid $800 charge).
- If the station is moved to a new location additional commissioning fees with a maximum of $5,000 may be required.
- Please include Ref Order number from top right of this document as well as a signed copy of this proposal when issuing a PO or payment.
- If Tax Exempt provide Tax Exempt Certificate so taxes are not collected otherwise taxes will be included on the invoice.
- Shipping: FOB ZAPS Technologies.
- Full Terms and Conditions can be found online at http://www.zapstechnologies.com/support/terms-and-conditions

Amount in US Dollars currency

Description	U.P. (net)	Qty	Reduc.	Total (net of tax)
LID2000-Rental - LiquID Model 2000 Waste Water 90 Day Project Includes 5 standard parameters at no addtional cost	10,000.00	1		10,000.00
8080-1 - Wireless Cell Modem Kit (Sprint Provider) Includes Antenna and Coax Cable Price included in project/rental cost	1,920.00	1	Offered	0.00
8506 - COD Standard Parameter	2,000.00	1	Offered	0.00
8502 - cBOD Standard Parameter	2,000.00	1	Offered	0.00
8527 - Ammonia Gas - NH3 Standard Parameter	2,000.00	1	Offered	0.00
8521 - TSS Standard Parameter	2,000.00	1	Offered	0.00
8513 - Nitrate + Nitrite Standard Parameter	2,000.00	1	Offered	0.00
8509 - E.coli Additional Parameter. Price included in rental cost.	2,000.00	1	Offered	0.00
8310 - Start Up & Training Final hook-up, systems checks, start-up, system monitoring and one (1) training session. (Priced per day.)	1,500.00	1		1,500.00

Commercial proposal
Ref. : PR1609-0511

Ref. customer : Chattanooga (90 Day)
Date : 09/23/2016
Validity ending date : 11/22/2016
Customer code : CU1608-0129

8311 - Start Up & Training Final Day Final checks, one (1) additional training session (if applicable). (Priced per day.)	900.00	1		900.00
8308 - Packaging Packaging, US	650.00	1		650.00
Shipping_Cost - Shipping Cost	642.00	1		642.00

Availability delay: 6 weeks after PO received

Payment terms: 30 days

Payment type: Purchase Order

Total (net of tax) 13,692.00

Written acceptance, company stamp, date and signature

October 4, 2016

Ms. Bonnie Woodward
Director of Purchasing
City of Chattanooga
100 East 11th Street
Chattanooga, TN 37402

Subject: Division of Waste Resources (WRD) request for sole source purchase

Dear Ms. Woodward,

WRD wishes to purchase a monitoring instrument to provide real-time monitoring of six (6) parameters of the Plant Effluent. Currently, the Effluent is only remotely monitored for one parameter. This instrument is not meant to replace lab analysis using approved procedures for reporting under our NPDES permit. The sole purpose of this instrument is to protect the Plant from violations by quickly identifying trends.

WRD wishes to purchase a ZAPS Technologies LiquiD Model 2000. All six of the desired parameters are monitored with one instrument. All parameters are reported to a designated work station approximately every 2 minutes providing continuous monitoring rather than scheduled sampling by lab personnel. This provides Operations personnel valuable time to make process corrections to avoid violations.

ZAPS Technologies' optical monitoring is protected by U.S. patent #7,411,668 (see attached). WRD requests approval to purchase from ZAPS as the sole source vendor in the amount of $ 76,724.00 (see attached quotes). This amount reflects a 90 day trial prior to the purchase with $7,500.00 of the cost of the trial credited to the purchase. We feel it is proper due diligence to verify performance of the instrument at our Plant before committing to purchase. Startup and Training are to be paid on the invoice for the trial. WRD requests the formal bid requirement to prove sole source per Procurement Instruction Manual Section 2.05.3 be waived because of the patent.

ZAPS Technologies best meets the needs of WRD and it cannot be duplicated. In my opinion the City's best interest is served by purchasing this particular product.

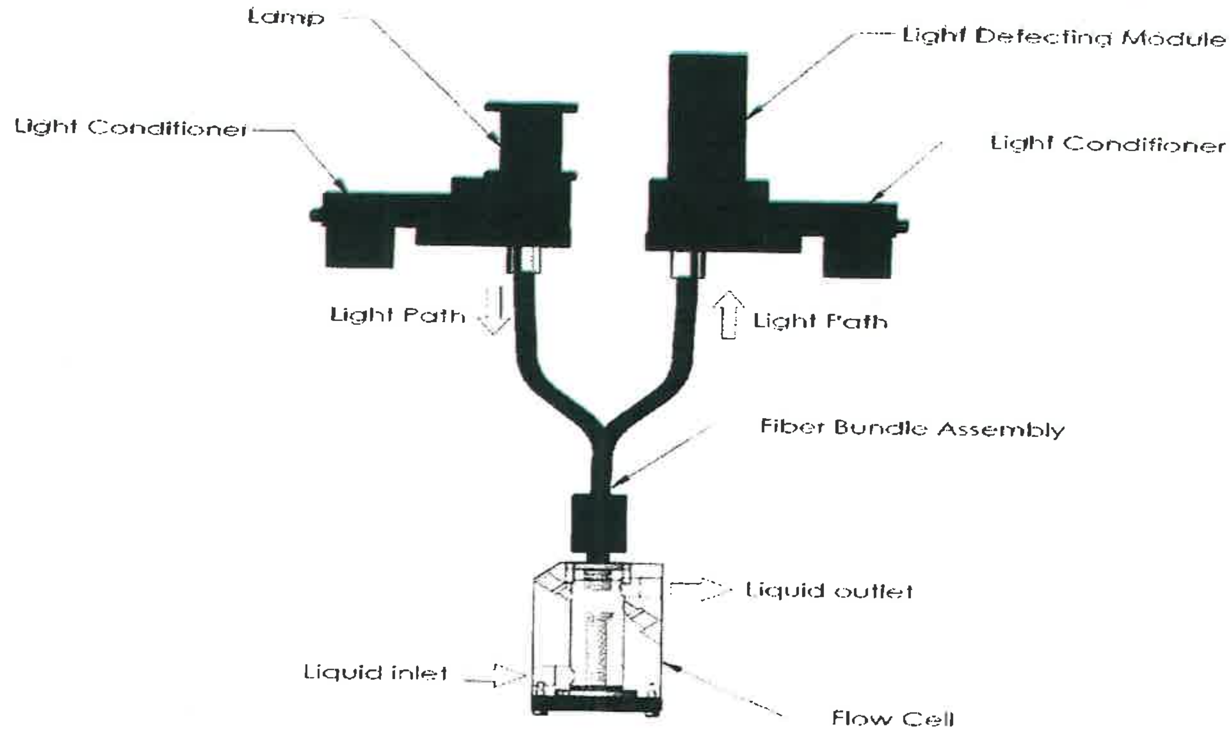
Respectfully yours,

Justin Holland
Administrator, Department of Public Works
Attachments

ZAPS TECHNOLOGIES

ZAPS TECHNOLOGIES

Detect. Respond.



PROPRIETARY AND CONFIDENTIAL

US Patents 7,44?,668, 8,102,518 and US & Foreign Patents Pending

ZAPS TECHNOLOGIES

Light and Liquid Path Assembly

A ZAPS Light and Liquid Path

US007411668B2

(12) **United States Patent**
Klinkhammer

(10) **Patent No.: US 7,411,668 B2**
(45) **Date of Patent: Aug. 12, 2008**

(54) **LIGHT RETURNING TARGET FOR A PHOTOMETER**

(75) Inventor: **Gary Klinkhammer**, Corvallis, OR (US)

(73) Assignee: **Zaps Technologies Incorporated**, Corvallis, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 298 days.

(21) Appl. No.: **11/236,177**

(22) Filed: **Sep. 26, 2005**

(65) **Prior Publication Data**

US 2007/0070333 A1 Mar. 29, 2007

(51) **Int. Cl.**
G01J 1/00 (2006.01)

(52) **U.S. Cl.** **356/213**

(58) **Field of Classification Search** 356/213–236; 359/664

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,904,277	A *	9/1975	Phillips et al.	235/472.03
5,304,492	A	4/1994	Klinkhammer	
5,403,773	A *	4/1995	Nitta et al.	438/7
5,738,677	A *	4/1998	Colvard et al.	606/4
5,940,564	A *	8/1999	Jewell	385/93
6,035,664	A *	3/2000	Hashizume	65/36
6,740,244	B2	5/2004	Baca	
6,747,805	B2 *	6/2004	Sayag	359/664
6,919,019	B2	7/2005	Baca et al.	
7,215,479	B1 *	5/2007	Bakin	359/664
2003/0127520	A1 *	7/2003	Aizawa et al.	235/472.03

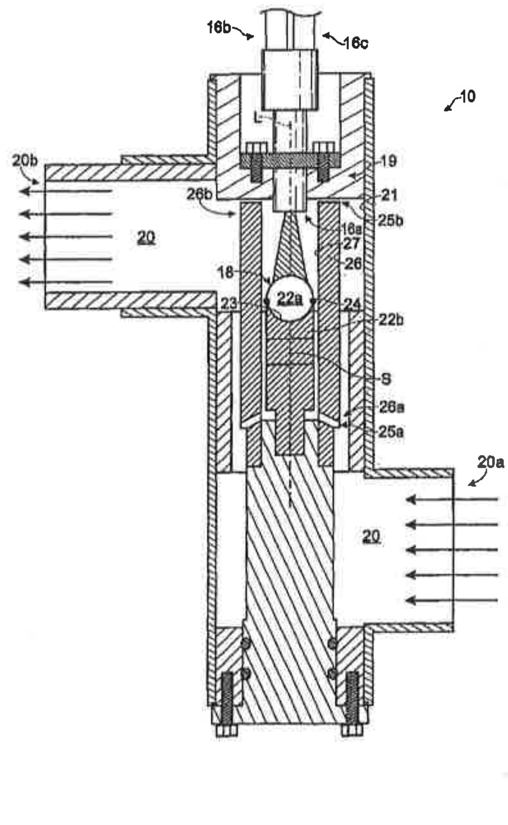
* cited by examiner

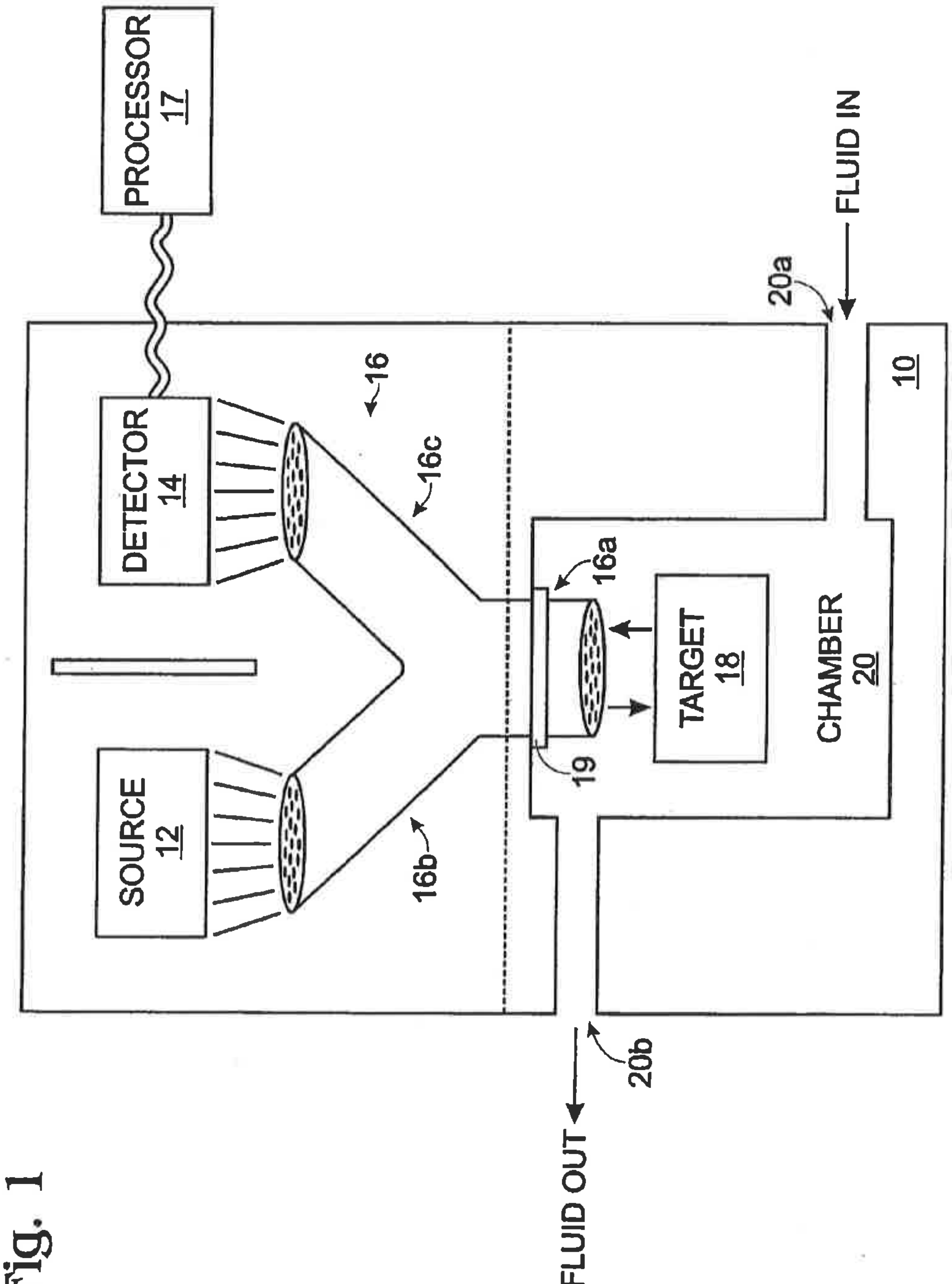
Primary Examiner—Gregory J Toatley, Jr.
Assistant Examiner—Jarreas C Underwood
(74) *Attorney, Agent, or Firm*—Portland Intellectual Property, LLC

(57) **ABSTRACT**

A light returning target for a photometer. The light returning target comprises a ball lens, and a cradle. The cradle has a hemispherical receptacle in which the lens is intimately received. Preferably, the lens is formed of fused silica, the receptacle is polished sufficiently to reflect, more than it scatters, light, and at least the surface of the receptacle is formed of a material that absorbs, more than it reflects, light.

33 Claims, 2 Drawing Sheets

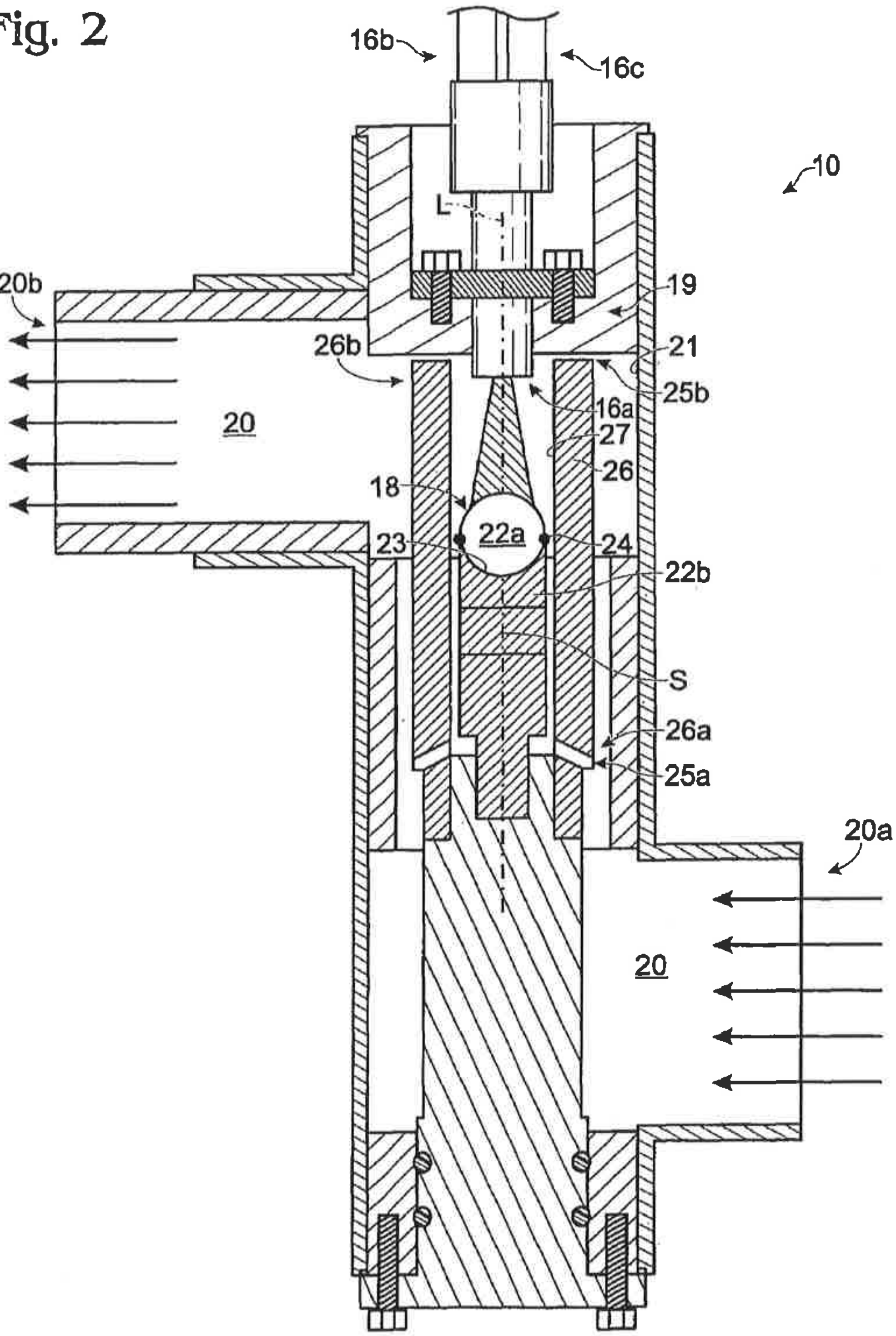




PROCESSOR
17
DETECTOR
14
SOURCE
12
16
16a
16b
16c
19
TARGET
18
CHAMBER
20
10
20a
20b
FLUID IN
FLUID OUT

Fig. 1

Fig. 2


16b
16c
10
L
20b
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26b
25b
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22a
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LIGHT RETURNING TARGET FOR A PHOTOMETER

FIELD OF THE INVENTION

The present invention relates to a light returning target for a photometer. More particularly, the invention relates to such a target in a fiber optic spectrophotometer for measuring absorption, reflection, and fluorescence from impurities in water.

BACKGROUND

There is a need to measure the purity of fluids in many different circumstances. In addition to the familiar examples of monitoring the quality of air and water, chemicals used for industrial processing and laboratory or analytical purposes must meet certain standards of purity. It is particularly important in processes for treating fluids, such as for processing raw water into potable water, or for processing wastewater so that it is safe for release into the environment, to measure purity both before and after the fluid is treated. That is, measuring purity in fluid before it is treated is often desirable to determine how to treat the fluid, and measuring purity at the end of treatment is often necessary as a quality control, or to confirm conformance to regulatory standards.

Devices used for measuring fluid purity in general, and for identifying and quantifying the amount of impurities in particular, commonly use light as a probing mechanism. Such devices are generally referred to as photometers. A specific type of photometer is the spectrophotometer, which permits adjustment of the light frequency (i.e., wavelength), for making measurements at multiple frequencies. The term "spectrophotometer" as used herein includes any photometer, including reflectometers, transmissometers, and nephelometers, adapted for this purpose.

Light that is used to irradiate material may either be reflected by the material, transmitted through the material, or absorbed by the material. Where the light is absorbed by the material, the material may also emit light in response, or fluoresce. In devices used to measure purity, one of three basic measurement methodologies following from these potential interactions of the light with the matter is generally employed. These methodologies measure the parameters absorption, reflectance, and fluorescence and are referred to herein as absorption, reflectance, and fluorescence methodologies. According to the various methodologies, a light detector is disposed with respect to a light transmitter so that the detector is optimally positioned to be responsive to the associated parameter.

For example, for responding to absorption, the detector is typically disposed directly opposite the transmitter, to detect light that is undeflected from its original path; for responding to reflectance, the detector is typically disposed directly adjacent or next to the transmitter, to detect light that is reflected from surfaces; and for responding to fluorescence, the detector is typically disposed at an angle from the transmitter, to detect omnidirectional fluorescent emissions.

However, as can be readily appreciated, in each of the above detector/transmitter configurations, the detector will in general respond to at least one other parameter. In the absorption methodology, the detector response will be affected by both reflectance and fluorescence as well as absorption; in the reflectance methodology, the detector response will be influenced by fluorescence as well as reflectance; and in the fluorescence methodology, the detector will be influenced by reflectance as well as fluorescence.

Accordingly, it is typical in analytical laboratories to preprocess the sample being tested, or to adjust the measurement methodology, to minimize or eliminate responses due to parameters that are not being measured. For example, in the absorption and fluorescence methodologies, the sample can be clarified to eliminate particulates that would introduce reflectance, and in the reflectance and absorption methodologies, the light can be filtered at both the transmitter and the receiver to limit the response to frequencies in which fluorescence is expected.

Testing fluid quality in a laboratory as a control mechanism has serious drawbacks, as explained in the present inventor's U.S. Pat. No. 5,304,492, incorporated by reference herein in its entirety. To solve these problems, the '492 patent discloses an in-situ spectrophotometer having a single transmitter/detector configuration that is indicated as being capable of use for measuring absorption, reflectance, and fluorescence. The device provided for measurement of any the three desired parameters in essentially real-time, in the flow stream of the fluid being tested. The device remains extremely advantageous for measuring a selected one of these different parameters. However, as recognized and explained herein, there is a need for a light returning target for a photometer for measuring more than one of these parameters in the same device.

SUMMARY

A light returning target for a photometer is disclosed herein. The light returning target comprises a substantially spherical lens, and a cradle. The cradle has a matchingly hemispherical receptacle in which the lens is intimately received. Preferably, the lens is formed of fused silica, the surface of the receptacle is polished sufficiently to reflect, more than it scatters, light, and at least the surface of the receptacle is formed of a material that absorbs, more than it reflects, light.

Also disclosed is a photometer comprising the target. The photometer comprises a light source and is adapted to emit light from the light source along a line. The cradle is oriented so that the lens and the cradle together return at least a portion of the light along this line.

Preferably, the photometer further comprises a chamber, a light detector, and a light pipe set including a bifurcated optical fiber for conducting the light from the light source to the chamber and for conducting the light from the chamber to the light detector, the target being disposed inside the chamber.

Further, the photometer preferably includes a flow tube having one or more fluid inlets and one or more fluid outlets providing for fluid flow through the flow tube. The target is disposed within the flow tube, and the flow tube has an interior surface that is smooth relative to the interior surface of the chamber, to help maintain laminar flow around the target.

It is to be understood that this summary is provided as a means of generally determining what follows in the drawings and detailed description and is not intended to limit the scope of the invention. Objects, features and advantages of the invention will be readily understood upon consideration of the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a photometer having a light returning target according to the present invention.

FIG. 2 is a section view of a particular, preferred embodiment of the photometer and light returning target of FIG. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As mentioned above, the '492 patent discloses an "in-situ" spectrophotometer that is advantageous for measuring a selected one of the aforementioned absorbance, reflectance, and fluorescence parameters. However, the present inventor has recognized further that it would be desirable to be able to measure a number of these parameters together, using a single "multi-parameter" device. Essentially, it is recognized that, the greater number of the parameters that are measured, the less likely a change in the impurity content of the fluid being tested can escape detection, particularly in a continuously flowing fluid. For example, this capability is especially important in continuous municipal monitoring of water quality, to provide safe and secure supply of drinking water; however, it is desirable when monitoring impurities in any fluid, for any purpose. Accordingly, while preferred embodiments of the invention are particularly adapted for measuring impurities in water, it should be understood that the principles of the invention may be applied to any fluid or use.

Referring to FIG. **1**, an impurity measurement device **10** is shown in general form that provides for measuring any combination of the parameters reflectance, absorption, and fluorescence, where it should be understood that all of these parameters may be related to transmission. That is, a beam of light is emitted into a space **20** in the device **10** in which resides the fluid to be tested. The beam of light has a frequency spectrum (which may be a single frequency but which is in general a range of frequencies) and an intensity that is a function of the frequency. This intensity function may be referred to for present purposes as simply representing a quantity of incoming light. Assuming an otherwise optically clear fluid, the light is either absorbed or reflected by impurities in the fluid, or there is no interaction of the light with the impurities and the light is simply transmitted through the fluid. In that regard, it should be noted that fluorescence is a special case of absorption, where the absorbed light is re-emitted at a different frequency instead of being dissipated as heat as is the case with non-fluorescent light absorbing materials. It may also be noted that reflection occurs from solid, or particulate impurities, while absorption may occur in dissolved impurities as well as particulate impurities. In any event, in general, the quantity of light transmitted equals the quantity of light emitted minus the quantities of light that are absorbed and reflected.

The device **10** includes a source **12**, a detector **14**, a light pipe set **16**, and a "target" **18**. All except the target **18** may be conventional, such as described in the '492 patent, and preferred embodiments of these components are described below, it being understood that the target **18** may be used with alternative embodiments.

The source **12** is preferably a source of intense white light such as a xenon flash tube, which provides for high intensity by producing the light in pulses. Preferably, the device **10** is adapted as a spectrophotometer, the source emits light in the frequency range of about 200-900 nm, and spectral filters are exchanged such as known in the art to select particular frequencies of the light. However, a frequency adjustable monochromatic light source, either continuous or discontinuous, may be used for the same purpose. As will be readily appreciated by persons of ordinary skill in the art, the use of light characterized by multiple frequencies is important to making multi-parameter measurements; however, the manner in which this is accomplished is not particularly pertinent to the invention and further discussion of this point is therefore omitted.

The detector **14** may be any component or device that is responsive to light intensity, such as a standard photo-multiplier tube, the output of which is amplified and preferably converted to digital form for processing, such as in a remote processor **17**, that includes providing a data output for display and/or storage for subsequent use.

The light pipe set **16** provides for two conductive paths (a) conducting light emitted from the source to an interior chamber **20** of the device **10**, and (b) conducting light from the chamber **20** to the detector **14**. The light pipe set **16** employs optical fibers, e.g., plastic clad fused silica, and is preferably bifurcated as shown in FIG. **1** so that it has a single end **16*a*** that connects to the chamber **20** via a block **19** for conducting light both in and out of the chamber **20**, and two separate ends **16*b*** and **16*c*** connecting to the light source and detector, respectively. Employing the single end **16*a*** to connect to the chamber advantageously provides that the detector is able to collect light returned from the chamber at a point that is very close to that at which light is emitted by the source into the chamber, as well as simplifies the physical connections required.

Especially where the device **10** is intended for submersible use, the source **12** and detector **14** are preferably remote from the remainder of the device, separating the device at the indicated dashed line.

Referring to FIG. **2**, the chamber **20** in the preferred embodiment shown is formed by connecting two, 2 inch diameter PVC "T" connectors together, but may be formed in any number of alternative ways. An upper opening of one of the connectors receives the block **19**. Respective side openings of the connectors provide for a water inlet **20*a*** and a water outlet **20*b***. Water flowing through the chamber envelopes the target **18** and the common end of the bifurcated fiber assembly **16*a***. Light enters the water directly from the end **16*a*** of the fiber bundle.

The target **18** returns the light emitted from the source **12** (FIG. **1**) through the end **16*a*** into the water, back into the end **16*a*** and thence to the detector **14** (FIG. **1**) in the absence of impurities in the water that would otherwise absorb or reflect the emitted light. The target **18** is specially adapted to enable the measurement of all three of the parameters absorption, reflection, and fluorescence, rendering the device **10** a "multi-parameter" device. The measurement of multiple parameters in the same device has a number of advantages. For example, the device is relatively simple and inexpensive as compared to employing a number of more specialized devices optimized for measuring particular parameters; signals for all measurements travel the same optical paths and employ the same source and detector, simplifying the monitoring of long-term drift in the device and facilitating corrections for drift in all measurements; and signal ratios are more constant because instrument artifacts are cancelled out. All of these features are enabled by the target **18**.

The target **18** comprises a ball lens **22*a*** and a cradle **22*b***. The cradle **22*b*** serves to support the ball lens and acts as a partially focusing reflector. The ball lens serves to focus light received from the end **16*a***, and to further focus light reflected back to the end **16*a*** by the cradle. In both cases, the light travels along a line "L."

It is believed to be important that the ball lens is substantially spherical, i.e., at least to within 5% and preferably at least to within 1%, and it will be readily appreciated that the ball lens should be substantially optically clear at the measuring frequencies of interest. Preferably, the ball lens is formed of fused silica because it has a broad transmission spectrum, particularly for transmitting ultraviolet light ("UV") down to a wavelength of less than about 200 nm, which is useful for probing, e.g., nitrates which are typically measured at a wavelength of 220 nm. However, the ball lens may be formed of other suitable materials.

The diameter of the ball lens **22***a* in the preferred embodiment shown is about 18 mm and the midpoint of the lens is preferably positioned such that outer-most rays of light exiting the end **16***a* and spreading about 22.5° encounter the lens about 1.0 mm from the edges thereof, to minimize optical aberrations that would result at the edges.

The cradle **22***b* includes a hemispherical or partially hemispherical (hereinafter "hemispherical") receptacle **23** shaped and sized to intimately receive the ball lens within close tolerance, and the interface between the ball lens and the cradle is preferably sealed against the seepage of water therebetween, such as by use of an O-ring **24**. The hemispherical receptacle **23** serves to reflect and partially focus light passing through the ball lens.

The receptacle **23** is preferably oriented so that a rotational axis of symmetry "S" of the receptacle is coincident with the aforementioned line L of travel of the light.

It is recognized by the present inventor that the amount of light returned to the end **16***a* by the target **18** should be balanced between competing objectives. That is, a larger quantity of reflected light is better for measuring absorption, for comparing the light returned with the light emitted, while on the other hand, this makes it more difficult to measure fluorescence and reflection because a high degree of reflection produces scattered light and tends to reduce the signal to noise ratio. It has been found that forming at least the surface of the receptacle **23** of the cradle **22***b* of a material that absorbs, more than it reflects, light that is, nevertheless, polished sufficiently to reflect, more than it scatters, light at the wavelengths of interest, provides a good balance between these competing objectives. In the preferred embodiment shown, the entire cradle is formed of black plastic acetyl resin, such as that marketed as Delrin®, and the surface of the receptacle **23** is polished accordingly.

The ball lens **22***a* provides an additional feature of minimizing the effect of fouling, e.g., by algae, that occurs during use of the device **10** in monitoring water incoming to a municipal treatment plant, or water in a river, or in the ocean, such that the target will tend to lose its effectiveness to return light back to the end **16***a*. The convex, hemispherical shape of the portion of the ball lens exposed to fouling ensures that backscatter directly back to the end **16***a* remains relatively low.

As mentioned above, while somewhat reflective to enable absorption measurements, the target **18** is sufficiently dark to enable fluorescence and reflectance measurements. It is believed to be important in practice, though not essential in principle, that the target is resistant to UV damage that may be caused by the source **12**. Therefore, the materials of which the target **18** is formed are preferably either inherently UV stable, such as the preferred fused silica for use in the ball lens **22***a*, or are treated to make them UV stable, such as the preferred acetyl resin for use in the cradle **22***b*.

The chamber **20** also houses an inner flow tube **26** which in turn houses the target **18**. The inner flow tube **26** includes one or more apertures **25***a*, at a first end **26***a* of the tube through which water in the device **10** enters the tube, and one or more apertures **25***b* at a second end **26***b* of the tube through which the water exits the tube. In the preferred embodiment shown, the apertures **25***a* are a series of drilled holes set at an angle inclined toward the direction of water flow, while the apertures **25***b* are providing by spacing the end **26***b* of the tube 2 mm from the block **19**.

The inner flow tube has an interior surface **27** that is relatively smooth as compared to the interior surface **21** of the chamber **20**, which helps to maintain laminar flow around the target **18**, to reduce the potential for forming bubbles that would interfere with the optical path of the light. In the preferred embodiment shown, the inner flow tube is formed of polyethylene terephthalate ("PET-P"), such as that marketed as Ertalyte®, chosen for its chemical inertness and low water permeability.

It is to be understood that, while a specific light returning target for a photometer has been shown and described as preferred, other configurations and methods could be utilized, in addition to those already mentioned, without departing from the principles of the invention.

The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention in the use of such terms and expressions to exclude equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

The invention claimed is:

1. A light returning target for a photometer, comprising:

a substantially spherical ball lens; and

a cradle having a matchingly hemispherical receptacle in which said lens is intimately received, said receptacle having a reflective surface for reflecting light passing through said lens.

2. The target of claim **1**, wherein said lens is formed of fused silica.

3. The target of claim **2**, wherein said surface is polished sufficiently to reflect, more than it scatters, light.

4. The target of claim **2**, wherein said receptacle absorbs, more than it reflects, light.

5. The target of claim **4**, wherein said surface is polished sufficiently to reflect, more than it scatters, light.

6. The target of claim **1**, wherein said receptacle absorbs, more than it reflects, light.

7. The target of claim **6**, wherein said surface is polished sufficiently to reflect, more than it scatters, light.

8. A photometer, comprising:

a light source which emits light along a line; and

a target, the target comprising a substantially spherical ball lens and a cradle having a matchingly hemispherical receptacle in which said lens is intimately received, said cradle being oriented so that said lens and said cradle together return at least a portion of the light along said line.

9. The photometer of claim **8**, further comprising a chamber, a light detector, and a light pipe set including a bifurcated optical fiber for conducting the light from said light source and emitting the light into said chamber along said line, and for conducting the light returned along said line from said chamber to said light detector, said target being disposed inside said chamber.

10. The photometer of claim **9**, wherein said chamber has an interior surface and further comprising a flow tube having one or more fluid inlets and one or more fluid outlets providing for fluid flow through said flow tube, said target being disposed within said flow tube, said flow tube having an interior surface that is smooth relative to said interior surface of said chamber, to help maintain laminar flow around said target.

11. The photometer of claim **9**, wherein said lens is formed of fused silica.

12. The photometer of claim 11, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

13. The photometer of claim 12, wherein said receptacle absorbs, more than it reflects, the light.

14. The photometer of claim 11, wherein said receptacle absorbs, more than it reflects, the light.

15. The photometer of claim 8, wherein said lens is formed of fused silica.

16. The photometer of claim 15, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

17. The photometer of claim 15, wherein said receptacle absorbs, more than it reflects, the light.

18. The photometer of claim 17, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

19. The photometer of claim 8, wherein said receptacle absorbs, more than it reflects, the light.

20. The photometer of claim 19, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

21. A photometer, comprising:

a light source, wherein light emitted from said light source is made available as an output at a predetermined first point; and

a target, the target comprising a substantially spherical ball lens and a cradle having a matchingly hemispherical receptacle in which said lens is intimately received, said cradle being oriented so as to at least partially focus light received from said first point at a predetermined second point.

22. The photometer of claim 21, further comprising a light detector and a light pipe set including a bifurcated optical fiber for coupling light emitted from said light source to said first point, and coupling light focused at said second point to said light detector.

23. The photometer of claim 22, further comprising a chamber in which said target is disposed, wherein said chamber has an interior surface and further comprising a flow tube having one or more fluid inlets and one or more fluid outlets providing for fluid flow through said flow tube, said target being disposed within said flow tube, said flow tube having an interior surface that is smooth relative to said interior surface of said chamber, to help maintain laminar flow around said target.

24. The photometer of claim 22, wherein said lens is formed of fused silica.

25. The photometer of claim 24, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, light received thereby.

26. The photometer of claim 25, wherein said receptacle absorbs, more than it reflects, light received thereby.

27. The photometer of claim 24, wherein said receptacle absorbs, more than it reflects, light received thereby.

28. The photometer of claim 21, wherein said lens is formed of fused silica.

29. The photometer of claim 28, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, light received thereby.

30. The photometer of claim 28, wherein said receptacle absorbs, more than it reflects, light received thereby.

31. The photometer of claim 30, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, light received thereby.

32. The photometer of claim 21, wherein said receptacle absorbs, more than it reflects, light received thereby.

33. The photometer of claim 32, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

* * * * *

Light returning target for a photometer
US 7411668 B2

ABSTRACT

A light returning target for a photometer. The light returning target comprises a ball lens, and a cradle. The cradle has a hemispherical receptacle in which the lens is intimately received. Preferably, the lens is formed of fused silica, the receptacle is polished sufficiently to reflect, more than it scatters, light, and at least the surface of the receptacle is formed of a material that absorbs, more than it reflects, light.

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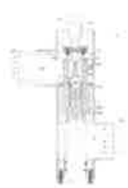

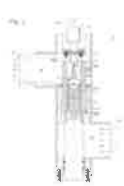

DESCRIPTION

FIELD OF THE INVENTION

The present invention relates to a light returning target for a photometer. More particularly, the invention relates to such a target in a fiber optic spectrophotometer for measuring absorption, reflection, and fluorescence from impurities in water.

BACKGROUND

There is a need to measure the purity of fluids in many different circumstances. In addition to the familiar examples of monitoring the quality of air and water, chemicals used for industrial processing and laboratory or analytical purposes must meet certain standards of purity. It is particularly important in processes for treating fluids, such as for processing raw water into potable water, or for processing wastewater so that it is safe for release into the environment, to measure purity both before and after the fluid is treated. That is, measuring purity in fluid before it is treated is often desirable to determine how to treat the fluid, and measuring purity at the end of treatment is often necessary as a quality control, or to confirm conformance to regulatory standards.

Devices used for measuring fluid purity in general, and for identifying and quantifying the amount of impurities in particular, commonly use light as a probing mechanism. Such devices are generally referred to as photometers. A specific type of photometer is the spectrophotometer, which permits adjustment of the light frequency (i.e., wavelength), for making measurements at multiple frequencies. The term "spectrophotometer" as used herein includes any photometer, including reflectometers, transmissometers, and nephelometers, adapted for this purpose.

CLAIMS (33)

1. A light returning target for a photometer, comprising:

a substantially spherical ball lens; and

a cradle having a matchingly hemispherical receptacle in which said lens is intimately received, said receptacle having a reflective surface for reflecting light passing through said lens.

2. The target of claim 1, wherein said lens is formed of fused silica.

3. The target of claim 2, wherein said surface is polished sufficiently to reflect, more than it scatters, light.

4. The target of claim 2, wherein said receptacle absorbs, more than it reflects, light.

5. The target of claim 4, wherein said surface is polished sufficiently to reflect, more than it scatters, light.

6. The target of claim 1, wherein said receptacle absorbs, more than it reflects, light.

7. The target of claim 6, wherein said surface is polished sufficiently to reflect, more than it scatters, light.

8. A photometer, comprising:

a light source which emits light along a line; and

a target, the target comprising a substantially spherical ball lens and a cradle having a matchingly hemispherical receptacle in which said lens is

Light that is used to irradiate material may either be reflected by the material, transmitted through the material, or absorbed by the material. Where the light is absorbed by the material, the material may also emit light in response, or fluoresce. In devices used to measure purity, one of three basic measurement methodologies following from these potential interactions of the light with the matter is generally employed. These methodologies measure the parameters absorption, reflectance, and fluorescence and are referred to herein as absorption, reflectance, and fluorescence methodologies. According to the various methodologies, a light detector is disposed with respect to a light transmitter so that the detector is optimally positioned to be responsive to the associated parameter.

For example, for responding to absorption, the detector is typically disposed directly opposite the transmitter, to detect light that is undeflected from its original path; for responding to reflectance, the detector is typically disposed directly adjacent or next to the transmitter, to detect light that is reflected from surfaces; and for responding to fluorescence, the detector is typically disposed at an angle from the transmitter, to detect omnidirectional fluorescent emissions.

However, as can be readily appreciated, in each of the above detector/transmitter configurations, the detector will in general respond to at least one other parameter. In the absorption methodology, the detector response will be affected by both reflectance and fluorescence as well as absorption; in the reflectance methodology, the detector response will be influenced by fluorescence as well as reflectance; and in the fluorescence methodology, the detector will be influenced by reflectance as well as fluorescence.

Accordingly, it is typical in analytical laboratories to pre-process the sample being tested, or to adjust the measurement methodology, to minimize or eliminate responses due to parameters that are not being measured. For example, in the absorption and fluorescence methodologies, the sample can be clarified to eliminate particulates that would introduce reflectance, and in the reflectance and absorption methodologies, the light can be filtered at both the transmitter and the receiver to limit the response to frequencies in which fluorescence is expected.

Testing fluid quality in a laboratory as a control mechanism has serious drawbacks, as explained in the present inventor's U.S. Pat. No. 5,304,492, incorporated by reference herein in its entirety. To solve these problems, the '492 patent discloses an in-situ spectrophotometer having a single transmitter/detector configuration that is indicated as being capable of use for measuring absorption, reflectance, and fluorescence. The device provided for measurement of any the three desired parameters in essentially real-time, in the flow stream of the fluid being tested. The device remains extremely advantageous for measuring a selected one of these different parameters. However, as recognized and explained herein, there is a need for a light returning target for a photometer for measuring more than one of these parameters in the same device.

SUMMARY

A light returning target for a photometer is disclosed herein. The light returning target comprises a substantially spherical lens, and a cradle. The cradle has a matchingly hemispherical receptacle in which the lens is intimately received. Preferably, the lens is formed of fused silica, the surface of the receptacle is polished sufficiently to reflect, more than it scatters, light, and at least the surface of the receptacle is formed of a material that absorbs, more than it reflects, light.

Also disclosed is a photometer comprising the target. The photometer comprises a light source and is adapted to emit light from the light source along a line. The cradle is oriented so that the lens and the cradle together return at least a portion of the light along this line.

Preferably, the photometer further comprises a chamber, a light detector, and a light pipe set including a bifurcated optical fiber for conducting the light from the

intimately received, said cradle being oriented so that said lens and said cradle together return at least a portion of the light along said line.

9. The photometer of claim 8, further comprising a chamber, a light detector, and a light pipe set including a bifurcated optical fiber for conducting the light from said light source and emitting the light into said chamber along said line, and for conducting the light returned along said line from said chamber to said light detector, said target being disposed inside said chamber.

10. The photometer of claim 9, wherein said chamber has an interior surface and further comprising a flow tube having one or more fluid inlets and one or more fluid outlets providing for fluid flow through said flow tube, said target being disposed within said flow tube, said flow tube having an interior surface that is smooth relative to said interior surface of said chamber, to help maintain laminar flow around said target.

11. The photometer of claim 9, wherein said lens is formed of fused silica.

12. The photometer of claim 11, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

13. The photometer of claim 12, wherein said receptacle absorbs, more than it reflects, the light.

14. The photometer of claim 11, wherein said receptacle absorbs, more than it reflects, the light.

15. The photometer of claim 8, wherein said lens is formed of fused silica.

16. The photometer of claim 15, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

17. The photometer of claim 15, wherein said receptacle absorbs, more than it reflects, the light.

18. The photometer of claim 17, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

19. The photometer of claim 8, wherein said receptacle absorbs, more than it reflects, the light.

20. The photometer of claim 19, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

21. A photometer, comprising:

a light source, wherein light emitted from said light source is made available as an output at a predetermined first point; and

a target, the target comprising a substantially spherical ball lens and a cradle having a matchingly hemispherical receptacle in which said lens is intimately received, said cradle being oriented so as to at least partially focus light received from said first point at a predetermined second point.

22. The photometer of claim 21, further comprising a light detector and a light pipe set including a bifurcated optical fiber for coupling light emitted from said light source to said first point, and coupling light focused at said second point to said light detector.

23. The photometer of claim 22, further comprising a chamber in which said target is disposed, wherein said chamber has an interior surface and further comprising a flow tube having one or more fluid inlets and one or more fluid outlets providing for fluid flow through said flow tube,

light source to the chamber and for conducting the light from the chamber to the light detector, the target being disposed inside the chamber.

Further, the photometer preferably includes a flow tube having one or more fluid inlets and one or more fluid outlets providing for fluid flow through the flow tube. The target is disposed within the flow tube, and the flow tube has an interior surface that is smooth relative to the interior surface of the chamber, to help maintain laminar flow around the target.

It is to be understood that this summary is provided as a means of generally determining what follows in the drawings and detailed description and is not intended to limit the scope of the invention. Objects, features and advantages of the invention will be readily understood upon consideration of the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a photometer having a light returning target according to the present invention.

FIG. 2 is a section view of a particular, preferred embodiment of the photometer and light returning target of FIG. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As mentioned above, the '492 patent discloses an "in-situ" spectrophotometer that is advantageous for measuring a selected one of the aforementioned absorbance, reflectance, and fluorescence parameters. However, the present inventor has recognized further that it would be desirable to be able to measure a number of these parameters together, using a single "multi-parameter" device. Essentially, it is recognized that, the greater number of the parameters that are measured, the less likely a change in the impurity content of the fluid being tested can escape detection, particularly in a continuously flowing fluid. For example, this capability is especially important in continuous municipal monitoring of water quality, to provide safe and secure supply of drinking water; however, it is desirable when monitoring impurities in any fluid, for any purpose. Accordingly, while preferred embodiments of the invention are particularly adapted for measuring impurities in water, it should be understood that the principles of the invention may be applied to any fluid or use.

said target being disposed within said flow tube, said flow tube having an interior surface that is smooth relative to said interior surface of said chamber, to help maintain laminar flow around said target.

24. The photometer of claim 22, wherein said lens is formed of fused silica.

25. The photometer of claim 24, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, light received thereby.

26. The photometer of claim 25, wherein said receptacle absorbs, more than it reflects, light received thereby.

27. The photometer of claim 24, wherein said receptacle absorbs, more than it reflects, light received thereby.

28. The photometer of claim 21, wherein said lens is formed of fused silica.

29. The photometer of claim 28, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, light received thereby.

30. The photometer of claim 28, wherein said receptacle absorbs, more than it reflects, light received thereby.

31. The photometer of claim 30, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, light received thereby.

32. The photometer of claim 21, wherein said receptacle absorbs, more than it reflects, light received thereby.

33. The photometer of claim 32, wherein the surface of said receptacle is polished sufficiently to reflect, more than it scatters, the light.

Referring to FIG. 1, an impurity measurement device **10** is shown in general form that provides for measuring any combination of the parameters reflectance, absorption, and fluorescence, where it should be understood that all of these parameters may be related to transmission. That is, a beam of light is emitted into a space **20** in the device **10** in which resides the fluid to be tested. The beam of light has a frequency spectrum (which may be a single frequency but which is in general a range of frequencies) and an intensity that is a function of the frequency. This intensity function may be referred to for present purposes as simply representing a quantity of incoming light. Assuming an otherwise optically clear fluid, the light is either absorbed or reflected by impurities in the fluid, or there is no interaction of the light with the impurities and the light is simply transmitted through the fluid. In that regard, it should be noted that fluorescence is a special case of absorption, where the absorbed light is re-emitted at a different frequency instead of being dissipated as heat as is the case with non-fluorescent light absorbing materials. It may also be noted that reflection occurs from solid, or particulate impurities, while absorption may occur in dissolved impurities as well as particulate impurities. In any event, in general, the quantity of light transmitted equals the quantity of light emitted minus the quantities of light that are absorbed and reflected.

The device **10** includes a source **12**, a detector **14**, a light pipe set **16**, and a "target" **18**. All except the target **18** may be conventional, such as described in the '492 patent, and preferred embodiments of these components are described below, it being understood that the target **18** may be used with alternative embodiments.

The source **12** is preferably a source of intense white light such as a xenon flash tube, which provides for high intensity by producing the light in pulses. Preferably, the device **10** is adapted as a spectrophotometer, the source emits light in the frequency range of about 200-900 nm, and spectral filters are exchanged such as known in the art to select particular frequencies of the light. However, a frequency adjustable monochromatic light source, either continuous or discontinuous, may be used for the same purpose. As will be readily appreciated by persons of ordinary skill in the art, the use of light characterized by multiple frequencies is important to making multi-parameter measurements; however, the manner in which this is accomplished is not particularly pertinent to the invention and further discussion of this point is therefore omitted.

The detector **14** may be any component or device that is responsive to light intensity, such as a standard photo-multiplier tube, the output of which is amplified and preferably converted to digital form for processing, such as in a remote processor **17**, that includes providing a data output for display and/or storage for subsequent use.

The light pipe set **16** provides for two conductive paths (a) conducting light emitted from the source to an interior chamber **20** of the device **10**, and (b) conducting light from the chamber **20** to the detector **14**. The light pipe set **16** employs optical fibers, e.g., plastic clad fused silica, and is preferably bifurcated as shown in FIG. 1 so that it has a single end **16** *a* that connects to the chamber **20** via a block **19** for conducting light both in and out of the chamber **20**, and two separate ends **16** *b* and **16** *c* connecting to the light source and detector, respectively. Employing the single end **16** *a* to connect to the chamber advantageously provides that the detector is able to collect light returned from the chamber at a point that is very close to that at which light is emitted by the source into the chamber, as well as simplifies the physical connections required.

Especially where the device **10** is intended for submersible use, the source **12** and detector **14** are preferably remote from the remainder of the device, separating the device at the indicated dashed line.

Referring to FIG. 2, the chamber **20** in the preferred embodiment shown is formed by connecting two, 2 inch diameter PVC "T" connectors together, but may be formed in any number of alternative ways. An upper opening of one of the connectors receives the block **19**. Respective side openings of the connectors provide for a water inlet **20** *a* and a water outlet **20** *b*. Water flowing through the chamber envelopes the target **18** and the common end of the bifurcated fiber assembly **16** *a*. Light enters the water directly from the end **16** *a* of the fiber bundle.

The target **18** returns the light emitted from the source **12** (FIG. 1) through the end **16** *a* into the water, back into the end **16** *a* and thence to the detector **14** (FIG. 1) in the absence of impurities in the water that would otherwise absorb or reflect the emitted light. The target **18** is specially adapted to enable the measurement of all three of the parameters absorption, reflection, and fluorescence, rendering the device **10** a "multi-parameter" device. The measurement of multiple parameters in the same device has a number of advantages. For example, the device is relatively simple and inexpensive as compared to employing a number of more specialized devices optimized for measuring particular parameters; signals for all measurements travel the same optical paths and employ the same source and detector, simplifying the monitoring of long-term drift in the device and facilitating corrections for drift in all measurements; and signal ratios are more constant because instrument artifacts are cancelled out. All of these features are enabled by the target **18**.

The target **18** comprises a ball lens **22** *a* and a cradle **22** *b*. The cradle **22** *b* serves to support the ball lens and acts as a partially focusing reflector. The ball lens serves to focus light received from the end **16** *a*, and to further focus light reflected back to the end **16** *a* by the cradle. In both cases, the light travels along a line "L."

It is believed to be important that the ball lens is substantially spherical, i.e., at least to within 5% and preferably at least to within 1%, and it will be readily appreciated that the ball lens should be substantially optically clear at the measuring frequencies of interest. Preferably, the ball lens is formed of fused silica because it has a broad transmission spectrum, particularly for transmitting ultraviolet light ("UV") down to a wavelength of less than about 200 nm, which is useful for probing, e.g., nitrates which are typically measured at a wavelength of 220 nm. However, the ball lens may be formed of other suitable materials.

The diameter of the ball lens **22** *a* in the preferred embodiment shown is about 18 mm and the midpoint of the lens is preferably positioned such that outer-most rays of light exiting the end **16** *a* and spreading about 22.5° encounter the lens about 1.0 mm from the edges thereof, to minimize optical aberrations that would result at the edges.

The cradle **22** *b* includes a hemispherical or partially hemispherical (hereinafter "hemispherical") receptacle **23** shaped and sized to intimately receive the ball lens within close tolerance, and the interface between the ball lens and the cradle is preferably sealed against the seepage of water therebetween, such as by use of an O-ring **24**. The hemispherical receptacle **23** serves to reflect and partially focus light passing through the ball lens.

The receptacle **23** is preferably oriented so that a rotational axis of symmetry "S" of the receptacle is coincident with the aforementioned line L of travel of the light.

It is recognized by the present inventor that the amount of light returned to the end **16** *a* by the target **18** should be balanced between competing objectives. That is, a larger quantity of reflected light is better for measuring absorption, for comparing the light returned with the light emitted, while on the other hand, this makes it more difficult to measure fluorescence and reflection because a high degree of reflection produces scattered light and tends to reduce the signal to noise ratio. It has been found that forming at least the surface of the receptacle **23** of the cradle **22** *b* of a material that absorbs, more than it reflects, light that is, nevertheless, polished sufficiently to reflect, more than it scatters, light at the wavelengths of interest, provides a good balance between these competing objectives. In the preferred embodiment shown, the entire cradle is formed of black plastic acetyl resin, such as that marketed as Delrin®, and the surface of the receptacle **23** is polished accordingly.

The [illegible] fouling, e.g., by algae, that occurs during use of the device **10** in monitoring water incoming to a municipal treatment plant, or water in a river, or in the ocean, such that the target will tend to lose its effectiveness to return light back to the end **16** *a*. The convex, hemispherical shape of the portion of the ball lens exposed to fouling ensures that backscatter directly back to the end **16** *a* remains relatively low.

As mentioned above, while somewhat reflective to enable absorption measurements, the target **18** is sufficiently dark to enable fluorescence and reflectance measurements. It is believed to be important in practice, though not essential in principle, that the target is resistant to UV damage that may be caused by the source **12**. Therefore, the materials of which the target **18** is formed are preferably either inherently UV stable, such as the preferred fused silica for use in the ball lens **22** *a*, or are treated to make them UV stable, such as the preferred acetyl resin for use in the cradle **22** *b*.

The chamber **20** also houses an inner flow tube **26** which in turn houses the target **18**. The inner flow tube **26** includes one or more apertures **25** *a*, at a first end **26** *a* of the tube through which water in the device **10** enters the tube, and one or more apertures **25** *b* at a second end **26** *b* of the tube through which the water exits the tube. In the preferred embodiment shown, the apertures **25** *a* are a series of drilled holes set at an angle inclined toward the direction of water flow, while the apertures **25** *b* are providing by spacing the end **26** *b* of the tube 2 mm from the block **19**.

The inner flow tube has an interior surface **27** that is relatively smooth as compared to the interior surface **21** of the chamber **20**, which helps to maintain laminar flow around the target **18**, to reduce the potential for forming bubbles that would interfere with the optical path of the light. In the preferred embodiment shown, the inner flow tube is formed of polyethylene terephthalate ("PET-P"), such as that marketed as Ertalyte®, chosen for its chemical inertness and low water permeability.

It is to be understood that, while a specific light returning target for a photometer has been shown and described as preferred, other configurations and methods could be utilized, in addition to those already mentioned, without departing from the principles of the invention.

The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention in the use of such terms and expressions to exclude equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

PATENT CITATIONS

Cited Patent	Filing date	Publication date	Applicant	Title
US3904277 *	Mar 20, 1974	Sep 9, 1975	Pitney Bowes Inc	Optical hand scanner optical assembly
US5304492	Nov 26, 1991	Apr 19, 1994	The State Of Oregon Acting By And Through The State Board Of Higher Education On Behalf Of Oregon State University	Spectrophotometer for chemical analyses of fluids
US5403773 *	Jul 9, 1993	Apr 4, 1995	Sumimoto Electric Industries, Ltd.	Method for producing a semiconductor light emitting device
US5738677 *	May 31, 1995	Apr 14, 1998	Premier Laser Systems, Inc.	Apparatus and method for performing eye surgery
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US6747805 *	Jul 22, 2002	Jun 8, 2004	Michel Sayag	Design and fabrication process for a lens system optically coupled to an image-capture device
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US20030127520 *	Dec 26, 2002	Jul 10, 2003	Sony Corporation	Optical data code reader

* Cited by examiner

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Citing Patent	Filing date	Publication date	Applicant	Title
US8981314	Feb 9, 2012	Mar 17, 2015	Zaps Technologies, Inc	Method and apparatus for the optical determination of total organic carbon in aqueous streams

CLASSIFICATIONS

U.S. Classification	356/213, 356/419, 356/436, 356/417

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Cooperative Classification	G01N21/31, G01N21/645, G01N21/05
European Classification	G01N21/64P, G01N21/05, G01N21/31

LEGAL EVENTS

Date	Code	Event	Description
Sep 26, 2005	AS	Assignment	**Owner name:** ZAPS TECHNOLOGIES, INCORPORATED, OREGON **Free format text:** ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNOR:KLINKHAMMER, GARY;REEL/FRAME:017046/0028 **Effective date:** 20050926
Feb 7, 2012	FPAY	Fee payment	**Year of fee payment:** 4
Mar 25, 2016	REMI	Maintenance fee reminder mailed	
Jul 15, 2016	FPAY	Fee payment	**Year of fee payment:** 8
Jul 15, 2016	SULP	Surcharge for late payment	**Year of fee payment:** 7