



US008653442B2

(12) **United States Patent**
Mueth et al.

(10) **Patent No.:** **US 8,653,442 B2**
(45) **Date of Patent:** **Feb. 18, 2014**

(54) **MULTIPLE LAMINAR FLOW-BASED PARTICLE AND CELLULAR SEPARATION WITH LASER STEERING**

USPC **250/251**; 494/36; 494/45; 435/173.1; 210/732; 210/800; 210/802

(58) **Field of Classification Search**

USPC 250/251; 494/36, 45; 435/173.1; 210/732, 800, 802

See application file for complete search history.

(75) Inventors: **Daniel Mueth**, Chicago, IL (US); **Joseph Plewa**, Park Ridge, IL (US); **Jessica Shireman**, Kansas City, MO (US); **Amy Anderson**, Palatine, IL (US); **Lewis Gruber**, Chicago, IL (US); **Neil Harris Rosenbaum**, Chicago, IL (US)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,390,449 A 7/1968 Fox
3,649,829 A 3/1972 Randolph

(Continued)

FOREIGN PATENT DOCUMENTS

DE 19952322 A1 5/2001
EP 0057907 A1 8/1982

(Continued)

OTHER PUBLICATIONS

Hori M. et al., "Cell fusion by optical trapping with laser—involves contacting different cells . . . ", WPI/Thomson, Dec. 27, 1991, Abstract.

(Continued)

Primary Examiner — Kiet T Nguyen

(74) *Attorney, Agent, or Firm* — Jean C. Edwards; Edwards Neils PLLC

(57) **ABSTRACT**

The invention provides a method, apparatus and system for separating cellular components, and can be combined with holographic optical trapping manipulation or other forms of optical tweezing. One exemplary method includes providing a first flow having a plurality of components; providing a second flow; contacting the first flow with the second flow to provide a first separation region; and differentially sedimenting a first cellular component of the plurality of components into the second flow while concurrently maintaining a second cellular component of the plurality of components in the first flow. The second flow having the first cellular component is then differentially removed from the first flow having the second cellular component. Holographic optical traps may also be utilized in conjunction with the various flows to move selected components from one flow to another, as part of or in addition to a separation stage.

64 Claims, 22 Drawing Sheets

(73) Assignee: **Premium Genetics (UK) Limited**, Cheshire (GB)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 46 days.

(21) Appl. No.: **13/412,969**

(22) Filed: **Mar. 6, 2012**

(65) **Prior Publication Data**

US 2012/0183947 A1 Jul. 19, 2012

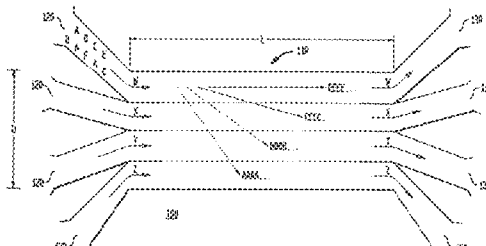
Related U.S. Application Data

(60) Continuation of application No. 12/659,277, filed on Mar. 2, 2010, now Pat. No. 8,158,927, which is a division of application No. 12/213,109, filed on Jun. 13, 2008, now Pat. No. 7,699,767, which is a division of application No. 11/543,773, filed on Oct. 6, 2006, now Pat. No. 7,402,131, which is a division of application No. 10/934,597, filed on Sep. 3, 2004, now Pat. No. 7,118,676, which is a continuation-in-part of application No. 10/867,328, filed on Jun. 13, 2004, now Pat. No. 7,150,834, which is a continuation-in-part of application No. 10/630,904, filed on Jul. 31, 2003, now Pat. No. 7,241,988.

(60) Provisional application No. 60/399,386, filed on Jul. 31, 2002, provisional application No. 60/435,541, filed on Dec. 20, 2002, provisional application No. 60/571,141, filed on May 14, 2004, provisional application No. 60/499,957, filed on Sep. 4, 2003, provisional application No. 60/511,458, filed on Oct. 15, 2003.

(51) **Int. Cl.**
B01D 21/01 (2006.01)

(52) **U.S. Cl.**
CPC **B01D 21/01** (2013.01)



(56)

References Cited

U.S. PATENT DOCUMENTS

4,325,706 A 4/1982 Gershman et al.
 4,409,106 A 10/1983 Furuta et al.
 4,424,132 A 1/1984 Iriguchi
 4,660,971 A 4/1987 Sage et al.
 4,667,830 A 5/1987 Nozaki, Jr. et al.
 5,007,732 A 4/1991 Ohki et al.
 5,100,627 A 3/1992 Buican et al.
 5,180,065 A 1/1993 Touge et al.
 5,194,909 A 3/1993 Tycko
 5,229,297 A 7/1993 Schnipelsky et al.
 5,483,469 A 1/1996 Van den Engh et al.
 5,620,857 A 4/1997 Weetall et al.
 5,674,743 A 10/1997 Ulmer
 5,800,690 A 9/1998 Chow et al.
 5,837,115 A 11/1998 Austin et al.
 5,849,178 A 12/1998 Holm et al.
 5,879,625 A 3/1999 Roslaniec et al.
 5,966,457 A 10/1999 Lemelson
 6,053,856 A 4/2000 Hlavinka
 6,071,442 A 6/2000 Dean et al.
 6,185,664 B1 2/2001 Jeddloh
 H1960 H 6/2001 Conrad et al.
 6,368,871 B1 4/2002 Christel et al.
 6,416,190 B1 7/2002 Grier et al.
 6,432,630 B1 8/2002 Blankenstein
 6,451,264 B1 9/2002 Bhullar et al.
 6,506,609 B1 1/2003 Wada et al.
 6,524,860 B1 2/2003 Seidel et al.
 6,637,463 B1 10/2003 Lei et al.
 6,727,451 B1 4/2004 Fuhr et al.
 6,833,542 B2 12/2004 Wang et al.
 6,838,056 B2 1/2005 Foster
 6,944,324 B2 9/2005 Tran et al.
 7,029,430 B2 4/2006 Hlavinka et al.
 7,241,988 B2 7/2007 Gruber et al.

7,472,794 B2* 1/2009 Oakey et al. 210/420
 7,482,577 B2 1/2009 Gruber et al.
 2002/0058332 A1 5/2002 Quake et al.
 2002/0176069 A1 11/2002 Hansen et al.
 2003/0032204 A1 2/2003 Walt et al.
 2003/0047676 A1 3/2003 Grier et al.
 2003/0186426 A1 10/2003 Brewer et al.
 2005/0061962 A1 3/2005 Mueth et al.
 2005/0121604 A1 6/2005 Mueth et al.
 2006/0058167 A1 3/2006 Regusa et al.
 2006/0152707 A1 7/2006 Kanda

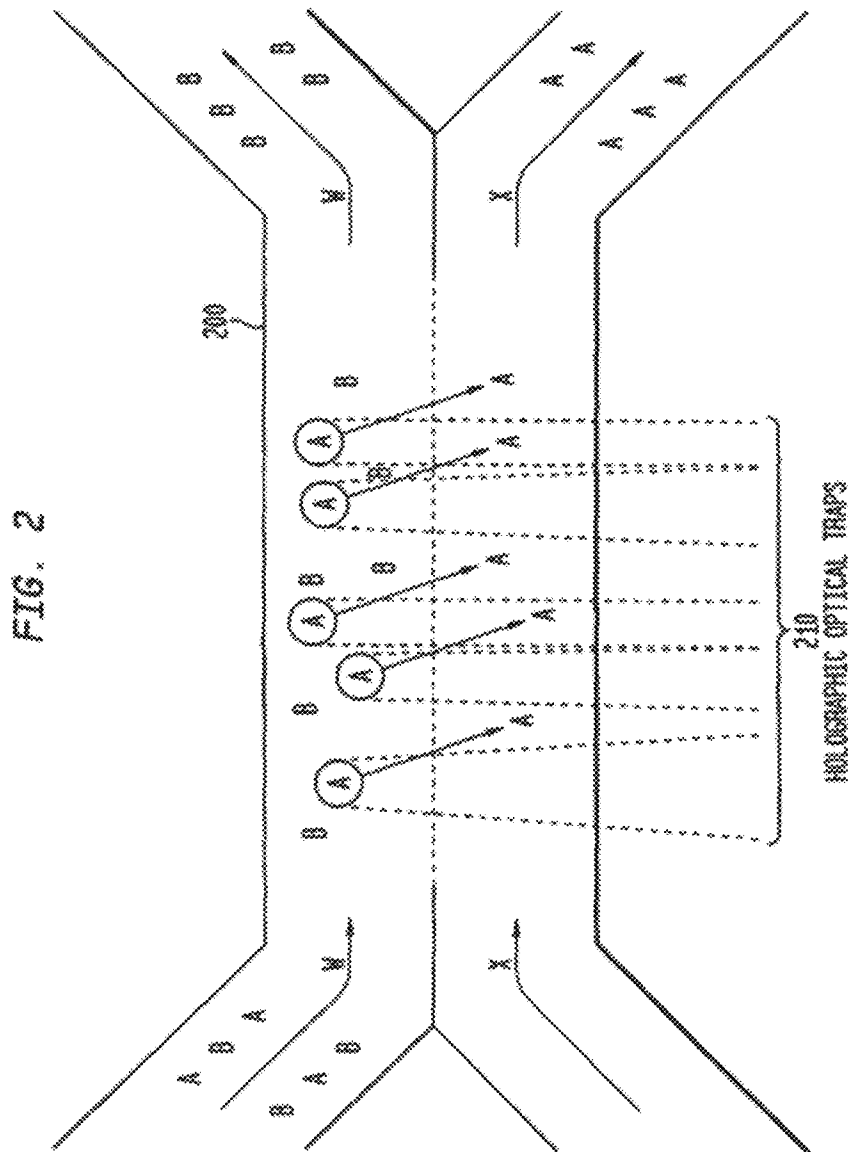
FOREIGN PATENT DOCUMENTS

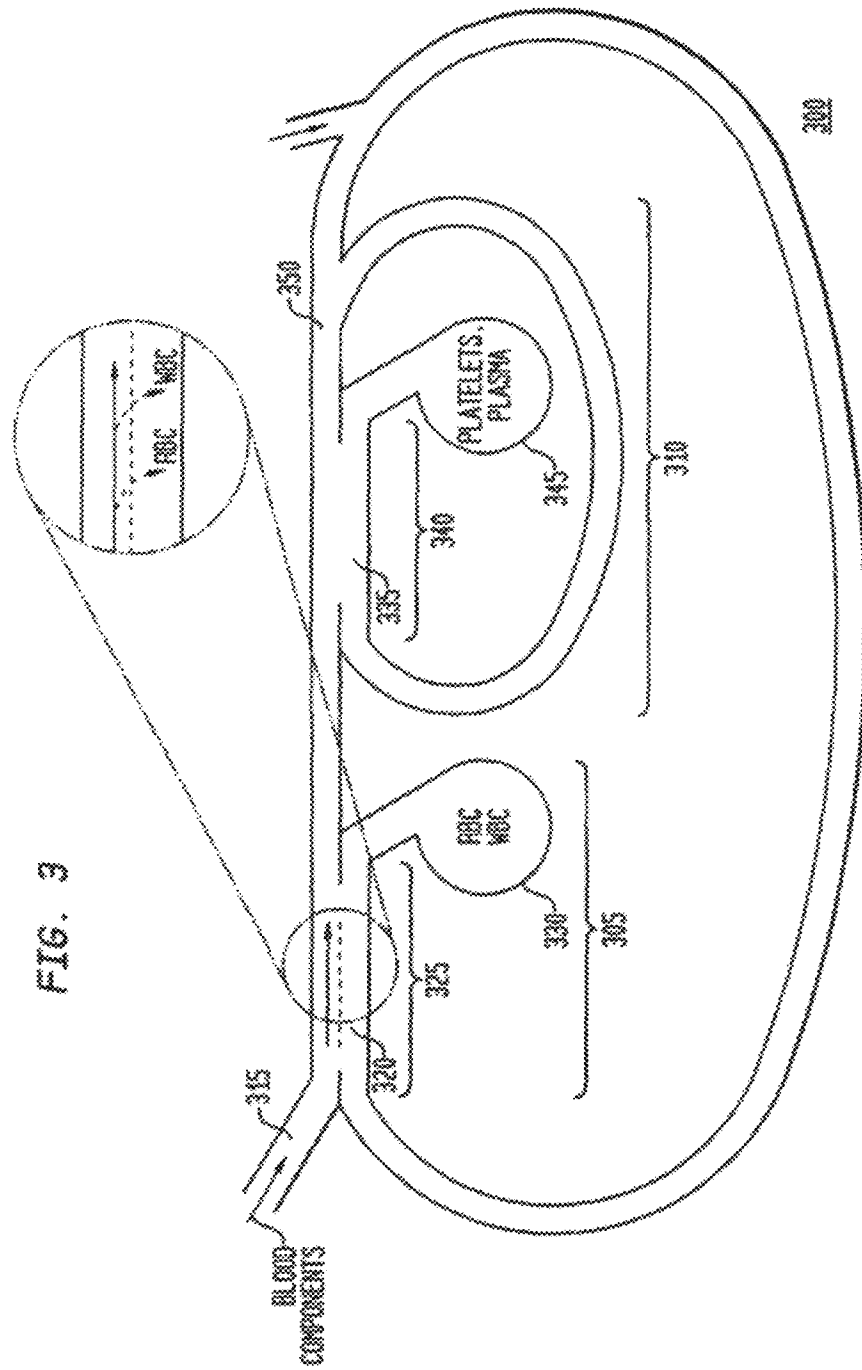
EP 0679325 A1 11/1995
 FR 2798557 A1 3/2001
 JP 57-131451 A 8/1982
 JP 58-090513 A 5/1983
 JP 06-327494 11/1994
 JP 07-024309 1/1995
 JP 2002-153260 5/2002
 JP 2005-502482 A 1/2005
 WO 99/39223 A1 8/1999
 WO 01/18400 A1 3/2001
 WO 2004/012133 A2 2/2004

OTHER PUBLICATIONS

S. Takayama et al., "Patterning cells and their environments using multiple laminar fluid flows . . .", Proc. Natl. Acad. Sci. USA, May 1999, pp. 5545-5548, vol. 96.
 Paul O.P. Ts'0, "Basic Principles in Nucleic Acid Chemistry", National Library of Medicine, 1974, pp. 311-387, Academic Press Inc., New York, NY.
 Stephen P. Smith et al., Inexpensive Optical Tweezers for Undergraduate Laboratories, Am. J. Phys., Jan. 1999, vol. 67.

* cited by examiner





Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.