

Declaration of Fedor A. Ilkov, Ph.D. in Support of
Petition for Post-Grant Review of
U.S. Patent No. 12,174,107 B2

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CYTEK BIOSCIENCES, INC.,
Petitioner

v.

BECKMAN COULTER, INC.,
Patent Owner

U.S. Patent No. 12,174,107 B2
Issue Date: December 24, 2024

Title: FLOW CYTOMETER

DECLARATION OF FEDOR A. ILKOV, PH.D.

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I, Fedor A. Ilkov, Ph.D., declare as follows:

I. INTRODUCTION AND QUALIFICATIONS

A. Qualifications and Experience

1. I received a Bachelor of Science degree in Physics from State University of Tashkent, a Master of Science degree in Nuclear Physics from State University of Tashkent, and a Ph.D. in Non-Linear Spectroscopy, Molecular and Atomic Physics from General Physics Institute in Moscow.

2. I have worked at various companies as an optical engineer since 1996. For example, I joined Iolon, Inc. as the Principal Optical Design Engineer in 2001. In that role, I was responsible for designing, prototyping, and testing novel optical devices, which included selecting the optimal optical elements and light sources, such as lasers.

3. In my over thirty years in the field, I have developed special expertise in designing biological analytical instruments, such as flow cytometers, cell sorters, and super-resolution microscopy. For example, I served as the Chief Optical Engineer for Guava Technologies, Inc., now part of Merck-Millipore Corp., from 2005 to 2014. During that time, I led a project directed at modeling next-generation laser-powered optical engines for flow cytometry applications. I was responsible

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for selecting the optimal light sources, optical elements, as well as detectors through various tests and analyses aimed at optimizing the performance of the device. My work at Guava earned me the Merck 2013 Innovation Award for my contribution to the Guava MUSE Cell Analyzer.

4. Since Guava, I have also worked at several other companies on optical devices, including flow cytometers. For example, from October 2018 through September 2020, I led BD Bioscience's development of next-generation optical platforms for novel cell analyzers. My work at BD Bioscience included extensive design and development of lasers (continuous wave and pulsed); light-emitting diode (LED) light sources; and photomultiplier tube (PMT), avalanche photodiode (APD), Geiger-mode avalanche photodiode (GMAPD), and silicon photomultiplier (siPM) detectors and detector modules in optical systems used in flow cytometry applications. I also designed, developed, and prototyped integrated fluorescence collection optics for these systems.

5. Over the past decade, I have also independently consulted for multiple clienteles related to optical systems for flow cytometers, cell sorters, and DNA sequencers, among other biotechnologies.

6. I also have held academic positions in optical engineering. I was a

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Director of Research Laboratory from 1981 to 1990 at the Thermo-Physics Institute in Tashkent, Uzbekistan, where my efforts were focused on multiphoton transitions in atomic vapors. In this position, I, along with the Master's and Ph. D. students who I supervised, designed and built custom lasers and studied multiphoton spin-forbidden transitions in two electron atoms. In 1991, I joined the Center for Optics, Photonics and Lasers at Laval University in Quebec City, Canada, as the Lead Research Scientist. For the following five years, I led a team of students and researchers focused on designing and implementing experiments for systems involving lasers, optics, and spectroscopy.

7. I have published more than fifty articles in international journals on my work in optics and optical engineering. I am also a named inventor to numerous patents in optical components and systems for flow cytometers (among other inventions in fiber optics and telecommunications), including but not limited to U.S. Patent No. 7,564,542 titled "Asymmetric Capillary for Capillary-Flow Cytometers," U.S. Patent No. 8,605,283 titled "Apparatus and Method for Increasing Collection Efficiency in Capillary Based Flow Cytometry" and U.S. Patent No. 11,821,830 titled "Clustered Wavelength Division Light Detection Systems and Methods of Using the Same."

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8. A more detailed description of my qualification is appended to this Declaration as **Appendix A**.

9. I am being compensated for my time working on this matter at my standard hourly rate plus expenses. I do not have any personal or financial stake or interest in the outcome of the present proceeding, and my compensation is not dependent on the outcome of this PGR and in no way affects the substance of my statements in this Declaration.

B. Materials Considered

10. The analysis that I provide in this Declaration is based on my education, research, and experience, as well as the documents I have considered. In forming my opinions, I have read and considered U.S. Patent No. 12,174,107 (“107 patent” or “107”) [EX1001] and its prosecution history [EX1003]. I have cited to or considered the following documents in my analysis below:

Ex. No.	Description of Document
1001	U.S. Patent No. 12,174,107 B2 to Yong Qin Chen (filed September 3, 2024, issued December 24, 2024) (“ 107 patent ”)
1003	Prosecution History of U.S. Patent No. 12,174,107 B2
1004	Nigel P. Carter and Michael G. Ormerod, <i>Chapter 1, Introduction to the Principles of flow cytometry</i> , Flow Cytometry, pp. 1-22 (3rd ed. 2000)
1005	U.S. Patent No. 6,683,314 B2 to Clifford A. Oostman, Jr. et al. (filed August 28, 2001; published January 27, 2004) (“ Oostman ”)

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Ex. No.	Description of Document
1006	U.S. Patent No. 5,317,162 to Bertram G. Pinsky et al. (filed September 9, 1992; published May 31, 1994) (“ Pinsky ”)
1007	Excerpts of Howard M. Shapiro, Practical Flow Cytometry (4th ed. 2003) (“ Shapiro ”)
1008	World Patent No. WO 2010/101623 A1 to Michael Thomas (filed March 2, 2010; published September 10, 2010) (“ Thomas ”)
1009	U.S. Patent No. 8,284,402 B2 to Erich Frazier et al. (filed February 26, 2010; published October 9, 2012) (“ Frazier ”)
1010	U.S. Patent No. 4,244,045 to Kiyoshi Nosu et al. (filed January 31, 1979; published January 6, 1981) (“ Nosu ”)
1011	U.S. Patent No. 8,537,468 B1 to Xuan Wang et al. (filed June 10, 2011; published September 17, 2013) (“ Wang ”)
1012	U.S. Patent No. 6,198,864 B1 to Brian E. Lemoff et al. (filed November 24, 1998; published March 6, 2001) (“ Lemoff ”)
1013	U.S. Patent No. 7,212,343 B1 to Chun He et al. (filed July 11, 2003; published May 1, 2007) (“ He ”)
1014	U.S. Patent No. 5,835,517 to Vijaysekhar Jayaraman et al. (filed October 4, 1996; published November 10, 1998) (“ Jayaraman ”)
1015	U.S. Patent No. 6,201,908 B1 to Eric B. Grann (filed July 2, 1999; published March 13, 2001) (“ Grann ”)
1016	U.S. Patent No. 6,542,306 B2 to Timothy D. Goodman (filed March 16, 2001; published April 1, 2003) (“ Goodman ”)
1017	Listing of Challenged Claims
1018	Joint Claim Construction Chart including Exhibit A Parties Agreed and Proposed Constructions filed in <i>Beckman Coulter, Inc. v. Cytek Biosciences, Inc.</i> , C.A. No. 24-945 (D. Del. May 28, 2025), D.I. 89 & 89-1

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Ex. No.	Description of Document
1019	Plaintiff's Disclosure of Asserted Claims and Infringement Contentions [Redacted Version], served in <i>Beckman Coulter, Inc. v. Cytek Biosciences, Inc.</i> , C.A. No. 24-945 (D. Del. Feb. 14, 2025)
1020	Definition of Mirror from Concise Oxford English Dictionary (12th ed. 2011)
1021	Excerpts of Course 1 Fundamentals of Light and Lasers, Optics and Photonics Series, Modules 1-6, OP-TEC (3rd ed. 2018)
1022	Henry Semat and Robert Katz, <i>Chapter 38: Mirrors and Lenses</i> , Physics, Robert Katz Publications, pp. 699-722 (1958)
1023	Steve Wasserman, <i>Geometrical optics and ray tracing</i> , Course Wiki (August 27, 2019)
1029	Excerpts of the Prosecution history of U.S. Patent No. 9,746,412
1030	Rochelle A. Diamond, <i>Chapter 8: Quality Control Guidelines for Research Flow Cytometry</i> , In Living Color, pp. 98-105 (2000)
1031	R.M.P. Doornbos et al., <i>White Blood Cell Differentiation Using a Solid State Flow Cytometer</i> , Cytometry 14:589-594 (1993) (“Doornbos”)
1032	SensL SPMMini High Gain APD (Oct. 2007)
1033	Menlo Systems APD210/310 High Sensitivity Detector Unit (Apr. 2021)
1034	Thorlabs.com – High-Sensitivity Avalanche Photodetectors website Overview, Specs and Documents & Drawings, (Aug. 31, 2011), https://web.archive.org/web/20110831115024/http://www.thorlabs.com/NewGroupPage9.cfm?ObjectGroup_ID=947
1035	World Patent No. WO 94/29695 to Oddbjørn Gjelsnes (filed June 8, 1993; published December 22, 1994) (“Gjelsnes”)
1036	Carleton C. Stewart et al., <i>Flow Cytometer in the Infrared: Inexpensive Modifications to a Commercial Instrument</i> , Cytometry Part A, 67A:104-111 (2005) (“Stewart”)

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Ex. No.	Description of Document
1037	William G. Lawrence et al., <i>A 16-channel avalanche photodiode detector array for visible and near-infrared flow cytometry</i> , Imaging, Manipulation, and Analysis of Biomolecules, Cells, and Tissues IV, Proc. of SPIE, Vol. 6088, 60880T, (2006) (“ Lawrence ”)
1038	William G. Lawrence et al., <i>A Comparison of Avalanche Photodiode and Photomultiplier Tube Detectors for Flow Cytometry</i> , Imaging, Manipulation, and Analysis of Biomolecules, Cells, and Tissues VI, Proc. of SPIE Vol. 6859, 68590M, (2008) (“ Lawrence 2008 ”)
1039	Shutao Zhao et al., <i>High gain avalanche photodiode (APD) arrays in flow cytometer optical [sic] system</i> , IEEE (2011) (“ Zhao ”)
1040	U.S. Patent No. 8,188,438 B2 to Dongqing Li (filed Mar. 8, 2010; published May 29, 2012) (“ Li-438 ”)
1041	Canadian Patent No. 2 771 324 to Paul Patt (filed Aug. 20, 2010; published June 21, 2016) (“ Patt-324 ”)
1042	U.S. Patent No. 7,580,120 B2 to Yuichi Hamada et al. (filed Apr. 6, 2006; published Aug. 25, 2009) (“ Hamada ”)
1043	World Patent No. 98/59233 to Van S. Chandler (filed June 22, 1998; published Dec. 30, 1998) (“ Chandler-233 ”)
1044	U.S. Patent No. 7,523,637 B2 to Wayne D. Roth et al. (filed Nov. 29, 2007; published Apr. 28, 2009) (“ Roth-637 ”)
1045	U.S. Patent No. 7,505,131 B2 to Wayne D. Roth (filed Mar. 6, 2008; published Mar. 17, 2009) (“ Roth-131 ”)
1046	U.S. Patent Application Publication No. 2008/0305481 A1 to Douglas F. Whitman et al. (filed Dec. 13, 2007; published Dec. 11, 2008) (“ Whitman ”)
1047	U.S. Patent Application Publication No. 2007/0269345 A1 to Adam Richard Schilffarth et al. (filed May 17, 2007; published Nov. 22, 2007) (“ Schilffarth-345 ”)

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Ex. No.	Description of Document
1048	U.S. Patent Application Publication No. 2007/0207513 A1 to Keld Sorensen et al. (filed Mar. 5, 2007; published Sept. 6, 2007) (“ Sorensen ”)
1049	U.S. Patent Application Publication No. 2009/0071225 A1 to Adam Richard Schilffarth (filed Sept. 17, 2008; published Mar. 19, 2009) (“ Schilffarth-225 ”)
1050	U.S. Patent Application Publication No. 2009/0237658 A1 to Edward Calvin et al. (filed Apr. 9, 2009; published Sept. 24, 2009) (“ Calvin ”)
1051	U.S. Patent No. 6,139,800 to Van S. Chandler (filed June 22, 1998; published Oct. 31, 2000) (“ Chandler ”)
1052	Luminex 100™ IS User Manual Version 2.3 (Oct. 2005)
1053	Luminex FlexMap 3D® User Manual (Jan. 2019)
1054	BD Biosciences Immunocytometry Systems Technical Specifications BD FACSArray (Oct. 2003)
1055	Archived website page for Hamamatsu NIR High Sensitivity Type products, (June 20, 2010), https://web.archive.org/web/20100620045039/http://jp.hamamatsu.com/products/sensor-ssd/pd078/pd079/pd083/index_en.html
1056	Archived website page for Hamamatsu Short Wavelength Type products, (June 20, 2010), https://web.archive.org/web/20100620044720/http://jp.hamamatsu.com/products/sensor-ssd/pd078/pd079/pd082/index_en.html
1060	Hamamatsu Si APD S5343 to S5345, S9073 to S9075, Short wavelength type APD (Apr. 2004)
1061	Hamamatsu Si APD S8890 series, Long wavelength type APD (June 2010)
1062	Hamamatsu Si APD S2381 to S2385, S5139, S8611, S3884, S4315 series, Low bias operation, for 800 nm band (May 2010)

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1063	Hamamatsu Products by Division, (Aug. 7, 2011), https://web.archive.org/web/20110807025645/http://sales.hamamatsu.com:80/en/products.php
1064	First Sensor APD Data Sheet Part Description AD800-11 to Order # 500970, Version 20-06-11 (June 2011)
1065	Thorlabs, Collimated Light's Non-Zero Beam Divergence, <i>Does collimated light maintain a constant beam diameter out to infinity?</i> (Apr. 20, 2021), https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=14489
1066	Edmund Optics, Considerations in Collimation, https://www.edmundoptics.com/knowledge-center/application-notes/optics/considerations-in-collimation/
1070	U.S. Patent No. 9,746,412 B2 to Yong Qin Chen (filed Nov. 26, 2014; published Aug. 29, 2017) (“ 412 ”)
1071	Prosecution History of PCT/US2013/043453 (the “ PCT App. ”)
1078	U.S. Patent No. 11,255,772 B2 to Yong Qin Chen (filed June 30, 2017; published Feb. 22, 2022) (“ 772 ”)
1085	How Gas-Ion Lasers Work, Lexel Laser (May 14, 2004), https://web.archive.org/web/20040817080937/http://www.lexellaser.com/techinfo_gas-ion.htm
1086	Clive Barnes, Copper at the Cutting Edge: The Copper Vapor Laser (June 2001), https://web.archive.org/web/20090101015131/https://copper.org/publications/newsletters/innovations/2001/06/cutting_edge.html
1087	Argon Lasers, Remanufactured Air-Cooled Argon and Argon/Krypton Lasers, Midwest Laser Products LLC (Dec. 2, 2015) https://web.archive.org/web/20151202062833/https://www.midwest-laser.com/Products/argon-lasers.html

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Ex. No.	Description of Document
1088	U.S. Patent No. 12,174,106 B2 to Yong Qin Chen (filed December 22, 2021, issued December 24, 2024) (“ 106 patent ”)
1089	Excerpts from Newport Catalog, including Focusing and Collimating pp. 479-481 and Optics Glossary pp. 500-505 available at http://rpdata.caltech.edu/courses/aph162/2007/Protocols/Optics/e3613_Focusing-and-Collimating.pdf and http://rpdata.caltech.edu/courses/aph162/2007/Protocols/Optics/e3878_Optics-Glossary.pdf
1090	Newport Catalog, <i>Precision Laser & Optics Products</i> , available at http://rpdata.caltech.edu/courses/aph162/2007/Protocols/Optics/Newport%20Catalog.pdf
1091	U.S. Patent No. 10,330,582 B2 to Yong Qin Chen (filed June 30, 2017, issued June 25, 2019) (“ 582 patent ”)
1092	Jean-Luc Néron, Application Note Fiber Coupling Efficiency Calculation, Doric Lenses Inc., (December 5, 2005), https://www-eng.lbl.gov/~shuman/NEXT/CURRENT_DESIGN/TP/FO/fiber_coupling_efficiency_doric_lenses.pdf
1093	Thorlabs, Single Mode Fiber, https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=949
1094	Thorlabs, 0.22 NA Silica Core, Glass Clad Multimode Optical Fiber, Step Index, https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=6838
1095	Thorlabs, 0.39 NA TECS-Clad Multimode Optical Fiber, Step Index, https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=6845
1096	Beckman Coulter, Spectral Flow Cytometry: A Detailed Scientific Overview, https://www.beckman.com/resources/reading-material/application-notes/spectral-flow-cytometry-detailed-scientific-overview
1097	Thermo Fisher Scientific, Electronics of a Flow Cytometer, https://web.archive.org/web/20200919201221/https://www.thermofisher.com/us/en/home/life-science/cell-analysis/cell-analysis-learning-

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Ex. No.	Description of Document
	center/molecular-probes-school-of-fluorescence/flow-cytometry-basics/flow-cytometry-fundamentals/electronics-flow-cytometer.html
1098	Claudio Ortolani, <i>Chapter 22 Non-Conventional Flow Cytometry</i> , Flow Cytometry Today, pp. 497-522 (2023)
1099	Beckman Coulter Life Sciences Launches Industry-First Modular Spectral Flow Cytometry Solution (March 18, 2025), https://www.beckman.com/news/beckman-coulter-life-sciences-launches-industry-first-modular-spectral-flow-cytometry-solution
1100	Beckman Coulter, CytoFLEX mosaic Spectral Detection Module, https://www.beckman.com/flow-cytometry/research-flow-cytometers/cytoflex-mosaic
1101	U.S. Patent No. 7,280,204 B2 to Joseph Paul Robinson et al. (filed April 8, 2005, issued October 9, 2007) (“ Robinson ”)
1102	Howard M. Shapiro and Michael Hercher, <i>Flow Cytometers Using Optical Waveguides in Place of Lenses for Specimen Illumination and Light Collection</i> , Cytometry, 7:221-223 (1986)
1103	Markman Hearing Transcript from <i>Beckman Coulter, Inc. v. Cytek Biosciences, Inc.</i> , C.A. No. 24-945 (D. Del. August 21, 2025)
1104	Newport, <i>Technical Note: Fiber Optic Coupling</i> , (2017), https://web.archive.org/web/20171018084228/https://www.newport.com/n/fiber-optic-coupling
1105	Markman Hearing Transcript from <i>Beckman Coulter, Inc. v. Cytek Biosciences, Inc.</i> , C.A. No. 24-945 (D. Del. September 17, 2025)
1107	U.S. Provisional Application 61/911,859 to Yong Qin Chen (filed December 4, 2013)

II. PERSON OF ORDINARY SKILL IN THE ART (“POSA”)

11. I am informed by counsel that, under the patent laws in effect after the America Invents Act (“AIA”) of 2011, an assessment of claims of a patent filed after the AIA took effect should be undertaken from the perspective of a person of

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ordinary skill in the art as of the “effective filing date” of the patent’s claimed inventions. I understand that there may be a priority dispute as to whether the AIA applies to the ’107 claims, as the ’107 patent was filed after the AIA was enacted but claims priority to earlier-filed applications that precede the date that the AIA came into effect. I understand that, should the AIA apply, the ’107 patent is evaluated from a skilled artisan’s perspective as of the patent’s effective filing date. I understand that the ’107 patent was filed on September 3, 2024. (*See* **EX1001** (’107 patent), cover page.)

12. I understand that the ’107 patent, as stated on its face, is a “[c]ontinuation of application No. 17/645,727, filed on December 22, 2021, which is a continuation of application No. 15/638,477, filed on Jun. 30, 2017, now Pat. No. 11,255,772, which is a division of application No. 14/555,102, filed on Nov. 26, 2014, now Pat. No. 9,746,412, which is a continuation-in-part of application No. PCT/US2013/043453, filed on May 30, 2013” and claims the benefit of multiple provisional applications with filing dates ranging from May 30, 2012 (provisional application No. 61/653,245) to December 4, 2013 (provisional application No. 61/911,859). (’107, cover pages; *see also id.*, 1:6-36.) As I explain in Section VII below, it is my opinion that the Challenged Claims of the ’107 patent are not entitled

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to any effective filing date earlier than the '107 patent's actual filing date of September 3, 2024.

13. Counsel has advised me that to determine the appropriate level of one of ordinary skill in the art, I may consider the following factors: (a) the types of problems encountered by those working in the field and prior art solutions thereto; (b) sophistication of the technology in question, and the rapidity with which innovations occur in the field; (c) the educational level of active workers in the field; and (d) the educational level of the inventor.

14. The relevant technical fields for the '107 patent are flow cytometry, fiber optics, and wavelength demultiplexing and detection. Based on this, and the four factors above, in my opinion a POSA as of September 2024 would have had at least a B.S. in physics, mechanical engineering, electrical engineering, or optical engineering (or equivalent degree) and at least two years of experience in designing optical and electro-optical systems, including for flow cytometer applications. A person could also have qualified as a person of ordinary skill in the art with a combination of (1) more formal education (such as a doctoral degree) and less technical experience, or (2) less formal education and more technical or professional experience.

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15. My opinions regarding the level of ordinary skill in the art are based on, among other things, my over twenty years of experience in the relevant areas, my understanding of the basic qualifications that would be relevant to an individual tasked with investigating the methods and devices in the relevant areas, and my familiarity with the backgrounds of researchers and practitioners in the related areas, including colleagues, students, employees, consultants and other individuals, both past and present, who work in these areas.

16. Although my qualifications and experience exceed those of the hypothetical person having ordinary skill in the art defined above, my analysis and opinions regarding the '107 patent have been based on the perspective of a person of ordinary skill in the art in September 2024. I note that my opinions would not change, should priority be found to instead be within the 2011 to 2013 time frame.¹

¹ If priority for all claims is found to predate the enactment of the AIA, I understand from counsel that under the patent laws in effect before the AIA, an assessment of claims of a patent filed before the AIA took effect should be undertaken from the

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17. My opinions herein regarding the understanding of a person of ordinary skill in the art and my other opinions set forth herein would remain the same if the person of ordinary skill in the art were determined to have somewhat more or less education and/or experience than I have identified above.

III. STATEMENT OF LEGAL PRINCIPLES

A. Claim Construction

18. I understand that a purpose of claim construction is to determine what a person of ordinary skill in the art would have understood the claim terms to mean. I understand that under the legal principles, claim terms are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art in question as of the critical date—here, the effective filing date of the patent application.

19. I understand that the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification. I

perspective of a person of ordinary skill in the art as of the earliest claimed priority date (i.e., the “time the invention was made”).

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understand that the patent specification, under the legal principles, has been described as the single best guide to the meaning of a claim term, and is thus highly relevant to the interpretation of claim terms. And I understand for terms that do not have a customary meaning within the art, the specification usually supplies the best context to understand the meaning of those terms.

20. I further understand that other claims of the patent in question, both asserted and unasserted, can be valuable sources of information as to the meaning of a claim term. Because the claim terms are normally used consistently throughout the patent, the usage of a term in one claim can often illuminate the meaning of the same term in other claims. Differences among claims can also be a useful guide in understanding the meaning of particular claim terms.

21. I understand that the prosecution history can further inform the meaning of the claim language by demonstrating how the inventors understood the invention and whether the inventors limited the invention during prosecution, making the claim scope narrower than it otherwise would be. Extrinsic evidence, such as dictionaries, may also be consulted in construing the claim terms.

22. I understand that, in Post-Grant Review (“PGR”) proceedings, a claim of a patent shall be construed using the same claim construction standard that would

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be used to construe the claim in a civil action filed in a U.S. district court (which I understand is called the “*Phillips*” claim construction standard), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.

23. I have been instructed by counsel to apply the “*Phillips*” claim construction standard for purposes of interpreting the claims in this proceeding, to the extent they require an explicit construction. The description of the legal principles set forth above thus provides my understanding of the “*Phillips*” standard as provided to me by counsel.

B. Obviousness

24. I understand that a patent claim is obvious if, as of the critical date (i.e., the effective filing date (under AIA or otherwise)), it would have been obvious to a person having ordinary skill in the field of the technology (the “art”) to which the claimed subject matter belongs.

25. I understand that the following factors should be considered in analyzing obviousness: (1) the scope and content of the prior art; (2) the differences between the prior art and the claims; and (3) the level of ordinary skill in the pertinent

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art. I also understand that, when present, evidence of “secondary considerations” of non-obviousness are to be considered. Such secondary considerations can include: copying, industry praise, commercial success, long-felt need, failure of others, skepticism, as well as other types of considerations. I am further informed that to support a finding of non-obviousness, the inventor must generally show a “nexus” between the secondary considerations and the features of the invention as claimed. For example, a secondary consideration such as commercial success is not relevant to non-obviousness unless the evidence shows that the commercial success was attributable to features of the claimed invention as opposed to attributable to features that already existed in the prior art.

26. I understand that a reference qualifies as prior art for obviousness purposes when it is analogous to the claimed invention. The test for determining what art is analogous is: (1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the field of the inventor’s endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved.

27. I understand that a person of ordinary skill in the art is assumed to have knowledge of all prior art. I understand that one skilled in the art can combine

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various prior art references based on the teachings of those prior art references, the general knowledge present in the art, or common sense. I understand that a motivation to combine references may be implicit in the prior art, and there is no requirement that there be an actual or explicit teaching to combine two references. Thus, one may take into account the inferences and creative steps that a person of ordinary skill in the art would employ to combine the known elements in the prior art in the manner claimed by the patent at issue. I understand that one should avoid “hindsight bias” and ex post reasoning in performing an obviousness analysis. However, this does not mean that a person of ordinary skill in the art for purposes of the obviousness inquiry does not have recourse to common sense.

28. I understand that when determining whether a patent claim is obvious in light of the prior art, neither the particular motivation for the patent nor the stated purpose of the patentee is controlling. The primary inquiry has to do with the objective reach of the claims, and that if those claims extend to something that is obvious, then the entire patent claim is invalid. By objective reach, I mean some portion of the claim clearly covers any subject matter that would be obvious from the prior art, even if the claims include other subject matter.

29. I understand one way that a patent can be found obvious is if there

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existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. I understand that a motivation to combine various prior art references to solve a particular problem may come from a variety of sources, including market demand or scientific literature. I understand that a need or problem known in the field at the time of the invention can also provide a reason to combine prior art references and render a patent claim invalid for obviousness. I understand that familiar items may have obvious uses beyond their primary purpose, and that a person of ordinary skill in the art will be able to fit the teachings of multiple prior art references together like the pieces of a puzzle. I understand that a person of ordinary skill is also a person of at least ordinary creativity. I understand when there is a design need or market pressure to solve a problem and there is a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp. If this finite number of predictable solutions leads to the anticipated success, I understand that the invention is likely the product of ordinary skill and common sense, and not of any sort of innovation. I understand that the fact that a combination was obvious to try might also show that it was obvious, and hence invalid, under the patent laws. I understand that if a patent claims a combination of

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familiar elements according to known methods, the combination is likely to be obvious when it does no more than yield predictable results. Thus, if a person of ordinary skill in the art can implement a predictable variation, an invention is likely obvious. I understand that combining embodiments disclosed near each other in a prior art reference would not ordinarily require a leap of inventiveness.

30. I understand that obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the patented invention. Obviousness may also be shown by demonstrating that it would have been obvious to combine the teachings of more than one item of prior art. I understand that a claimed invention may be obvious if some teaching, suggestion, or motivation exists that would have led a person of ordinary skill in the art to combine the invalidating references. I also understand that this suggestion or motivation may come from the knowledge of a person having ordinary skill in the art, or from sources such as explicit statements in the prior art. I understand that when there is a design need or market pressure, and there is a finite number of predictable solutions, a person of ordinary skill may be motivated to apply common sense and his skill to combine the known options to solve the problem.

31. I understand the following are examples of approaches and rationales

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that may be considered in determining whether a piece of prior art could have been combined with other prior art or with other information within the knowledge of a person having ordinary skill in the art:

- (1) Some teaching, motivation, or suggestion in the prior art that would have led a person of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention;
- (2) Known work in one field of endeavor may prompt variations of it for use in the same field or a different field based on design incentives or other market forces if the variations would have been predictable to a person of ordinary skill in the art;
- (3) Combining prior art elements according to known methods to yield predictable results;
- (4) Applying a known technique to a known device, method, or product ready for improvement to yield predictable results;
- (5) Applying a technique or approach that would have been “obvious to try” (choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success);
- (6) Simple substitution of one known element for another to obtain

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predictable results; or

(7) Use of a known technique to improve similar products, devices, or methods in the same way.

32. I understand that, when determining whether a claimed combination is obvious, the correct analysis is not whether one of ordinary skill in the art, writing on a blank slate, would have chosen the particular combination of elements described in the claim. Instead, I understand the correct analysis considers whether one of ordinary skill, facing the wide range of needs created by developments in the field of endeavor, would have seen a benefit to selecting the combination claimed.

33. I understand that the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference. By *bodily incorporated*, I mean that the express combination of the disclosures of the prior art have already been combined in the manner that renders the claim invalid for obviousness. Rather, in other words, the test for obviousness is not whether the references could be physically combined without any modification from the disclosures therein, but whether the claimed inventions are rendered obvious by the teachings of the prior art as a whole.

34. I understand that a statement in the challenged patent that something is

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in the prior art is binding on the patentee for determinations of obviousness.

35. I have been informed that when a range disclosed in the prior art overlaps with a range in a patent claim, the overlap creates a presumption of obviousness. I have been informed that a patent owner can rebut the presumption of obviousness based on claiming an overlapping range with the prior art, such as where: (1) the claimed range differs from the prior art range in a manner that produces a new and unexpected result for the claimed invention which differs in kind and not merely in degree from that of the prior art; (2) the prior art teaches away from the claimed range despite the overlap with the prior art; and (3) if the claimed parameter is not recognized as a result-effective parameter (but a recognition in the prior art that a property is affected by the variable is sufficient to find the variable result-effective); and (4) the prior art range is extremely broad such that it does not permit routine optimization.

C. Written Description

36. I understand that lack of written description may also lead to a patent claim being invalidated. Based on a filing date or a priority claim of an application, I have been informed that the written description requirement is set forth in the first paragraph of 35 U.S.C. § 112, prior to the America Invents Act (“AIA”) taking

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effect, and 35 U.S.C. § 112(a) after the AIA took effect.

37. I understand that, in order to determine whether a patent claim has an adequate written description, one must analyze whether the patent application as originally filed sufficiently demonstrated to a POSA that the inventor(s) had possession of the claimed invention. I have been informed that the written description need not use the exact claim language and may even be disclosed in the patent's figures. I have also been informed that the written description requirement is not satisfied if a POSA would not have understood the inventor(s) to have been in possession of the claimed subject matter, even if the claimed inventions would have been obvious to a POSA based on the disclosures of the patent specification.

D. Enablement

38. I understand that a patent claim may also be held invalid if it fails to meet the enablement requirement described in the first paragraph of 35 U.S.C. § 112, prior to the AIA taking effect, and 35 U.S.C. § 112(a) after the AIA took effect. I understand that the test for enablement is whether, based on the specification, a POSA could have made and used the full scope of the claimed invention without "undue experimentation." Counsel has informed me that a determination of whether there is "undue experimentation" depends on several factors, referred to as the "*Wands*

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Factors,” such as: (1) the breadth of the claims; (2) the quantity of experimentation; (3) the amount of direction or guidance present in the application; (4) the presence or absence of working examples; (5) the state of the prior art; (6) the nature of the invention; (7) the relative skill of those in the art; and (8) the predictability or unpredictability of the art.

39. I understand that the specification must enable the claimed invention as of the date that the patent application was filed. If a POSA could make and use the invention only with the benefit of developments that occurred after the patent’s filing, the invention is not enabled.

IV. TECHNOLOGY BACKGROUND

A. Flow Cytometers

40. Flow cytometry is a technique for taking rapid measurements on particles, cells, or beads flowing one-by-one in suspension through a flow channel as this material intercepts one or more beams of light radiation. These particles, cells, or beads are often illuminated by lasers at different points within the flow channel. Particles, cells, or beads are often prepared with fluorescent markers (e.g., dyes) that will fluoresce and emit light of a certain peak wavelength when illuminated by one or more lasers. Laser light incident on the particles, cells, or

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beads is either scattered (forward and/or side) or absorbed by the fluorescent markers; the absorbed light causes a fluorescence emission from the fluorescent markers. The scattered light and/or fluorescent light can be collected, detected, and digitized to provide quantitative information about properties of the analyzed particle, cell, or bead. (EX1004, pp.010, 016-017.)

41. Fluorescence detection-based flow cytometers, like what is disclosed in the '107 patent, typically consist of four functional components or subsystems: (1) an illumination subsystem with optics and electro optics (e.g., a laser or arc lamp); (2) a fluidic subsystem that includes the flow channel for transporting samples in suspension to an illumination site; (3) a collection subsystem with optics, such as an objective lens, to collect scattered and/or fluorescent light and focus it; and (4) a detection subsystem with optics and electro optics that separate collected light into color bands and direct those bands into photodetectors for computational analysis. (EX1004, pp.016-024.) A general schematic for a flow cytometer is shown below:

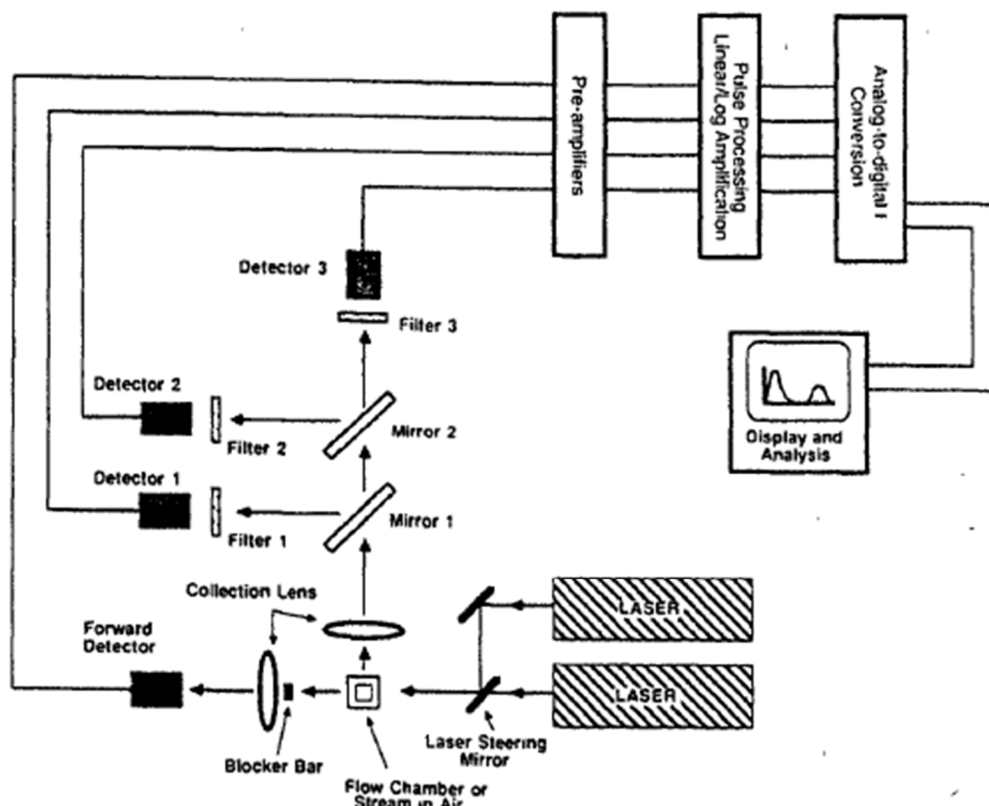


Figure 4 A generalized flow cytometer system.

(*Id.*, p.017.)

B. Wavelength Division Demultiplexers

42. A detection subsystem in fluorescence detection-based flow cytometers typically involves spectrally separating collected light into multiple color bands (i.e., wavelength ranges) and then directing those color bands into separate photodetectors to digitize these signals for computer-based analytics. A person of ordinary skill would have known that a “wavelength division [de]multiplexer” or “WDM” refers

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to the optical components that split, or demultiplex, light into those color bands, as the color bands represent the division of wavelengths into a particular subrange compared to the full spectrum of wavelengths that comprise the collected light.

43. WDMs accomplish spectral separation through the use of filters, mirrors, and lenses to separate light into color bands and focus those color bands into photodetectors. Multiple WDM configurations (e.g., polygonal or star, linear, or zig-zag) existed in the art by 2011 to accomplish this task. The '107 patent describes a “star configuration” of WDM disclosed by Oostman [EX1005] (*see* '107, 5:23-30), shown below:

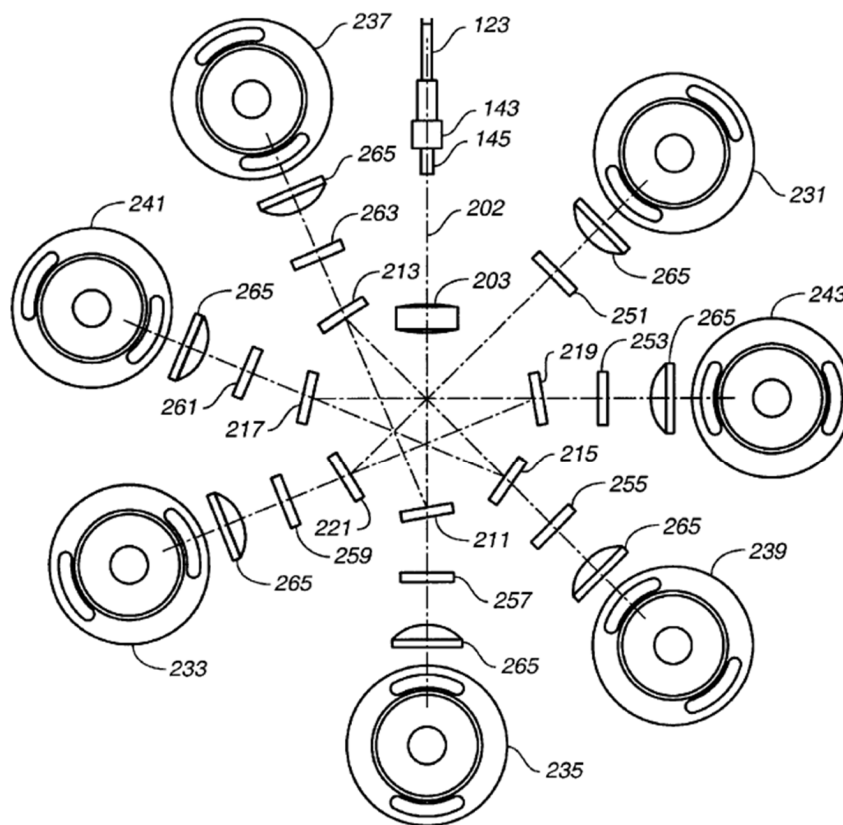
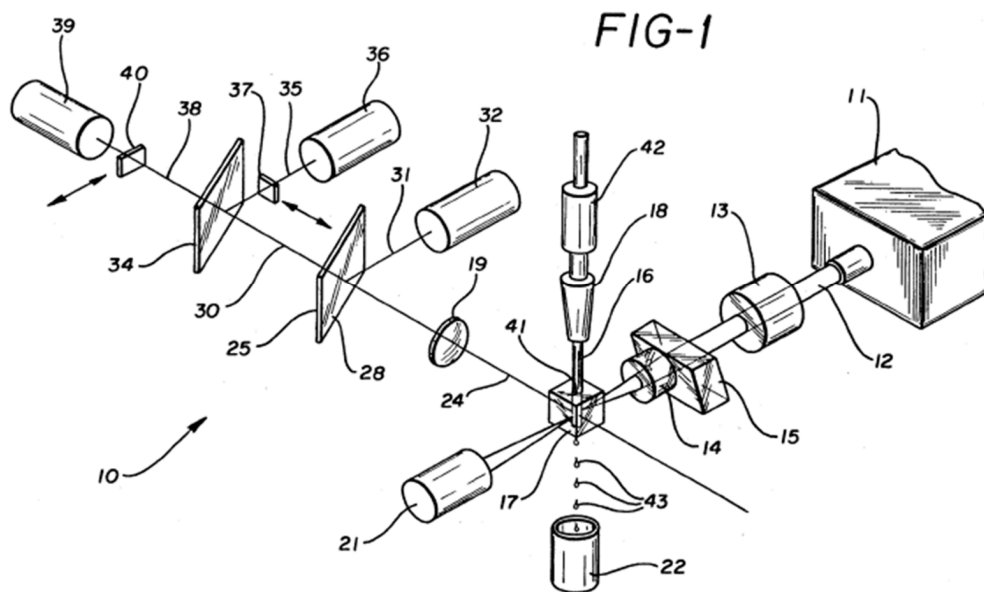


FIG. 6

(Oostman, FIG. 6.)

44. Another detector array design, a linear WDM configuration, involves passing collected light through a series of dichroic filters arranged in a line, where each filter except the last in line reflects a certain color band toward an associated detector and transmits the remaining bands to the next detector. The last filter reflects one color band to a detector and transmits the remaining light to a final

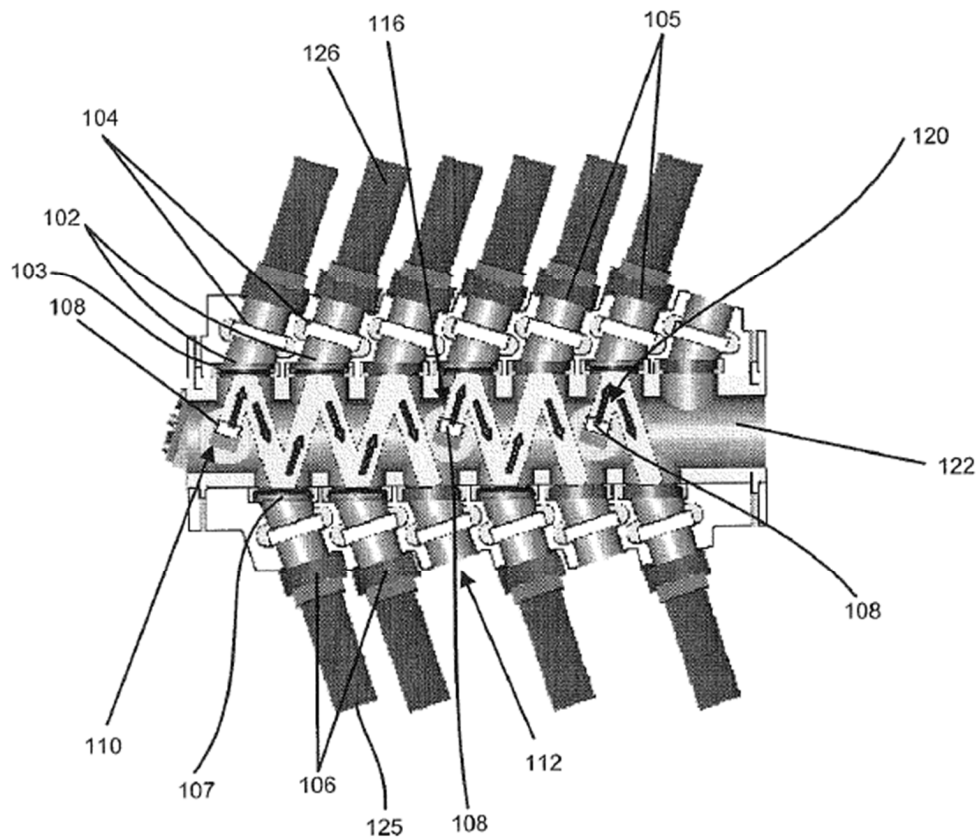
detector. An exemplary linear WDM configuration from U.S. Patent No. 5,317,162 to Pinsky [EX1006] is shown below:



(Pinsky, FIG. 1, *see also id.*, Abstract, 6:19-57 (describing WDM arrangement); *see also* Shapiro [EX1007], p.082 (Fig. 1-21); WO 2010/101623 to Thomas [EX1008], FIG. 1, [0017].)

45. The zig-zag WDM configuration depicted in the '107 patent was a well-known alternative to the above detector array configurations in flow cytometry. For example, Patent Owner also disclosed a zig-zag WDM configuration before December 2011 in U.S. Patent No. 8,284,402 to Frazier [EX1009]. Like the '107

patent's purported invention, Frazier discloses optical fibers that transport light collected from a flow cell, where the light is collimated by a lens and then spectrally separated for detection by zig-zagging between arrays of filters and mirrors.



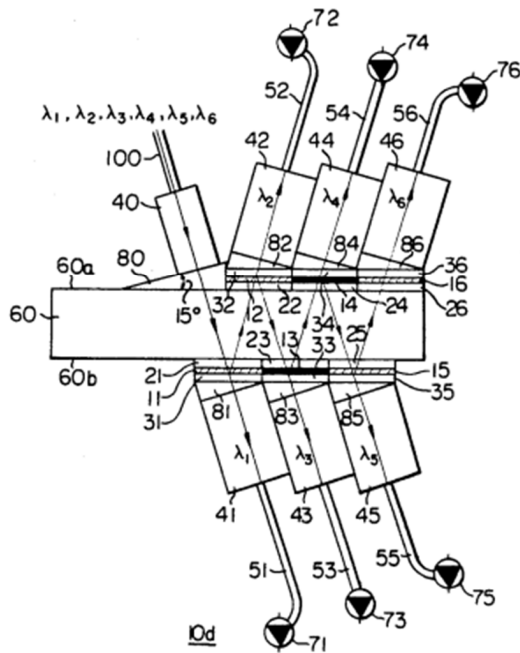
(Frazier, FIG. 1; *see also id.*, 4:14-5:17, 7:3-17, 7:34-61 (easily modified to extend number of dichroic filters and detectors per light beam).)

46. This zig-zag configuration was commonly used for both single-mode and multimode optical fiber waveguides in the optical communication industry,

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which would have been a further source of information to a POSA seeking light demultiplexing and detection designs in a flow cytometer system. Frazier refers in its specification to this detector array configuration by pointing to U.S. Patent No. 4,244,045 to Nosu [EX1010], a demultiplexer device in fiber optic communications. (Frazier, 2:9-24.) Nosu shows this zig-zag configuration in FIG. 12.

Fig. 12



(Nosu, FIG. 12; *see also id.*, Abstract, 6:28-42 (describing how light from optical fiber **100** is collimated through a graded index rod lens **40** then travels between, and is spectrally separated by, opposing optical filters for photo detection).)

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47. The '107 patent admits that “WDM techniques well-established in the optical communication industry can be readily adapted for fluorescence light detection,” indicating that the optical communication industry is an analogous field of art. ('107, 4:62-5:5.) A POSA would have expected such, particularly because the WDMs in both fields are “almost identical in function and architecture,” addressing the same set of problems in light demultiplexing and detection. (*Id.*, 44:25-33.) U.S. Patent No. 8,537,468 to Wang [EX1011], related to the area of optical communications, also shows a zig-zag WDM configuration that involves a zig-zag optical path for collimated light from a collimating lens **302** received from an optical fiber. Generally, wavelengths of the collimated light propagate along the zig-zag optical path between a filter array **310** and a set of mirrors (HR coating **314**) coupled to an optical glass block **304**.

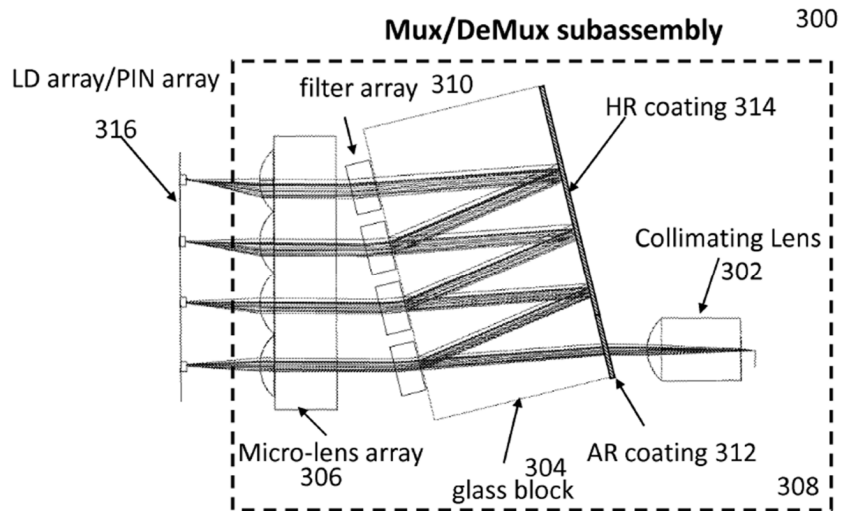


FIG. 3

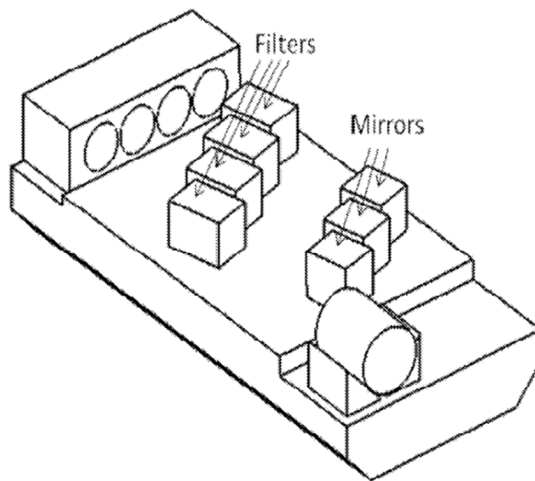


FIG. 12

(Wang, FIGs. 3, 12; *see also id.*, 4:59-5:7, 6:58-7:11 (suggesting a single reflective surface, HR coating 314, in FIG. 3 can be replaced by a plurality of separate mirrors).)

48. U.S. Patent No. 6,198,864 to Lemoff [EX1012] shows a similar configuration to Wang and Nosu, further including a series of separate curved relay mirrors **30, 32, 36** in its optical block **14** that help control divergence in a beam of light as it travels through the optical path.

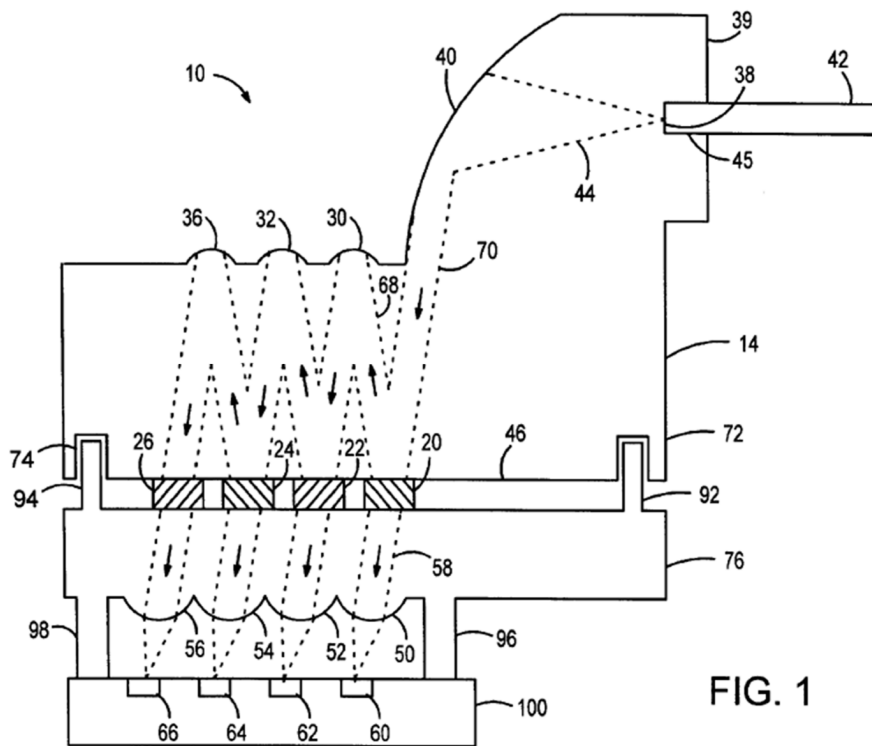


FIG. 1

(Lemoff, FIG. 1; *see also id.*, 4:38-5:29 (describing WDM arrangement that focuses a beam of light **70** into opposing arrays of interference filters **20, 22, 24, 26** and concave mirrors **30, 32, 36**).)

49. Numerous other examples existed in the art by 2011, and a POSA

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would have readily understood that arranging filters and mirror arrays in a zig-zag WDM configuration was a common, accepted approach in wavelength division demultiplexing, including for flow cytometry applications. (*See, e.g.*, U.S. Patent No. 7,212,343 to He [EX1013], 4:43-5:9, 5:62-6:4, FIG. 7 (concave mirror array used in WDM); U.S. Patent No. 5,835,517 to Jayaraman [EX1014], 3:37-4:11, FIG. 1 (curved microlens with reflective coating and interference filter substrate in optical block WDM); U.S. Patent No. 6,201,908 to Grann [EX1015], 3:54-62, 4:4-26, FIG. 1.) Goodman [EX1016], described further below, is a further example of this zig-zag WDM configuration that was already well-established in the art by 2011.

C. Use of Avalanche Photodiodes (APDs) in Flow Cytometry

50. The '107 specification acknowledges that “[i]n many multicolor fluorescence detection instrumentations, such as flow cytometers ... the fluorescence light emitted from the object of interest is: ... detected by [a] photo detector, such as a photomultiplier tube (PMT), PIN photodiode or avalanche photodiode (APD).” ('107, 43:50-61.) The Challenged Claims are directed toward a “semiconductor detector” that a POSA would have understood to be a PIN photodiode or an APD, but not a PMT.

51. With respect to APDs, the '107 specification alleges that the “PMT has

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been the de-facto low-level light detector in many commercial fluorescence detection flow cytometers” and contends that “[o]nly in certain scientific applications where event rate is low and dark current may be discriminated against by expensive photon-counting techniques that the PMT has been replaced by APD detectors[.]” (’107, 44:6-11.) I respectfully disagree with the ’107 patent’s characterization of prior use of APDs in flow cytometers.

52. APDs had been used in fluorescence detection for flow cytometers for almost twenty years before the date of the alleged invention, their benefits were well-known, and technical hurdles to their implementation had long been overcome. In 1993, researchers at the University of Twente in The Netherlands published “White Blood Cell Differentiation Using a Solid State Flow Cytometer” in *Cytometry*, Doornbos [EX1031], a leading academic journal in flow cytometry, that discussed advantages and ease of use for APDs in fluorescence-detection flow cytometers. The authors acknowledged that APDs at the time had a “large temperature dependence” but that problem would be resolved by built-in temperature regulators that would later become commercially available. (EX1031, p.006; *see also, e.g.*, EX1032, p.001 (integrated cooling option); EX1033, p.001 (temperature compensation circuits to control gain).) The authors recognized:

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There are several advantages with a flow cytometer containing APDs, CD-lenses, and a diode laser. First, the flow cytometer system can be very small Second, the components used are very cheap. No high-voltage power supplies are needed for the APDs: a voltage of 200 V suffices.

(EX1031, p.006.)

53. Shapiro reached a similar conclusion in 2003. Discussing APDs almost a decade before the claimed invention, Shapiro noted that an APD “combines some desirable properties of photodiodes and PMT’s; like the former, it has high cathode quantum efficiency, like the latter, it has gain.” (EX1007, p.155.) While noting APDs’ superior quantum efficiency over PMTs (particularly at the near infrared region), Shapiro also acknowledged APDs’ then technical issues with having relatively high dark current and gain that fluctuated with slight variations in temperature. (*Id.*) But, like Doornbos, Shapiro recognized that both issues could be solved “effectively by controlled cooling of the devices.” (*Id.*) While Shapiro expressed concerns that APDs were expensive in 2003, those costs reduced considerably by 2011, making APDs an attractive alternative to PMTs in flow cytometers. (*See, e.g.*, EX1034, p.001.)

54. APD use in flow cytometers also appeared in the patent literature as

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early as 1994. WO 94/29695 to Oddbjørn Gjelsnes [EX1035], published and disclosed a liquid flow cytometer where scattered and/or fluorescent light from an illuminated flow cell passes through a dichroic mirror 5 into a fluorescence detector 13 that “preferably employs a photodiode and particularly a silicon avalanche diode.” (EX1035, 5:25-29.)

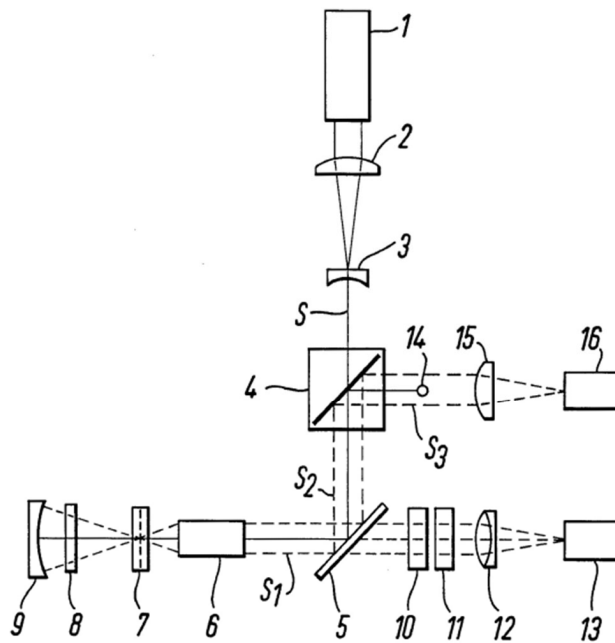


Fig. 5

(*Id.*, FIG. 5.) Gjelsnes observed back in 1994 that use of an APD is “an advantage if the fluorescent light is weak in addition to making the use of a photomultiplier for

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light intensification superfluous.” (*Id.*, 6:10-13.)

55. In 2005, researchers from several prominent laboratories published “Flow Cytometer in the Infrared: Inexpensive Modifications to a Commercial Instrument” in *Cytometry* [EX1036] where they swapped out a PMT detector for an APD detector in a Becton Dickinson LSR-I and FACScan commercial flow cytometers because APDs have “high quantum efficiency in the IR region” over PMTs. (EX1036, pp.003, 006.) With APDs, the researchers recognized that “a new dimension in multicolor fluorescence becomes practical” and that “[t]he capability of a commercial flow cytometer can be enhanced by modification to provide excitation and fluorescence measurements in the IR region.” (*Id.*, p.007.) The authors also noted that their modifications, substituting PMTs for APDs, could be readily made to Becton Dickinson’s LSR-II, a commercial embodiment of the Oostman polygonal arrangement discussed below. (*Id.*, p.006 (“[A]lthough the PMT arrangement is different, replacing one of the PMTs with an APD as described here should not be difficult.”).)

56. From 2006 through 2008, a team of engineers from Radiation Monitoring Devices (RMD) published several papers (*see, e.g.*, EX1037, EX1038) discussing the development of a flow cytometer that used a 16-channel APD linear

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detector array for fluorescence detection of light in the 400 nm to 1000 nm wavelength range. (EX1037, p.001.) The authors acknowledged at the time that “[e]fforts to extend the usable spectral range into the near infrared have been limited by the poor detection efficiency of PMTs in that region” but that “[r]ecent reports on the modification of available instruments and new designs of commercial instruments have shown that avalanche photodiodes can be used for flow cytometry studies in the near IR spectral region.” (*Id.* (citation omitted).) In developing its APD detector array, the authors observed of APDs that:

The responsivity of the APD is better than the PMT in the near infrared. We report initial studies on cell proliferation measurements that demonstrate application of the APD detector in the near infrared. These results show the improved spectral operating range of the APD detector.

(EX1037, p.009; *see also* EX1038, p.010 (“In the red and near infrared spectral regions, the APD has better signal to noise performance than the PMT at low and high signal intensity conditions.”).)

57. APDs were a known and increasingly favored alternative to PMTs by 2011, being an “excellent photo-counting device, whose features include the following: excellent photon detection efficiency; high gain 10^5 - 10^6 ; room temperature operation; insensitive to magnetic fields; excellent time resolution, that

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are important for the laboratory-built optical system.” (Zhao [EX1039], p.002; *see also* EX1032, p.001 (noting that an APD “combines the high gain (10^6) and high quantum efficiency of the PMT with the well appreciated benefits of silicon including size, low operating voltage, robustness, reliability, magnetic field insensitivity, tolerance of excess/ambient light, and suitability for miniaturization” along with “high signal to noise and fast timing properties”).)

58. With advances in APD technology and their known benefits, use of APD photodetectors in flow cytometers arose with more frequency in commercial systems and the patent literature, including for Patent Owner. Frazier [EX1009], discussed with respect to Grounds 10 and 11 recognizes that its zig-zag WDM could be adapted to use APD detectors. (Frazier, 4:19-21.) Other pre-2011 flow cytometry patents similarly discuss use of APDs for fluorescence detection in flow cytometers. (*See, e.g.*, Li-438 [EX1040], 13:5-19; Patt-324 [EX1041], [0020]; Hamada [EX1042], Abstract.)

59. Luminex Corporation also developed flow cytometers that implemented APD detector arrays, obtaining patent rights to the technology as early as the late 1990s. (*See* Chandler-233 [EX1043], 6:14-23; Roth-637 [EX1044], Abstract; Roth-131 [EX1045], 3:16-28; Whitman [EX1046], [0089]; Schilffarth-

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345, [EX1047], [0036]; Sorensen [EX1048], [0055]; Schilffarth-225 [EX1049], [0028]; Calvin [EX1050], [0078].) Chandler [EX1051], discussed with respect to Grounds 8 and 9, is among the Luminex patents that implement APD photodetectors within a flow cytometer. These patent disclosures were hardly academic—Luminex commercially sold several flow cytometer systems (e.g., Luminex 100 IS System and Luminex Flexmap 3D System) before the date of invention of the '107 patent disclosing a flow cytometer with APD detectors. (*See* EX1052, p.031; EX1053, p.015.) Commercial flow cytometers with APD detectors were also available from Partec, Optoflow, and Becton Dickinson as early as 2003. (EX1007, p.155; EX1054, p.002.)

V. THE '107 PATENT

A. '107 Patent Specification

60. The '107 patent discloses zig-zag WDM configurations that pass light through a collimating optical element that projects a collimated beam into a cascaded relay architecture of filters and mirrors while maintaining the beam's size throughout. (*See, e.g.,* '107, 2:36-45, 4:46-67, 5:8-34, 6:53-64, 8:65-9:2, 9:63-10:10, 20:31-46, 21:8-23, 21:52-60.) FIG. 25, an optical ray tracing diagram reproduced below, shows how light rays travel through the zig-zag WDM's 1:1 relay

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architecture as a collimated beam. Dichroic filters **903, 909, 914, 915, 916, 917** separate the beam into color bands (i.e., wavelength ranges) passing the color band of interest for detection by photodetectors at a focal point **906**. Dichroic filters **903, 909, 914, 915, 916** reflect the remaining colors in the beam of light for further processing within the zig-zag WDM while the last dichroic filter **917** can either reflect some, absorb some, or pass all of the remaining light for detection by a photodetector. The zig-zag WDM's 1:1 relay architecture maintains the collimated beam's size as the beam zig-zags between mirrors **907, 910, 911, 912, 913** and the dichroic filters **903, 909, 914, 915, 916, 917**.

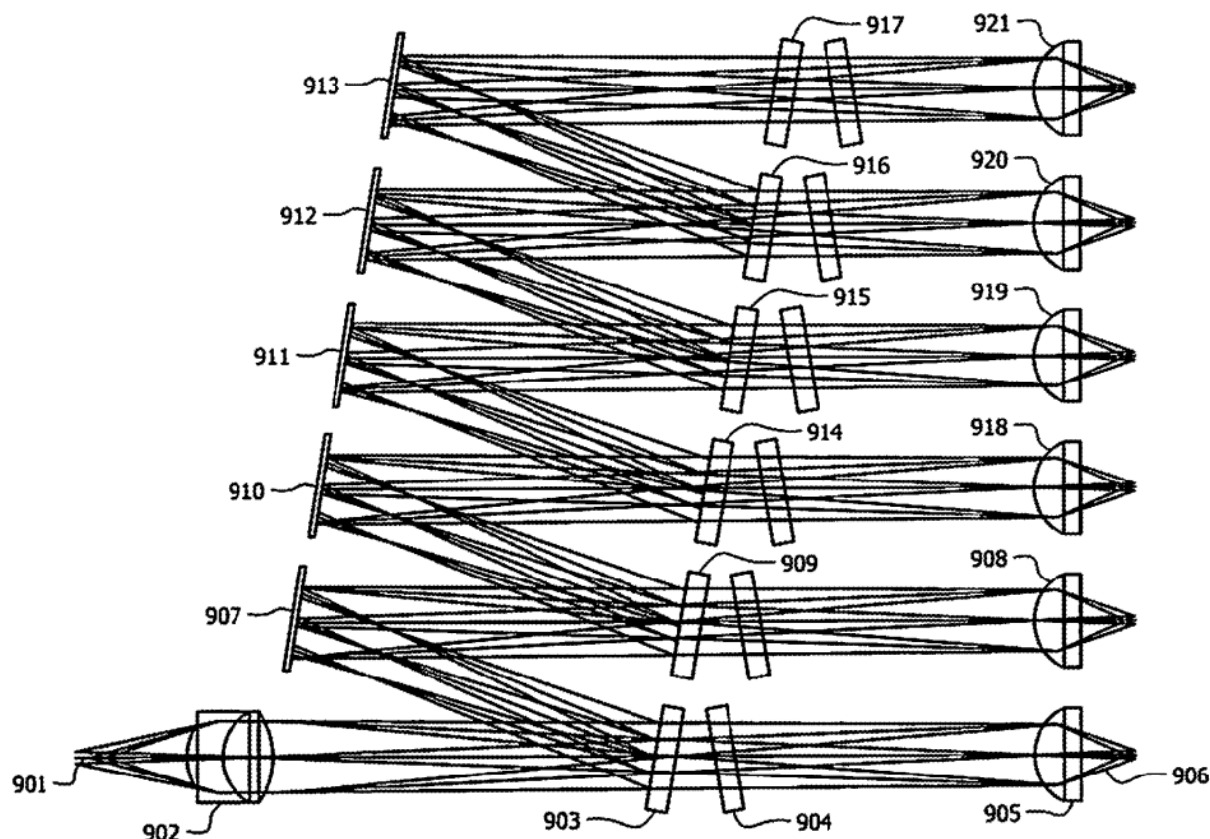


FIG. 25

(’107, FIG. 25.)

61. The ’107 describes how a collimating optical element **902** captures light from source **901** and projects a collimated beam toward a dichroic filter **903**. (’107, 45:10-29, FIG. 25.) Dichroic filter **903** spectrally separates the incident beam, “pass[ing] the color band of interest” to a focusing lens **905** to focus light into a photodetector while “reflect[ing] the remaining colors in the beam of light for further processing[.]” (*Id.*, 45:23-32.) The portion of light that passes through the filter **903**

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may also pass through an (optional) band pass filter **904** to improve color isolation.
(*Id.*, 45:32-34.)

62. The remaining color bands in the collimated light incident on dichroic filter **903** are reflected toward and impinge on a next relay element, e.g., a concave mirror **907**. ('107, 45:35-36.) The collimated light reflects off concave mirror **907** toward a second dichroic filter **909** and passes another color band in the collimated beam to a second focusing lens while reflecting the remainder to another concave mirror. (*Id.*, 45:37-48, 45:54-57.) The process continues to separate and process additional color bands in the collimated beam. (*Id.*, 45:63-46:1.)

B. Challenged Claims

63. This Declaration addresses claims 1-3, 5-14, 16-18, 20-22, 26-30 (the “Challenged Claims”). (See **EX1017** (Listing of Challenged Claims).) Claims 1 and 16 are independent claims. Claims 2-3 and 5-14 depend directly or indirectly from Claim 1. Claims 17-18, 20-22, and 26-30 depend directly or indirectly from Claim 16.

64. Independent claim 1 recites:

1[pre] A flow cytometer comprising:

1[a] an optical fiber; and

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- 1[b]** a wavelength division multiplexer (WDM) configured to receive light from the optical fiber, wherein the WDM comprises:
 - 1[c]** an array of mirrors;
 - 1[d]** an array of filters; and
 - 1[e]** an array of avalanche photodiodes (APDs) configured to receive light that passed through one or more filters in the array of filters;
 - 1[f]** wherein each of the filters in the array of filters is configured to receive light such that: a portion of the light passes through the filter; and another portion of the light is reflected; and
 - 1[g]** wherein each of the mirrors in the array of mirrors is configured to: receive light reflected by a filter in the array of filters; and reflect light to another filter in the array of filters.

('107, cl. 1 (bracket annotations added).)

65. Independent claim 16 recites:

- 16[pre]** A flow cytometer comprising:
 - 16[a]** a flow cell configured to permit liquid to flow through the flow cell;
 - 16[b]** a laser configured to project light into the flow cell;

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- 16[c]** a multimode optical fiber configured to receive light from the flow cell; and
- 16[d]** a wavelength division multiplexer (WDM) configured to receive light from the multimode optical fiber, wherein the WDM comprises:
 - 16[e]** a plurality of mirrors,
 - 16[e][i]** wherein at least one of the mirrors is a concave mirror;
 - 16[f]** a plurality of filters; and
 - 16[g]** a plurality of avalanche photodiodes (APDs) configured to receive light that passed through one or more filters of the plurality of filters;
 - 16[h]** wherein each of the plurality of filters is configured to receive light such that: a portion of light passes through the filter; and another portion of light is reflected; and
 - 16[i]** wherein each of the plurality of mirrors is configured to: receive light reflected by a filter of the plurality of filters; and reflect light to another filter of the plurality of filters.

('107, cl. 16 (bracket annotations added).)

VI. CLAIM CONSTRUCTION

66. I am informed that in the underlying district court litigation between Petitioner and Patent Owner, the claim construction process is currently ongoing. I understand that Petitioner and Patent Owner have exchanged proposed constructions. I further understand that, in the underlying district court litigation, the district court has construed certain terms (*see* EX1103, pp.71-75, 133-135, 182-183, 192-193) and, as relevant to the Challenged Claims of the '107 patent, the term “portion” in the Challenged Claims and the term “focusing lens” in Claim 13. I understand that the district court construed “focusing lens” according to its plain meaning, i.e., “lenses that capture and converge light.” (EX1105, pp.033:23-034:19.) I also understand that the district court construed the term “portion” as “subset of the spectrum of wavelengths of light.” (*Id.*, p.092:21-24.) I have applied these constructions in my analysis below.

67. It is also my understanding that the parties reserved additional terms for construction that may later require the Court’s resolution, but the parties’ disputes are not presently being resolved. (*See* EX1018, p.001 n.1.)

68. For the sole purpose of the opinions I express below in this proceeding, I have applied both Petitioner and Patent Owner’s proposed constructions for the

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disputed terms identified in the chart of the preceding paragraph or in the parties' set of reserved terms.

69. I further understand that Patent Owner has taken the position that all disputed terms should be accorded their plain meaning. While I offer no opinion as to whether there is a plain meaning to these terms, or whether its application is appropriate in the context of the '107 patent claims, I nevertheless apply what I understand Patent Owner's positions to include based on my review of its infringement contentions.

70. I also understand that Patent Owner also served infringement contentions on Petitioner regarding one or more of Petitioner's products. (*See* EX1019.) I understand that Patent Owner's infringement allegations with respect to Petitioner's products may provide insight into Patent Owner's understanding of how Patent Owner is interpreting the scope of the claims in light of the recited language in the Challenged Claims of the '107 patent and in view of Patent Owner's understanding of the plain and ordinary meaning of the above identified terms. I have reviewed Patent Owner's infringement contentions, including the implied and express constructions Patent Owner made through these contentions, in preparing my Declaration.

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71. For purposes of applying the prior art to the claims in the present post-grant review, however, it is unnecessary to resolve the parties' dispute over the claim terms identified above, and I have not performed claim construction analysis to evaluate the parties' competing positions. My analysis below will show how the prior art satisfies each claim element under the constructions advanced in the pending litigation by Patent Owner.

72. To the extent that Patent Owner attempts to distinguish my mapping of the prior art to the claims based on claim interpretations that differ (either explicitly or implicitly) from the ones it advocated for in the underlying litigation (as identified above), I reserve the right to respond accordingly.

73. I further understand that as part of claim construction proceedings in the underlying district court litigation, Petitioner has asserted indefiniteness for certain claim terms in dispute. I have been informed by counsel that the Board may not cancel claims for indefiniteness in a PGR, and I have not included indefiniteness analyses that are unnecessary to my mapping of the prior art to the claim language for purposes of demonstrating obviousness.

VII. PRIORITY DATE OF THE CHALLENGED CLAIMS

74. I am informed by counsel that claims in a patent are entitled to claim

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priority to an earlier-filed application only where there is written description support in the earlier-filed application for the claims. I also understand that the written description must show to a POSA to a reasonable degree of certainty that the patentee had possession of the claimed invention at the time the earlier-filed application was filed. I understand that showing possession applies to the subject matter that is disclosed, not what would have been obvious to a POSA at the time that the earlier-application was filed.

75. I have been asked to review the written description for U.S. Patent No. 12,174,106 (the “’106 patent”) [EX1088], U.S. Patent No. 11,255,772 (the “’772 patent”) [EX1078], U.S. Patent No. 9,746,412 (the “’412 patent”) [EX1070] and PCT/US2013/043453 (the “PCT App.”) [EX1071] to determine whether support exists for the ’107 patent claim terms set forth in Grounds 1, 3, 5, and 7. I understand that the ’107 patent is a “continuation” of the ’106 patent, which I understand to mean that the two patents share a similar specification. I understand that the ’106 patent is a continuation of the ’772 patent. I understand that the ’772 patent is a “divisional” of the ’412 patent, which I understand to mean that the two patents also share a similar specification but that the ’772 patent claims are directed to a different invention than what is claimed in the ’412 patent. I also understand that the ’412

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patent is a “continuation-in-part” of the PCT App., which I understand to mean that the ’412 patent’s specification includes the disclosure from the PCT App. but also has new matter added.

76. I have also been asked to review the written description for the provisional applications to the ’107 patent, including provisional app. Nos. 61/715,819 and 61/715,836 (“pre-AIA provisional applications”) with filing dates that predate March 1, 2013, which I understand is the date that the America Invents Act (“AIA”) took effect. I understand that, if a single claim in the ’107 patent lacks written description support in the pre-AIA provisional applications, then the ’107 patent is governed by the AIA.

77. Having reviewed the written description for the ’106 patent, ’772 patent, ’412 patent, PCT App., and provisional applications, it is my opinion that one or more of the Challenged Claims lack written description support for the reasons discussed in my analysis for Grounds 1, 3, 5, and 7, incorporated here, and that one or more of the Challenged Claims are not fully enabled for the reasons discussed in my analysis for Grounds 2, 4, and 6. I understand that under the AIA, without written description support, the Challenged Claims can only claim priority as of the filing date of the ’107 patent, September 3, 2024.

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78. I have also been asked to review the '106 patent, '772 patent, '412 patent, PCT App., and provisional applications to determine where written description support first appears for limitations recited in Claims 6, 14, 18, and 22. In my opinion, written description support does not exist for these claims in any pre-AIA provisional applications.

79. Claims 14 and 18 of the '107 patent each recite “the diameter of the spot is less than 1 mm” that appears for the first time in new matter added to the '412 patent. For example, the following representative new matter was added to the '412 patent that contains this disclosure.

The wavelength division multiplexer (WDM) may include a collimating optical element that magnifies an to produce an image of substantially the same size as the effective size of said collimating optical element, at least one dichroic filter located between said collimating optical element and said image, said dichroic filter separating the collimated beam of light into two (2) branches of distinctive colors, a focusing optical element located in one of said branches, the beam of light in said branch being focused to a spot having a diameter of less than 1.0 mm by said focusing optical element, and an image relay optical element located near the image produced by said collimating optical element in the other branch, said image relay optical element producing an image of said collimating optical element

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at substantially unit magnification.

(’412, 9:46-60 (underlining added); *see also id.*, 12:35-38, 12:39-44, 20:12-27, 20:34-37, 20:38-43, 20:56-21:4, 21:11-14, 21:15-20, 57:23-26, 58:11-13.) These disclosures are not present in the PCT App. or any of the pre-AIA provisional applications to which the ’107 patent claims priority, and nothing in the pre-AIA provisional applications would have indicated to a POSA on their respective filing dates that the inventor had possession of the invention recited by Claims 14 and 18.

80. Claims 6 and 22 recite a “laser [that] is configured to emit blue light, yellow-green light, violet light, or ultraviolet light.” I found the earliest and first written description support for this claim element appearing in the PCT App.:

The optical illumination subsystem provides a collimated and then focused beam of light, usually laser light of a single wavelength, that impinges upon the hydrodynamically-focused stream of liquid passing through the flow cell. Accordingly, the flow cytometer system may have one or more light sources that may include:

1. one or more lamps, e.g., mercury or xenon;
2. one or more high-power water-cooled lasers, e.g., argon, krypton or dye laser;
3. one or more low-power air-cooled lasers, e.g., argon (488 nm), HeNe

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(red-633 nm), HeNe (green) and HeCd (UV); and/or

4. one or more diode lasers (blue, green, red and violet).

(PCT App., Background Art, p.009.) This passage is absent from any of the '107 patent's pre-AIA provisional applications,² and those applications lack any description that would have indicated to a POSA on their respective filing dates that the inventor had possession of the invention recited by Claims 6 and 22.

**VIII. DETAILED EXPLANATION OF THE UNPATENTABILITY
GROUNDS UNDER 35 U.S.C. § 112**

81. I have reviewed and analyzed the '107 patent and its file history. In my opinion, the claims of the '107 patent are invalid for either lack of written description or enablement under the following grounds:

Ground	Claim(s)	§ 112 Basis for Challenge
1	1-3, 5-14, 16-18, 20-22, 26-30	Lack of written description for “wavelength division multiplexer (WDM)”

² I did find the same passage on page 42 in U.S. provisional application No. 61/911,859 filed on December 4, 2013 after the March 16, 2013 effective date of Section 3 (First-Inventor to File) of the AIA. (EX1107, p.042.) This provisional was also filed after the filing date of the PCT App.

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Ground	Claim(s)	§ 112 Basis for Challenge
2	1-3, 5-14, 16-18, 20-22, 26-30	Lack of full scope enablement for “wavelength division multiplexer (WDM)”
3	1-3, 5-14	Lack of written description for “optical fiber”
4	1-3, 5-14	Lack of full scope enablement for “optical fiber”
5	9, 25, 29	Lack of written description for “the WDM is capable of detecting a substantially full spectrum of visible light”
6	9, 25, 29	Lack of enablement for “the WDM is capable of detecting a substantially full spectrum of visible light”
7	30	Lack of written description for “or more”

A. Ground 1: The Challenged Claims Lack Written Description Support for “wavelength division multiplexer (WDM)”

82. I have been asked by counsel to determine whether written description support exists in the ’107 patent for a wavelength division (de)multiplexer (WDM) that lacks a “collecting optical element” and projects a non-collimated beam through its relay architecture. In my opinion, while written description support exists for a WDM that includes a “collimating optical element” to project a collimated beam through a cascaded unit-magnification relay architecture, a POSA would not have understood to a reasonable degree of certainty that the inventor had possession of the more broadly claimed WDM that includes just filters, mirrors, and APDs. In my

opinion, a “collimating optical element” to project a collimated beam through the WDM’s relay architecture is an essential feature of the disclosed inventions reciting a WDM in the ’107 patent.

1. Technical Background on Light Beam Properties

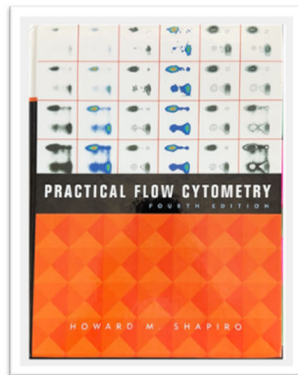
83. To assist with the discussion that follows, I provide an overview of different light beam properties.

a. Converging vs. Parallel/Collimated vs. Diverging Light

84. A POSA would have known that the nature of a beam of light can be characterized by the rays of light contained within the beam in three different ways—converging, collimated, or diverging. As explained in the Shapiro textbook that is cited in the ’107 patent³ (and as a POSA would have readily known), the relative nature of the rays of light from a point source are distinctly and separately characterized as being either (1) converging (i.e., the rays get closer together as they go along); (2) collimated (i.e., light consisting of parallel rays); or (3) diverging (i.e., the rays get further apart as they go along):

³ See, e.g., ’107, 28:33-37; *id.*, 43:50-61 (citing “Practical Flow Cytometry, Howard M. Shapiro, Wiley (2003) ISBN 0471411256”).

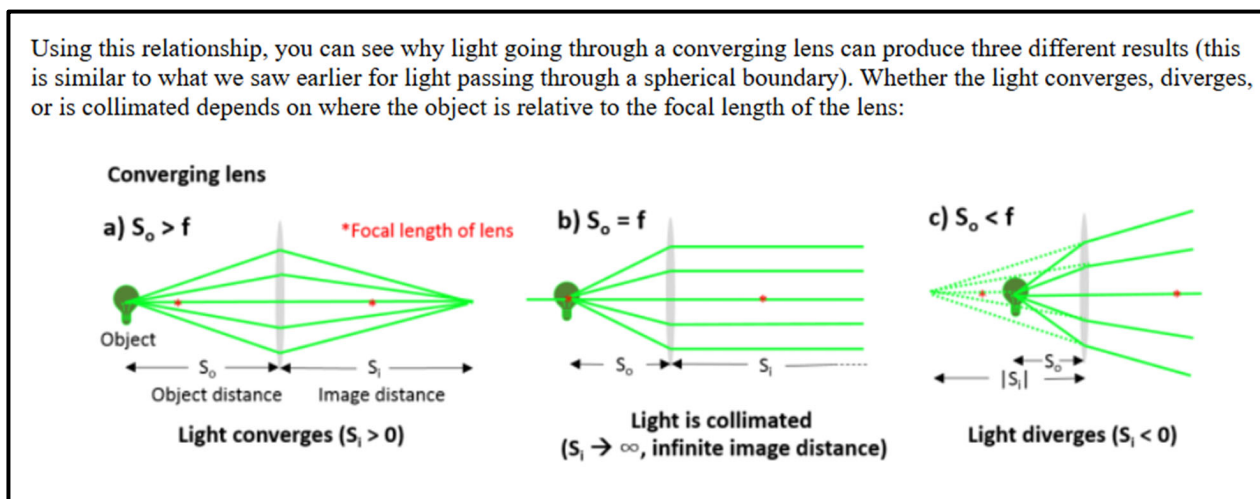
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Rays from a point source get farther apart as they go along; they are divergent, or have negative vergence. Parallel rays have zero vergence; light consisting of parallel rays is said to be collimated. Rays that converge, or have positive vergence, get closer together as they go along. Convergent

(EX1007, p.110 (annotated).)

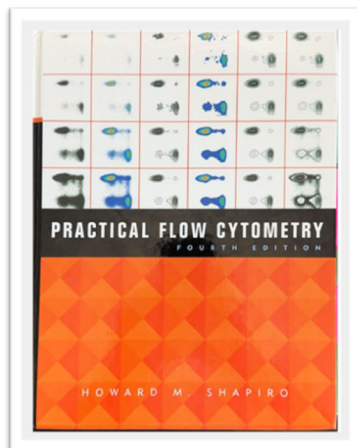
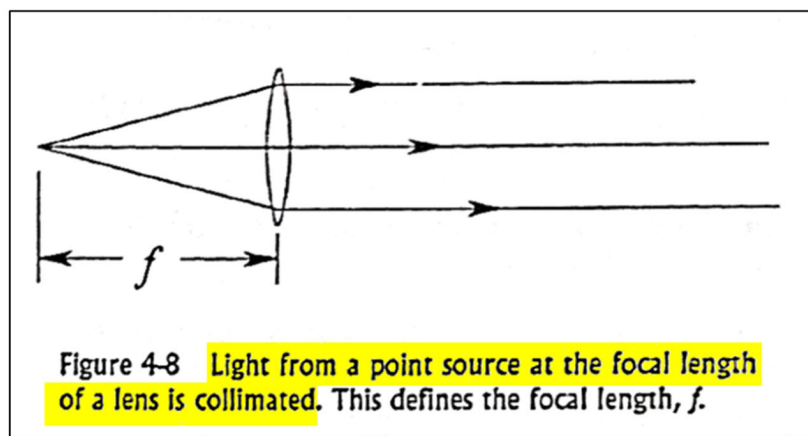
85. The distinction between light in which the light rays converge (i.e., a focused beam), are parallel (i.e., a collimated beam), or diverge (i.e., a defocused beam) is illustrated in the following graphic by the nature of resulting light rays emitted from a point source (below, depicted within the lightbulb) affected by a spherical surface like a lens (below, the gray shading) in different ways:



(EX1023, pp.009-010.)

b. The placement of the light source relative to the focal length determines whether the emitted light rays are converging, collimated/parallel, or diverging

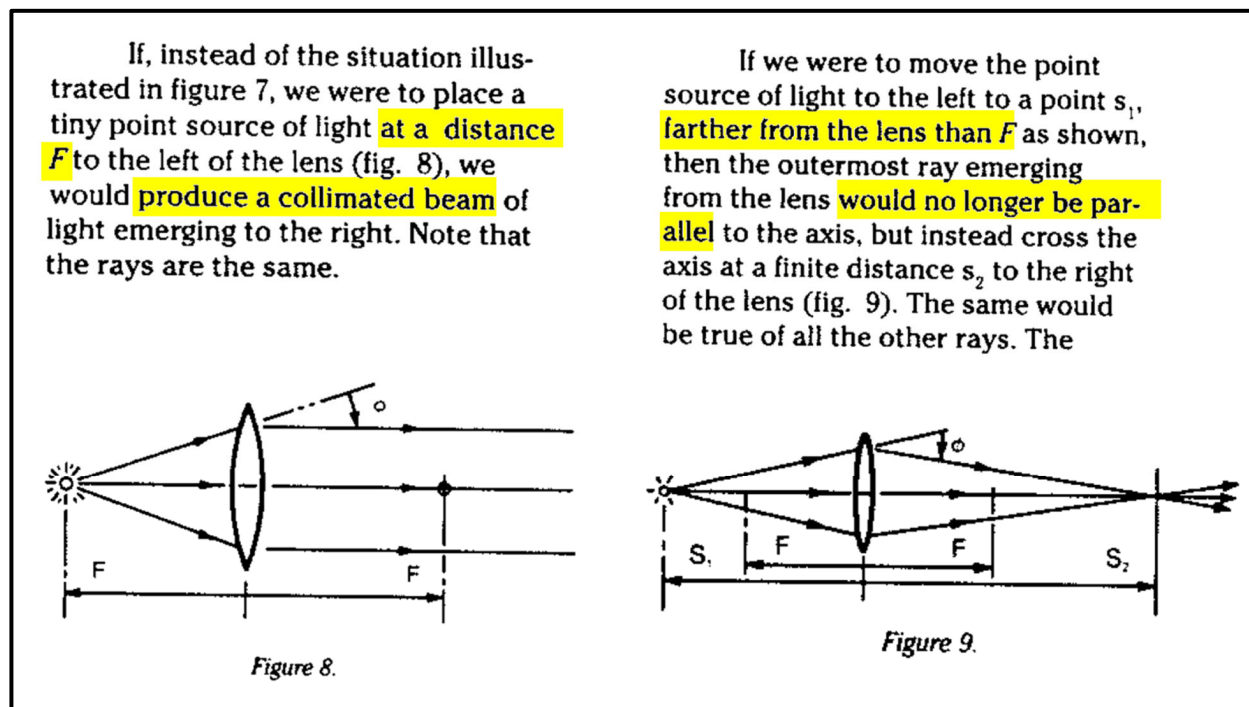
86. A POSA also would have known, for example, that whether light projected into a lens results in a focused beam, a collimated beam, or a defocused beam depends on where the light source is positioned relative to focal length of the lens. For instance, when light from a point source is positioned at the focal length of the lens, the rays of light are made parallel by the lens and the light is collimated:



(EX1007, p.110; *see also id.* (“Lenses are pieces of material, (usually glass, plastic, or quartz) with a shape such that all rays traversing them reach a distant point having traveled the same optical path. In Figure 4-8, that point is at infinity. The rays from the point source **all emerge parallel to each other**, so we say that they are **collimated**. The distance from the point source to the lens is the **focal length, f** , of

the lens.” (emphasis added)); EX1089, p.004 (“Optics Glossary” – “**Collimated Beam**: A beam of light in which all of the rays are parallel to each other.”).)

87. When a point source of light is positioned *at* the focal length of the lens, the rays of light become parallel and the produced light beam is collimated (Figure 8, below), whereas if the light source is positioned *further from* the lens than the focal point, the rays of light converge and produce a focused light beam (Figure 9, below):

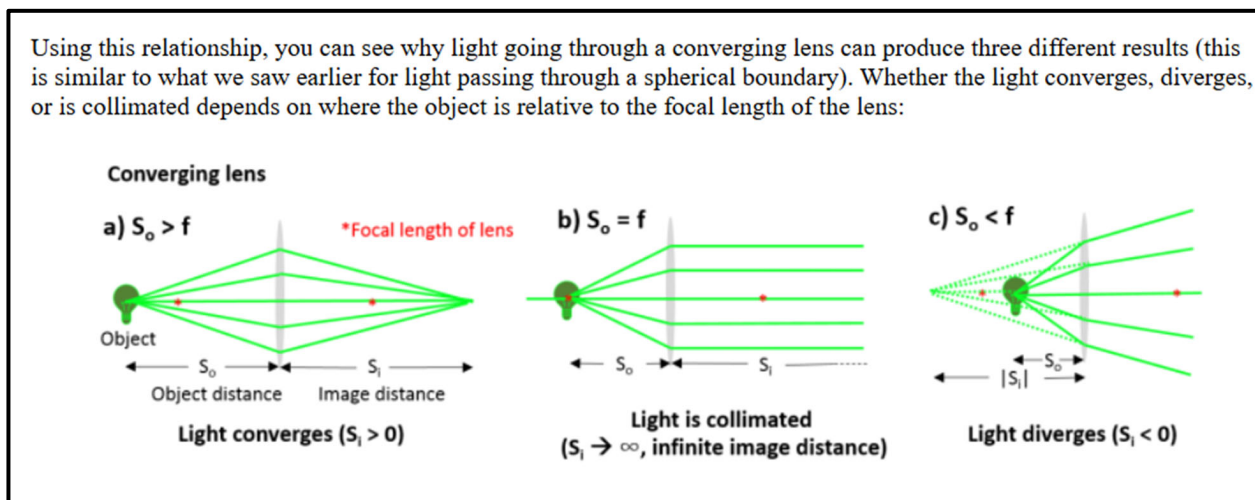


(EX1090, p.006 (highlighting added).)

88. A POSA also would have known that if the light source was positioned

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at a distance from the lens that is *closer than* the focal length, the rays of light exiting the lens would be diverging and produce a “defocused” light beam. Thus, a POSA would have known that a given lens can produce three different types of beams—either converging/focused light, collimated/parallel light, or diverging/defocused light—depending on where the light source is positioned relative to the focal length of the lens, as described and depicted in the following (where S_o is the distance of the object from the lens and f is the focal length of the lens):



(EX1023, pp.009-010.)

89. That is, a key feature of collimating light into parallel rays—as opposed to the rays converging or diverging—is placement of the light source *at* the focal length of a lens. (See, e.g., EX1066, p.001 (“[t]o produce collimated light you can . . . place an infinitesimally small source *exactly one focal length away from an*

optical system” (emphasis added).)

- c. **A “collimated beam” from a real light source consists of individually “collimated” ray bundles made parallel to each other from each point on the source that collectively create a “collimated beam” with some divergence**

90. A POSA would have understood that a real light source with a finite diameter (d) placed at the focal length (f) of a lens (D) and centered on the optical axis will project a “collimated beam” wherein the light from each point on the source is individually collimated into parallel rays, and the overall beam has a divergence angle (θ) that arises from points that are not on the optical axis, as depicted in the following image:

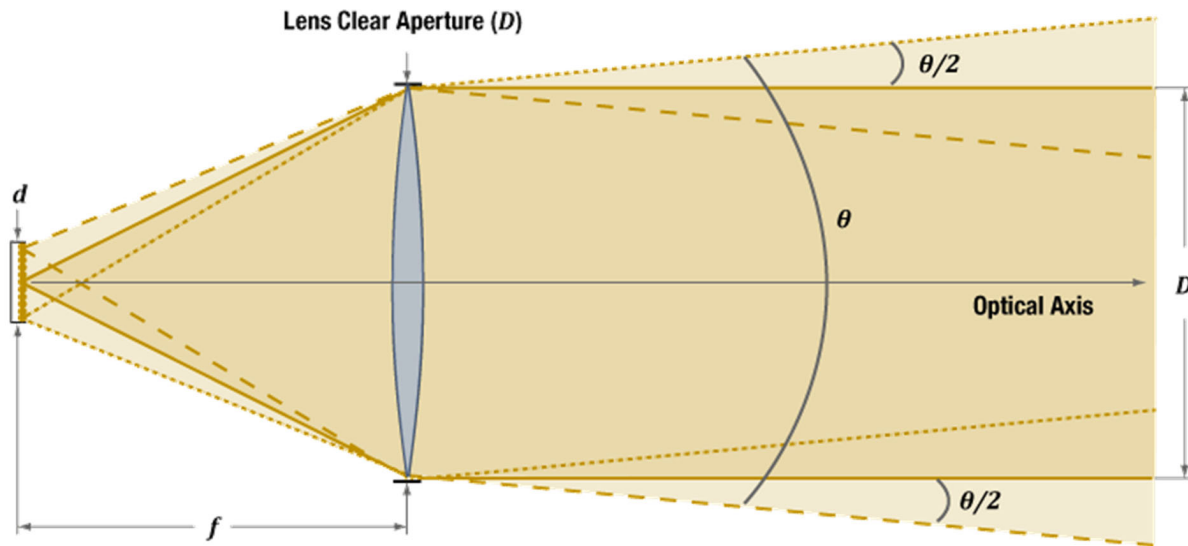


Figure 1.1 If a broadband-wavelength source, like a lamp or LED, is placed one focal length (f) away from a lens, light from each point on the source is individually collimated. The full divergence angle ($\theta \sim d / f$) of the output beam depends on the focal length and source diameter (d).

(EX1065, p.003; *see also* EX1066, p.001 (“Some level of divergence will always be present when collimating light. . . . The divergence exists because, as the size of the source increases, the source’s distance from the optical axis increases, and thus the resultant ray bundle’s angle increases with respect to the optical axis.”).)

91. The ratio of the diameter (d) of the physical light source to the lens focal length (f) provides an estimate of the full divergence angle (θ)—i.e., $\theta \sim d / f$ —of the

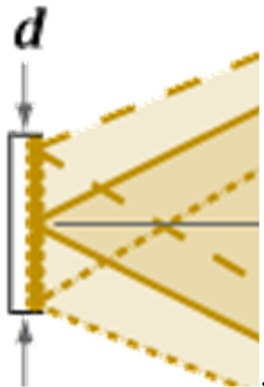
collimated beam. (EX1065, p.003.) The use of the size of the light source and the focal length to “approximate the divergence of a collimated beam” is also given in EX1066, as follows:

$$\text{Divergence} \approx \frac{\text{Size of Source}}{\text{Focal Length of Collimating System}}$$

(EX1066, p.001.)

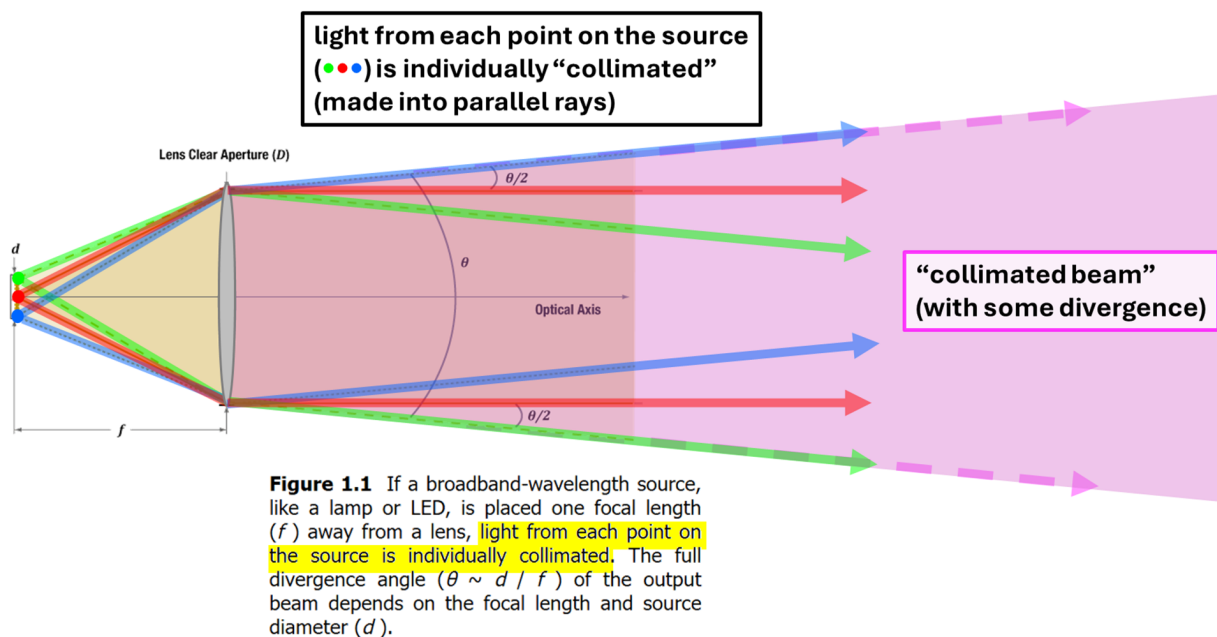
92. Physical light sources of finite extent like that depicted in the foregoing image “resemble groupings of multiple point sources.”⁴ (EX1065, p.003; *see also*

⁴ In EX1065, the representation of a light source being a collection of individual point sources (filled circles), each of which projects a diverging rays of light based on the solid, dashed, and short-dashed lines, is as follows:



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EX1066, pp.001-002 (The “Real Source” in Figure 2 “can be thought of as a collection of closely spaced ideal point sources”).) As such, a light source at the focal length projects a collimated beam consisting of “light from each point on the source [that] is individually collimated.” (EX1065 (Fig. 1.1. caption).) EX1066 recognizes the same: “Individually, each point creates a ray bundle of parallel rays, but as a collection the series of ‘point sources’ create a beam with some divergence.” (EX1066, p.001.) The following annotated image highlights how the light from each point on the source (● ● ●) is “individually collimated” by bringing the rays parallel to each other and, collectively, project a “collimated beam” with some divergence (that arises because the location of the green and blue points on the source are not on the optical axis):



(EX1065, p.003 (annotations added); *see also* EX1066, p.001 (“Figures 2 and 4 can be thought of as a collection of closely spaced ideal point sources. Individually, each point creates a ray bundle of parallel rays, but as a collection the series of ‘point sources’ create a beam with some divergence.”).)

2. The Omitted “collimating optical element” That Projects a “collimated beam” is an Essential Feature to Operate the Claimed WDM

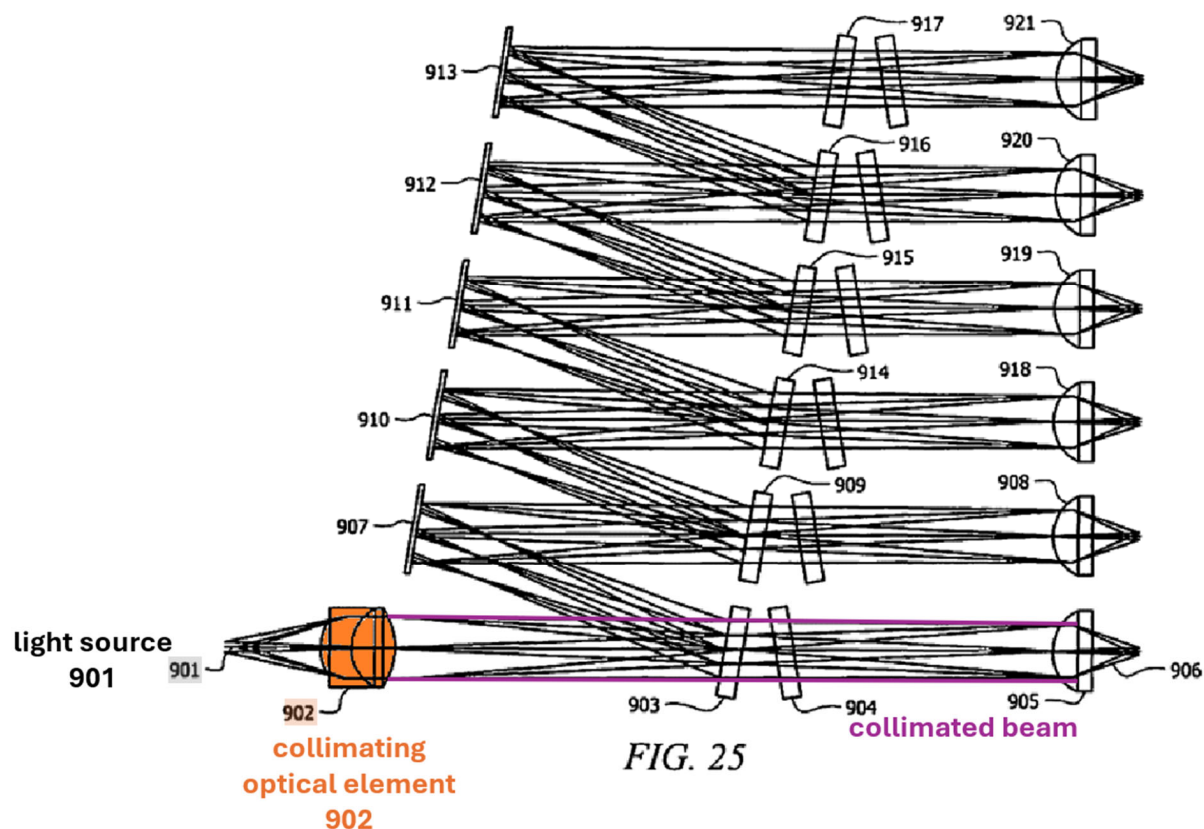
93. The purportedly inventive WDM in the ’107 written description separates fluorescent light into distinct color bands using a specific configuration that **requires** use of a “collimating optical element” and projects a “collimated beam” throughout a unit-magnification relay architecture. This critical component appears

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throughout the written description and is featured in every WDM embodiment.

94. In its summary disclosures, the '107 describes how its WDM must include “at least two optical elements,” among them an optical element that “collimates a beam of light received from an extended light source[.]” ('107, 4:46-56.) Other optical elements relay the projected collimated beam to “further extend the collimated optical path” such that “[t]he cascaded unit-magnification image relay architecture of the present disclosure extends the collimated optical path length without large beam expansion.” (*Id.*, 4:56-65.) A collimated beam projected from a “collimating optical element” is relayed at unit magnification in varying filter and mirror configurations. (*See id.*, 5:19-32.)

95. The '107 written description makes repeated reference to using a “collimating optical element” to project a collimated beam through a unit-magnification relay architecture, in both its Summary of Disclosure and Detailed Description. (*See* '107, 9:63-10:10, 20:31-46, 21:8-23, 20:52-60, 45:10-26, 46:34-41, FIGs. 25, 27, 28.) This “collimating optical element” appears in each of the disclosed embodiments, and its placement and function within the unit-magnification relay architecture is shown in FIG. 25 below:



(*Id.*, FIG. 25 (annotated).)

96. The '107 written description explains why a “collimating optical element” is an essential feature to the purported invention. As background, the '107 contends that “many multicolor fluorescence detection instrumentations” function where fluorescent light emitted from a target material is collected by a microscope objective, reimaged into a multimode optical fiber, “then collimated and separated into multiple colored bands,” and detected by PMTs or APDs. ('107, 43:50-58 (underlining added).) The '107 written description contends that “efficient color

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separation can *only* be accomplished economically with [a] collimated light beam” but technical hurdles exist to using a collimated beam with small area APDs. (’107, 44:33-47 (emphasis added).) Based on these purported technical hurdles, the ’107 written description suggests:

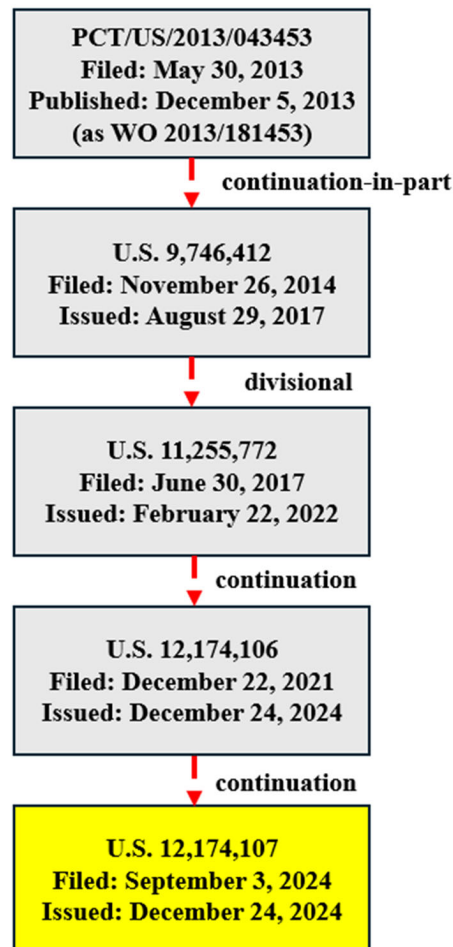
Clearly, a technology capable of collimating a large etendue light beam over an extended distance without significantly expanding the beam diameter would be highly desirable. Such a technology would enable a WDM like device for fluorescence light detection with characteristics comparable to low noise semiconductor detectors.

(*Id.*, 44:47-53.) A POSA would thus have understood that the ’107 sought to solve the problem of “collimating a large etendue light beam over an extended distance,” which would require a “collimating optical element” to collimate fluorescent light received into a WDM to begin with. (*Id.*) In the WDM, the ’107 specification teaches how to manage beam divergence after collimating a large etendue beam (as discussed above in Section VIII.A.1.c) as the beam travels along the optical path through use of concave mirrors to re-collimate, to maintain “substantially the same” beam size throughout the WDM. (*Id.*, 45:10-46:6.)

97. The criticality of the “collimating optical element” to the inventor’s WDM is further confirmed in every earlier-filed application to the ’107 patent that

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claims a WDM. From the filing of the PCT App., I have received the following representation of the purported priority chain of the '107 patent from counsel, which I have reproduced below:



I have reviewed these earlier-filed applications, as well as U.S. Patent No. 10,330,582 (the “582 patent”) discussed below. I note that claims directed to a

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WDM in every application that preceded the '107 patent also recite a “collimating optical element,” confirming its criticality to the purported invention.

98. To start, the original PCT App. recites a “collimating optical element” in all independent claims that recite a WDM. Claim 1 directed to a flow cytometer is partially reproduced below and shows how the “collimating optical element” is recited as an element of the claimed WDM.

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e) a wavelength division multiplexer 90 ("WDM (90)") for separating into multiple colored bands a beam of light emitted initially from the viewing zone and imaged by the composite microscope objective (60) into an optical fiber for transmission to the WDM (90), the WDM (90) comprising:

- i. a collimating optical element that magnifies an to produce an image of substantially the same size as the effective size of said collimating optical element;
- ii. at least one dichroic filter located between said collimating optical element and said image, wherein said dichroic filter separates the collimated beam of light into two (2) branches of distinctive colors;
- iii. a focusing optical element located in one of said branches, wherein the beam of light in said branch is focused to a spot having a diameter of less than 1.0 mm by said focusing optical element; and
- iv. an image relay optical element located near the image produced by said collimating optical element in the other branch, wherein said image relay optical element produces an image of said collimating optical element at substantially unit magnification.

(PCT App., p.059 (highlighting added).) Claim 162 directed to a WDM, separate from a flow cytometer, also recites a "collimating optical element":

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162. A WDM (90) for separating a beam of light emitted from an into multiple colored bands, the WDM (90) comprising:

- a) a collimating optical element that magnifies an to produce an image of substantially the same size as the effective size of said collimating optical element;
- b) at least one dichroic filter located between said collimating optical element and said image, wherein said dichroic filter separates the collimated beam of light into two (2) branches of distinctive colors;
- c) a focusing optical element located in one of said branches, wherein the beam of light in said branch is focused to a spot having a diameter of less than 1.0 mm by said focusing optical element; and
- d) an image relay optical element located near the image produced by said collimating optical element in the other branch, wherein said image relay optical element produces an image of said collimating optical element at substantially unit magnification.

(*Id.*, p.083 (highlighting added).)

99. The next patent application in the purported priority chain, issuing into the '412 patent, also recites a “collimating optical element” in its only independent claim, claim 1 directed to a flow cytometer having a WDM.

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What is claimed is:

1. A flow cytometer having a wavelength division multiplexer (WDM), the WDM comprising:
an extended light source providing light that forms an object;
a collimating optical element that captures light from the extended light source and projects a magnified image of the object as a first light beam; and
a first focusing optical element configured to focus the first light beam to a size smaller than the object of the extended light source to a first semiconductor detector.

(EX1070, cl. 1 (highlighting added).)

100. I note that, during the prosecution of the patent application that issued into the '412 patent, the Examiner issued what I understand is called a “restriction requirement.” (EX1029, pp.029-034.) I understand from counsel that a “restriction” in patent prosecution means that the examiner has indicated that the applicant’s specification includes more than one distinct invention and requires the applicant to make an election of the invention it seeks to pursue for each subsequent patent application. I also understand that the applicant for the '412 patent later pursued multiple patent applications directed to different distinct inventions separately discussed in the '412 specification.

101. I understand that the applicant filed one “continuation” application from the '412 patent, the '582 patent, reciting claims related to the WDM (claimed

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as an “optical subsystem”). I have reviewed the ’582 patent’s claims. In every independent claim reciting an “optical subsystem for a flow cytometer,” the claims further recite a “collimating optical element.” Claim 1 is reproduced below:

1. An optical subsystem for a flow cytometer, the optical subsystem comprising:
a collimating optical element arranged to receive light from a light source, the collimating optical element configured to project a collimated beam;
an optical relay element arranged to receive at least a portion of the collimated beam from the collimating optical element, the optical relay element comprising a curved mirror configured to reflect the portion of the collimated beam received from the collimating optical element to produce a first image;
a first focusing optical element arranged to receive at least a portion of the collimated beam reflected by the optical relay element; and
a first semiconductor detector,
wherein the first focusing optical element is configured to focus the portion of the collimated beam received from the optical relay element onto the first semiconductor detector.

(EX1091, cl. 1 (highlighting added).)

102. I understand that the applicant filed four divisional applications in addition to the ’582 continuation: U.S. Patent Publ. Appl. No. 2018/0059000 (abandoned); and U.S. Patent Nos. 11,255,772; 10,126,227 and 10,209,174. I understand from counsel that a “divisional” application refers to an application

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where the applicant made an election to pursue an invention contained in the shared disclosures with the parent application but not otherwise pursued in the parent application's claims. I understand that the '772 patent, an ancestor application to the '107 patent, is a divisional application to the '412 patent that claims certain methods for the fluidic pump used with a flow cell in a flow cytometer. I have reviewed the claims of the '772 patent and confirm that they do not claim a WDM.

103. I understand that the applicant filed a "continuation" application from the '772 patent, U.S. Patent No. 12,174,106, with claims directed to flow cytometers that recite a WDM including a "collimating optical element" in every independent claim. Claim 13 is reproduced below:

13. A flow cytometer comprising:
- a light source arranged to illuminate a stream of particles in a viewing zone;
 - a collecting optical element configured to collect and focus fluorescent light emitted by a particle illuminated by the light source such that the fluorescent light leaving the collecting optical element converges; and
 - a wavelength division multiplexer (WDM) configured to separate into color bands the fluorescent light collected by the collecting optical element, the WDM including,
 - a collimating optical element that is separate from the collecting optical element and is arranged to receive the fluorescent light collected by the collecting optical element, the collimating optical element configured to collimate the fluorescent light;
 - a row of mirrors arranged and configured to sequentially reflect different color bands of the fluorescent light collected by the collecting optical element after the fluorescent light has passed through the collimating optical element, the row of mirrors including at least one curved mirror;
 - a row of dichroic filters opposed to the row of mirrors, each of the dichroic filters configured to pass one color band of the fluorescent light reflected by a mirror in the row of mirrors, and to reflect another color band of the fluorescent light reflected by the mirror;
 - a row of semiconductor detectors, each of the semiconductor detectors arranged and configured to detect and quantitate the band of fluorescent light passing through a dichroic filter in the row of dichroic filters.

(EX1088, cl. 13 (highlighting added).)

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104. A POSA would have understood—based on the '107's written description's extensive disclosures on collimating fluorescent light and its importance as allegedly the “only” economical way to efficiently separate color bands, and the various techniques disclosed to extend the collimated beam distance in the WDM—that a “collimating optical element” is an essential feature to the purported invention.

105. Claims 1 and 16 of the '107 patent, however, fail to recite a “collimating optical element” and are instead broadly directed toward a “wavelength division multiplexer (WDM)” comprising an “[array / plurality] of mirrors,” an “[array / plurality] of filters,” and an “[array / plurality] of avalanche photodiodes (APDs).” A POSA would have understood from this broad recitation that the inventor sought to claim WDMs that did or did not include a “collimating optical element” and were operable in relaying any type of light (e.g., diverging, collimated, converging), in any conceivable configuration.

106. In my opinion, a POSA would not have understood with a reasonable degree of certainty that the inventor had in his possession any WDM other than one that included a “collimating optical element” and relayed a collimated beam through a unit-magnification relay architecture. This is the *only* technology disclosed in the

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'107 written description's several WDM embodiments, as discussed above. Nowhere does the written description provide any disclosure on the design and use of a WDM with a non-collimated beam, let alone one without a collimating optical element.

107. Nor would a POSA have recognized the '107 written description to suggest a WDM that lacks a "collimating optical element" or propagates a non-collimated beam through its relay architecture. The '107 written description teaches *against* such a WDM configuration, indicating that "efficient color separation can only be accomplished economically with [a] collimated light beam" and addressing a problem with collimating fluorescent light from an extended light source. ('107, 44:33-53.)

108. For these reasons, it is my opinion that Claims 1 and 16 of the '107 patent, as well as corresponding dependent Claims 2-15 and 17-30, lack written description support for a "wavelength division multiplexer (WDM)."

B. Ground 2: The Challenged Claims Lack Full Scope Enablement for "wavelength division multiplexer (WDM)"

109. In my opinion, Claims 1 and 16 of the '107 patent, as well as corresponding dependent Claims 2-15 and 17-30, are not fully enabled as to the term "wavelength division multiplexer (WDM)." As discussed for Ground 1,

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incorporated here, the specification discloses a WDM that uses a collimating optical element to project a collimated beam through a unit-magnification relay architecture as purportedly the “only” way to achieve economical and efficient color separation of fluorescent light. But the claims more broadly recite any WDM with arrays of filters, mirrors, and APDs, including WDMs that propagate any type of light in any filter/mirror configuration. These other WDM configurations are undisclosed in the specification, and a POSA would not have understood how to make or use them without undue experimentation.

110. I have considered the so-called *Wands* Factors for undue experimentation, listed in the Legal Principles section (Section III) above, and which consist of: (1) the breadth of the claims; (2) field or nature of the invention; (3) the state of the prior art; (4) the level of skill of a POSA; (5) the predictability of the art; (6) the amount of direction or guidance provided by the patent’s specification; (7) working examples included in the patent’s specification; and (8) the amount of experimentation necessary. Below, I apply the *Wands* Factors to determine that the recited “wavelength division multiplexer (WDM)” is not enabled for use without a “collimating optical element” projecting a collimated beam at unit magnification through its (cascaded) relay architecture.

111. ***Wands Factor No. 1 – Breadth of the Claims.*** Independent Claims 1 and 16 are broadly directed toward a “wavelength division multiplexer (WDM)” comprising an “[array / plurality] of mirrors,” an “[array / plurality] of filters,” and an “[array / plurality] of avalanche photodiodes (APDs).” (’107, cls. 1, 16.) The claims are silent as to the shape of the light beam that propagates through the WDM, a marked change from the claims in earlier-filed applications to which the ’107 patent claims priority. The breadth of the claims would extend to, and thus require enablement for, WDM embodiments, in any conceivable configuration, that propagate an initially collimated beam, a non-focused (diverging) beam, or a focused (converging) beam through the relay architecture. The ’107 specification’s teachings are directed toward a cascaded unit-magnification relay architecture using a collimated beam, yet the claims omit any collimating optical element, an essential feature in the purported invention.

112. ***Wands Factor Nos. 2 and 4 – Field or Nature of the Invention and Level of Ordinary Skill.*** The relevant technical fields of the invention, as I noted in Section II, are flow cytometry, fiber optics, and wavelength demultiplexing and detection. (*See also* ’107, 1:42-45, 2:7-10, 2:40-45.) The ’107 patent discusses various subassemblies in a flow cytometer, among them a WDM that includes a

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collimating optical element and a cascaded unit-magnification relay architecture that propagates a collimated beam throughout. (*See, e.g., id.*, 4:46-65.) I also identify the level of ordinary skill in Section II, incorporated here, though I note that my overall *Wands* analysis would not change if another level of ordinary skill were adopted, given the lack of guidance from the specification and excessive experimentation required to enable these overbroad claims.

113. ***Wands Factor Nos. 6 and 7 – Guidance from the Specification and Working Examples.*** As discussed for Ground 1, the specification’s guidance is limited to WDM embodiments that include a collimating optical element and a cascaded unit-magnification relay architecture that propagates a collimated beam throughout. The specification provides no guidance or working examples for any WDM that propagates a non-collimated beam through the relay architecture. Instead, the specification teaches against such a WDM configuration, indicating that “efficient color separation can only be accomplished economically with [a] collimated light beam” and addressing a problem with collimating fluorescent light from an extended light source. (’107, 44:33-53.)

114. ***Wands Factor Nos. 3, 5, and 8 – State of the Art, Predictability, and Amount of Experimentation.*** In my opinion, because of the absence of any teaching

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or working example in the specification for a WDM configuration that propagates a non-collimated beam, a POSA would have had to engage in excessive experimentation to design a WDM configuration using a non-collimated beam that practices the Challenged Claims. As an example, a POSA would have had to understand how to design a WDM where filters in the array of filters receive light directly from the optical fiber for demultiplexing and processing of sufficient signal strength to overcome known technical signal-to-noise issues with APDs. A POSA, regardless of the level of ordinary skill, would not have understood how to develop an operable WDM with the input of a diverging beam that also included the other recited elements of a mirror, filter, and APD arrays (with their respective functionalities). As of 2012 (and after), fluorescence detection systems that used diverging light with APDs separated wavelengths of light by diffraction with, e.g., a diffraction grating or prism. (*See, e.g.*, EX1101, FIG. 1, 8:59-9:1, 9:5-12, 9:21-26, 10:37-46.) This separate technology involved a fundamentally different configuration relying on different optical principles than the claimed invention.

C. Ground 3: Claims 1-3, 5-14 Lack Written Description Support for an “optical fiber”

115. Claim 1 recites an “optical fiber,” which a POSA would have understood to include both single-mode and multi-mode optical fibers. The breadth

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of the term “optical fiber” in Claim 1 is confirmed by Claim 16, which more narrowly recites a “multimode optical fiber.” The ’107 written description identifies both single-mode and multimode optical fibers but directs its disclosures of the claimed WDM solely toward an implementation with a multimode optical fiber. In my opinion, a POSA reviewing the ’107 written description would not have thought that the inventor had possession of a WDM that operates with the broader class of optical fibers when only the use of a multimode optical fiber with a WDM is supported by the written description.

116. The ’107 written description provides no disclosures for how its WDM would operate with a single-mode optical fiber but instead *distinguishes* the purported invention from technology that relays light from a single-mode optical fiber. The ’107 written description claims that “[t]he only industry where APD has found wide acceptance is in optical communication” and (incorrectly) contends that “[i]n optical communication, the light is a laser beam out of single mode optical fiber.” (’107, 44:20-25.) The ’107 written description goes on to argue that “[a] fundamental reason[] preventing the use of small area APD in fluorescence detection instrumentation is the well-known theorem of etendue conservation: the fluorescence light coming through a pinhole or **multimode optical fiber** is an

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extended light source with an etendue hundreds of times greater than that of a laser beam out of a single mode optical fiber.” (*Id.*, 44:33-39 (emphasis added).) The ’107 written description then indicates that “a technology capable of collimating a large etendue light beam over an extended distance without significantly expanding the beam diameter would be highly desirable.” (*Id.*, 44:47-50.) A POSA would have thus understood that the inventor sought to solve the problem of how to efficiently demultiplex and detect fluorescent light (using APDs) for a large etendue beam from an extended light source, such as a multimode optical fiber.

117. What follows from the ’107 written description’s framing of the issue to be solved are disclosures directed toward a WDM that demultiplexes and detects fluorescent light originating from an extended light source, such as a multimode optical fiber. The ’107 describes with respect to FIG. 25 “fluorescent light going through a pinhole or emitted from the facet of a multimode optical fiber, such as the optical fiber **852** depicted in FIG. 1” that “forms an extended object or light source at location **901**, i.e., the optical input of the WDM **90**.” (’107, 44:56-61.) The ’107 written description again distinguishes the purported invention’s use of a multimode optical fiber from applications using a single-mode optical fiber, explaining that “[t]he size of the object is defined by ... the core diameter of the multimode optical

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fiber” and that “the core diameter of the multimode optical fiber is measured in millimeters, *in contrast to the diameter of single mode optical fibers* that are measured in micrometers.” (*Id.*, 44:61-66 (emphasis added).) The ’107 written description again distinguishes its current application of a multimode optical fiber from single-mode optical fibers, stating that “the etendue of the fluorescence light source, defined as the product of beam size and its divergence angle, is hundreds times greater than its counterpart in optical communication.” (*Id.*, 44:67-45:3.) All disclosures related to the WDM embodiments refer to a multimode optical fiber as an extended light source. (*See id.*, 46:29-30 (referring to “[a] beam of light which emits from the facet of the optical fiber **852**” (underlining added)), 46:41-43 (same), 48:39-42 (describing an “embodiment of the present disclosure ... for optically processing a beam of light from an extended light source.” (underlining added))).) A POSA would have recognized that all references to “optical fiber **852**” in the disclosed embodiments refer to a multimode optical fiber, as the ’107 written description refers to optical fiber **582** as an example of a multimode optical fiber that is also an extended light source. (*Id.*, 44:58-60.) Collectively, a POSA would have perceived these many disclosures as teaching *away* from use of a single-mode optical fiber as an extended light source with the disclosed WDMs.

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118. The '107 written description lacks any disclosures that use a single-mode optical fiber as a light source with the disclosed WDMs, nor would a POSA have recognized that the inventor had in his possession a purported invention that used a single-mode optical fiber. While the '107 written description includes a generalized statement that “various aspects of the present disclosure are not limited to specific numbers of ... optical fibers,” no parallel statements exist as to the *kind* of optical fiber that may be used. ('107, 49:59-65.)

119. The applicant also did not consider a single-mode optical fiber to be an “extended light source” in the '107's written description to suggest the use of a single-mode optical fiber with the disclosed WDMs. In the prosecution history for the parent '412 patent, the applicant indicated that a single-mode optical fiber was a “point light source.” The applicant argued that the use of a single-mode optical fiber in the optical system disclosed in U.S. Publication No. 2004/0165828 filed by Capewell taught against combining Capewell with Oostman that used a multimode optical fiber instead.

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and focusing elements to form a beam emitted from a light source, and a photomultiplier tube to detect the beam. *See Oostman*, at col. 6, lns. 40-49. In *Oostman*, the photomultiplier tube is used to detect light emitted from a pinhole or a multimode optical fiber (common light source of the detector) in fluorescence detection instrument, e.g., flow cytometer. The size of an object of such light source is usually measured in millimeters. *See* specification, on p. 69, lns. 19-22; *see also Oostman*, at col. 10, lns. 25-47. However, such light source has an etendue hundreds of times greater than that of a laser beam out of a single mode optical fiber, and, therefore, it is more difficult to focus a beam from such light source down to a small size. *See* specification, on p. 69, lns. 1-8. As such, a photomultiplier tube, as illustrated by *Oostman* in detail, instead of a semiconductor detector with a small active area, is normally used to detect light with greater etendue in fluorescence detection instrument in the prior art. *Id.*

On the contrary, *Capewell* teaches an optical communication system that includes multiple optical assemblies to collimate and redirect a beam emitted from a light source, and a detector to detect the beam. *See Capewell*, at ¶s [0002] and [0039]. In *Capewell*, the detector is used to detect light emitted from a point light source, such as a single mode optical fiber, in a WDM to be used with a communication system. *Id.*, at ¶ [0030]. The size of an object of such point light source is usually measured in micrometers. *See* specification, on p. 69, lns. 22-23; *see also Capewell*, at ¶ [0049]. As such, such point light source has much less etendue than a bigger light source. *See* specification, on p. 69, lns. 1-8.

From the foregoing, it is clear that *Oostman* and *Capewell* discuss different kinds of optical systems (fluorescence detection instrument v. optical communication system) with different sizes of light sources. The Office Action fails to provide any explicit analysis to

(EX1029, p.084 (October 27, 2016 Reply to Office Action of June 27, 2016)
(highlighting added).)

120. Use of a single-mode optical fiber is also not inherent to the '107's

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description of using an optical fiber to transport light from the flow cell to the WDM. Single-mode optical fibers were (and are) usually manufactured for a limited bandwidth, i.e., a single center wavelength with minimal spread. This design choice is contrary to the '107 written description's goal to guide fluorescent light of many different wavelengths to the WDM for demultiplexing and processing. (*See also* EX1102, p.003 (describing advantageous use of multimode optical fibers from telecom for guiding light from objective to detectors because of high numerical aperture).)

121. In summary, the multiple disclosures in the '107 written description and related file history would have demonstrated to a POSA to a reasonable degree of certainty that the inventor lacked possession of any WDM that used a single-mode optical fiber. Rather, the '107 written description teaches away from using a single-mode optical fiber with the disclosed WDMs.

D. Ground 4: Claims 1-3, 5-14 Are Not Fully Enabled with Respect to “optical fiber”

122. As no written description support exists for the broader class of “optical fiber” in Claims 1-3 and 5-14, I similarly find that these claims are not fully enabled as to the use of a single-mode optical fiber with the recited WDMs. The specification lacks any enabling disclosures for making or using the claimed WDM with a single-

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mode optical fiber, and a POSA would not have been able to implement such a design without undue experimentation. I provide my analysis under the *Wands* factors below.

123. ***Wands Factor Nos. 1 and 2 – Breadth of the Claims and Field or Nature of the Invention and Level of Ordinary Skill.*** With respect to *Wands* Factor No. 1, Claims 1-14 recite an “optical fiber” that is broader than “multi-mode optical fiber” recited in Claim 16 and would capture single-mode optical fibers. *Wands* Factor No. 2 that I discussed in Ground 2 is also incorporated here.

124. ***Wands Factors Nos. 3 and 4 – State of the Prior Art at the Time of the Invention and Level of a POSA.*** As of September 3, 2024, a POSA would have been aware of using multimode optical fibers to transport light from collection optics to a WDM in a flow cytometer, but not single-mode optical fibers. This is because a POSA would have understood that optical fiber used to deliver light to the WDM must have high light collection efficiency, low sensitivity to bending and mechanical displacements, low sensitivity for mechanical positioning, and be cost-efficient. Single-mode optical fibers lack these key technical features and are an inferior choice compared to multimode optical fibers for routing light collected and focused by the collection optics of the flow cytometer to a WDM. I am not aware of any

flow cytometers in the art that use a single-mode optical fiber for this purpose.

125. *Wands Factors Nos. 5-8 – Predictability, Guidance from the Specification, Working Examples, and Amount of Experimentation.* As explained for Ground 3, incorporated here, the specification offers no guidance or working examples to teach a POSA how to make or use the claimed WDM with a single-mode optical fiber and instead teaches away from its implementation. The applicant also expressly distinguished the claimed invention from optical communications systems (e.g., *Capewell*) during prosecution of the parent '412 patent on the distinction between using single-mode optical fiber versus multi-mode optical fiber (and collimating a large etendue light beam).

126. In my opinion, a POSA would have had to engage in an excessive amount of experimentation required to implement an operable version of the claimed WDM (with APDs) using a single-mode optical fiber. Single-mode optical fibers have considerably smaller core diameters and numerical apertures that, if used, would result in a signal loss of almost ninety-percent compared to multimode optical fibers.

127. The '107 specification teaches that an optical fiber is positioned between a composite microscope objective and the WDM to serve the purpose of

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routing fluorescent light gathered and focused by the composite microscope objective to the WDM for processing. (*E.g.*, '107, 28:19-27, FIG. 1 (item **852**).) The composite microscope objective gathers and focuses light scattered and/or fluoresced by particles to images on an image plane (*see id.*, FIG. 9A, 34:44-67), represented by spot diagrams in FIGs. 9B1 through 9B3 (*id.*, FIG. 9B1, FIG. 9B2, FIG. 9B3, 35:20-25). A POSA would have understood these image locations to also be the position of the optical fibers that would route collected and focused light to the WDM. The '107 specification teaches that the diameter of these images “may be less than 35 microns,” (*id.*, 35:20-25), indicating to a POSA that, at a minimum, the optical fiber must have a core diameter greater than 35 microns to avoid significant signal loss.

128. The amount of fluorescent light guided into the WDM by an optical fiber is affected at its input end by (1) light transport from the source towards the optical fiber (*e.g.*, properties of the composite microscope objective) not discussed here; and (2) the light coupling efficiency of light into the core of the optical fiber. The goal is to minimize optical power (*e.g.*, signal) losses in order to maximize optical power transfer into the optical fiber and the WDM. Coupling efficiency can be determined from a ratio of the measured optical power input coupled into the

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optical fiber over the measured optical power provided by the light source directed at the optical fiber.

129. There are three different loss factors to consider to maximize coupling efficiency into an optical fiber: geometrical losses, Fresnel losses (not discussed here), and angular losses. (EX1092, p.003.) I discuss here the geometrical losses and geometrical coupling efficiency because it is effected by the core diameter selected for the optical fiber. For geometrical losses, assuming substantial optical alignment within an acceptance cone, there is a couple of conditions to consider in comparing the light source dimensions (e.g., light spot size) with the fiber core diameter. (*Id.*, pp.003-004.) If the light source dimensions are smaller than the fiber core area, then from a geometric standpoint, all of the optical power in the light from the light source can be coupled into the optical fiber such that the geometric coupling efficiency is one. If the light source dimensions are larger than the fiber core area, then from a geometric standpoint, the coupling efficiency is directly proportional to the square of fiber core diameter as set out in the equation $\eta_{geo} = \left(\frac{\pi \phi^2}{4H \times L} \right)$ where ϕ is the fiber core diameter, H is the height of spot size, L is length of spot size with $H \times L$ computing the area of the spot size. (*Id.*) Accordingly, an optical fiber with a larger core diameter will be able to accept more light than a smaller core diameter.

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130. Ignoring angular distribution of light from a light source, a major contributor to coupling efficiency into an optical fiber is the angle of the light source with the face at the end of the optical fiber defined as the acceptance angle. The acceptance angle is related to the fiber numerical aperture (NA) by the equation $\theta_{fiber} = \arcsin(NA)$. (EX1092, p.005.) Generally, optical fibers with a greater acceptance angle (correlated to having a higher numerical aperture) have a higher coupling efficiency than optical fibers with a smaller acceptance angle (correlated to having a lower numerical aperture).

131. A POSA would have understood that an optical fiber with a larger core diameter and higher numerical aperture would be necessary to minimize photon loss between the collection optics in the flow cytometer to the fiber optic pickup to render the claimed WDM, with its APD detectors, operable. (See, e.g., EX1104 (Application No. 6).) As discussed in Section IV.C, while APDs exhibit highly sensitive detection capabilities and fast response times, they have high dark current and require a greater signal-to-noise ratio for operation.

132. The requirement for a greater signal-to-noise ratio is unmet when using a single-mode optical fiber to route light to the WDM. The '107 specification indicates that the core diameter of single-mode optical fibers are "measured in

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micrometers,” in contrast to the core diameter of a multimode optical fiber being measured “in millimeters.” (’107, 44:63-66.) Commonly available single-mode optical fibers capable of transporting visible light typically has a core diameter between 2.5 to 4.6 microns with a small numerical aperture (around 0.1). (*See, e.g.*, EX1093.) In contrast, a multimode optical fiber capable of transporting visible light typically has a core diameter at or above 50 microns with a larger numerical aperture of 0.2 or more. (*See, e.g.*, EX1094, EX1095.)

133. The parameters for a single-mode optical fiber would render the claimed WDM inoperable, and a POSA would have had to engage in undue experimentation in the overall design of the flow cytometer to accommodate the technical limitations of the single-mode optical fiber. As explained above, the ’107 specification teaches that the core diameter of a single-mode optical fiber is one-tenth of the image diameter taught by the ’107 specification, and its use (including with a narrow acceptance angle) would cause significant signal loss as compared to using a multimode optical fiber. Accordingly, a weak resultant signal transported to the WDM by a single-mode optical fiber would provide a lower signal to noise ratio and be inadequate to allow APDs, with their inherently high dark current, to be used.

134. The specification provides no guidance about what changes would need

to be made to the overall system to accommodate the use of a single-mode optical fiber. A POSA would have had to engage in undue experimentation to build and/or use the claimed WDM with a single-mode optical fiber (if it could be done). This is confirmed by the absence of flow cytometers in the art today using a single-mode optical fiber with APD detectors to detect fluorescent light.

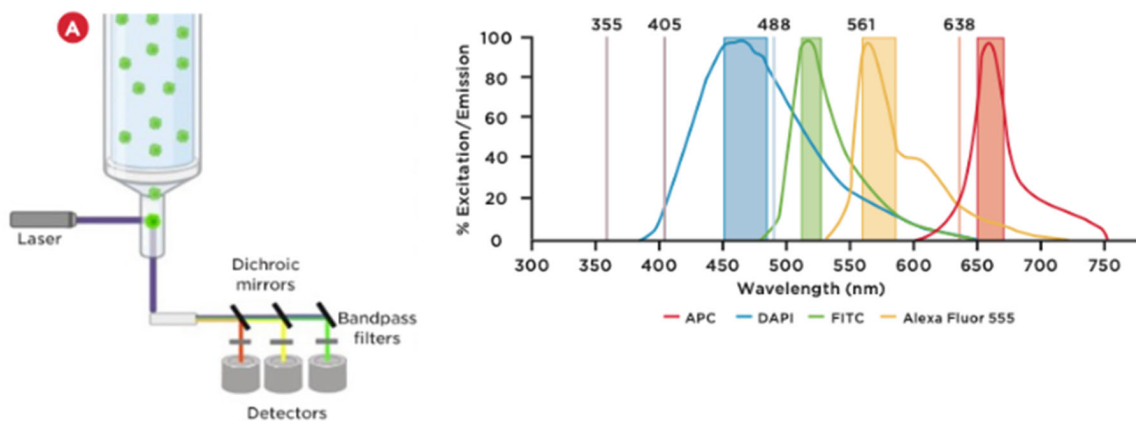
E. Ground 5: Claims 9 and 29 Lack Written Description Support

135. Claims 9 and 29 each recite the additional claim element that the “WDM is capable of detecting a substantially full spectrum of visible light.” A POSA reviewing this claim language would have interpreted Claims 9 and 29 to cover a WDM with non-conventional spectral flow cytometry capabilities. In my opinion, the ’107 written description lacks any disclosure directed to a non-conventional spectral flow cytometer, and instead includes contrary teachings on replaceable dichroic filter assemblies and detecting fluorochrome emission peaks that would have indicated to a POSA that the claimed WDM was used in conventional flow cytometers that process voltage pulse data by binning per known wavelength emission peak and compensating to account for spectra overlap (spill over) between adjacent fluorochromes.

136. Conventional flow cytometers process fluorescent light to capture

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fluorescence signals using a combination of dichroic mirrors and bandpass filters, where bandpass filters pass a color band (pass band) centered about a known emission peak of a fluorochrome. Photons with wavelengths in that color band pass through and are then focused into a photodetector. Patent Owner's website provides an exemplary configuration of four color bands (indicated in blue, green, orange, and red rectangles on right) for four different bandpass filters and fluorochromes directed into four different photodetectors of a conventional flow cytometer, which is similar in principle to the claimed WDM:



(EX1096, Fig. 1A.) The full fluorescent light emission of each fluorochrome is plotted in the chart over the spectrum. An ideal bandpass filter characteristic is represented by the colored rectangles indicating what fraction of the spectrum that a photodetector can capture for the fluorochrome fluorescent light spectral emission.

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There are one or more significant spectral gaps between the color bands of the four ideal bandpass filter characteristics where light is not detected. However, the fluorescent light spectral emission can still spill over into adjacent color bands. For example, the blue DAPI, green FITC, and orange ALEXA Fluor 555 plots spillover into the red rectangle (ideal bandpass filter) that is used to capture the peak intensity of the red APC plot. One obvious option to reduce the effects of spill over into other detectors is to separate the adjacent color bands to be further apart, forming larger gaps if practical. Bandpass filters can be selected with pass bands having more separation between them with the fluorochromes having peak emission wavelengths to match. Another obvious option to avoid spill over would be to mark particles or biological cells with fluorochromes that have narrower bandwidth emission characteristics and use bandpass filters with narrower pass bands to match if practical. Accordingly, having replaceable bandpass filters to match the selection of fluorochromes is desirable in a conventional flow cytometer to achieve better results in the analysis of a sample of unknown counts of a plurality of different biological cells or particles. Additionally, with a limited number of photodetectors, replaceable bandpass filters are useful to support usage of a wider variety of fluorochromes for a wider variety of analysis of biological cells and particles in a single test tube.

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Indeed, with reference to FIGS. 29A-29C, the '107 patent describes “fabricating a replaceable dichroic filter assembly **934** illustrated in FIG. **29C** suitable for small area detectors” for its WDM. ('107, 48:1-3, 48:33-36 (underlining added).)

137. When photons of fluorescent light pass through a bandpass filter within its color band and enter the photodetector (e.g., APDs), the photons are converted into electrons that are multiplied by the photodetector to form an analog current signal (photocurrent). Generally, the analog current signal is then amplified and converted from the analog current signal into an analog voltage signal by a transimpedance amplifier or preamplifier. Over the total period of time of an event, when a laser interacts with each fluorochrome attached to a cell or particle so that it emits fluorescent light, the analog voltage signal varies over periods of time of the event forming a voltage pulse (also called a signal pulse). Over periods of time during the event, the analog voltage signal is further sampled and converted by an analog-to-digital converter into digital numbers for each time period. (*See* EX1097, FIG. 7.) The digital numbers over the time periods representing the voltage pulse are transferred to a computer for analysis and storage. (EX1097.) Generally, each voltage pulse for each event has three attributes of interest—height (amplitude), full pulse width (overall sum of time periods over the event), and area (integration or

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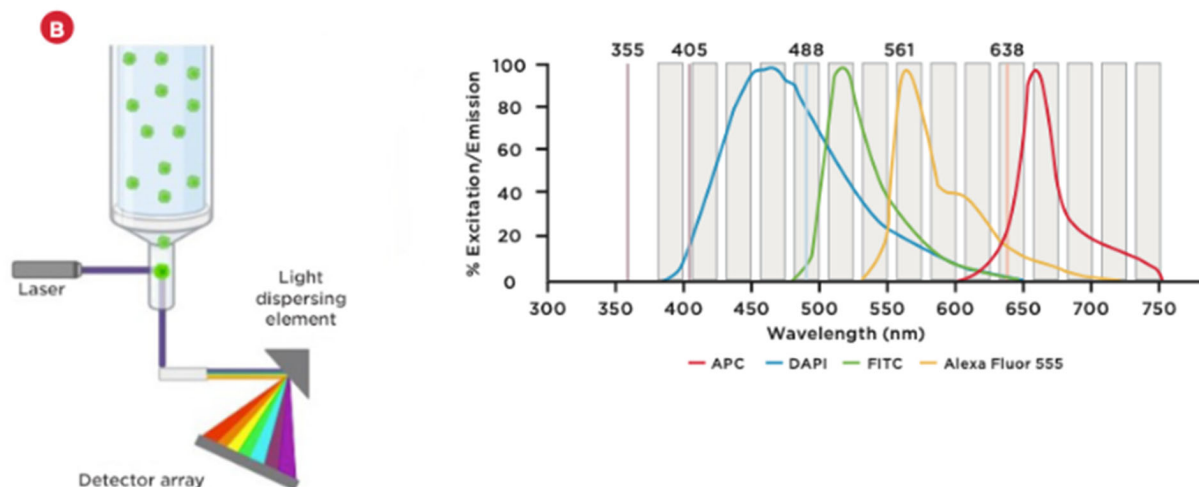
summation of amplitude multiplied by time periods over the event)—that can provide different information to identify and count the target material (particle or cell to which the fluorochromes were attached) of interest in a sample with a plurality of particles or cells. (*Id.*) For each event, the voltage pulse data from each detector then goes through a process called “binning,” where the voltage pulse data (height, full pulse width, area) for each event (e.g., cell) of each target material is assigned a bin or bucket of a plurality based on its digital value. (*See* EX1097, FIG. 6.) To adjust for spillover in a conventional digital flow cytometer, compensation for each detector channel can be applied to the voltage pulse data to separate out spectra overlap between adjacent fluorochromes that bleed or spill over from adjacent color bands. (*See* EX1096, FIG. 7A.) When the sample of a plurality of particles or cells in a test tube are all examined by events with each laser, all of the data from all events aggregated into the plurality of bins form a sample distribution for each detector channel, including each fluorescent detector channel associated with emission peaks within each color band. The sample distribution for each detector channel can be used to form dot plots or histograms on a computer display. (*See* EX1097, computer display in FIG. 8.) The sample distribution of the sample for each fluorescent detector channel is formed by using fluorochrome emission peak

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wavelength detection methods using mirrors and bandpass filters, where each fluorescent photodetector corresponds to a known emission peak wavelength for a given fluorochrome.

138. In contrast, for each event, spectral flow cytometry detects the *entire emission* of fluorescent light substantially over the whole visible range of the spectrum, where the number of detectors exceeds the number of fluorochromes used to mark cells or particles in a sample. (EX1098, p.019; *see also* EX1096, right side of FIG. 1B.) Patent Owner's website provides an illustrative spectral flow cytometry configuration for dispersing fluorescent light into different wavelength bands and detection by a detector array during each event. Fifteen (15) different wavelength bands (shown by grey rectangles) are used to detect fluorescent light emitted by four fluorochromes (plotted in blue, green, orange, and red curves) substantially across the visible light spectrum during each event:

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(EX1096, FIG. 1B.) Notably, the configuration shown on Patent Owner’s website employs a light dispersing element (e.g., grating or prism instead of WDM) that is unclaimed and not discussed with respect to the ’107 written description’s WDM disclosures. (See EX1096, left side of FIG. 1B.)

139. A “major difference” between conventional flow cytometry and spectral flow cytometry “lies in the way the contribution of each fluorochrome is separated from similar signals[.]” (EX1096, p.009.) Whereas conventional flow cytometers use compensation to correct for overlapping spectra (spill over) from adjacent fluorochromes to isolate individual contribution, spectral flow cytometers use deconvolution to “unmix” the mixed fluorescent signals of a plurality of fluorochromes that are detected across the entire spectrum by each and every

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detector. (EX1098, p.019 (underlining); *see also* EX1096, FIG. 7.) Generally, the predetermined spectral signature of each individual fluorochrome for every detector channel is used by sophisticated computer algorithms to distinguish between different fluorochromes based on differences in their overall emission profiles substantially extending across the visible light spectrum. (*See* EX1097, FIG. 6; EX1098, p.019.) The resultant differences between these two data processing techniques for two fluorochromes is shown below in a simplified manner, again from Patent Owner's website:

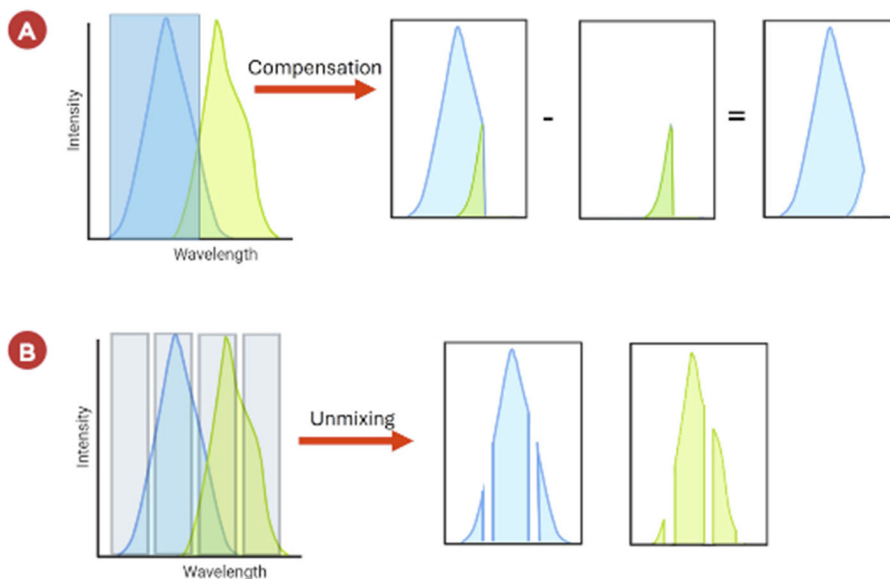


Figure 7. Graphical representation of differences between compensation used in traditional flow cytometry and unmixing used in spectral flow cytometry. **(A)**Graph on the left side shows overlapping spectra of 2 fluorescent signals (for example, from different fluorophores). After compensation, the overlapping signal, as seen for the blue detector, is adjusted by reducing the interference from spillover. **(B)**Graph on the left side shows data being captured by a spectral flow cytometer where unmixing process uses more detectors than fluorophores to deconvolute signals, showing individual isolated spectra for each fluorophore.

(EX1096, p.009, FIG. 7.)

140. The '107 written description nowhere describes how the claimed WDM (and its detectors) has spectral flow cytometry capabilities. Instead, the written description is clear that the disclosed WDM is configured only for emission peak wavelength analysis as is performed in conventional flow cytometers:

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Detecting and analyzing brightness changes in a combination of scattered and fluorescent light at each detector (one for each fluorescent emission peak) permits deriving various types of information about the physical and chemical structure of each individual particle.

(’107, 27:45-49 (underlining added).) Spectral flow cytometers, as discussed, have more detectors than fluorochromes to capture the full emission spectrum.

141. This conclusion is confirmed by the ’107 patent’s disclosures of a “replaceable dichroic filter assembly,” which would be unnecessary in a spectral flow cytometer. The ’107 specification describes how, “to accommodate different types of fluorescence probe, various techniques have been developed to enable user selection of dichroic filters suitable for their particular needs.” (’107, 47:54-56.) The patent continues to describe a replaceable dichroic filter assembly, including a replaceable dichroic filter **927**, and how filter replacement is expected to occur, presumably to “accommodate different types of fluorescence probes.” (*Id.*, 48:39-42 (use of “replaceable dichroic filter assembly” in WDM), 48:46-50 (describing a replaceable assembly mounted to a glass reference block by a spring-loaded screw), 48:53-56 (describing filter replacement), FIG. 30A (showing replaceable dichroic filters **934** in assembly.) In a spectral flow cytometer, filters are positioned before

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detectors and there would be no need to replace them for different applications (e.g., different fluorochromes), as a spectral flow cytometer system substantially collects the entire emission spectrum for fluorochromes and then unmixes their respective spectral signatures with computer algorithms.

142. The recent state of the art supports my conclusion that Claims 9 and 29 lack written description support. As late as 2023, spectral flow cytometers were marketed by Sony, Thermo Fisher Scientific, and Petitioner, with Becton Dickinson having also released a “module for spectrally enhanced cytometric analysis” with its FACSymphony A5 SE instrument. (EX1098, p.019.) But Patent Owner had no such commercially-available spectral flow cytometer (or spectral flow cytometry module) by 2023 or anytime earlier. Patent Owner only recently announced a spectral flow cytometry add-on module for its CytoFLEX on March 18, 2025, over a decade after the inventor submitted the PCT App. (EX1099; EX1100.) Spectral flow cytometry capabilities were unavailable with the Patent Owner’s CytoFLEX flow cytometer before then.

F. Ground 6: Claims 9 and 29 Are Not Enabled

143. As no written description support exists for Claims 9 and 29, I similarly find that these claims are not enabled, and a POSA would not have been able to

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practice a “WDM [that] is capable of detecting a substantially full spectrum of visible light” without undue experimentation. With respect to *Wands* Factor No. 1 (Breadth of the Claims), Claims 9 and 29 broadly recite that a “WDM is capable of detecting a substantially full spectrum of light,” and a POSA would have understood reading the claims that Patent Owner sought to cover techniques in spectral flow cytometry despite the lack of enabling disclosure in the specification. Under *Wands* Factor Nos. 6 (Guidance from the Specification) and 7 (Working Examples), the ’107 specification provides no teachings or working examples to enable spectral flow cytometry capabilities in the claimed WDM but instead contains multiple passages that confirm that the claimed WDM is implemented in a conventional flow cytometer that measures fluorochrome emission peak wavelength signals and performs compensation. (*See* ’107, 27:45-49, 47:54-56, 48:39-42, 48:46-50, 48:53-56, FIG. 30A; *see also* Ground 5.) Finally, a POSA would have required excessive experimentation (*Wands* Factor Nos. 3, 8) to arrive at the functionality recited in Claims 9 and 29. As explained in Ground 5 above, as late as 2023, spectral flow cytometers were marketed by only a handful of companies, and notably not Patent Owner. (EX1098, p.019.) Despite filing the original PCT App. in May 2013, Patent Owner took over a decade to develop a spectral flow cytometry add-on module for

its commercialized CytoFLEX flow cytometer product, strongly indicating that the inventor's disclosures were not enabled with respect to Claims 9 and 29. (EX1099; EX1100.)

G. Ground 7: Claim 30 Lacks Written Description Support

144. Claim 30 depends from multiple claims that trace back to Claim 16 and further recites “the plurality of mirrors comprise five or more mirrors; and the plurality of filters comprise six or more filters.” (’107, cl. 30 (underlining added).) In my opinion, the written description does not support claiming a “plurality” in such an unbound matter. As written, Claim 30 could conceivably cover a WDM with hundreds of mirrors and filters when a POSA would not have understood the inventor to have been in possession of an operable version of such a hypothetical device.

145. The ’107 written description *only* supports the specific number of filters and mirrors recited in Claim 30 (that also perform the functions recited in Claim 16). FIG. 25 depicts an exemplary six-port WDM with six dichroic filters (**903, 909, 914, 915, 916, 917**) and five mirrors (**907, 910, 911, 912, 913**) where each optical component performs the recited functions in Claim 16. (’107, 45:35-46:6, FIG. 25.) While the ’107 specification baldly claims that “it is readily apparent to those skilled

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in the art that WDM's having different numbers of ports can be easily built in accordance with some embodiments of the present disclosure," (*id.*, 46:9-12), a POSA would not have understood this nondescript passage to indicate the inventor's possession of an infinite number of filters and mirrors within the claimed WDM.

146. The lack of written description for "or more" is made clear by admissions in the written description that light from an extended source "can only be kept collimated for a very limited distance," ('107, 45:5-9), and the fact that a collimated beam will nevertheless have some minor divergence overall, resulting in some photon loss that increases with optical distance along the optical path. (*See* Ground 1.) The written description does not explain how to compensate for this photon loss over an infinite set of mirrors and filters, particularly when independent Claim 16 recites a WDM that may include relaying a non-collimated beam. This is especially true for Claim 30, where the claims are directed to a "plurality of *mirrors*," that need only include a single concave mirror, not a plurality of concave mirrors that may be able to re-collimate the beam at certain intervals along the optical path.

**IX. DETAILED EXPLANATION OF THE UNPATENTABILITY
GROUNDS UNDER 35 U.S.C. § 103**

147. I have reviewed and analyzed the prior art references and materials

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listed in Section I.B above. In my opinion, the claims of the '107 patent would have been obvious to a person of ordinary skill in the art based on the following combinations of the prior art:

Ground	Claim(s)	Basis for Challenge
8	1-3, 5-14, 16-18, 20-22, 26-30	Unpatentable under 35 U.S.C. § 103 as obvious over Chandler and Goodman
9	13, 14, 17, 18	Unpatentable under 35 U.S.C. § 103 as obvious over Chandler, Goodman, and Hamamatsu
10	1-3, 5-14, 16-18, 20-22, 26-30	Unpatentable under 35 U.S.C. § 103 as obvious over Oostman, Goodman, and Frazier
11	13, 14, 17, 18	Unpatentable under 35 U.S.C. § 103 as obvious over Oostman, Goodman, Frazier, and Hamamatsu

148. I understand that each of the references cited in the grounds identified above qualifies as prior art to the Challenged Claims because each reference was effectively filed or published more than a year before the '107 patent's earliest possible effective filing date of September 2024. I next provide a summary of these references before applying them to the claims.

A. Brief Summary of the Prior Art

1. Chandler [EX1051]

149. U.S. Patent No. 6,139,800 to Chandler ("Chandler"), titled "Interlaced

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Lasers for Multiple Fluorescence Measurement,” discloses a flow cytometer that uses multiple lasers to irradiate fluorescence-tagged materials in a flow cell and color-separates and detects scattered and/or fluorescent light from the irradiated fluorescence-tagged materials in a detection subsystem called an “FADC unit.” (Chandler, 4:62-5:4, 5:23-33, 7:24-45.) I am informed that Chandler qualifies as prior art because it issued on October 31, 2000, more than one year before the filing date of the earliest patent application to which the ’107 patent claims priority.

150. Chandler teaches an improved fluorescence-detection based flow cytometer where multiple light sources (e.g., lasers) may irradiate fluorescence-tagged materials within a flow cell (called a “viewing chamber”) and fluorescent and/or scattered light is then gathered by multiple collecting optical units (called “optical detectors”) that route collected light through multi-modal fiber optic cables to coupled filtering, amplification, and digital conversion units (FADC units) for demultiplexing and signal processing. (Chandler, 4:62-5:4, 5:23-33, 7:24-45.) FIG. 4 provides a representative configuration:

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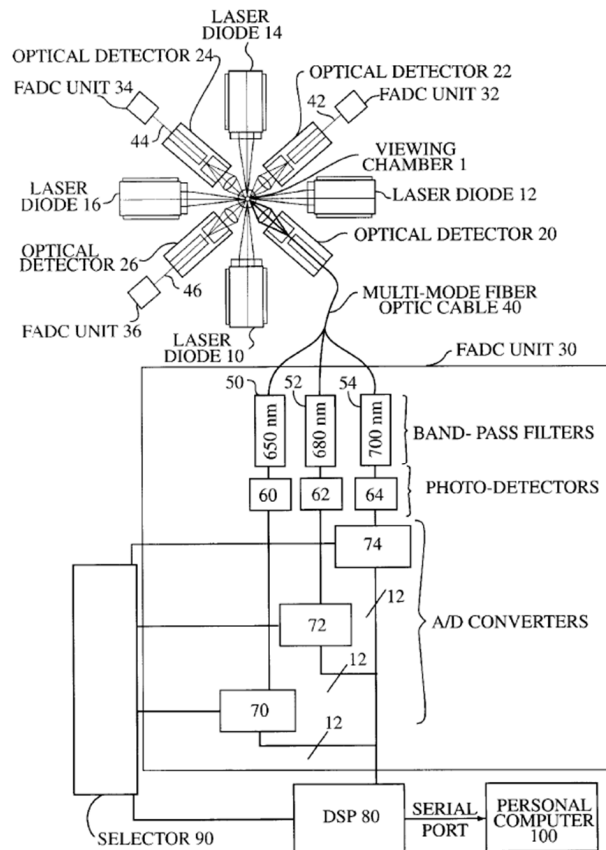


FIG. 4

(*Id.*, FIG. 4.)

151. Each FADC unit consists of a set of standard bandpass filters **50, 52, 54**; a set of standard photodetectors **60, 62, 64**; and a set of standard analog to digital converters **70, 72, 74**. (Chandler, 3:66-4:15, 7:46-49.) Chandler explains that the photodetectors may consist of either photomultiplier tube detectors (PMTs) or avalanche photo-diode detectors (APDs). (*Id.*, 4:6-8, 5:30-32, 8:32-34.)

2. Goodman [EX1016]

152. U.S. Patent No. 6,542,306 to Goodman (“Goodman”), titled “Compact Multiple Channel Multiplexer/Demultiplexer Devices,” discloses a “compact demultiplexer device based on wide wavelength division multiplexer bandpass filters.” (Goodman, 1:9-12.) I am informed that Goodman qualifies as prior art because it was issued on April 1, 2003, more than one year before the filing date of the earliest patent application to which the ’107 patent claims priority.

153. Goodman explains that in a typical wavelength division (de)multiplexing (“WDM”) system, optical signals, generated by some light sources, are transmitted over a waveguide, such as an optical fiber and then demultiplexed into individual color bands to be routed to an optical detector, corresponding to each channel wavelength range. (Goodman, 1:46-52.) Goodman also identifies, and provides a solution for, conventional, bulky WDMs with optical attenuation issues. (*Id.*, 3:37-44.)

154. Goodman depicts an exemplary WDM device **10** in FIG. 1 below:

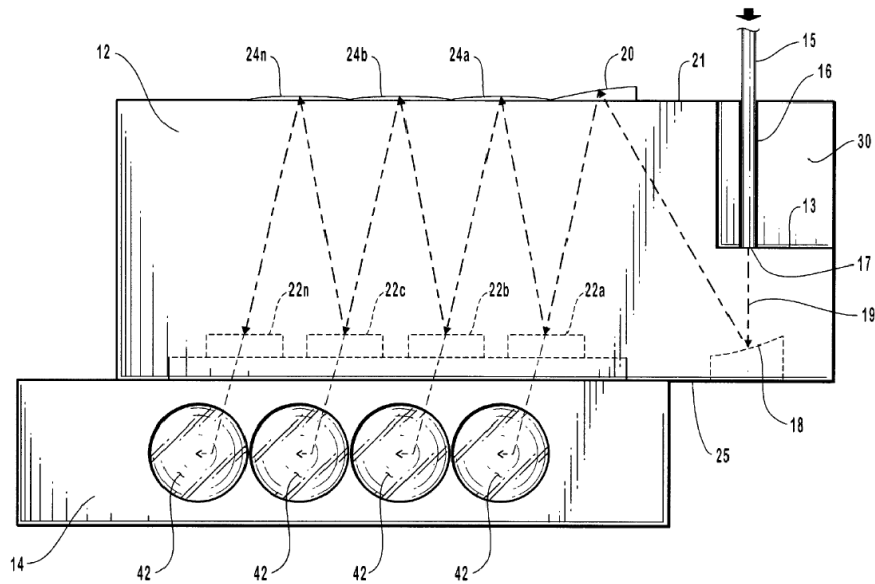


FIG. 1

(Goodman, FIG. 1.)

155. WDM device **10** includes an optical block **12**, configured to receive an optical beam **19** from an optical fiber **15**. (Goodman, 7:1-3, 7:17-21.) The optical beam **19** first impinges on imaging optical element **18** that reflects the beam to imaging optical element **20**. (*Id.*, 7:17-30.) Imaging optical element **20** then reflects optical beam **19** onto a first of a set of wavelength selective elements **22a-22n**. (*Id.*, 8:21-23.)

156. Wavelength selective elements **22a-22n** are further “each capable of transmitting a selected range of wavelengths within beam **19** and reflecting other wavelengths.” (Goodman, 8:23-26.) These wavelength selective elements can be

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dichroic filters, among other types, and separate each wavelength channel and demultiplex the entire multi-wavelength beam. (*Id.*, 9:16-49.) A set of reflectors **24a-24n** are positioned on the top surface of the optical block **12**, opposite from the wavelength selective elements **22a-22n**, such that “each of the reflectors directs beam **19** from one wavelength selective element to an adjacent wavelength selective element.” (*Id.*, 9:58-67.) Goodman also explains that “[t]he reflective surface can comprise at least one collimating reflector or at least one non-collimating reflector,” for example, “converging lenses or mirrors, collimating lenses or mirrors, or simple reflecting surfaces.” (*Id.*, 10:17-21.)

157. Selected ranges of wavelengths transmitted through wavelength selective elements **22a-22n** travel into a beam-directing member **14** that is configured to “redirect and focus the optical energy transmitted through wavelength selective elements **22a-22n**.” (Goodman, 10:45-51.) Beam-directing member **14** includes a set of focusing lenses **42** within each optical channel that focuses a selected wavelength beam into a corresponding optical receiver, such as a detector. (*Id.*, 11:30-41.)

3. Hamamatsu [EX1055, EX1056]

158. Hamamatsu refers to two archived website pages that depict

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commercial sale of small area APDs used in low light measurement applications, including use with flow cytometers. EX1055 discloses Hamamatsu's offer for sale part nos. S8890-02, S8890-05, S8890-10, S9251-02, S9251-05, and S9251-10 of small area APDs with active areas of 1 mm or less in diameter and spectral response ranges from 440 – 1100 nm (visible to near IR). EX1056 discloses Hamamatsu's offer for sale part nos. S5343, S8664-02K, S8664-05K, S8664-10K, S9073, and S9074 of small area APDs with active areas of 1mm or less in diameter and spectral response ranges from 200/320 nm to 1000 nm. I am informed that Hamamatsu qualifies as prior art because the website was publicly available at least as early as June 20, 2010, more than one year before the filing date of the earliest patent application to which the '107 patent claims priority.

4. Oostman [EX1005]

159. U.S. Patent No. 6,683,314 to Oostman ("Oostman"), titled "Fluorescence Detection Instrument with Reflective Transfer Legs for Color Decimation," discloses "an improved system for detecting fluorescent light having multiple colors emitted from a target[.]" (Oostman, 2:60-63.) The preferred embodiment of the invention features a flow cytometer that uses multiple WDMs for fluorescent and scattered light color band separation and detection. (*Id.*, 5:33-

37.) I am informed that Oostman qualifies as prior art because it issued on January 27, 2004, more than one year before the filing date of the earliest patent application to which the '107 patent claims priority.

160. Oostman discloses an optical instrument (flow cytometer) that includes multiple laser light sources, a flow cell, a collection lens, optical fibers, and a plurality of detector array clusters as depicted in FIG. 4 below:

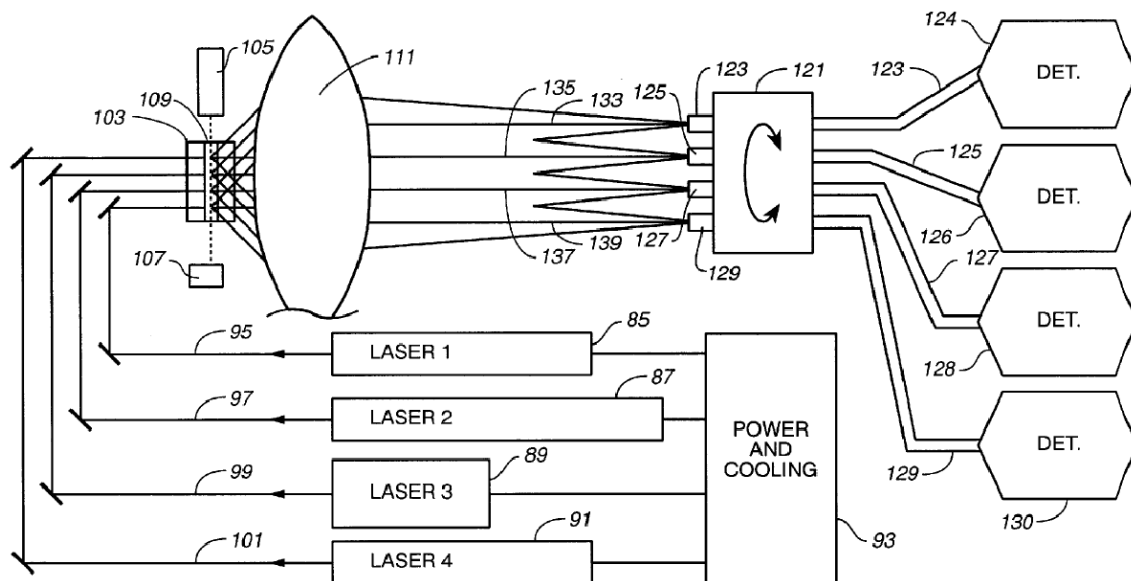


FIG. 4

(Oostman, FIG. 4.)

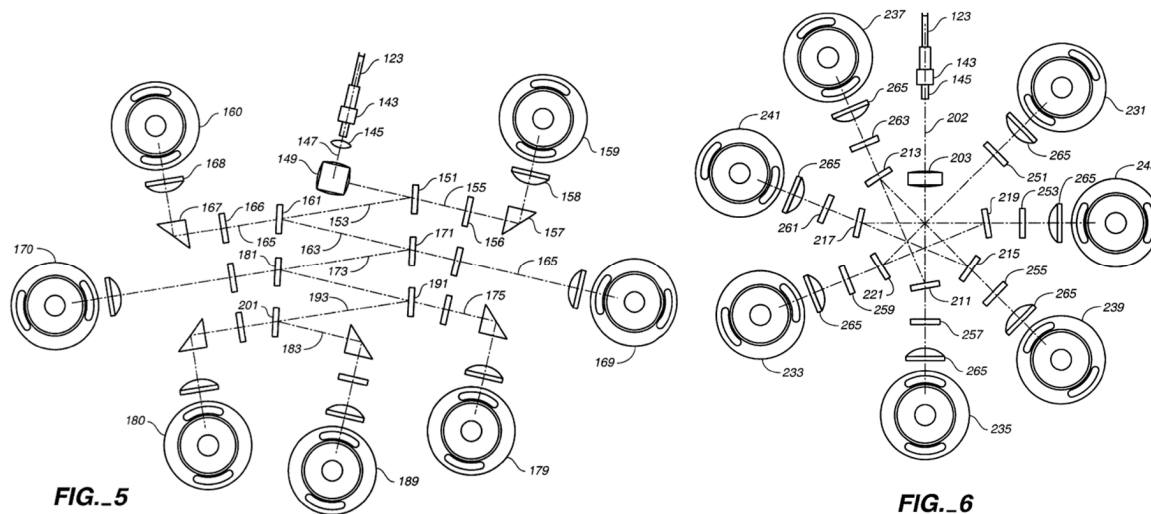
161. Each of lasers **85, 87, 89, 91** produces a beam of light with a unique wavelength that is directed toward a flow stream **103** in fluid system **105** that

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contains fluorescent dye-marked particles within a liquid sample. (Oostman, 5:27-33, 5:41-44.) Laser beams interact with the fluorescent dye-marked particles, “causing scattering and fluorescence that is spatially separated along a line parallel to the flow channel **109**.” (*Id.*, 5:58-62.) This impinging of the laser beams upon the fluorescent dye-marked particles of the liquid sample of flow stream **103** in flow channel **109** creates an “illuminated zone.” (*Id.*, 5:44-46.)

162. Scattered and fluorescent light is then “imaged by a lens light collector **111** to four respective optical fibers **123**, **125**, **127**, and **129**,” each of which is a multi-mode optical fiber. (Oostman, 5:63-6:7.) Light collected and focused into each optical fiber is then transmitted to a respective detector cluster **124**, **126**, **128**, **130**, which comprises an array of detectors. (*Id.*, 6:26-28.) “Each array of detectors differentially separates bands of light by filtering, using coatings on beam splitters and lenses, in a known manner.” (*Id.*, 6:34-36.)

163. Oostman’s FIG. 5 and FIG. 6 each shows a detector cluster with two polygonal WDM arrangements to demultiplex the fluorescent light into separate bands for each detector.



(Oostman, FIGs. 5, 6.) An optical fiber **123** guides light into each of Oostman’s polygonal WDMs within each detector cluster.

5. Frazier [EX1009]

164. U.S. Patent No. 8,284,402 to Frazier (“Frazier”), titled “Fluorescence Detection Instrument with Orthogonal Laser Entry,” discloses a “detector assembly for analysis of light emitted from [sic] a fluorescent material, an optical alignment assembly for introducing an output beam into a detector array or demultiplexer, and methods of demultiplexing a beam of light into wavelength bands.” (Frazier, Abstract.) In addition to the previously mentioned WDM disclosures, Frazier also indicates that its detectors can be “various ... types of photodetectors, for example, photo avalanche detectors[.]” (*Id.*, 4:19-20.) I am informed that Frazier qualifies as

prior art because it was filed on February 26, 2010, before the filing date of the earliest patent application to which the '107 patent claims priority.

B. Ground 8: Chandler in View of Goodman Renders the Challenged Claims Obvious

1. Motivation to Combine Chandler with Goodman and Reasonable Expectation of Success

165. A POSA would have found it obvious to combine Chandler's flow cytometers with Goodman's teachings regarding its wavelength division demultiplexer devices. Chandler, as modified by Goodman, would have predictably resulted in the substitution of the branched configuration of Chandler's bandpass filters within its FADC units with Goodman's more modular, efficient, cost-effective optical block demultiplexers.

166. Chandler identified in 1998 that a few "commercially available dyes that emit a spectrum of wavelengths narrow enough and sufficiently separated enough" to allow for individual, simultaneous measurements existed, and a large quantity of samples and longer measurement time were required for a "meaningful analysis." (Chandler, 2:38-42, 2:46-50.) Chandler sought to overcome this issue by using multiple lasers to excite a sample particle, resulting in "more assays or measurement per quantity of sample using the instant invention, thereby acquiring

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more information using a smaller quantity of the sample than using conventional flow cytometers.” (*Id.*, 3:23-26, 3:46-50.) In adding lasers, Chandler also associated a WDM (called a FADC unit) with each laser for demultiplexing and fluorescence/scatter detection. (*E.g., id.*, FIG. 4.)

167. While Chandler discloses that “any number of optical sources/detectors may be used[,]” (Chandler, 7:1-6), a POSA would have recognized by the configuration set out in FIG. 4 that each FADC unit had an associated footprint that would have to be managed and/or miniaturized with the ever-increasing number of light sources used to irradiate fluorescence-tagged material.

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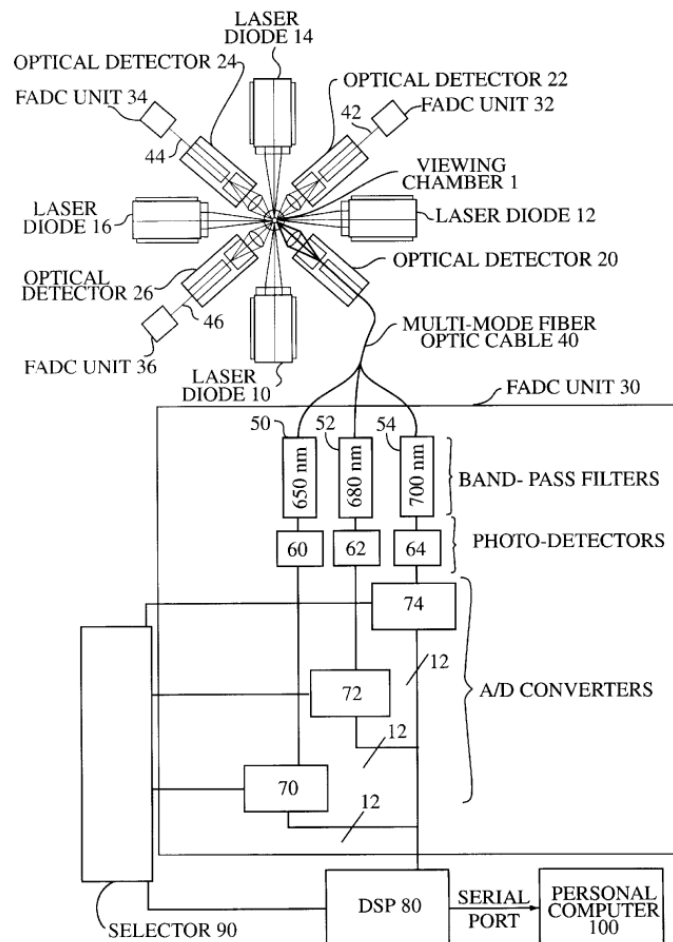


FIG. 4

(Chandler, FIG. 4.) Chandler expressly discloses a design goal to make conventional flow cytometers “small and inexpensive.” (*Id.*, 3:51-55.) But a POSA would have recognized that Chandler’s branched design in the FADC units was a suboptimal configuration for achieving Chandler’s stated goals, particularly if additional color separation per light source was desired. Within the FADC, a POSA would have recognized that adding bandpass filter in the branched configuration incrementally

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drives up costs.

168. A POSA seeking to reduce the footprint of Chandler's FADC units, while also ensuring efficient, accurate, and (if possible) expanded color separation and detection, would naturally have consulted alternate WDM arrangements, including Goodman. Goodman and Chandler are analogous references in the same fields of the alleged invention related to optical fibers and, more particularly, modular optical instruments (flow cytometers) for color separation and detection. (Chandler, 1:11-15 ("The invention relates generally to small particle measurement systems and/or methods, and more particularly, to flow cytometric systems and/or methods of fluorescence measurement, including, multiple fluorescence measurement."), 3:32-35 ("I have also determined that it would be desirable to have a system and/or a method for measuring multiple fluorescence wavelengths substantially simultaneously that is small and inexpensive relative to conventional flow cytometers."); Goodman, 1:8-12 ("The present invention relates to multiple channel multiplexer/demultiplexer optical devices. In particular, the present invention relates to a compact demultiplexer device[.]"), 3:48-67 (noting, among other things, that inventive demultiplexers are designed to "incorporate into other optical systems"), 6:19-35 (citing design advantages of compact demultiplexer

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devices and further identifying that “the simple component geometry allows the design to be easily scaled or modified”); *see also, e.g.,* ’107, 2:45 (citing an advantage of its WDM in being “reconfigurable”).) Chandler and Goodman are directed to the same problems faced by the inventor of efficiently demultiplexing and detecting light, and the ’107 specifically identifies WDMs in the optical communication industry as analogous to WDMs in flow cytometry. (’107, 4:62-5:5 (“WDM techniques well-established in the optical communication industry can be readily adapted for fluorescence light detection.”), 44:25-33 (WDMs in both fields are “almost identical in function and architecture”).)

169. A POSA would have been motivated to combine Chandler with Goodman because Goodman’s teachings address and provide an improvement in harmony with Chandler’s design goals. Goodman explains that its invention is intended to provide a demultiplexer device:

- “in which each optical surface therein can be produced within current standard molding tolerances”;
- “in which all surfaces are simple geometric forms and are easily accessible for measurement”;
- “that is easy to mold and fabricate accurately”;

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- “that is easy to handle and assemble due to simple component geometries”;
- “that is easy to incorporate into other optical systems”; and
- “is easily scalable or modified.”

(Goodman, 3:48-67.) These motivations are confirmed by multiple references in the prior art. (*See, e.g.*, Oostman, 2:60-64 (object of invention to provide an “improved” optical system with “a greater number of detectors than has been achieved in the prior art”), 3:36-42, 4:14-24, 4:39-45 (discussing desirability of modularity); Frazier, 2:39-46 (discussing desire for scalability, and fine-tuning granularity of wavelength division); Wang, 1:65-2:2 (“[T]here is a great need for such optical modules being made small, and at the same time, the modules so designed are amenable to small footprint, broad operating wavelength range, enhanced impact performance, lower cost, and easier manufacturing process.”); Lemoff, 2:19-24 (“In view of the size constraints involved with bulk optical multiplexers and the drawbacks involved with utilizing filters arranged in series along an optical path, what is needed is an optical demultiplexer that can be easily produced with greater miniaturization.”); He, 2:36-38 (“There thus has been a need for compact WDM modules that minimize the problem of error amplification as discussed above and

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provide high tolerance for manufacturing with high yield.”); Grann, 2:51-56 (“One of the key features and a primary object of the present invention is to provide a compact and cost effective optical multiplexer and demultiplexer for both single-mode or multi-mode fiber optic communication systems wherein the device includes preformed and premolded passively aligned optics.”); Nosu, 3:31-52.)

170. Goodman’s compact demultiplexer confers the benefits that a POSA would have sought in seeking improvements to Chandler’s design. The Goodman demultiplexers are smaller, more scalable, and more portable than Chandler’s configuration. Goodman’s simple geometric design provides similar ease of access as Chandler’s configuration while simplifying fabrication/assembly, reducing the bill of material (BOM) costs by using less materials, and still offering a design that is easily scaled or modified to the number of channels desired for a particular application.

171. It would have been obvious to try Goodman’s demultiplexer device in Chandler’s flow cytometer system. Goodman provides a zig-zag pattern in an optical block that was widely accepted in optical communications and had long found adoption within flow cytometry applications. (*See* Section IV.B.) Goodman’s WDM configuration is an alternate, known option to the branched arrangements in

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Chandler's detector arrays, and one of several options available to a POSA at the time of the invention.

172. A POSA would have had a reasonable expectation that the combination would have been successful. Goodman designed its invention to specifically provide a “demultiplexer device that is easy to incorporate into other optical systems.” (Goodman, 3:65-67.) Its demultiplexing devices satisfy this objective by advantageously being “formed with geometrically simple shapes and without complex off-axis surfaces” that “allows for ease of fabrication, ease of metrology, and relatively simple incorporation into more complex optical systems.” (*Id.*, 6:19-24.) Chandler also describes that its FADC unit configuration is flexible. (Chandler, 8:25-30, 11:39-67, 12:42-51.) The '107 specification confirms that a WDM from the optical communication industry can be “readily adapted for fluorescence light detection,” as such a WDM is “almost identical in function and architecture” to WDMs used in flow cytometry. ('107, 4:62-5:5, 44:25-33.)

2. Independent Claim 1

a. Claim 1[pre]: “A flow cytometer comprising:”

173. I understand from counsel that the parties agree that Claim 1's preamble is limiting. In my opinion, the preamble to Claim 1 is disclosed by Chandler.

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Chandler directs its invention to “flow cytometric systems and/or methods of fluorescence measurement, including, multiple fluorescence measurement.” (Chandler, 1:11-15.) FIG. 4, discussed in my mapping below, depicts an “improved flow cytometer” that includes “four standard laser diodes, or light emitting sources, **10, 12, 14, 16** and four standard optical detectors **20, 22, 24, 26**” surrounding a viewing chamber **1**. (*Id.*, 7:1-4.)

b. Claim 1[a]: “an optical fiber; and”

174. Both Chandler and Goodman disclose Claim 1[a]. Chandler notes how its optical detectors **20, 22, 24, 26** are connected to corresponding FADC units **30, 32, 34, 36** via multi-mode fiber optic cables **40, 42, 44, 46**, respectively. (Chandler, 7:35-49, 9:35-41, 9:52-61, 11:39-67.)

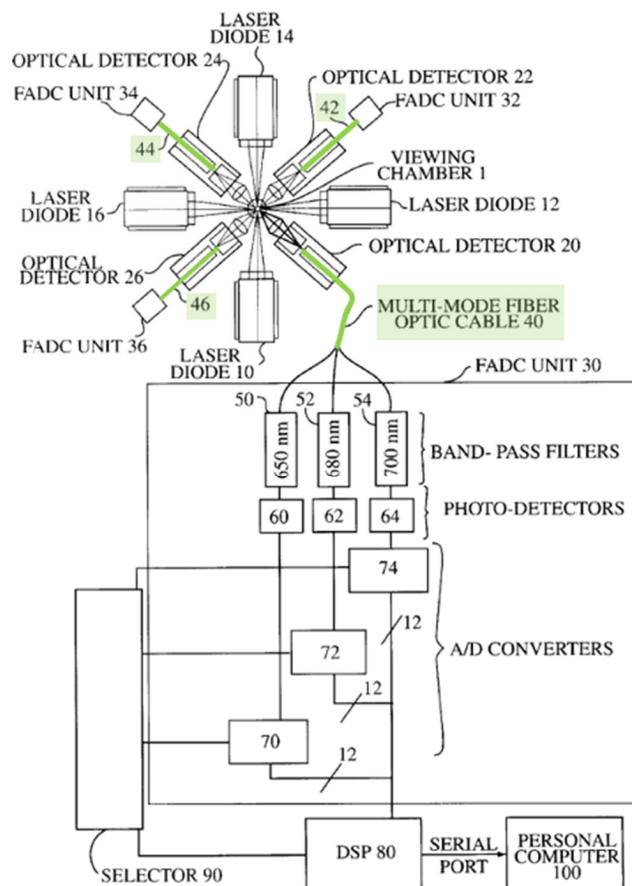


FIG. 4

(*Id.*, FIG. 4 (annotated); *see also id.*, 7:35-38, 7:66-8:3 (noting a single multimode fiber optic cable can be used where various signals are multiplexed).)

175. Goodman also discloses an “**optical fiber.**” Goodman teaches that, “[a]s illustrated in FIG. 1, optical block 12 has a generally rectangular shape and is configured to receive an optical signal through a waveguide such as an optical fiber 15.” (Goodman, 7:1-3 (underlining added).) Optical fiber 15 is a multimode optical fiber and is configured “as an input port for receiving a plurality of optical signal

channels from an outside optical energy source.” (*Id.*, 7:10-12, 14:15-17.) Light emits from a facet of the optical fiber and travels through the WDM. (*Id.*, 10:22-24 (noting relay of “image of the fiber facet ...” (underlining added)).) I have annotated optical fiber **15** (light green) in FIG. 1 below:

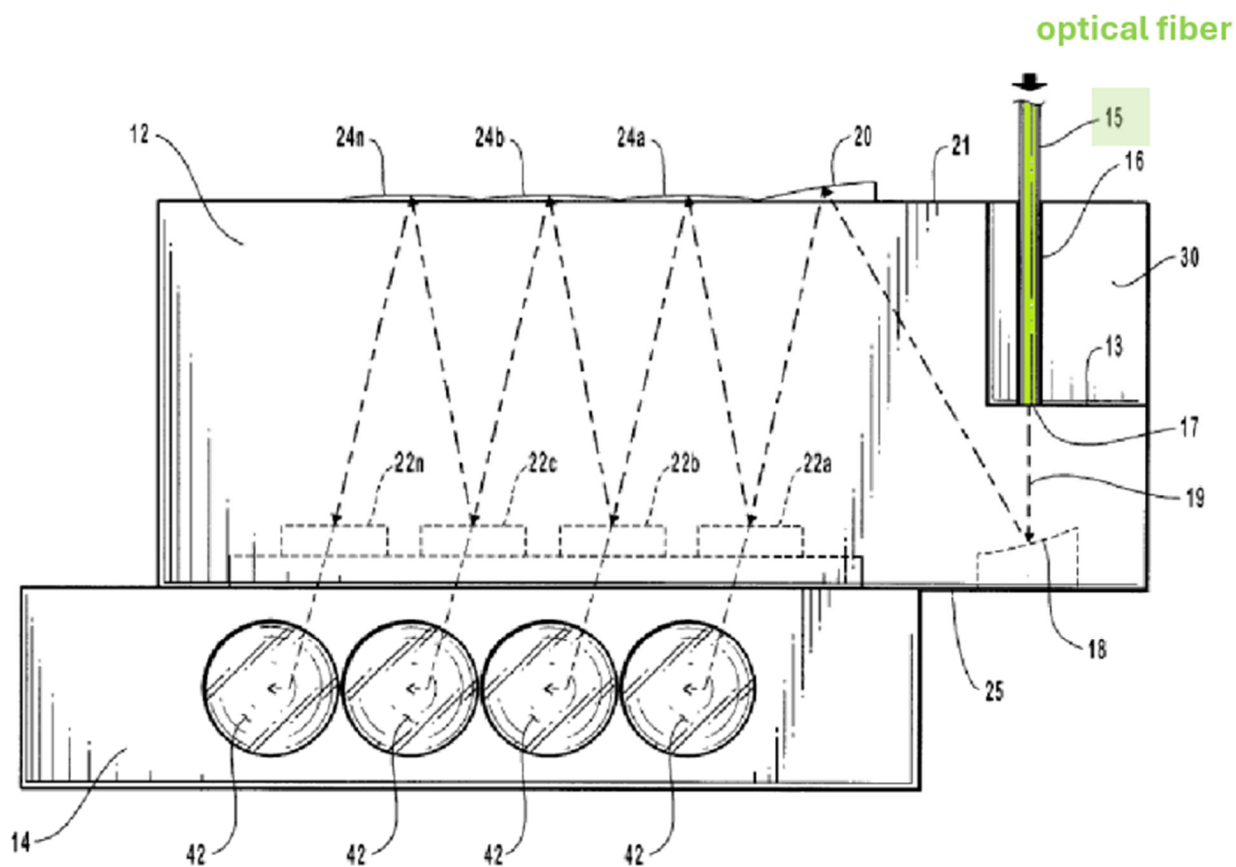


FIG. 1

(*Id.*, FIG. 1 (annotated).)

c. Claim 1[b]: “a wavelength division multiplexer (WDM) configured to receive light from the optical fiber, wherein the WDM comprises:”

176. The combination of Chandler and Goodman discloses Claim 1[b]. Chandler discloses an “improved flow cytometer” that includes “four standard laser diodes, or light emitting sources, **10, 12, 14, 16** and four standard optical detectors **20, 22, 24, 26**” surrounding a viewing chamber **1**. (Chandler, 7:1-4.) Optical detectors **20, 22, 24, 26** are each connected via a multimode fiber optic cable to a “filtering, amplification, and digital conversion (FADC) unit” that includes sets of bandpass filters **50, 52, 54** and photodetectors **60, 62, 64** in a branched demultiplexing configuration for color separation and detection. (*Id.*, 7:35-49, 9:35-41, 9:52-61, 11:39-67.)

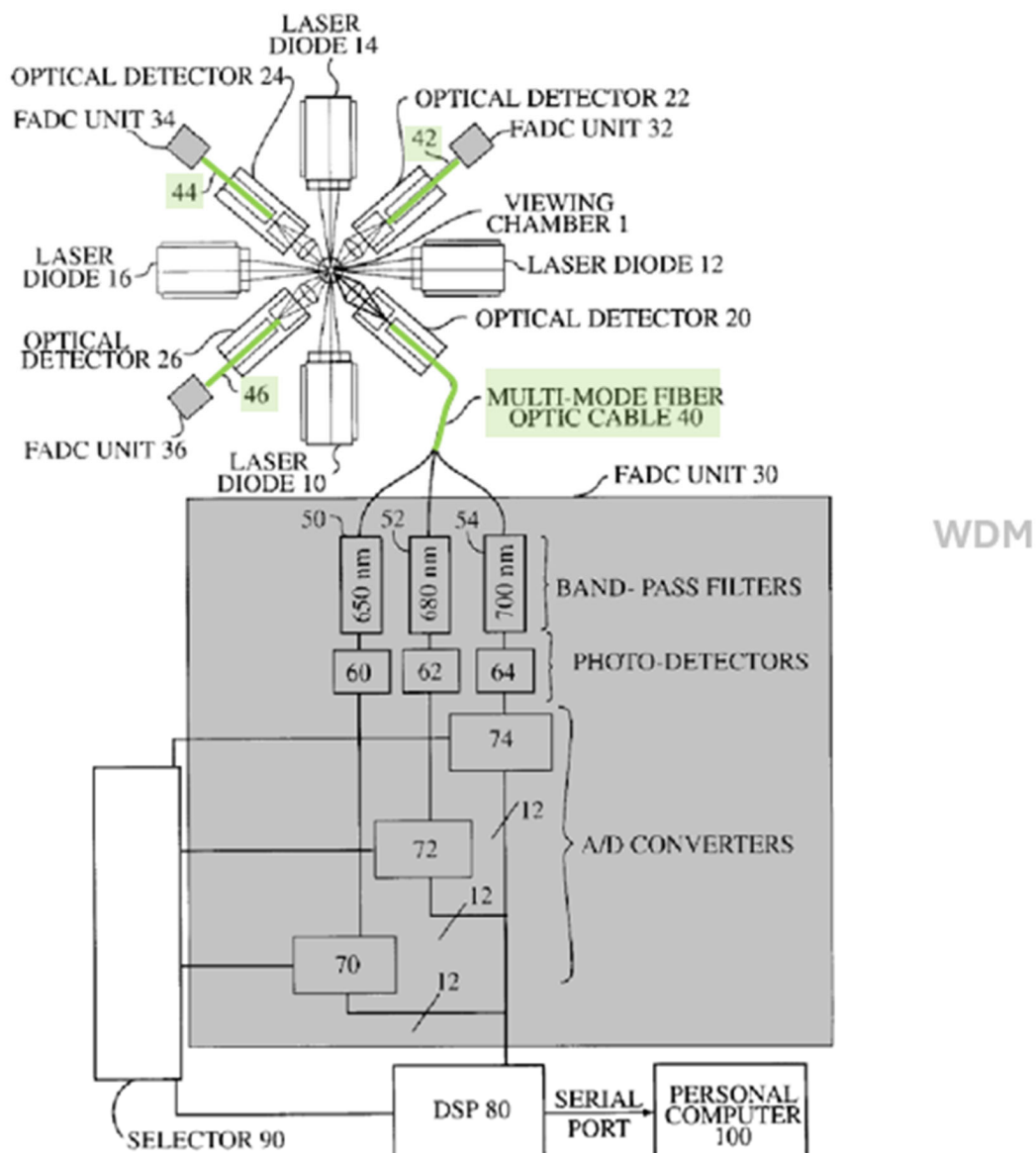


FIG. 4

(Chandler, FIG. 4 (annotated); *see also id.*, 7:35-38, 7:66-8:3 (noting a single multi-mode fiber optic cable can be used where various signals are multiplexed).) These FADC units are “**configured to receive light from the optical fiber,**” as Chandler

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explains that each optical detector “gathers photons and can couple or transmit them to a respective multi-mode fiber optic cable” that “conveys the photons” to a corresponding FADC unit. (*Id.*, 9:52-56.)

177. As stated above, the combination of Chandler and Goodman replaces the branched demultiplexing configuration from Chandler’s FADC unit(s) with an alternate, known zig-zag demultiplexing configuration described in Goodman. Additional details regarding Goodman’s demultiplexer are described below.

d. Claim 1[c]: “an array of mirrors;”

178. Goodman discloses Claim 1[c]. Goodman describes how its “demultiplexer device ... generally includes an optically transparent optical block seated atop an optically transparent beam-directing member,” where the “optical block includes ... a plurality of relay reflectors[.]” (Goodman, 5:63-6:1; *see also id.*, 4:35-40 (“The optical block includes ... a plurality of reflectors[.]”).) These reflectors comprise “**mirrors**” as recited in Claim 1[c]. A POSA would have understood reflectors to include mirrors, as a mirror is defined by its ability to reflect incident light. (*See* EX1020, p.003; *see also* Goodman, 10:19-23 (including mirrors as examples of reflectors).)

179. Goodman also discloses an “**array of mirrors,**” reflectors **24a-24n-1**,

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teaching that its FIG. 1 embodiment includes “a plurality of discrete reflectors **24a-24n** that are positioned on top surface **21** of optical block **12** in a linear arrangement.” (Goodman, 9:58-61.) These reflectors “can be collimating lenses or mirrors.” (*Id.*, 10:19-23.) A POSA would have understood that the use of “n” notation signals that a POSA could use any number of reflectors (i.e., “**array of mirrors**”). FIG. 1 depicts these reflectors **24a-24n-1** (highlighted green but for last) and ray tracing that demonstrates that the optical beam reflects from each reflector. For purposes of mapping an “**array of mirrors**” **24a-24n-1** to the claim limitations, I have identified all reflectors except the last reflector, reflector **24n**, as the “**array of mirrors.**”

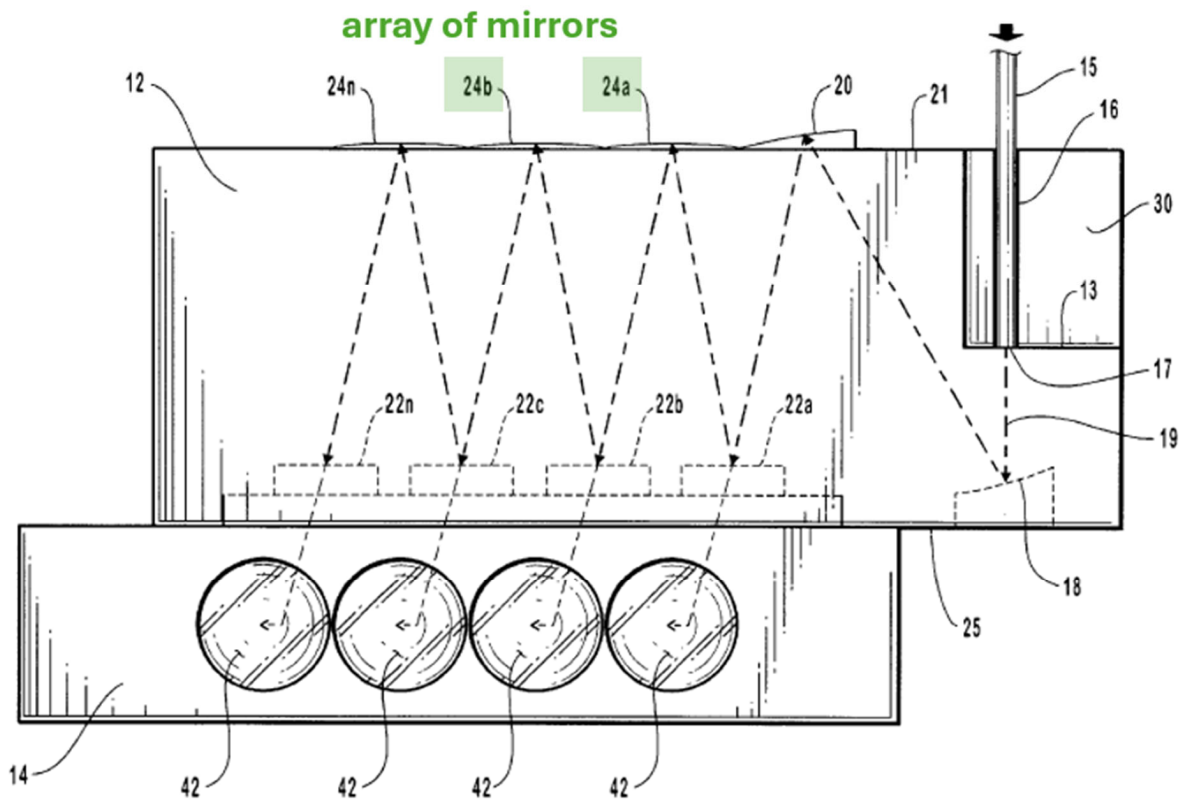


FIG. 1

(Goodman, FIG. 1 (annotated).)

e. **Claim 1[d]: “an array of filters; and”**

180. Goodman discloses Claim 1[d]. Goodman describes how its “demultiplexer device ... generally includes an optically transparent optical block seated atop an optically transparent beam-directing member,” where the “optical block includes a plurality of wavelength selective elements such as optical interference filters[.]” (Goodman, 5:63-67; *see also id.*, 4:35-40 (“The optical block

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includes a plurality of wavelength selective elements[.]”).) Goodman explains how its wavelength selective elements are “**filters**” because they “separate selected wavelengths” from an incident optical beam, permitting the separated wavelengths to each pass through a wavelength selective element to be focused onto the corresponding optical detector while reflecting the remaining wavelengths through the optical block to a reflector positioned opposite of the wavelength selective element. (Goodman, 4:48-50, 4:53-65.)

181. Goodman teaches an “**array of filters**” in its wavelength selective elements **22a-22n-1**⁵ that are “configured in optical block **12** to receive beam **19** propagating along an optical path.” (Goodman, 8:21-23.) During operation “[e]ach wavelength selective element is preselected to pass a designated wavelength range and reflect both higher and lower wavelengths. The wavelength selective elements pass the separated wavelength bands into the beam-directing member[.]” (*Id.*, 6:12-

⁵ My notation of “n-1” in my Declaration refers to the penultimate element in the linear arrangement of elements, as Goodman uses the “n” notation to describe that a range of elements can have an unspecified number within the arrangement.

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16; *see also id.*, 8:21-26 (describing how “wavelength selective elements **22a-22n** are each capable of transmitting a selected range of wavelengths within beam **19** and reflecting other wavelengths.”).)

182. FIG. 1 depicts a four-filter embodiment, where the “array” of filters includes wavelength selective elements **22a-22n-1** (in brown) within optical block **12**. Similar to the “array of mirrors” as discussed in Claim 1[c], a POSA would have understood that the use of “n” notation signals that a POSA could use any number of filters (i.e., “**array of filters**”). For purposes of mapping the “**array of filters**,” I have identified all wavelength selective elements except the sequential last wavelength selective element **22n**. Ray tracing shows a portion of optical beam **19** passing through wavelength selective elements **22a-22n-1** and separate portions reflecting back to reflectors **24a-24n-1** opposite the wavelength selective elements, demonstrating how the wavelength selective elements are filters.

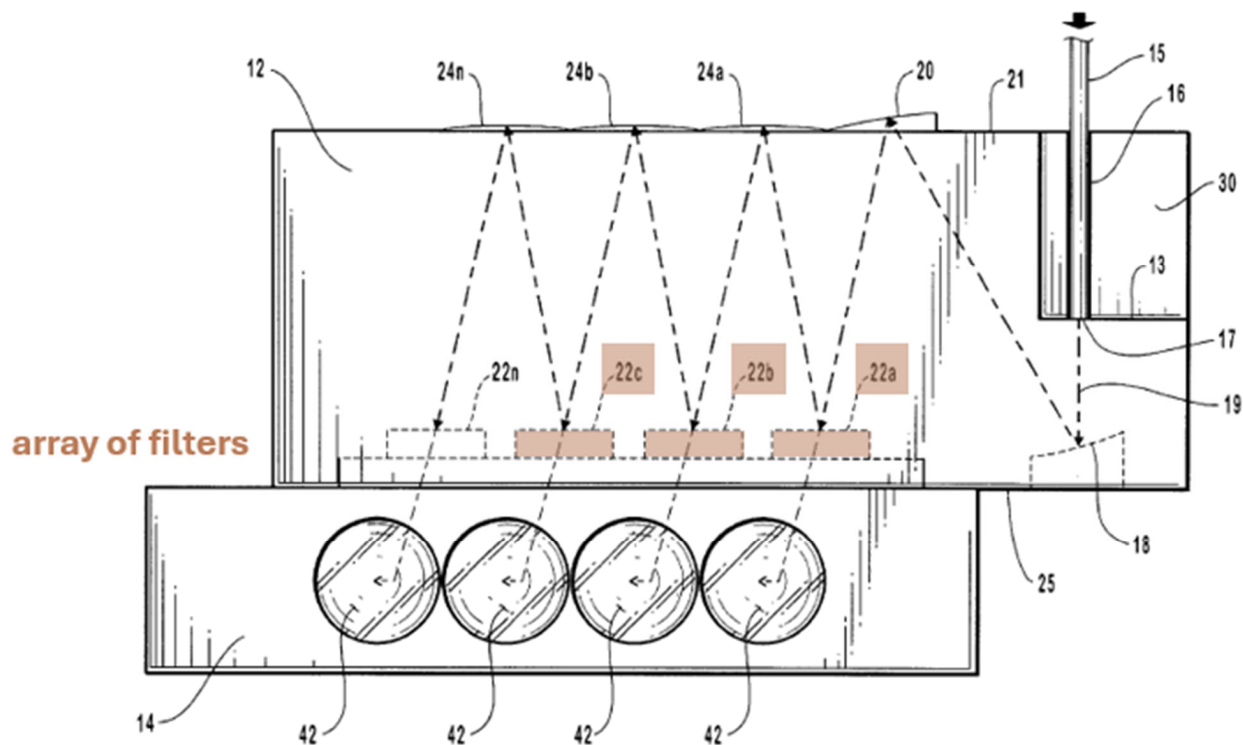


FIG. 1

(Goodman, FIG. 1 (annotated); *see also id.*, 12:1-18 (describing how selected wavelengths incident upon a particular wavelength selective element “pass therethrough while the remainder are reflected or absorbed”).)

f. Claim 1[e]: “an array of avalanche photodiodes (APDs) configured to receive light that passed through one or more filters in the array of filters;”

183. The combination of Chandler and Goodman discloses Claim 1[e].

Goodman describes a beam-directing member that includes a set of focusing lenses

42. Goodman teaches that “emitted wavelength beams” propagating from

wavelength selective elements **22a-22n-1** may be “transmitted to the focusing lenses” **42** and then “[e]ach of [the] lenses **42** can focus a selected wavelength beam onto a corresponding optical receiver such as an optical detector[.]” (*Id.*, 11:24-30, 11:40-42 (underlining added).) The beam-directing member is shown below where light transmitted through the array of filters is incident on focusing lenses **42** (pink) arranged in a linear array such that a POSA would have understood that the corresponding optical detectors would also be arranged in a linear array.

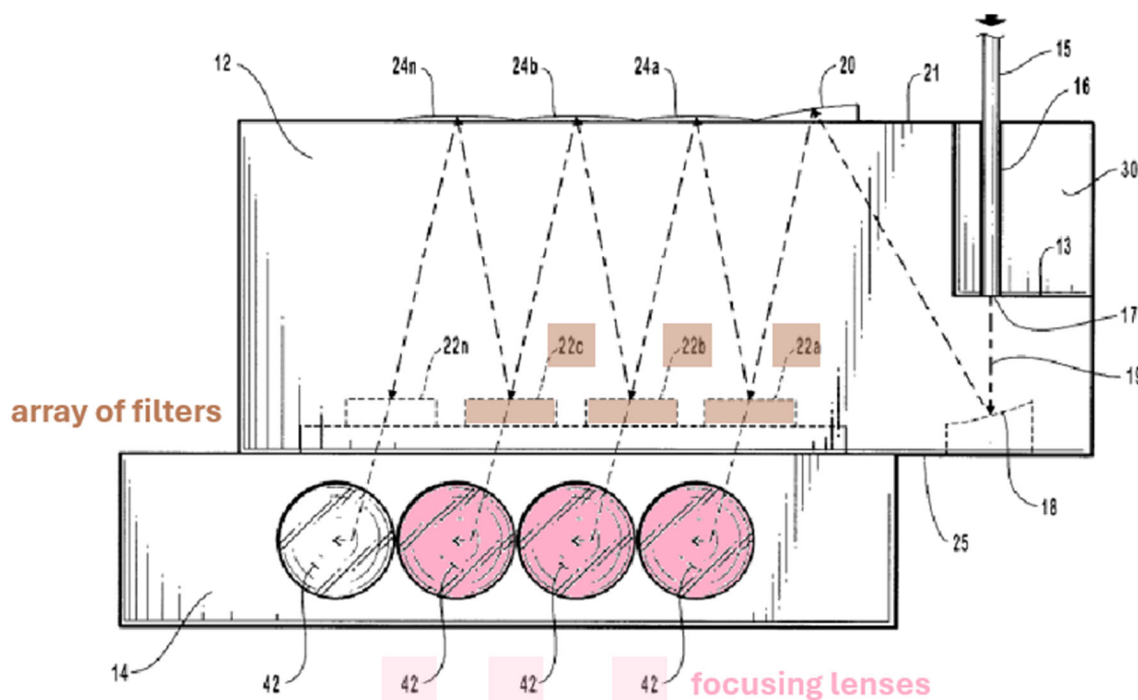


FIG. 1

(Goodman, FIG. 1 (annotated); *id.*, 4:59-63.)

184. While Goodman generally teaches an array of focusing lenses where each focusing lens may “focus a selected wavelength beam onto a corresponding optical receiver such as an optical detector,” (Goodman, 11:40-42), Goodman does not disclose whether its optical detector is an “**APD.**” Chandler provides these implementation details, teaching that its “amplifying photo-detector” may be “an avalanche photo-diode.” (Chandler, 4:6-8, 5:30-31, 8:31-34.) The “**array of avalanche photodiodes (APDs)**” in the combined Chandler-Goodman system are the APDs (from Chandler) that would be “optical detectors,” each associated with a focusing lens in Goodman’s set of focusing lenses **42**.

- g. Claim 1[f]: “wherein each of the filters in the array of filters is configured to receive light such that: a portion of the light passes through the filter; and another portion of the light is reflected; and”**

185. Goodman discloses Claim 1[f]. To start, each filter in the array of filters is “**configured to receive light.**” Goodman teaches that “wavelength selective elements **22a-22n** are configured in optical block **12** to receive beam **19** propagating along an optical path.” (Goodman, 8:21-23 (underlining added).) FIG. 1 shows how each of wavelength selective elements **22a-22n-1** receives a portion of light (red arrows) from optical beam **19**.

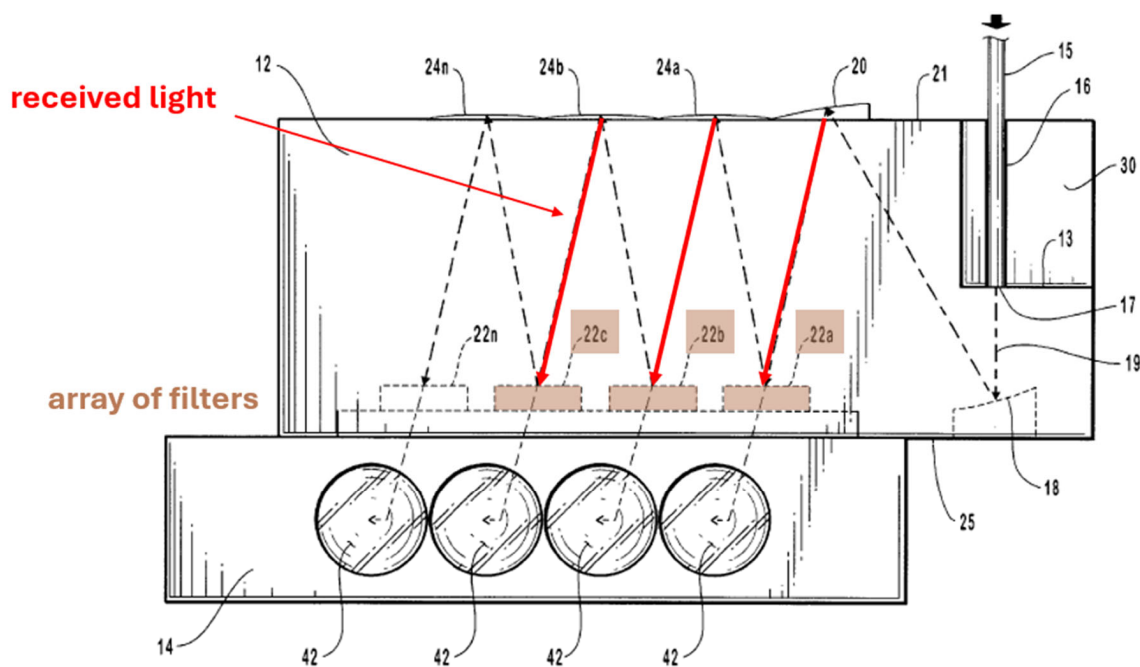
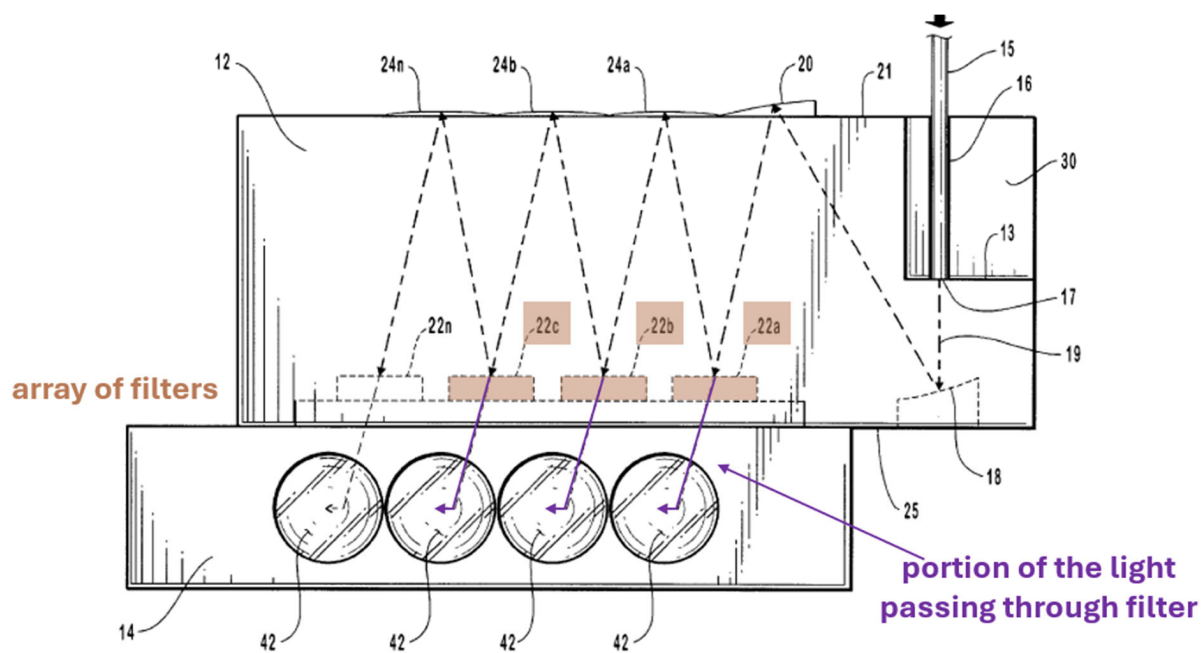


FIG. 1

(*Id.*, FIG. 1 (annotated).)

186. Goodman also discloses that “**a portion of the light passes through**” each wavelength selective element consistent with the district court’s construction for “portion.” Goodman teaches that “[e]ach wavelength selective element is preselected to pass a designated wavelength range and reflect both higher and lower wavelengths. The wavelength selective elements pass the separated wavelength bands into the beam-directing member[.]” (Goodman, 6:12-16 (underlining added); *see also id.*, 8:21-26 (describing how “wavelength selective elements **22a-22n** are each capable of transmitting a selected range of wavelengths within beam **19** and

reflecting other wavelengths.” (underlining added).) Ray-tracing in FIG. 1 depicts a portion of optical beam **19** passing through wavelength selective elements **22a-22n-1**.



(*Id.*, FIG. 1 (annotated).)

187. Finally, Goodman teaches that “**another portion of the light is reflected**” by wavelength selective elements **22a-22n-1**, consistent with the district court’s construction for “portion.” Goodman describes that “[t]he wavelength selective elements **22a-22n** are each capable of ... reflecting other wavelengths.” (Goodman, 8:23-26; *see also id.*, 12:1-11.) FIG. 1 again shows how each

wavelength selective element in the array represented by wavelength selective elements **22a-22n-1** reflects a portion of the light.

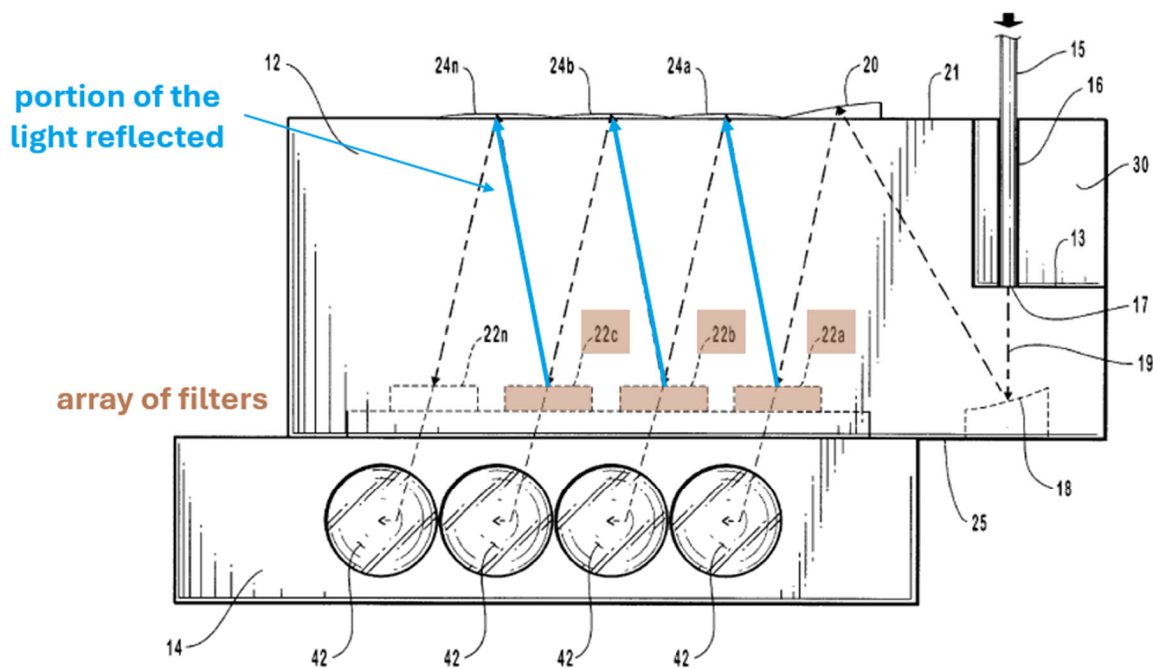


FIG. 1

(*Id.*, FIG. 1 (annotated).)

- h. Claim 1[g]: “wherein each of the mirrors in the array of mirrors is configured to: receive light reflected by a filter in the array of filters; and reflect light to another filter in the array of filters.”**

188. Goodman discloses Claim 1[g]. Goodman expressly describes that “reflectors are positioned opposite from the wavelength selective elements such that each of the reflectors, as part of an imaging relay system, directs the beam of optical energy from one wavelength selective filter to an adjacent wavelength selective

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filter.” (Goodman, 4:53-58 (underlining added); *see also id.*, 4:60-62 (“a multi-channel beam is directed into the optical block and relayed in a zigzag pattern onto the wavelength selective elements[.]”).) A POSA would have understood that, to direct a beam of light within an imaging relay system, a reflector must both “**receive light reflected by a filter in the array of filters**” from a filter and then “**reflect light to another filter in the array of filters**” to the next filter in the set of wavelength selective filters. Goodman describes that its reflectors accomplish these recited functions with more detail in disclosures related to FIG. 1.

189. Goodman states with respect to FIG. 1 that “reflectors **24a-24n** are positioned opposite from wavelength selective elements **22a-22n** such that each of the reflectors directs beam **19** from one wavelength selective element to an adjacent wavelength selective element.” (Goodman, 9:61-65 (underlining added).) A POSA would have understood from these disclosures that each reflector in reflectors **24a-24n-1** will “**receive**” portions of light from a wavelength selective element within the array of wavelength selective elements **22a-22n-1** and “**reflect**” those portions of light back to the next sequential wavelength selective element within the array of wavelength selective elements **22a-22n-1**.

190. Each of reflectors **24a-24n-1** in Goodman’s FIG. 1 embodiment both

receive a portion of beam **19** (in blue) from a wavelength selective element and
reflect a portion of beam **19** (in red) to another wavelength selective element.

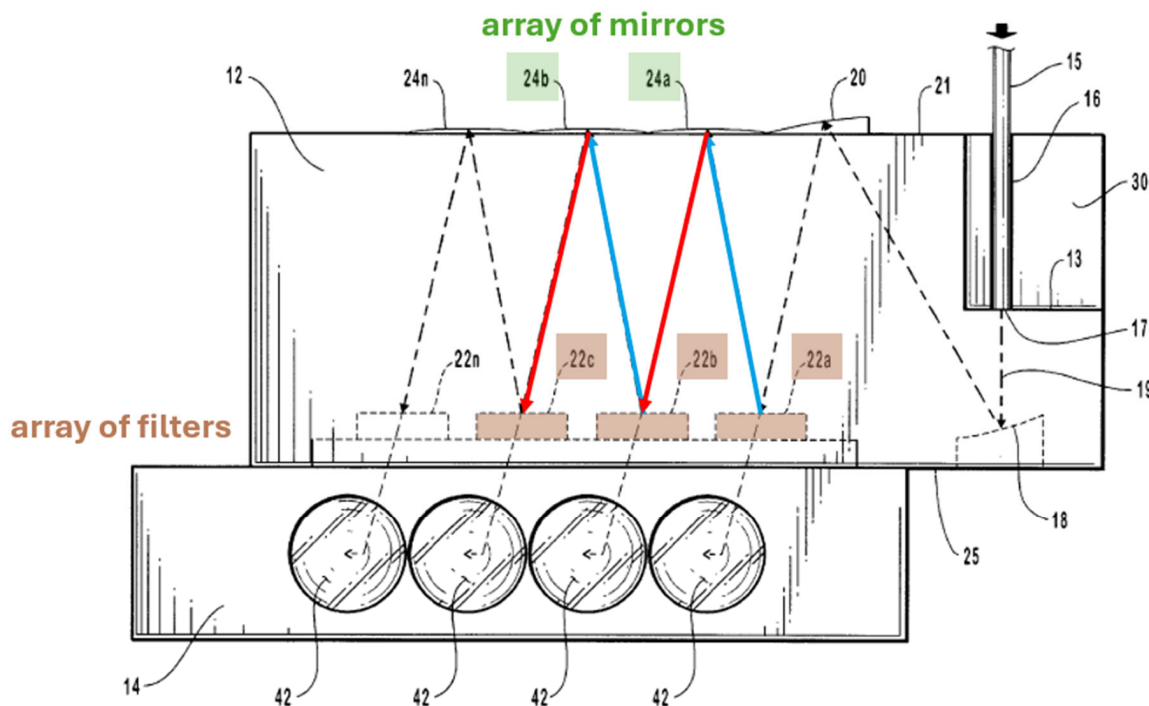


FIG. 1

(Goodman, FIG. 1 (annotated).)

191. Goodman expressly discloses the dual function of each of its reflectors within the linear arrangement shown in FIG. 1. For example, Goodman describes how “selected wavelengths incident upon wavelength selective element **22a** pass therethrough while the remainder are reflected or absorbed.” (Goodman, 12:1-4.) “The reflected wavelengths are directed to reflector **24a**”—that is, reflector **24a**

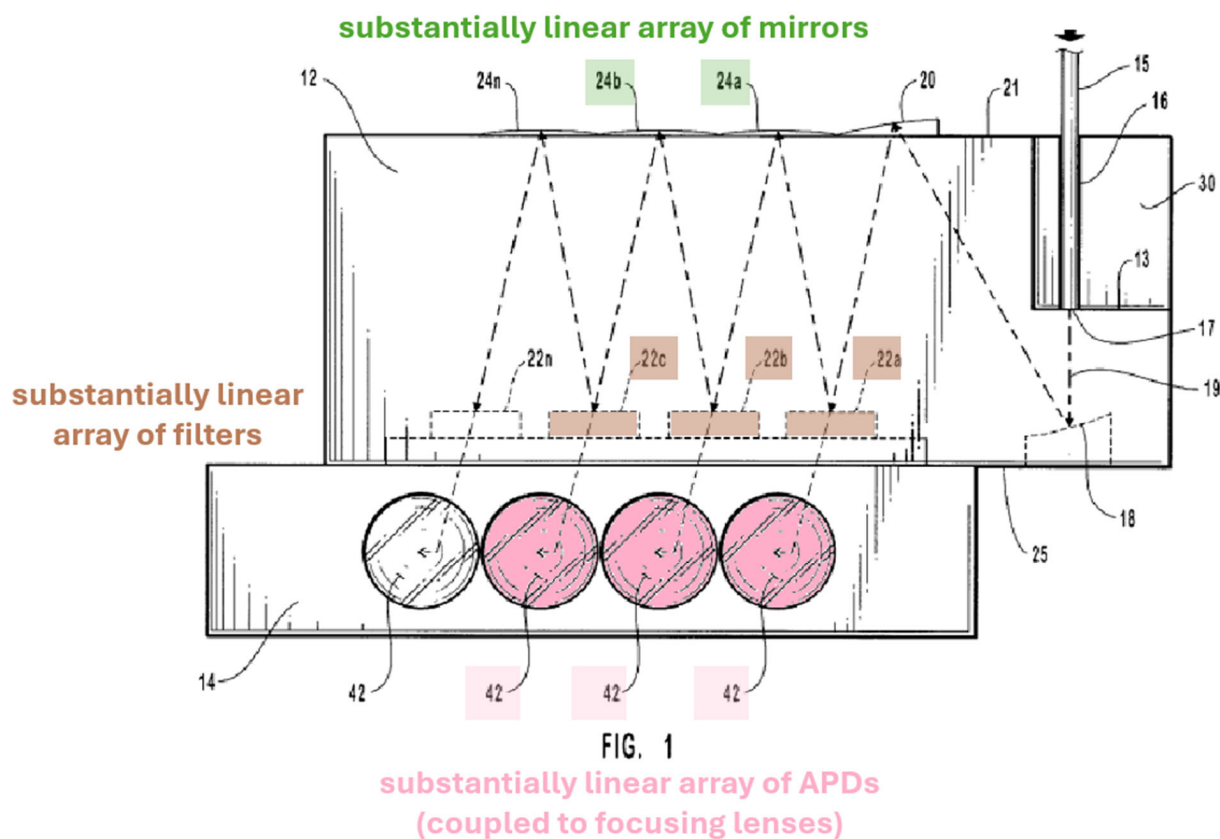
“receive[s] light reflected by a filter in the array of filters.” (*Id.*, 12:4-5.)

Goodman goes on to explain that reflector **24a** then “reflects the light incident thereupon towards wavelength selective element **22b**,” and so **“reflect[s] light to another filter in the array of filters.”** (*Id.*, 12:5-6.) The subsequent reflectors within Goodman’s array of reflectors **24a-24n-1** perform the same **“receive”** and **“reflect”** operations relative to the array of wavelength selective elements **22a-22n-1**. (*See id.*, 12:5-15.)

3. Dependent Claim 2

192. Claim 2 depends from Claim 1 and further recites (1) **“the array of mirrors is substantially linear;”**; (2) **“the array of filters is substantially linear; and”** (3) **“the array of APDs is substantially linear.”** In my opinion, Goodman (incorporating Chandler’s APDs) discloses the additional claim elements in Claim 2. Goodman explains that its FIG. 1 embodiment includes “a plurality of discrete reflectors **24a-24n** that are positioned on top surface **21** of optical block **12** in a linear arrangement.” (Goodman, 9:58-61 (underlining added).) Wavelength selective elements **22a-22n** are positioned opposite of the linearly-arranged reflectors **24a-24n** and are similarly linearly-arranged as are the series of focusing lenses **42** of the beam-directing member **14**, shown in FIGs. 1 and 5. (*See id.*, 9:61-65.) A POSA

would also have understood that the array of APDs, optically coupled to receive focused bands of light from the linearly-arranged focusing lenses, would also be linearly-arranged. (*Id.*, 11:37-42; 6:14-19.) Goodman's FIG. 1 shows how each of these arrays is “**substantially linear**” as required by Claim 2.



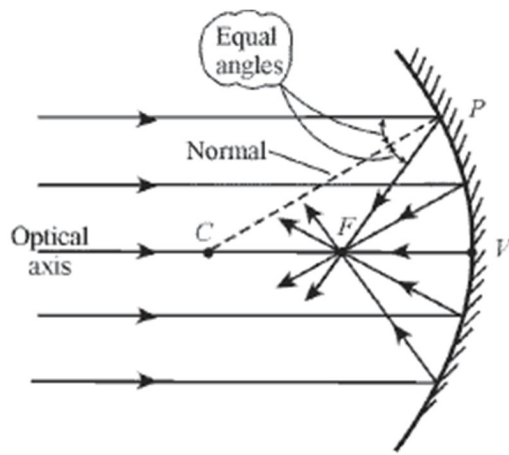
(Goodman, FIG. 1 (annotated).)

4. Dependent Claim 3

193. Claim 3 depends from Claim 2 and further recites “**at least one of the mirrors in the array of mirrors is a concave mirror.**” In my opinion, Goodman

discloses Claim 3.

194. Goodman explains how its reflectors **24a-24n** may comprise a “**concave mirror**.” A mirror is “concave” where its surface curves inward, as the interior of a circle or sphere, and the mirror has a positive radius of curvature. Concave mirrors typically act to converge incident light, or at minimum, reduce divergence in a defocused light beam. Below is an example of this phenomenon:



(a) Concave mirror

(EX1021, Module 1-4, p.032; *see also* EX1022, p.002.)

195. With respect to its FIG. 1 embodiment, Goodman explains that its reflectors **24a-24n** are “shaped to produce the desired spatial and angular characteristics of a beam that propagates in a zigzag fashion” between reflectors and wavelength selective elements and “can be converging lenses or mirrors[.]”

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(Goodman, 10:3-7, 10:19-21.) A POSA would have understood that a “converging mirror” in the FIG. 1 configuration includes a “concave mirror” because Goodman describes that the reflector is “designed so that the demultiplexer device can be operated with a non-collimated light beam, with the reflectors controlling the tendency of such a beam to diverge.” (*Id.*, 10:25-28.) A reflector that controls divergence in a non-collimated beam is likely (although not required) concave, and a POSA naturally would have considered a concave mirror as among the reflectors disclosed in Goodman.

196. Reflectors **24a**, **24b**, ... **24n-1** in FIG. 1 show concave surfaces that reflect incident light from optical beam **19**. As shown in the magnified view below, these reflectors have a small, positive radius of curvature and curve inward to a horizontal plane of the optical block, demonstrating their concavity.

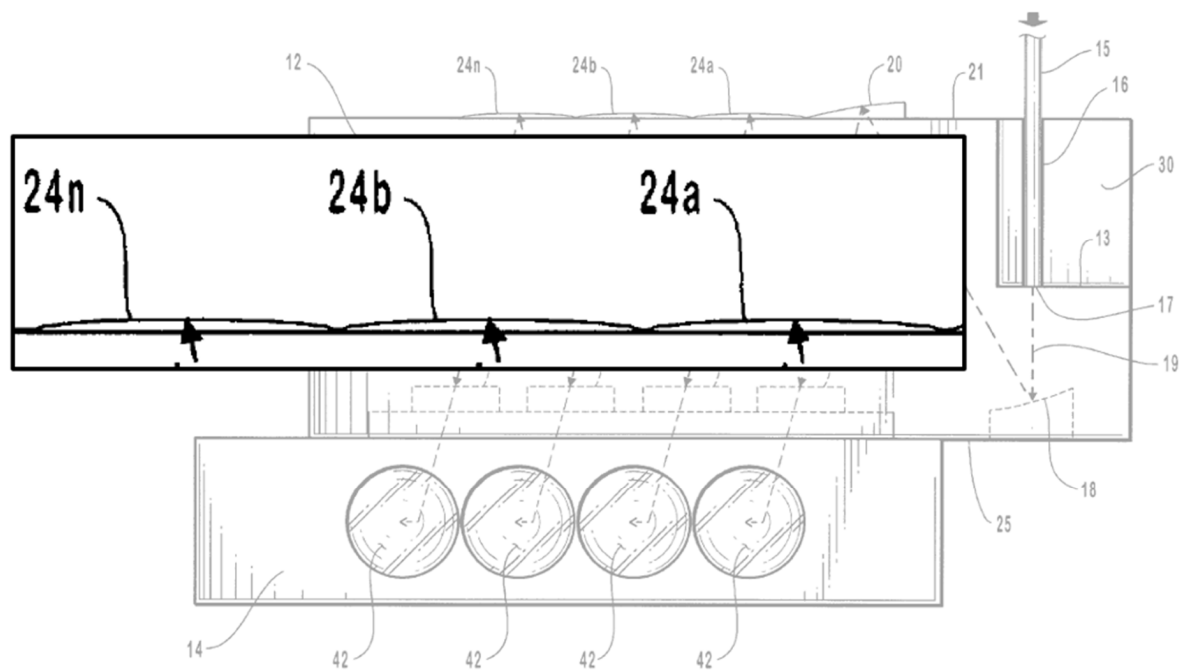


FIG. 1

(Goodman, FIG. 1 (annotated with a magnified view of reflectors **24a-24n**).)

5. Dependent Claim 5

197. Claim 5 depends from Claim 3 and further recites “**wherein the WDM is configured such that a portion of an optical path between the array of mirrors and the array of filters forms a zig-zag pattern.**” Goodman discloses the additional limitations of Claim 5.

198. As a preliminary matter, I understand that the parties dispute the meaning of the term “portion of the.” (EX1018, pp.049-052.) I also understand that the dispute over the term “portion of the” is immaterial to my analysis for Claim 5,

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which recites a “portion of an optical path here.” As I understand it, the disputed term “portion of the” refers to light, from different claims in different patents. I have thus applied my plain meaning understanding of “portion of an optical path,” consistent with the ’107 specification.

199. Goodman expressly describes an optical configuration between its array of wavelength selective elements and reflectors as a “**zig-zag pattern**”:

During operation of a demultiplexer device of the invention, a multi-channel optical energy beam is directed into the transparent optical block and onto the afocal relay system, which directs the beam along a predetermined optical path between the wavelength selective elements and reflectors in a zigzag pattern. The term “zigzag” as used herein refers to a series of short sharp turns in an optical path taken by a beam. Each wavelength selective element is preselected to pass a designated wavelength range and reflect both higher and lower wavelengths. The wavelength selective elements pass the separated wavelength bands into the beam-directing member where the beam-folding mirror directs the wavelength bands out of plane onto the focusing lenses, which focus the wavelength bands onto optical detectors or other optical relay systems.

(Goodman, 6:5-19 (underlining added).) The discussed zig-zag pattern appears in

FIG. 1 described below.

200. The FIG. 1 embodiment depicts that a portion of the light beam's optical path (in red) is a “**zig-zag pattern**” between reflectors (e.g., **24a, 24b**) and wavelength selective elements (e.g., **22a, 22b, 22c**).

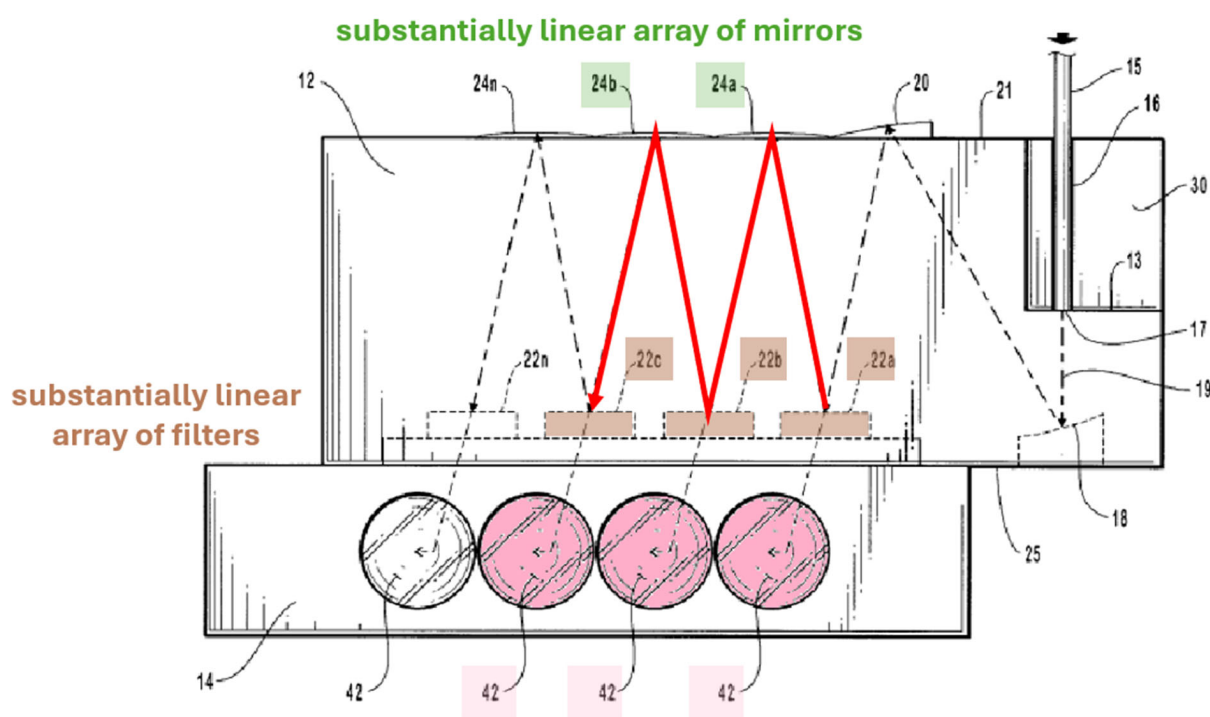


FIG. 1
substantially linear array of APDs
(coupled to focusing lenses)

(Goodman, FIG. 1 (annotated).) The specification confirms that “[t]he reflectors are located and shaped to produce the desired spatial and angular characteristics of a beam that propagates in a zigzag fashion between the wavelength selective elements

and the reflectors.” (*Id.*, 10:3-7 (underlining added).)

6. Dependent Claim 6

201. Claim 6 depends from Claim 5 and further recites “**a laser that is configured to emit blue light, yellow-green light, violet light, or ultraviolet light.**” In my opinion, Chandler discloses Claim 6, observing that “laser diodes having respective excitation frequencies of 414 nm, 710 nm, and 780 nm are available and are suitable for use as light sources in the instant invention.” (Chandler, 10:51-54; *see also id.*, 10:59-62 (noting acceptable use of lasers with 357 nm and 488 nm excitation frequencies).) A POSA would have understood the wavelength ranges within the electromagnetic spectrum, and thus that Chandler’s lasers with center excitation frequencies of 357 nm (ultraviolet), 414 nm (violet), and 488 nm (blue) fall within the blue-to-UV light range and disclose Claim 6.

7. Dependent Claim 7

202. Claim 7 depends from Claim 6 and further recites “**wherein the flow cytometer is a benchtop flow cytometer.**” In my opinion, the combination of Chandler and Goodman discloses Claim 7. The term “**benchtop flow cytometer**” only appears within the ’107 claims and is absent from the specification. Nevertheless, a POSA would have understood Chandler-Goodman system to

disclose a benchtop flow cytometer, as Chandler describes how it is “a feature and an advantage of the instant invention to provide a means of measuring multiple fluorescence wavelengths that is small and inexpensive relative to conventional flow cytometers,” (Chandler, 3:52-55), and Goodman indicates that its WDM is (advantageously) compact, (Goodman, Title, 1:1-2, 1:8-12, 3:65-67, 5:42-45). Chandler, as modified to include Goodman’s compact WDMs, would have predictably resulted in a **“benchtop flow cytometer.”**

8. Dependent Claim 8

203. Claim 8 depends from Claim 6 and further recites **“wherein the flow cytometer is compact.”** In my opinion, a POSA would have found the Chandler-Goodman system to disclose Claim 8 for the same reasons I provided for Claim 7, fully incorporated here. Chandler sought to design a “small” flow cytometer, (Chandler, 3:52-55), and a POSA would have further pursued Chandler’s design goals by incorporating Goodman’s compact WDM, (Goodman, Title, 1:1-2, 1:8-12, 3:65-67, 5:42-45), to make Chandler’s already “small” flow cytometer even more **“compact.”** I also incorporate my analysis from Section IX.B.1 regarding a POSA’s motivations to combine Chandler with Goodman to further reduce the footprint of Chandler’s flow cytometer.

9. Dependent Claim 9

204. Claim 9 depends from Claim 8 and further recites “**wherein the WDM is capable of detecting a substantially full spectrum of visible light.**” As explained in my analysis for Grounds 5 and 6, it is my opinion that Claim 9 lacks written description support and is not enabled. Claim 9 is directed to full spectral analysis capabilities that the inventor did not conceive of or provide a POSA with disclosures on within the ’107 written description. The ’107 written description makes no mention of full spectral analysis, passingly refers to conventional emission peak wavelength analysis, (*see* ’107, 27:45-49), and never explains how the disclosed WDM is capable of enabling full spectral analysis.

205. To the extent Patent Owner contends that Claim 9 captures a WDM capable of processing light where excitation wavelengths from light sources may span the visible light spectrum, Chandler discloses the additional claim element in Claim 9. The visible light spectrum range is from approximately 380 to 750 nm, and the ’107 specification recites that its WDM is compatible with light sources with excitation wavelengths at 375 nm, 405 nm, 440 nm, 488 nm, 502 nm, 534 nm, 561 nm, 591 nm, and 637 nm. (’107, 49:20-25.) Chandler expressly discloses a wider range of excitation wavelengths for light sources than is in the ’107 patent, observing

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that its flow cytometer is compatible with excitation wavelengths at 414 nm, 488 nm, 633 nm, 670 nm, 710 nm, and 780 nm. (Chandler, 7:10-12, 10:51-62.) Chandler also notes that “[a]ny light source suitable for flow analysis is acceptable” and that “He-Ne, Ar-ion, Ar/Kr, and UV lasers, can optionally be used.” (*Id.*, 10:50-51, 10:57-58.) The additional laser types have excitation wavelengths that include, e.g., 488 nm (Ar-ion), 543 nm (He-Ne), 568 nm (Ar/Kr - *see* EX1087), 594 nm (He-Ne), and 647 nm (Ar/Kr - *see id.*) as I explain in part for Claim 6 in Ground 10, incorporated here. These excitation wavelengths span substantially the full visible light spectrum, and would have been able to accommodate the commercially-available fluorescent dyes across the visible light spectrum at the time of invention. Chandler expressly states that it is “an advantage of the instant invention to extend such a means/system and such a method to a multitude of excitation wavelengths at no substantial cost or effect to measurement accuracy.” (Chandler, 3:43-46.)

206. In addition, I note that scattered and/or fluorescent light that results from illuminating fluorescent-tagged target material with a shorter-wavelength laser (e.g., 357 nm) may result in demultiplexed light with wavelength separation across the full visible light spectrum depending on the number of available detection channels. To the extent Patent Owner argues that Claim 9 contemplates a WDM

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that can separate low-wavelength light into color bands that substantially cover the full visible light spectrum, the combination of Chandler and Goodman discloses Claim 9. The combined Chandler-Goodman system includes sufficient scalability to accommodate an array of demultiplexing channels and corresponding APDs that can demultiplex light across substantially the full visible light spectrum, as Goodman teaches that “more or fewer channels can be demultiplexed by adding or subtracting filters and reflectors in the device.” (Goodman, 12:40-44; *see also id.*, 8:28-33 (“As shown, one preferred number of wavelength selective elements **22a-22n** is four. Of course, one skilled in the art will recognize, in view of the disclosure herein, that a greater or lesser number of filters may be used, for example, two, eight or sixteen, depending on the number of channels to be demultiplexed [sic].”).)

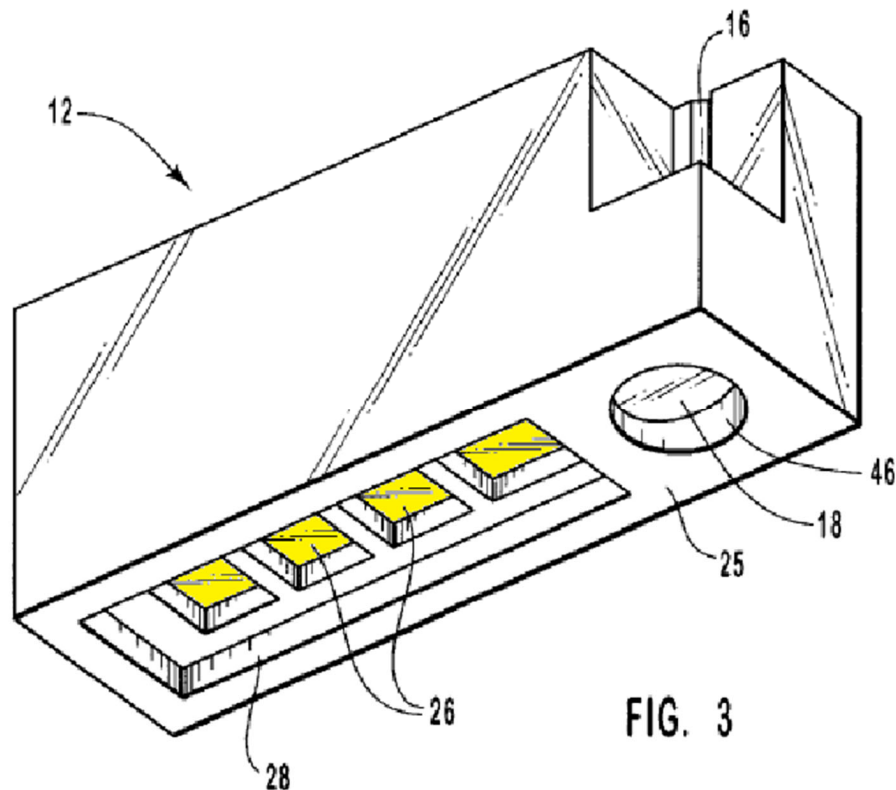
10. Dependent Claim 10

207. Claim 10 depends from Claim 6 and further recites (1) “**the WDM further comprises a block comprising a first surface; and**” (2) “**each of the filters in the array of filters is coupled to the first surface of the block.**” In my opinion, Goodman discloses Claim 10.

208. Goodman discloses “**a block,**” noting that its demultiplexer device “includes a transparent optical block having an upper surface defining a plane, and

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a lower surface” where an imaging optical element is “positioned on the upper surface of the optical block and is configured to direct a multiwavelength beam of optical energy along a predetermined optical path.” (Goodman, 4:42-48 (underlining added); *see also id.*, 6:44-47 (demultiplexer device **10** “includes a monolithic optical element such as transparent optical block **12**, which is seated atop a beam-directing member **14**” (underlining added)).) Optical block **12** includes a “**first surface**” in the bottom surface **25** shown in FIG. 3. The surface, where Goodman’s wavelength selective elements are coupled is highlighted in yellow (receiving indentation **26**).



(*Id.*, FIG. 3 (annotated).)

209. Goodman explains that “**each of the filters in the array of filters is coupled to the first surface of the block**” at receiving indentations 26. Receiving indentations 26 are “molded into bottom surface 25 of optical block 12.” (Goodman, 8:37-38.) “[D]uring assembly of device 10, prefabricated wavelength selective elements 22a-22n are inserted into receiving indentations 26 and are affixed therein such as by an optical adhesive.” (*Id.*, 8:44-47 (underlining added).)

11. Dependent Claim 11

210. Claim 11 depends from Claim 10 and further recites “**wherein the flow cytometer is a benchtop flow cytometer.**” The combination of Chandler and Goodman discloses Claim 11 for the reasons I provided for Claim 7, incorporated here.

12. Dependent Claim 12

211. Claim 12 depends from Claim 10 and further recites “**wherein the flow cytometer is compact.**” The combination of Chandler and Goodman discloses Claim 12 for the reasons I provided for Claim 8, incorporated here.

13. Dependent Claim 13

212. Claim 13 depends from Claim 6 and further recites that the WDM additionally comprises “**an array of focusing lenses, wherein each of the focusing lenses in the array of focusing lenses is configured to focus light that passed through a filter in the array of filters to a spot on an APD in the array of APDs, wherein the spot has a diameter that is smaller than a diameter of a core of the optical fiber.**” In my opinion, the combination of Goodman and Chandler renders Claim 13 obvious.

213. To start, Goodman discloses “**focusing lenses**” under the district

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court's construction as "lenses that capture and converge light." Goodman describes focusing lenses that a POSA would have understood to capture and converge light. Goodman teaches that "emitted wavelength beams" propagating from wavelength selective elements **22a-22n** may be "transmitted to the focusing lenses" and then "[e]ach of [the] lenses **42** can focus a selected wavelength beam onto a corresponding optical receiver such as an optical detector[.]" (Goodman, 11:24-30, 11:40-42.)

214. Goodman also discloses an "**array of focusing lenses.**" Goodman explains that "selected wavelength beams that pass through wavelength selective elements **22a-22n** enter beam-directing member **14**[.]" (Goodman, 12:24-26.) A beam-directing member includes an array of focusing lenses **42**. (*Id.*, 11:8-30, 12:24-32.) FIG. 1 depicts an array of focusing lenses **42** that are downstream along the optical path into wavelength-selection elements **22a-22n-1**.

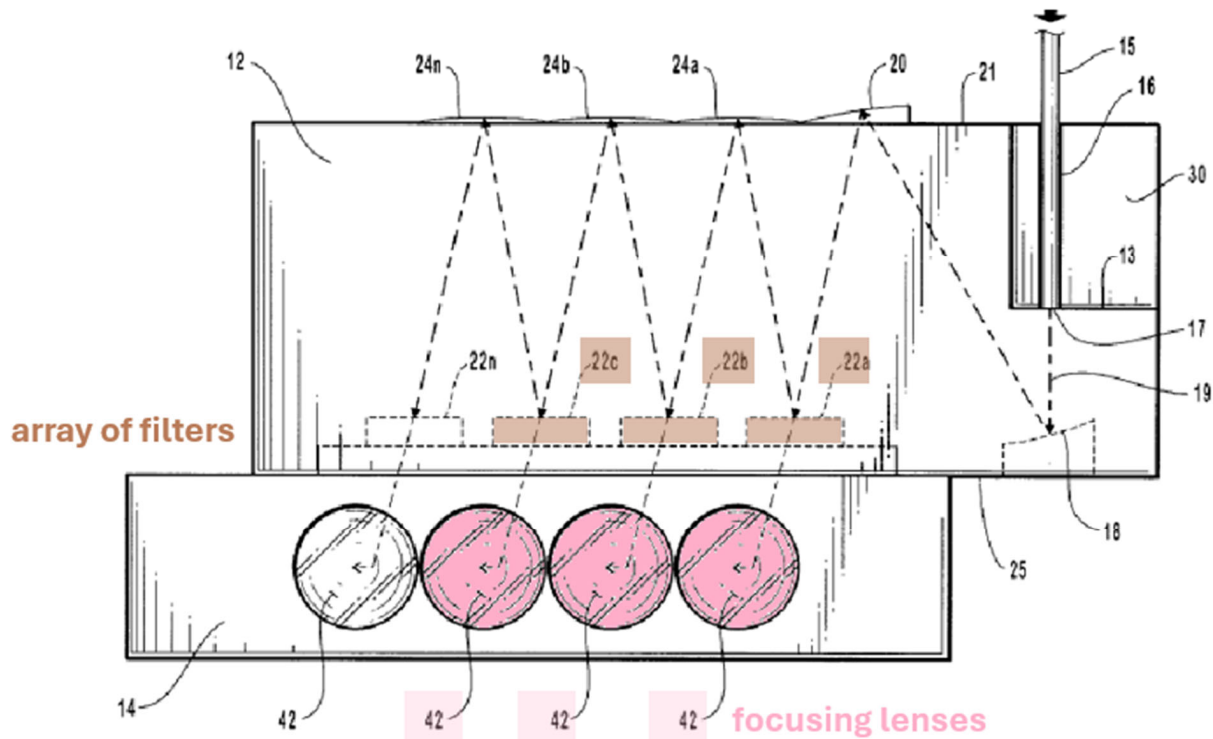


FIG. 1

(*Id.*, FIG. 1 (annotated).)

215. The focusing lenses are each “**configured to focus light that passed through a filter in the array of filters to a spot on an APD in the array of APDs.**”

In a given channel of the optical block-beam-directing member combination within Goodman’s WDM, a focusing lens **42** is positioned between a wavelength selective element in the optical block and its corresponding optical detector. (*See* Goodman, 11:40-42, 12:23-32.) The described optical detector is an APD in my proposed Chandler-Goodman combination (*see* Claim 1[e]), and a POSA would naturally

have understood that each focusing lens focuses light onto a spot on its corresponding APD among the array of APDs. (Goodman, 11:40-42.)

216. These focusing lenses also focus light down to a spot size “**wherein the spot has a diameter that is smaller than a diameter of a core of the optical fiber.**” The diameter for a core of a multimode optical fiber is measured in millimeters. (See, e.g., ’107, 44:61-65.) As discussed in my analysis for Claim 14 below and fully incorporated here, a POSA would have known that using small area APDs that were commercially available by 2011 or later, as Chandler contemplates, would have required design or selection of a focusing lens **42** in Goodman’s WDM that focused light to a spot size approximately at the APD’s effective active area to maximize signal-to-noise ratio and minimize photon loss. These small area APDs had diameters less than 1 mm, and a POSA implementing the small area APDs in the Goodman-Chandler WDM would naturally have focused the light down to a spot size less than the diameter of a core of a multimode optical fiber (which is typically greater than 1 mm).

14. Dependent Claim 14

217. Claim 14 depends from Claim 13 and further recites “**wherein for each of the focusing lenses in the array of focusing lenses, the diameter of the spot is**

less than 1 mm.” That is, the beam of light must be focused to an approximate circular area size of 0.785 mm^2 or less, or, for a rectangular configuration, less than 1 mm by 1 mm. Goodman does not specifically describe the spot size that its focusing lenses focus light down to but does acknowledge that “the focusing lenses are selected or designed so that the output beam meets the requirements of the detector or receiving fiber.” (Goodman, 11:48-50.) While Chandler does not disclose the size of its APDs, a POSA would have understood that Goodman’s focusing lenses should be able to focus the beam of light down to a size smaller than or equal to the effective detection area of the APD. Off-the-shelf APDs from multiple vendors were available by 2011 or later with small effective area sizes, and a POSA would have understood that use of these APDs in the Goodman-Chandler optical subsystem would have required that Goodman’s focusing lenses focus incident light down such that “**the diameter of the spot is less than 1 mm.**”

218. The ’107 specification does not describe a customized or unique APD, and thus a POSA would have understood the ’107’s WDM would have used off-the-shelf APDs. As discussed for Claim 1[e], Chandler discloses use of APDs in its FADC units but does not specify the size, make, model, or part number of the APD. Nevertheless, a POSA would have understood that major semiconductor

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manufacturers, like Hamamatsu and SensL referenced in the '107 specification (*see* '107, 44:14-18), sold small-area APDs with effective active area sizes less than 1 mm in diameter. For example, Hamamatsu's June 26, 2011 product catalog for short wavelength type APDs lists models S9073, S9074, and S5343 with effective active areas from 0.03 – 0.78 mm².

■ General ratings / Absolute maximum ratings

Type No.	Dimensional outline/ Window material *1	Package	Effective active *2 area size (mm)	Effective active area (mm ²)	Absolute maximum ratings	
					Operating temperature Topr (°C)	Storage temperature Tstg (°C)
S9073	①/U	TO-18	φ0.2	0.03	-20 to +60	-55 to +100
S9074			φ0.5	0.19		
S5343			φ1.0	0.78		
S9075	②/U	TO-5	φ1.5	1.77		
S5344			φ3.0	7.0		
S5345	③/U	TO-8	φ5.0	19.6		

(EX1060, p.001 (annotated).) By 2011, Hamamatsu similarly listed long wavelength type APDs, S8890-02, S8890-05, and S88890-10, with the same effective active areas as S9073, S9074, and S5343, respectively. (*See* EX1061, p.001; *see also* EX1062, p.001 (same effective active area size for 800nm band APDs: S2381; S2382, S5139 and S8611; and S2383 and S2383-10, respectively); EX1055-EX1056; EX1034 (showing public availability before 2011).) A POSA would have understood that these short- and long-wavelength-type APDs would have been applicable for use in the Goodman-Chandler system, as (1) these types of APDs had been studied and used in flow cytometers for over a decade (*see* Section

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IV.C); and (2) Hamamatsu specifically advertised features for these APDs that a POSA would have found highly desirable in flow cytometry applications: high sensitivity, high gain, and low noise in the UV to visible range. (EX1060, EX1061, EX1062.) Such APDs were intended for low-light-level measurement and for use with analytical equipment (EX1060), the precise use-case in the Chandler-Goodman WDM, and their small footprint would have been especially conducive to integration with Goodman's compact WDM configuration.

219. By 2007, SensL also offered several APD modules with active areas of 1 x 1 mm, indicating to a POSA that an incident beam would have to be focused to less than that diameter to minimize photon loss.

Module Specifications

Typical Values	Part Number								Units
	SPMMLni 1000X03A1	SPMMLni 1000X03A3	SPMMLni 1000X06A1	SPMMLni 1000X06A3	SPMMLni 3000X03A1	SPMMLni 3000X03A3	SPMMLni 3000X06A1	SPMMLni 3000X06A3	
Chip Area	1.14x1.14	1.14x1.14	1.4x1.4	1.4x1.4	3x3	3x3	3x3	3x3	mm ²
Active Area	1x1	1x1	1x1		2.85x2.85	2.85x2.85	2.85x2.85	2.85x2.85	mm ²

(EX1032, p.002 (annotated).) SensL specifically identifies these APDs for use in flow cytometer applications.

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Applications

- Fluorescence Lifetime Measurement
- Biological Sensors
- Scanning Microarrays
- DNA Biochips/Sequencing
- Proteomics/Protein Biochips
- Point-of-Use Biological Agent Detection
- Confocal Microscopy
- Nuclear Medicine
- Environmental Monitoring
- Nuclear Radiation Detection
- Homeland Security
- High Energy Physics
- Flow Cytometry
- Capillary Electrophoresis
- Range Finding

(EX1032, p.001 (annotated).)

220. Other manufacturers had similar small-area APD offerings by 2011 or later with active area sizes optimized to capture a beam with less than 1 mm diameter while maximizing signal-to-noise ratio. For example, Menlo Systems offered APD210 and APD310 for ultra-low light level signal applications, with detector diameters of 0.5 mm and 0.04 mm, respectively. (EX1033, pp.001-002; EX1063 (offered 2011).) First Sensor similarly offered its AD800-11 APD with a 0.5 mm² active area and designed for detection with high quantum efficiency (350-750 nm)

and low noise. (EX1064, p.001 (offered June 2011).)

221. Given the ubiquity of commercially-available small-area APDs, a POSA would have generally known of their use in flow cytometry applications, would have used them in the Chandler-Goodman optical subsystem, and would have selected and/or designed focusing lenses to focus the incident light down to the effective active area size for these APDs. A POSA would have found implementation of small-area size APDs to be highly desirable because (1) smaller size APDs improve compactness of the WDM, enabling additional channels to be built into the device within a form factor; and (2) these types of APDs further address the known issue in APDs of having high dark current by improving the signal-to-noise ratio with a smaller active detection area. A POSA would have known, based on the effective active area sizes of commercially-available small-area APDs (and their implementation) that the focusing lenses would have to focus light down such that **“the diameter of the spot is less than 1 mm.”**

15. Independent Claim 16

a. Claim 16[pre]: “A flow cytometer comprising:”

222. I understand from counsel that the parties agree that Claim 16’s preamble is limiting. In my opinion, Chandler discloses the preamble of Claim 16

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for the reasons I provided for the preamble of Claim 1, incorporated here.

b. Claim 16[a]: “a flow cell configured to permit liquid to flow through the flow cell;”

223. Chandler discloses Claim 16[a]. Chandler describes a “sample delivery viewing chamber **1**,” also referred to as “cuvette **1**,” that can be “a standard quartz cuvette used in standard flow cytometers[.]” (Chandler, 6:61-64, 7:1-4.) This cuvette **1** is a “**flow cell**” as shown in FIGs. 3, 5, and 7.

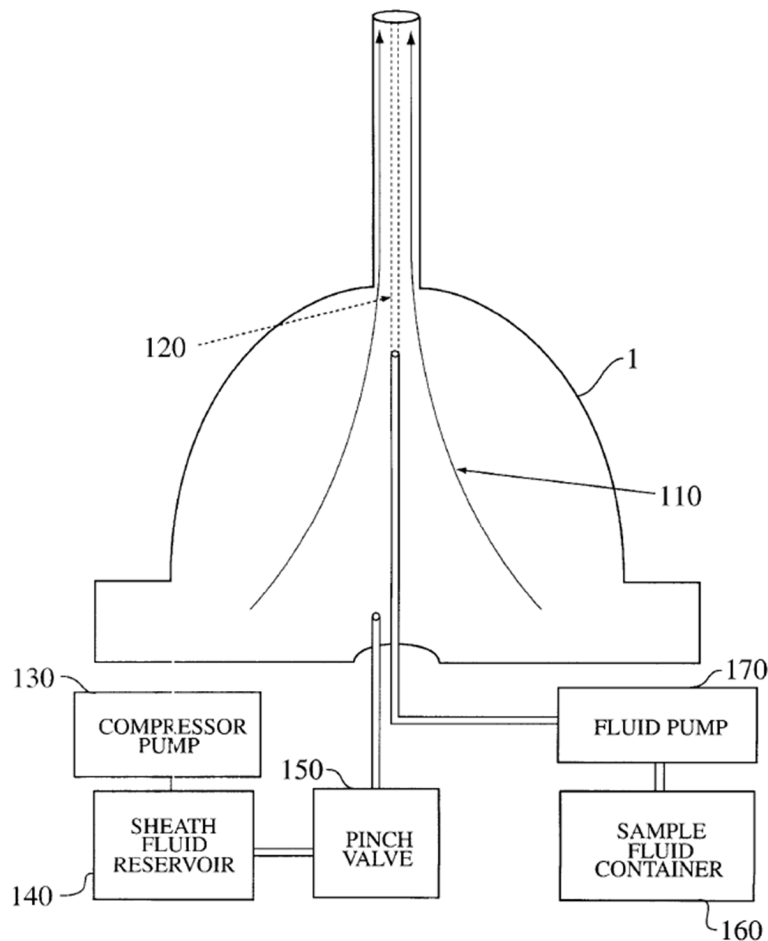


FIG. 5

(*E.g.*, Chandler, FIG. 5.)

224. A flow cell includes a small channel where cells are suspended in a fluid and aligned / focused into a single file as they pass through a spot illuminated by an illumination source (e.g., an arc lamp, laser). (EX1007, p.081.) The '107 patent also explains that “a liquid stream, usually called a sheath flow, carries and

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hydrodynamically aligns cells or particles so that they pass single file through the flow cell.” (’107, 27:6-9.) As the “sample flow carrying objects and a sheath flow” passes through the viewing zone, “a light source ... illuminat[es] the object in the viewing zone.” (*E.g., id.*, 5:35-38, 30:50-53, 53:47-50; *see* FIGs. 3 and 7.)

225. Cuvette 1 is “**configured to permit liquid to flow through the flow cell.**” Chandler explains that, in operation, “conventional fluid pump 170, for example, draws sample fluid 120 containing the cells and fluorescent microspheres out of a sample fluid container 160 and presents a drop of the sample fluid 120 into the flow of the sheath fluid 110 at approximately the neck down region of the cuvette 1.” (*Id.*, 9:5-10.) That is, “cells and microspheres in the sample fluid 120 pass out of the end of the fluid pump 170 and become ensheathed in the sheath fluid 110.” (*Id.*, 9:13-16.) When the sheath fluid reaches the neck down region of cuvette 1, the reduced cross-section of this region causes the sheath fluid 110 to accelerate, elongating the sample fluid 120 within the sheath fluid 110 and causing particles to “form a substantially single file” before reaching the illumination region in cuvette 1. (*Id.*, 9:16-25.)

c. **Claim 16[b]: “a laser configured to project light into the flow cell;”**

226. Chandler discloses Claim 16[b]. Chandler explains with respect to FIG.

4 that its flow cytometer includes “four standard laser diodes, or light emitting sources, **10, 12, 14, 16** ... [that] surround the periphery of the viewing chamber **1**.” (Chandler, 7:1-4.) FIG. 4 shows the relative placement of each “**laser**” about Chandler’s viewing chamber **1** (“**flow cell**”).

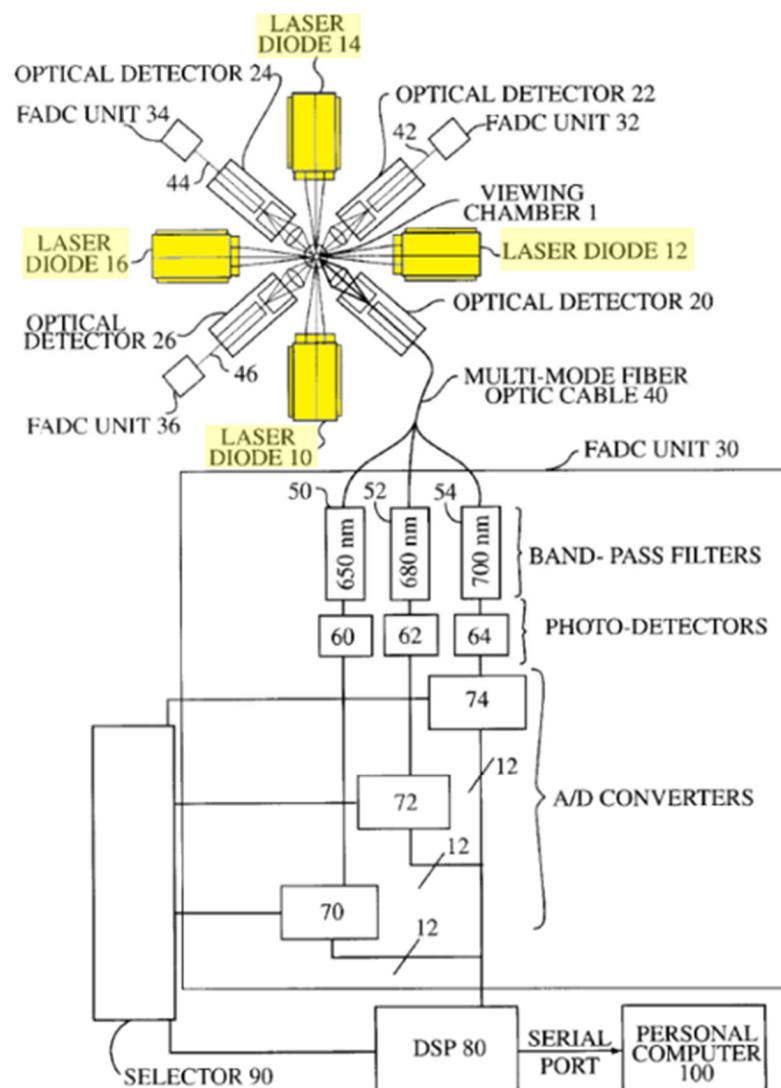


FIG. 4

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(*Id.*, FIG. 4 (annotated).)

227. The laser diodes are “**configured to project light into the flow cell.**” Chandler teaches that “sample fluid **120**” in cuvette **1** is “illuminated by one of the light sources for a period of time,” and specifically, “as a particle enters the focal region, it is illuminated by one of the four laser diodes **10, 12, 14, 16** for example, laser diode **10**, for about one microsecond, by way of illustration.” (*Id.*, 9:26-31; FIG. 7.)

d. Claim 16[c]: “a multimode optical fiber configured to receive light from the flow cell; and”

228. The combination of Chandler and Goodman discloses Claim 16[c] for the reasons I provided for Claim 1[a], incorporated here. The optical fiber in the Chandler-Goodman system is a “**multimode optical fiber,**” as both Chandler and Goodman identify that their respective optical fibers are multimode optical fibers. Moreover the “**multimode optical fiber**” disclosed by the Chandler-Goodman system is “**configured to receive light from the flow cell.**” (Chandler, 7:25-27 (“Optical detector **20** detects emissions resulting from excitation by, for example, laser diode **10[.]**”), 7:35-37 (“The optical detectors **20, 22, 24, 26** are connected to respective filtering, amplification, and digital conversion (FADC) units **30, 32, 34, 36** via respective multi-mode fiber optic cables **40, 42, 44, 46.**”), 9:52-54 (“By way

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of explanation, when the laser diode **10** is on, the optical detector **20** gathers photons and can couple or transmit them to a respective multi-mode fiber optic cable **30**.”), FIG. 4 (depicting multimode fiber optic cables); Goodman, 14:15-17 (“The device according to the present invention is capable of use with both single-mode fiber applications and multi-mode fiber applications.”).)

e. Claim 16[d]: “a wavelength division multiplexer (WDM) configured to receive light from the multimode optical fiber, wherein the WDM comprises:”

229. The combination of Chandler and Goodman discloses Claim 16[d] for the reasons I provided for Claim 1[b], incorporated here.

f. Claim 16[e]: “a plurality of mirrors,”

230. The combination of Chandler and Goodman discloses Claim 16[e] for the reasons I provided for Claim 1[c], incorporated here. A POSA would have understood that an “array of mirrors” as discussed for Claim 1[c] constitutes a “plurality,” which means more than one. Goodman expressly refers to its reflectors as “[a] plurality of reflectors.” (Goodman, 4:50-53.)

g. Claim 16[e][i]: “wherein at least one of the mirrors is a concave mirror;”

231. Goodman discloses Claim 16[e][i] for the reasons I provided for Claim 3, incorporated here.

h. Claim 16[f]: “a plurality of filters; and”

232. Goodman discloses Claim 16[f] for the reasons I provided for Claim 1[d], incorporated here. A POSA would have understood that an “array of filters” as discussed for Claim 1[d] constitutes a plurality. Goodman expressly refers to these interference filters as a “plurality of wavelength selective elements[.]” (Goodman, 4:48-50 (underlining added).)

i. Claim 16[g]: “a plurality of avalanche photodiodes (APDs) configured to receive light that passed through one or more filters of the plurality of filters;”

233. The combination of Chandler and Goodman discloses Claim 16[g] for the reasons I provided for Claim 1[e], incorporated here. A POSA would have understood that an “array of avalanche photodiodes (APDs)” as discussed for Claim 1[e] constitutes a plurality.

j. Claim 16[h]: “wherein each of the plurality of filters is configured to receive light such that: a portion of light passes through the filter; and another portion of light is reflected; and”

234. Goodman discloses Claim 16[h] for the reasons I provided for Claim 1[f], incorporated here.

- k. **Claim 16[i]: “wherein each of the plurality of mirrors is configured to: receive light reflected by a filter of the plurality of filters; and reflect light to another filter of the plurality of filters.”**

235. Goodman discloses Claim 16[i] for the reasons I provided for Claim 1[g], incorporated here.

16. Dependent Claim 17

236. Claim 17 depends from Claim 16 and further recites **“a plurality of focusing lenses, wherein each of the plurality of focusing lenses is configured to focus light that passed through a filter of the plurality of filters to a spot on an APD of the plurality of APDs, wherein the spot has a diameter that is smaller than a diameter of a core of the multimode optical fiber.”** The combination of Chandler and Goodman discloses Claim 17 for the reasons I provided for Claim 13, incorporated here.

17. Dependent Claim 18

237. Claim 18 depends from Claim 17 and further recites **“wherein for each of the plurality of focusing lenses, the diameter of the spot is less than 1 mm.”** The combination of Chandler and Goodman discloses Claim 18 for the reasons I provided for Claim 14, incorporated here.

18. Dependent Claim 20

238. Claim 20 depends from Claim 16 and further recites “**wherein the plurality of mirrors includes more than one concave mirror.**” Goodman teaches that multiple reflectors in reflectors **24a-24n** can be a collimating mirror (*see* Goodman, 10:19-22), each of which a POSA would have understood to be a “**concave mirror**” for the reasons I provided for Claim 3, fully incorporated here.

19. Dependent Claim 21

239. Claim 21 depends from Claim 20 and further recites “**wherein the WDM is configured such that a portion of an optical path between the plurality of mirrors and the plurality of filters forms a zig-zag pattern.**” Goodman discloses Claim 21 for the reasons I provided for Claim 5, incorporated here.

20. Dependent Claim 22

240. Claim 22 depends from Claim 21 and recites “**wherein the laser is configured to emit blue light, yellow-green light, violet light, or ultraviolet light.**” The combination of Chandler and Goodman discloses Claim 22 for the reasons I provided for Claim 6, incorporated here.

21. Dependent Claim 26

241. Claim 26 depends from Claim 22 and recites that (1) “**the WDM**

further comprises a block comprising a first surface; and,” (2) “each of the plurality of filters is coupled to the first surface of the block.” Goodman discloses Claim 26 for the reasons I provided for Claim 10, incorporated here.

22. Dependent Claim 27

242. Claim 27 depends from Claim 26 and further recites “**wherein the flow cytometer is a benchtop flow cytometer.**” The combination of Chandler and Goodman discloses Claim 27 for the reasons I provided for Claim 7, incorporated here.

23. Dependent Claim 28

243. Claim 28 depends from Claim 26 and further recites “**wherein the flow cytometer is compact.**” The combination of Chandler and Goodman discloses Claim 28 for the reasons I provided for Claim 8, incorporated here.

24. Dependent Claim 29

244. Claim 29 depends from Claim 28 and further recites “**wherein the WDM is capable of detecting a substantially full spectrum of visible light.**” Chandler discloses the additional claim element in Claim 29 for the reasons I provided for Claim 9, incorporated here.

25. Dependent Claim 30

245. Claim 30 depends from Claim 29 and recites “**wherein: the plurality of mirrors comprise five or more mirrors; and the plurality of filters comprise six or more filters.**” Goodman renders obvious Claim 30, as it explains how “one skilled in the art will recognize, in view of the disclosure herein, that a greater or lesser number of filters may be used, for example two, eight or sixteen, depending on the number of channels to be demultiplexed.” (Goodman, 8:29-33.) Given that the reflectors are positioned opposite the wavelength selective elements, a POSA would have understood that an expansion of Goodman’s relay architecture to use “eight or sixteen” filters would have also required a similar addition of corresponding reflectors. (*Id.*, 8:29-33, 9:61-65.) Goodman confirms this common-sense understanding by explaining that “more or fewer channels can be demultiplexed by adding or subtracting filters and reflectors in the device.” (*Id.*, 12:40-44.)

C. Ground 9: Chandler in View of Goodman and Hamamatsu Render Obvious Claims 13, 14, 17, and 18

246. While it is my opinion that a POSA’s general knowledge based on the state of the art for APDs by 2011 would have rendered obvious the use of small-area APDs in my proposed Chandler-Goodman WDM, I provide the following Ground 9 that relies on Hamamatsu’s express teachings for small-area APDs as an alternative

as to Claims 13, 14, 17, and 18:

1. Motivation to Combine Chandler and Goodman with Hamamatsu and Reasonable Expectation of Success

247. In my opinion, a POSA would have been motivated to combine Chandler and Goodman with Hamamatsu. While Chandler describes use of APDs, it does not specify the effective area size of its detectors. Hamamatsu provides these implementation details. As described in my analysis for Claim 14 in Ground 8 and Section IV.C above, incorporated here, small-area APDs were well-known, commercially available, and would have been obvious to use in the Chandler-Goodman WDM to further reduce footprint and to improve signal-to-noise ratio through having less of an active area size.

248. A POSA seeking to further the benefits of using APDs for fluorescence detection while also reducing footprint would have been motivated to implement the commercially-available Hamamatsu small-area APDs into the Goodman-Chandler system. As shown in Hamamatsu, small-area APDs by 2011 were relatively inexpensive and very small. (*See also* EX1031, p.006 (small size).) Goodman and Chandler both teach as a design goal to implement a compact WDM with low footprint. (Goodman, 1:9-12; Chandler, 3:51-55.) A POSA would have understood that small-area APDs such as those disclosed in Hamamatsu would have furthered

this express design goal, and it would have been obvious to try Hamamatsu's small-area APDs in the proposed Chandler-Goodman WDM.

249. Given the well-known benefits of APDs in flow cytometry applications and already existing commercially-available flow cytometers using APDs (*see* Section IV.C), a POSA would have had reasonable expectation of success that Hamamatsu's small-area APDs could be used in the proposed Chandler-Goodman WDM. Chandler already teaches use of APDs (Chandler, 5:29-31), and the small footprint of Hamamatsu's small-area APDs would have been especially conducive to integration with Goodman's compact WDM configuration.

2. Dependent Claim 13

250. Claim 13 depends from Claim 6 and further recites that the WDM additionally comprises **“an array of focusing lenses, wherein each of the focusing lenses in the array of focusing lenses is configured to focus light that passed through a filter in the array of filters to a spot on an APD in the array of APDs, wherein the spot has a diameter that is smaller than a diameter of a core of the optical fiber.”** The combination of Chandler and Goodman discloses Claim 13 for the same reasons I provide for Claim 13 in Ground 8, fully incorporated here. Hamamatsu merely makes express what would have been well-known to a POSA at

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the time of invention. EX1055 shows that, as of June 20, 2010, Hamamatsu provided multiple high sensitivity type, small-area APDs with spectral ranges from 400 nm to 1100 nm and active area diameters at or smaller than 1 mm:

Type No.	Active Area	Spectral Response Range	Peak Wavelength	Breakdown Voltage	Temperature Coefficient of VBR	Package Feature
<u>S8890-02</u>	dia.0.2 mm	400 to 1100 nm	940 nm	500 V	2.5 V/deg. C	TO-5
<u>S8890-05</u>	dia.0.5 mm	400 to 1100 nm	940 nm	500 V	2.5 V/deg. C	TO-5
<u>S8890-10</u>	dia.1 mm	400 to 1100 nm	940 nm	500 V	2.5 V/deg. C	TO-5
<u>S8890-15</u>	dia.1.5 mm	400 to 1100 nm	940 nm	500 V	2.5 V/deg. C	TO-5
<u>S8890-30</u>	dia.3 mm	400 to 1100 nm	940 nm	500 V	2.5 V/deg. C	TO-8
<u>S9251-02</u>	dia.0.2 mm	440 to 1100 nm	860 nm	250 V	1.85 V/deg. C	TO-18
<u>S9251-05</u>	dia.0.5 mm	440 to 1100 nm	860 nm	250 V	1.85 V/deg. C	TO-18
<u>S9251-10</u>	dia.1 mm	440 to 1100 nm	860 nm	250 V	1.85 V/deg. C	TO-5
<u>S9251-15</u>	dia.1.5 mm	440 to 1100 nm	860 nm	250 V	1.85 V/deg. C	TO-5

(EX1055, p.001 (annotated).) These offerings include S8990-02, S8890-05, and S88890-10 disclosed in EX1061 and discussed in Ground 8 above. Their spectral response range covers the full visible light spectrum (approximately 380 – 700 nm).

251. EX1056 provides similar disclosures of several small-area APDs with active area diameters at or smaller than 1 mm:

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Type No.	Active Area	Spectral Response Range	Peak Wavelength	Breakdown Voltage	Temperature Coefficient of VBR	Package Feature
S5343	dia.1 mm	200 to 1000 nm	620 nm	150 V	0.14 V/deg. C	TO-18
S5344	dia.3 mm	200 to 1000 nm	620 nm	150 V	0.14 V/deg. C	TO-5
S5345	dia.5 mm	200 to 1000 nm	620 nm	150 V	0.14 V/deg. C	TO-8
S8664-02K	dia.0.2 mm	320 to 1000 nm	600 nm	400 V	0.78 V/deg. C	TO-5
S8664-05K	dia.0.5 mm	320 to 1000 nm	600 nm	400 V	0.78 V/deg. C	TO-5
S8664-1010	10 x 10 mm	320 to 1000 nm	600 nm	400 V	0.78 V/deg. C	
S8664-10K	dia.1 mm	320 to 1000 nm	600 nm	400 V	0.78 V/deg. C	TO-5
S8664-20K	dia.2 mm	320 to 1000 nm	600 nm	400 V	0.78 V/deg. C	TO-5
S8664-30K	dia.3 mm	320 to 1000 nm	600 nm	400 V	0.78 V/deg. C	TO-8
S8664-50K	dia.5 mm	320 to 1000 nm	600 nm	400 V	0.78 V/deg. C	TO-8
S8664-55	5 x 5 mm	320 to 1000 nm	600 nm	400 V	0.78 V/deg. C	
S9073	dia.0.2 mm	200 to 1000 nm	620 nm	150 V	0.14 V/deg. C	TO-18
S9074	dia.0.5 mm	200 to 1000 nm	620 nm	150 V	0.14 V/deg. C	TO-18
S9075	dia.1.5 mm	200 to 1000 nm	620 nm	150 V	0.14 V/deg. C	TO-5

(EX1056, p.001 (annotated).) These offerings include S5343, S9073, and S9073 disclosed in EX1060 and are discussed in Ground 8 above. They also have a spectral response range that covers the full visible light spectrum.

3. Dependent Claim 14

252. Claim 14 depends from Claim 13 and further recites “**wherein for each of the focusing lenses in the array of focusing lenses, the diameter of the spot is less than 1 mm.**” The combination of Chandler, Goodman, and Hamamatsu

discloses Claim 14 for the same reasons I provided for Claim 14 in Ground 8, fully incorporated here (but also incorporating my analysis for Claim 13 in this Ground 9).

4. Dependent Claim 17

253. Claim 17 depends from Claim 16 and further recites **“a plurality of focusing lenses, wherein each of the plurality of focusing lenses is configured to focus light that passed through a filter of the plurality of filters to a spot on an APD of the plurality of APDs, wherein the spot has a diameter that is smaller than a diameter of a core of the multimode optical fiber.”** The combination of Chandler, Goodman, and Hamamatsu discloses Claim 17 for the same reasons I provided for Claim 17 in Ground 8, fully incorporated here (but also incorporating my analysis for Claim 13 in this Ground 9).

5. Dependent Claim 18

254. Claim 18 depends from Claim 17 and further recites **“wherein for each of the plurality of focusing lenses, the diameter of the spot is less than 1 mm.”** The combination of Chandler, Goodman, and Hamamatsu discloses Claim 18 for the same reasons I provided for Claim 18 in Ground 8, fully incorporated here (but also incorporating my analysis for Claim 13 in this Ground 9).

D. Ground 10: Oostman in View of Goodman and Frazier Render Claims 1-3, 5-14, 16-18, 20-22, and 26-30 Obvious

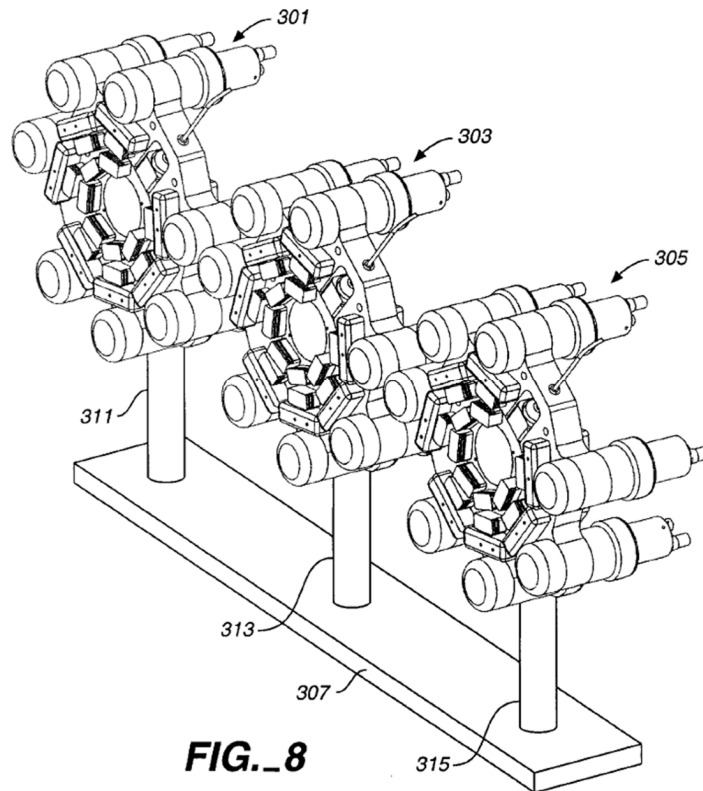
1. Motivation to Combine Oostman with Goodman and Reasonable Expectation of Success

255. A POSA would have found it obvious to combine Oostman's flow cytometers with Goodman's teachings regarding its wavelength division demultiplexer devices. Oostman, as modified by Goodman, would have predictably resulted in the substitution of Oostman's detector array clusters with Goodman's more modular, compact, and efficient optical block demultiplexers.

256. Oostman describes the need to "provide an improved system for detecting fluorescent light having multiple colors emitted from a target using a greater number of detectors than has been achieved in the prior art." (Oostman, 2:60-64.) Oostman strives for this objective with a modular design that feeds a "greater number of fibers" that can "feed a greater number of [detector] clusters" for color separation and detection. (*Id.*, 4:14-16.) But a POSA would have recognized that the ability to perform color separation for additional spatially-separate lasers in Oostman's system comes at the cost of overall footprint and scalability. Oostman's polygonal WDM clusters (including its star configuration WDM) only permits "between five and ten light detectors in a common plane," a potential design

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constraint that limits how finely-grained light fed into a detector cluster from an optical fiber can be separated. (*Id.*, 3:53-55.) In addition, Oostman claims its detector clusters are modular by noting that they “may be physically separated since optical fibers can feed light to clusters in remote locations or in stacks or racks.” (*Id.*, 3:39-41.) But a POSA would have understood that feeding light to a cluster in remote locations (1) increases complexity in the geometry of the optical fibers to minimize signal loss (and maximize internal reflection of incident light) while transmitting light to the clusters, and (2) does not reduce but merely redistributes the flow cytometer’s overall footprint. And, while “[c]lusters may be mounted on rails, racks or stacks in a modular arrangement,” (*id.*, 4:44-45), FIG. 8 shows that these stacks and racks still occupy significant space.



(*Id.*, FIG. 8.) Against these constraints, a POSA would have sought to improve Oostman's design to enable further color-band separation with additional detectors per cluster while also taking advantage of a modular arrangement that allows for a scalable overall design. A POSA would also have sought to miniaturize Oostman's polygonal WDM, as doing so would have unlocked additional cost efficiencies by using less materials to accomplish the same function. For example, a WDM with a smaller footprint design would have permitted the use of the same amount of material in a single dichroic filter for a single channel to be distributed across

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multiple channels.

257. A POSA reviewing Oostman's polygonal WDM configurations would also have recognized potential technical challenges related to aligning its various optical components to ensure efficient and accurate color separation, and the labor, time, and costs associated with post-production calibration. Optical alignment is critical to WDM operation, particularly in non-integrated designs like those described in Oostman where light propagates through air and optical components are oriented/fixated through holders. (Oostman, 8:48-59, FIGs. 9-11.) Optical alignment and calibration were known technical challenges by and before 2011 that practitioners actively attempted to solve in optical systems, including flow cytometer applications. (*See, e.g.*, EX1030, pp.013-014, (“[a]ccurate and reproducible test results are integral” and requires “aligning lasers, optical filters, focussing lenses”); EX1007, p.089 (“An instrument in which optical alignment is adjustable by the operator will typically yield the lowest measurement[.]”).)

258. A POSA seeking to improve color band separation, modularity, scalability, miniaturization, ease of alignment, and portability in Oostman's flow cytometer would naturally have consulted alternate WDM arrangements, including Goodman. Goodman and Oostman are analogous references in the same fields of

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the alleged invention related to optical fibers and, more particularly, modular optical instruments for color separation and detection. (Oostman, 1:8-12 (“The invention relates to analytical instruments for fluorescent light analysis from target specimens and, more particularly, to such an instrument employing increased color decomposition of fluorescent signals from target substances.”), 5:34-40 (teachings not restricted to flow cytometers but extend to “instruments which employ fluorescence detection and color separation”); Goodman, 1:8-12 (“The present invention relates to multiple channel multiplexer/demultiplexer optical devices. In particular, the present invention relates to a compact demultiplexer device[.]”), 3:48-67 (noting, among other things, that inventive demultiplexers are designed to “incorporate into other optical systems”), 6:19-35 (citing design advantages of compact demultiplexer devices and further identifying that “the simple component geometry allows the design to be easily scaled or modified”); *see also, e.g.*, ’107, 2:45 (citing an advantage of its WDM in being “reconfigurable”).) Oostman and Goodman are directed to the same problems faced by the inventor of efficiently demultiplexing and detecting light, and the ’107 specifically identifies WDMs in the optical communication industry as analogous to WDMs in flow cytometry. (’107, 4:62-5:5 (“WDM techniques well-established in the optical communication industry

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can be readily adapted for fluorescence light detection.”), 44:25-33 (WDMs in both fields are “almost identical in function and architecture”).)

259. A POSA would have been motivated to combine Oostman with Goodman because Goodman’s teachings address and provide an improvement on Oostman’s design constraints. These express motivations are confirmed by multiple prior art references and further described in my motivation to combine analysis for Ground 8, incorporated here.

260. Goodman’s compact demultiplexer confers the benefits that a POSA would have sought in seeking improvements to Oostman’s design. Through use of an optical block with integrated filters and reflectors, Goodman’s demultiplexer reduces optical alignment challenges with thermoplastic molded integrated componentry, reducing the time, labor, and costs associated with optical component calibration that would have been more prevalent in Oostman’s detector arrays. The Goodman demultiplexers are also smaller, more scalable, and more portable than Oostman’s configuration. Goodman’s simple geometric design provides the same ease of access as Oostman’s configuration while simplifying fabrication/assembly, reducing the bill of material (BOM) costs by using less materials, and still offering a design that is easily scaled or modified to the number of channels desired for a

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particular application.

261. These motivations, and the associated benefits, are consistent with my pre-2011 experience at Guava Technologies where I extensively reviewed demultiplexing technologies from the field of optical communications in the design of a next-generation mini-flow cytometer.

262. It would have been obvious to try Goodman's demultiplexer device in Oostman's flow cytometer system. Goodman provides a zig-zag pattern in an optical block that was widely accepted in optical communications and had long found adoption within flow cytometry applications. (*See* Section IV.B.) Goodman's WDM configuration is an alternate, known option to the polygonal arrangements in Oostman's detector arrays, and one of several options available to a POSA at the time of the invention.

263. A POSA would have had a reasonable expectation that the combination would have been successful. Goodman designed its invention to specifically provide a "demultiplexer device that is easy to incorporate into other optical systems." (Goodman, 3:65-67.) Its demultiplexing devices satisfy this objective by advantageously being "formed with geometrically simple shapes and without complex off-axis surfaces" that "allows for ease of fabrication, ease of metrology,

and relatively simple incorporation into more complex optical systems.” (*Id.*, 6:19-24.) The ’107 specification confirms that a WDM from the optical communication industry can be “readily adapted for fluorescence light detection,” as such a WDM is “almost identical in function and architecture” to WDMs used in flow cytometry. (’107, 4:62-5:5, 44:25-33.)

2. Motivation to Combine Oostman and Goodman with Frazier and Reasonable Expectation of Success

264. A POSA would have found it obvious to combine the Oostman-Goodman WDM with Frazier’s teachings on the use of APDs within its WDM. (*See* Frazier, 4:19-21.) The Oostman-Goodman optical subsystem, as further modified by Frazier’s APD teachings, would have predictably resulted in the implementation of APDs as the fluorescence detectors in the Oostman-Goodman optical subsystem. The small footprint of APDs would have been particularly conducive for integration in Goodman’s compact WDM design.

265. A POSA would have regarded the teachings of Frazier as naturally combinable with the optical subsystem discussed in Oostman as modified by Goodman. Oostman, Goodman, and Frazier are analogous references in the same field as the alleged invention related to wavelength division demultiplexing, fluorescence detection, and/or flow cytometry. (*See, e.g.*, Oostman, 1:8-12, 5:34-

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40; Goodman, 1:8-12, 3:48-7, 6:19-35; Frazier, Abstract, 1:15-20 (“[T]he present invention relates to fluorescence detection assemblies for analysis of fluorescent signals from target substances.”), 4:5-13 (disclosed WDM configuration incorporated into flow cytometry system but also applicable to other “native environments” like blood analysis, cell sorting, DNA analysis).) Frazier discloses a zig-zag WDM configuration that is similar to Goodman (including use of detectors, interference filters, and mirrors) albeit with a central boulevard design. (*Compare, e.g., Frazier, FIG. 1, with Goodman, FIG. 1.*).

266. A POSA would have been motivated to combine Oostman and Goodman with Frazier to achieve the benefits of using APDs (*see* Section IV.C) while furthering the previously discussed objective of improving Oostman’s flow cytometer with design improvements that result in a more compact flow cytometer with expanded color separation and more sensitive detection capabilities. A POSA would have understood that APDs are significantly smaller than larger PMTs with bulkier housing, allowing for even more compact WDMs due to their “very small” size. (EX1031, p.006; *see also, e.g.,* EX1032, pp.001-002 (small chip areas).) APDs were also known to have high gain and higher cathode quantum efficiency than PMTs (particularly in the IR region), resulting in an expanded spectral operating

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range, higher spectral sensitivity, and better signal-to-noise performance at longer wavelengths. (EX1007, p.155; EX1037, p.009; EX1036, pp.003, 006; EX1038, p.010; EX1039, p.002.) A POSA would have found these technical features of APDs to be highly desirable over PMTs, as APDs deliver (1) more sensitive and accurate photon detection where fluorescent light signals are weak, (2) more efficient photon detection at longer wavelengths (e.g., near infrared spectral regions); and (3) comparable performance at higher energy wavelengths. (EX1035, 6:10-13; EX1037, p.009; EX1036, pp.003, 006; EX1038, p.010; EX1039, p.002; EX1032, p.001; *see also* EX1060, EX1061, EX1062.)

267. A POSA would have had a reasonable expectation that the combination would have been successful. While Oostman discloses use of PMTs, researchers in the field had already demonstrated that PMTs could be substituted for APDs with relative ease and expected to be able to do so in the very commercial system (LSR-II) embodied in Oostman's polygonal arrangement. (EX1036, p.006.) A POSA would not have anticipated any additional technical hurdles from implementing APDs, as opposed to PMTs using Goodman's zig-zag configuration in the Oostman flow cytometer system. Frazier's zig-zag WDM configuration is substantively similar the Goodman WDM design and discloses use of APDs. In addition, as

described in Section IV.C incorporated here, skilled artisans in the field had already long since resolved the technical issues that early APD adopters had encountered when using APDs in flow cytometry applications (e.g., temperature dependence, high dark current).

268. A POSA would not have perceived any teaching from Oostman or Goodman that would discourage incorporation of Frazier's APDs into the combined Oostman-Goodman optical subsystem. Rather, the combination would have entailed only the routine techniques in integration, calibration, and optimization to implement APDs for fluorescence detection in the Oostman-Goodman optical subsystem.

3. Independent Claim 1

a. Claim 1[pre]: "A flow cytometer comprising:"

269. I understand from counsel that the parties agree that Claim 1's preamble is limiting. In my opinion, the preamble reciting a flow cytometer is disclosed by Oostman. Oostman describes how its "preferred embodiment features a flow cytometer" is "illustrative of instruments which employ fluorescence detection and color separation." (Oostman, 5:34-37.) Oostman's FIG. 4 depicts a flow cytometer setup comprising lasers **95, 97, 99, 101** irradiating a target sample within fluidic system **105**, with an optical subsystem where fluorescent and scattered light is

collected by a light collector **111** and focused into optical fibers **123**, **125**, **127**, **129** to route the light to respective detector clusters **124**, **126**, **128**, **130**, each of which comprises an array of detectors for color separation and detection.

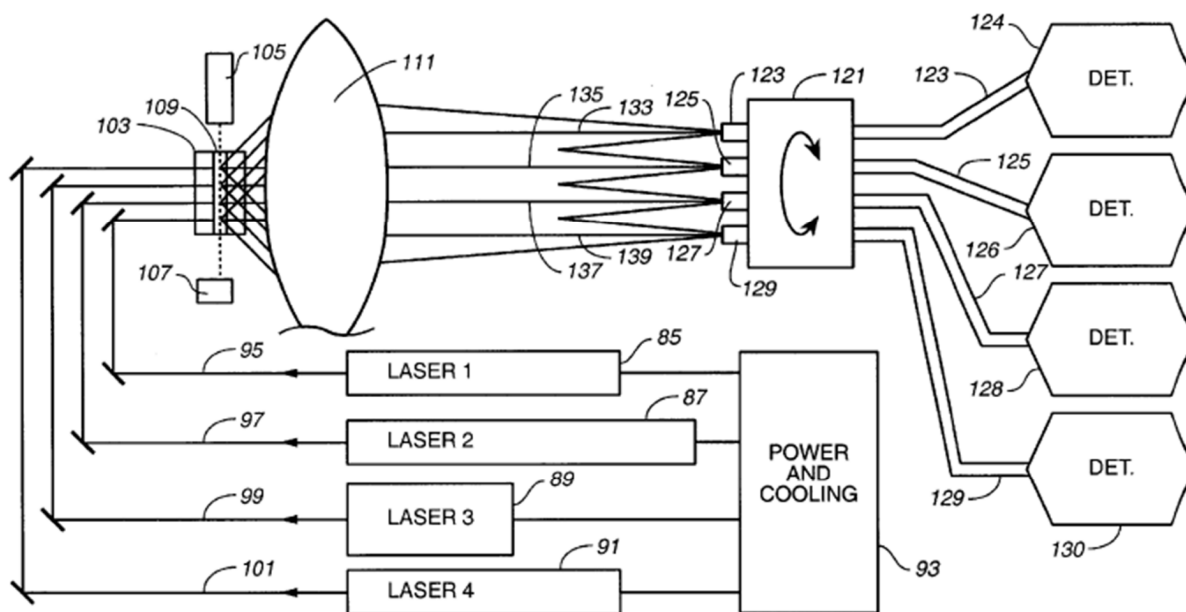


FIG. 4

(*Id.*, FIG. 4.)

b. Claim 1[a]: “an optical fiber; and”

270. Both Oostman and Goodman disclose Claim 1[a]. Oostman discloses an “**optical fiber.**” After light from multiple lasers intersects the flow stream and interacts with fluorescent marked particles in a fluid sample to cause scattering and fluorescence, a light collector “gathers fluorescent light from the fluorescent target

material” and focuses the light into several optical fibers 123, 125, 127, 129.

(Oostman, 5:58-66, 6:12-13.)

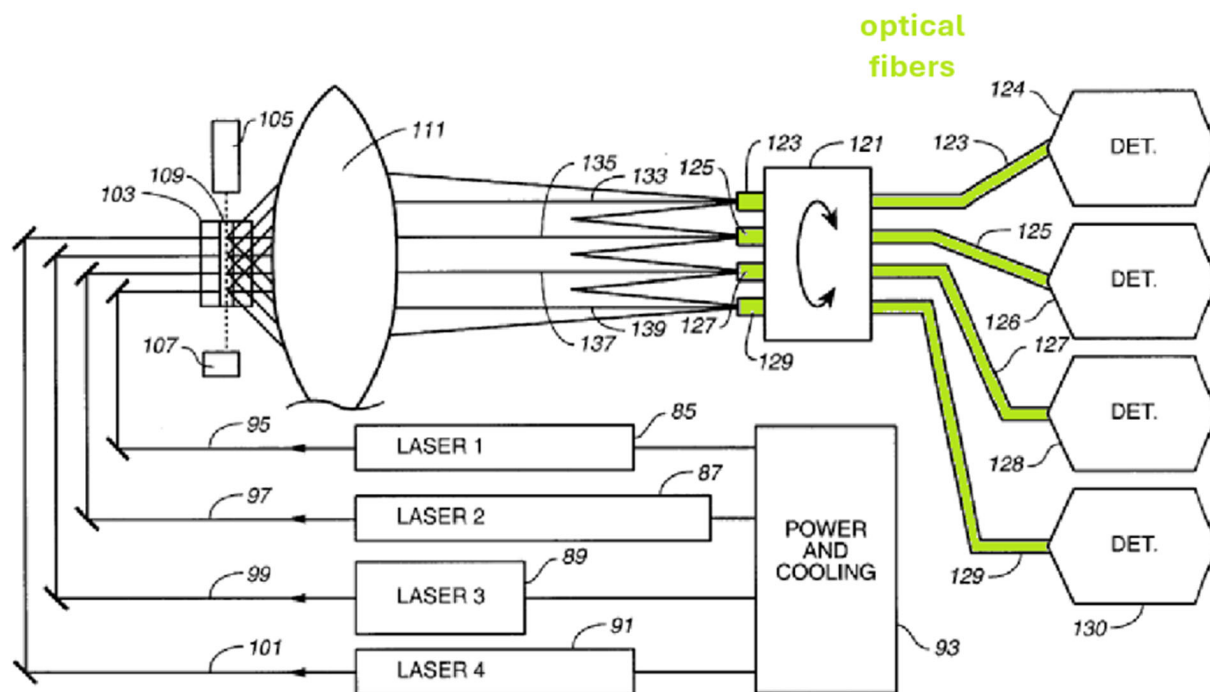


FIG. 4

(*Id.*, FIG. 4 (annotated).)

271. Goodman also discloses an “**optical fiber**” for the same reasons I provided in my analysis for Claim 1[a] in Ground 8 with respect to Goodman, incorporated here.

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c. Claim 1[b]: “a wavelength division multiplexer (WDM) configured to receive light from the optical fiber, wherein the WDM comprises:”

272. The combination of Oostman and Goodman discloses Claim 1[b]. Oostman discloses that “[l]ight in each of the fibers **123, 125, 127** and **129** is transmitted to a respective detector cluster **124, 126, 128** and **130** which houses an array of detectors.” (Oostman, 6:26-28.) A POSA would have understood Oostman’s “array of detectors” to be wavelength division [de]multiplexers, as Oostman describes how the “array processes fluorescent light” and “[e]ach array of detectors differentially separates bands of light by filtering, using coatings on beam splitters and lenses, in a known manner.” (*Id.*, 6:28-36.)

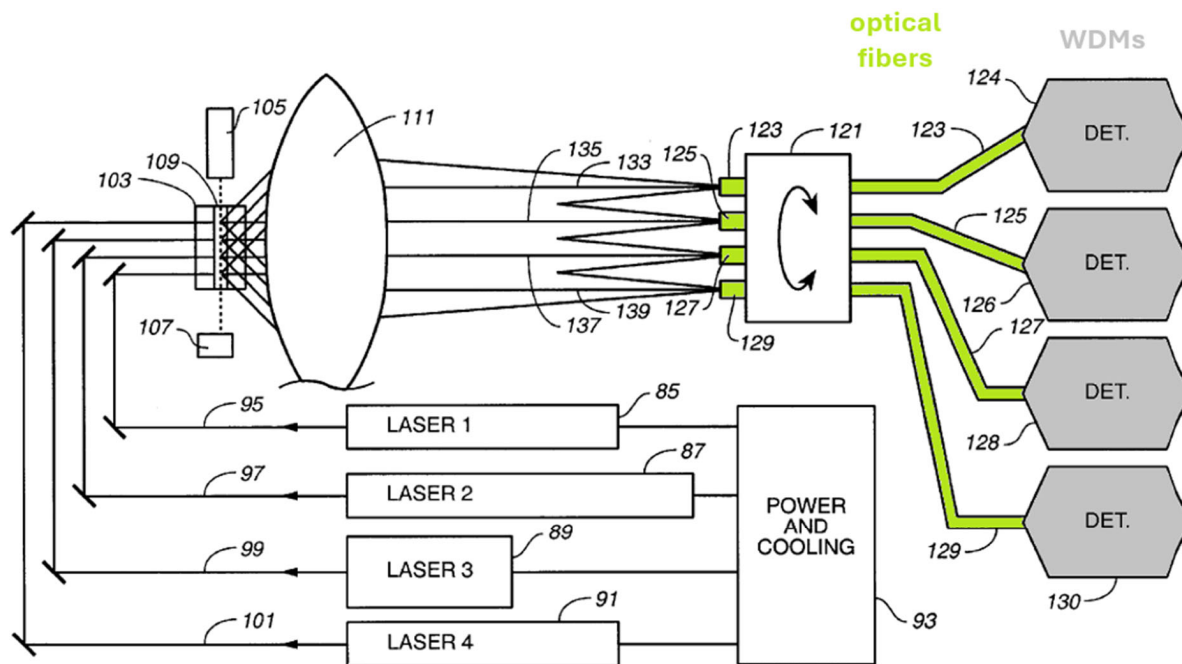


FIG. 4

(*Id.*, FIG. 4 (annotated).)

273. As stated above, the combination of Oostman and Goodman replaces the polygonal arrangement from Oostman's detector arrays with an alternate, known zig-zag demultiplexing configuration described in Goodman.

d. Claim 1[c]: "an array of mirrors;"

274. In my opinion, Goodman discloses Claim 1[c] for the same reasons I provided in my analysis for Claim 1[c] in Ground 8, fully incorporated here.

e. Claim 1[d]: "an array of filters; and"

275. In my opinion, Goodman discloses Claim 1[d] for the same reasons I

provided in my analysis for Claim 1[d] in Ground 8, fully incorporated here.

f. Claim 1[e]: “an array of avalanche photodiodes (APDs) configured to receive light that passed through one or more filters in the array of filters;”

276. The combination of Goodman and Frazier discloses Claim 1[e]. Goodman describes a beam-directing member that includes a set of focusing lenses **42**. Goodman teaches that “emitted wavelength beams” propagating from wavelength selective elements **22a-22n-1** may be “transmitted to the focusing lenses” and then “[e]ach of [the] lenses **42** can focus a selected wavelength beam onto a corresponding optical receiver such as an optical detector[.]” (Goodman, 11:24-30, 11:40-42 (underlining added).) Goodman’s beam-directing member **14** is shown below where light transmitted through the array of filters is incident on focusing lenses **42** (in pink) arranged in a linear array such that a POSA would have understood that the corresponding optical detectors would also be arranged in a linear array.

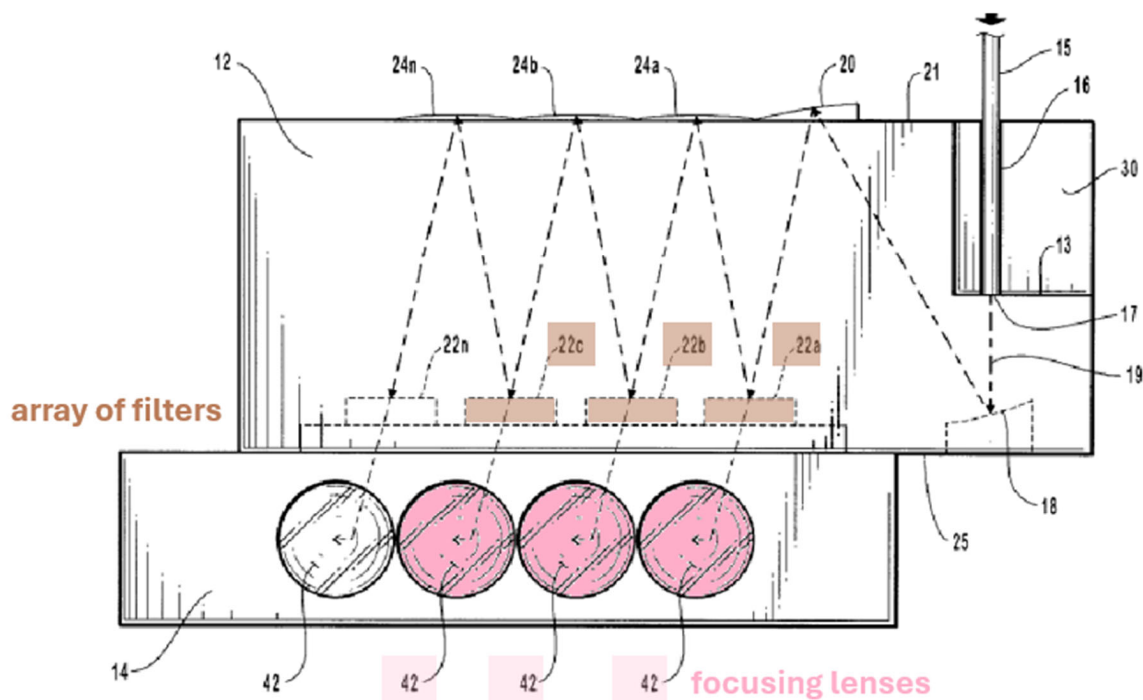


FIG. 1

(*Id.*, FIG. 1 (annotated); *id.*, 4:59-63.)

277. While Goodman generally teaches an array of focusing lenses where each focusing lens may “focus a selected wavelength beam onto a corresponding optical receiver such as an optical detector,” (Goodman, 11:40-42), Goodman does not disclose whether its optical detector is an “APD.” Frazier provides these implementation details, teaching that its photodetectors can include “photo avalanche detectors” (i.e., “APDs”). (Frazier, 4:19-21.) The “**array of avalanche photodiodes (APDs)**” in the combined Oostman-Goodman-Frazier system are the

APDs (from Frazier) that would be “optical detectors” each associated a focusing lens in Goodman’s set of focusing lenses 42.

- g. Claim 1[f]: “wherein each of the filters in the array of filters is configured to receive light such that: a portion of the light passes through the filter; and another portion of the light is reflected; and”**

278. In my opinion, Goodman discloses Claim 1[f] for the same reasons I provided in my analysis for Claim 1[f] in Ground 8, fully incorporated here.

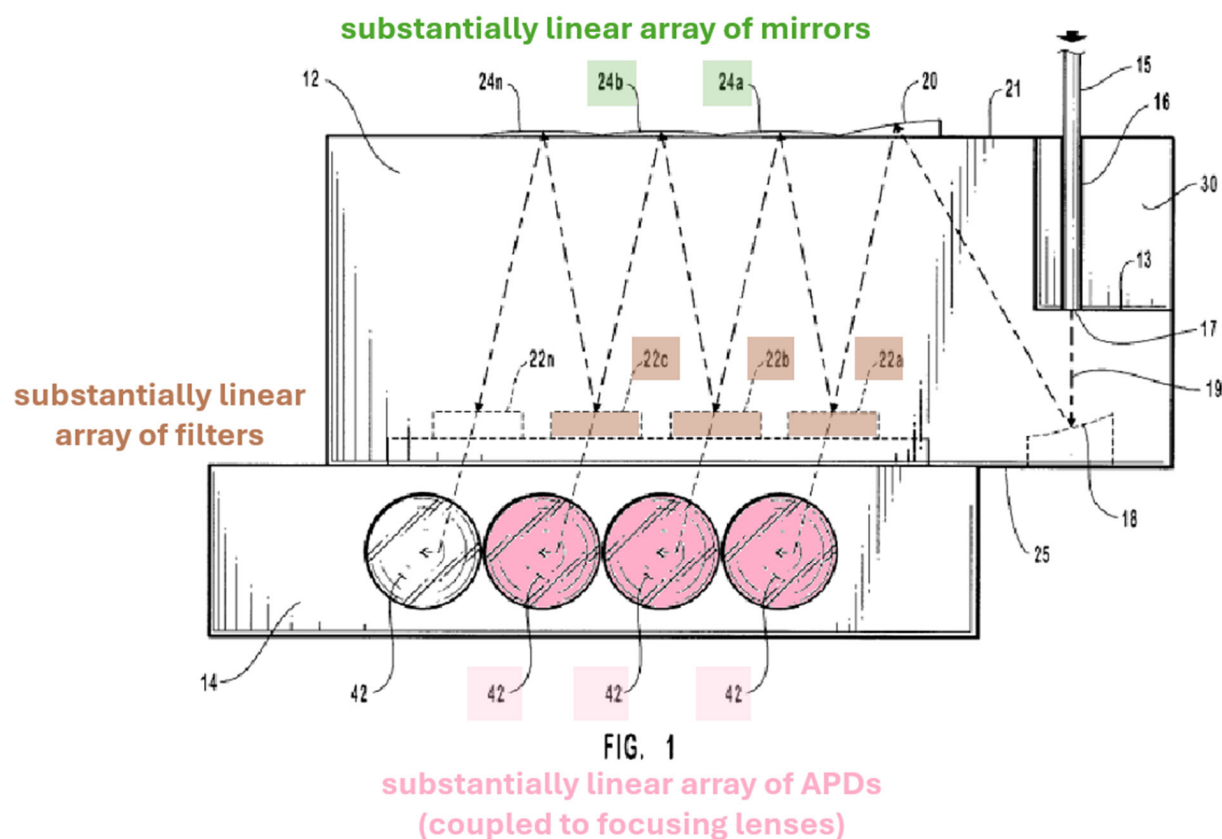
- h. Claim 1[g]: “wherein each of the mirrors in the array of mirrors is configured to: receive light reflected by a filter in the array of filters; and reflect light to another filter in the array of filters.”**

279. In my opinion, Goodman discloses Claim 1[g] for the same reasons I provided in my analysis for Claim 1[g] in Ground 8, fully incorporated here.

4. Dependent Claim 2

280. Claim 2 depends from Claim 1 and further recites (1) **“the array of mirrors is substantially linear”**; (2) **“the array of filters is substantially linear; and”** (3) **“the array of APDs is substantially linear.”** In my opinion, Goodman discloses that **“the array of mirrors is substantially linear”** and **“the array of filters is substantially linear.”** In my opinion, Goodman (incorporating Frazier’s APDs) discloses the additional claim elements Claim 2 for the same reasons I

provided in my analysis for Claim 2 in Ground 8, fully incorporated here. A POSA would also have understood that the array of APDs as taught in Frazier, optically coupled to Goodman's linearly-arranged focusing lenses, would also be linearly-arranged. (Goodman, 11:37-42.) FIG. 1 shows how each of these arrays is “**substantially linear**” as required by Claim 2.



(Goodman, FIG. 1 (annotated).)

5. Dependent Claim 3

281. Claim 3 depends from Claim 2 and further recites “**at least one of the**

mirrors in the array of mirrors is a concave mirror.” In my opinion, Goodman discloses Claim 3 for the same reasons I provided in my analysis for Claim 3 in Ground 8, fully incorporated here.

6. Dependent Claim 5

282. Claim 5 depends from Claim 3 and further recites “**wherein the WDM is configured such that a portion of an optical path between the array of mirrors and the array of filters forms a zig-zag pattern.**” In my opinion, Goodman discloses Claim 5 for the same reasons I provided in my analysis for Claim 5 in Ground 8, fully incorporated here.

7. Dependent Claim 6

283. Claim 6 depends from Claim 5 and further recites “**a laser that is configured to emit blue light, yellow-green light, violet light, or ultraviolet light.**” Oostman explains that each of its laser beams “has a characteristic color produced by different types of lasing material.” (Oostman, 5:46-48.) Exemplary lasers with different lasing materials are disclosed, and Oostman teaches that “characteristic laser illumination wavelength profiles may be produced by CO₂ lasers, argon ion lasers, copper vapor lasers, and helium neon lasers.” (*Id.*, 5:48-61.) A POSA would have understood that Oostman teaches Claim 6 because several

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exemplary lasers emit light among the claimed colors, depending on their rated power level. Argon ion lasers include lasing wavelengths considered “**blue light**” at 351 nm, 364 nm, 458 nm, and 477 nm. (EX1085.) Argon-ion lasers also include lasing wavelengths considered “**yellow-green light**” at 488 nm, 515 nm, and 529 nm. (*Id.*) Helium neon lasers may emit “**yellow-green light**” and were available at 543 nm and 594 nm as early as 2003. (EX1007, p.132.) Copper vapor lasers also emit “**yellow-green light**” at 510 nm (green) and 578 nm (yellow). (EX1086, p.002.)

8. Dependent Claim 7

284. Claim 7 depends from Claim 6 and further recites “**wherein the flow cytometer is a benchtop flow cytometer.**” The term “**benchtop flow cytometer**” only appears within the ’107 claims and is absent from the specification. Nevertheless, a POSA would have understood the Oostman-Goodman-Frazier system to disclose a benchtop flow cytometer. Oostman describes how “[e]ach array of detectors is arranged in a polygonal compact cluster,” (Oostman, 3:34-35 (underlining added); *see also id.*, Abstract (“A large number of detectors is mounted in a compact polygonal arrangement[.]”)), and Goodman indicates that its WDM is (advantageously) compact, (Goodman, Title, 1:1-2, 1:8-12, 3:65-67, 5:42-45).

Frazier also describes that its invention provides a solution for prior art detector arrays utilizing a boulevard arrangement that would have had an “unnecessarily large footprint.” (Frazier, 6:61-7:1.) Oostman, as modified to include Goodman’s compact WDMs and Frazier’s APDs, would have predictably resulted in a **“benchtop flow cytometer.”**

9. Dependent Claim 8

285. Claim 8 depends from Claim 6 and further recites **“wherein the flow cytometer is compact.”** A POSA would have found the Oostman-Goodman-Frazier system to disclose Claim 8 for the same reasons I provided for Claim 7 in this Ground 10, fully incorporated here. Oostman and Frazier sought to design a “compact” flow cytometer and minimize an unnecessarily large footprint, (Oostman, 3:34-35; *see also id.*, Abstract; Frazier, 6:61-7:1), and a POSA would have further pursued Oostman’s and Frazier’s design goals by incorporating Goodman’s compact WDM, (Goodman, Title, 1:1-2, 1:8-12, 3:65-67, 5:42-45), resulting in the Oostman-Goodman-Frazier **“compact”** flow cytometer, utilizing the zig-zag detector arrangement and APDs. I also incorporate my analysis from Section IX.D.1 regarding a POSA’s motivations to combine Oostman with Goodman to further reduce the footprint of Oostman’s flow cytometer.

10. Dependent Claim 9

286. Claim 9 depends from Claim 8 and further recites “**wherein the WDM is capable of detecting a substantially full spectrum of visible light.**” As explained in my analysis for Grounds 5 and 6, it is my opinion that Claim 9 lacks written description support and is not enabled. Claim 9 is directed to full spectral analysis capabilities that the inventor did not conceive of or provide a POSA with disclosures on within the ’107 written description. The ’107 written description makes no mention of full spectral analysis, passingly refers to conventional peak wavelength analysis, (*see* ’107, 27:45-49), and never explains how the disclosed WDM is capable of enabling full spectral analysis.

287. To the extent Patent Owner contends that the Claim 9 captures a WDM capable of processing light where excitation wavelengths from light sources may span the visible light spectrum, Oostman discloses Claim 9. The visible light spectrum range is from approximately 380 to 750 nm, and the ’107 specification recites that its WDM is compatible with light sources with excitation wavelengths at 375 nm, 405 nm, 440 nm, 488 nm, 502 nm, 534 nm, 561 nm, 591 nm, and 637 nm. (’107, 49:20-25.) As I explained for Claim 6 of this Ground, incorporated here, Oostman explains that each of its laser beams “has a characteristic color produced

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by different types of lasing material” and cites use of “CO₂ lasers, argon ion lasers, copper vapor lasers, and helium neon lasers.” (Oostman, 5:46-61.) Each laser type may have multiple excitation wavelengths based on the power level they are rated for. Accounting for varying power levels, the excitation wavelengths for these exemplary lasers in the UV-to-visible light range may include 458 nm (Ar-ion), 477 nm (Ar-ion), 488 nm (Ar-ion), 510 nm (copper vapor), 515 nm (Ar-ion), 529 nm (Ar-ion), 543 nm (He-Ne), 578 nm (copper vapor), and 594 nm (He-Ne). (EX1007, pp.129-130, 132; EX1085; EX1086.) These excitation wavelengths span substantially the full visible light spectrum, and would have been able to accommodate the commercially-available fluorescent dyes across the visible light spectrum at the time of invention.

288. In addition, I note that scattered and/or fluorescent light that results from illuminating fluorescent-tagged target material with a shorter-wavelength laser, such as UV lasing wavelengths from an Ar-ion laser (e.g., at 351 nm or 364 nm – *see* EX1085) may result in demultiplexed light with wavelength separation across the full visible light spectrum depending on the number of available detection channels. To the extent Patent Owner argues that Claim 9 contemplates a WDM that can separate shorter-wavelength light into color bands that substantially cover

the full visible light spectrum, the combination of Oostman, Goodman, and Frazier discloses Claim 9. The combined Oostman-Goodman-Frazier system includes sufficient scalability to accommodate an array of demultiplexing channels and corresponding APDs that can demultiplex light across substantially the full visible light spectrum, as Goodman teaches that “more or fewer channels can be demultiplexed by adding or subtracting filters and reflectors in the device.” (Goodman, 12:40-44; *see also id.*, 8:28-33 (“As shown, one preferred number of wavelength selective elements **22a-22n** is four. Of course, one skilled in the art will recognize, in view of the disclosures herein, that a greater or lesser number of filters may be used, for example, two, eight or sixteen, depending on the number of channels to be demultiplexed.”).)

11. Dependent Claim 10

289. Claim 10 depends from Claim 6 and further recites (1) “**the WDM further comprises a block comprising a first surface; and**” (2) “**each of the filters in the array of filters is coupled to the first surface of the block.**” In my opinion, Goodman discloses Claim 10 for the same reasons I provided in my analysis for Claim 10 in Ground 8, fully incorporated here.

12. Dependent Claim 11

290. Claim 11 depends from Claim 10 and further recites “**wherein the flow cytometer is a benchtop flow cytometer.**” The combination of Oostman, Goodman, and Frazier discloses Claim 11 for the reasons I provided for Claim 7 of this Ground, incorporated here.

13. Dependent Claim 12

291. Claim 12 depends from Claim 10 and further recites “**wherein the flow cytometer is compact.**” The combination of Oostman, Goodman, and Frazier discloses Claim 12 for the reasons I provided for Claim 8 of this Ground, incorporated here.

14. Dependent Claim 13

292. Claim 13 depends from Claim 6 and further recites that the WDM additionally comprises “**an array of focusing lenses, wherein each of the focusing lenses in the array of focusing lenses is configured to focus light that passed through a filter in the array of filters to a spot on an APD in the array of APDs, wherein the spot has a diameter that is smaller than a diameter of a core of the optical fiber.**” In my opinion, the combination of Oostman, Goodman, and Frazier, in view of a POSA’s general knowledge regarding the state of the art in small-area

APDs by December 2011 (or later), renders obvious Claim 13 for the reasons I provided in my analysis for Claim 13 in Ground 8, incorporated here. The only difference in my analysis here compared to Ground 8 is that the APDs in the Oostman-Goodman-Frazier system are taught by Frazier.

15. Dependent Claim 14

293. Claim 14 depends from Claim 13 and further recites “**wherein for each of the focusing lenses in the array of focusing lenses, the diameter of the spot is less than 1 mm.**” In my opinion, the combination of Oostman, Goodman, and Frazier, in view of a POSA’s general knowledge regarding the state of the art in small-area APDs by December 2011 (or later), renders obvious Claim 14 for the reasons I provided in my analysis for Claim 14 in Ground 8, incorporated here.

16. Independent Claim 16

a. Claim 16[pre]: “A flow cytometer comprising:”

294. Oostman discloses the preamble of Claim 16 for the reasons I provided for the preamble of Claim 1 of this Ground, incorporated here.

b. Claim 16[a]: “a flow cell configured to permit liquid to flow through the flow cell;”

295. Oostman teaches a “**flow cell configured to permit liquid to flow through the flow cell.**” A flow cell includes a small channel where cells are

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suspended in a fluid and aligned / focused into a single file as they pass through a spot illuminated by an illumination source (e.g., an arc lamp, laser). (EX1007, p.081.) Oostman describes its flow cell as a “fluidic system **105**” that “feeds tagged target liquid substances into a stream **103** in a controlled manner.” (Oostman, 5:41-42.) Fluidic system **105** includes a flow channel **109** that is “**configured to permit liquid to flow through the flow cell**” via flow stream **103**. (*Id.*, 5:42-44 (“Material which passes through the beam illuminated zone is collected in collection cup **107**.”), 5:58-61 (“Light of different colors intersects the flow stream **103** and interacts with fluid sample causing scattering and fluorescence that is spatially separated along a line parallel to the flow channel **109**.”).) FIG. 4 depicts fluidic system **105** that includes flow channel **109** (in pink) that enables passage of sample material (in red) in flow stream **103** (in orange).

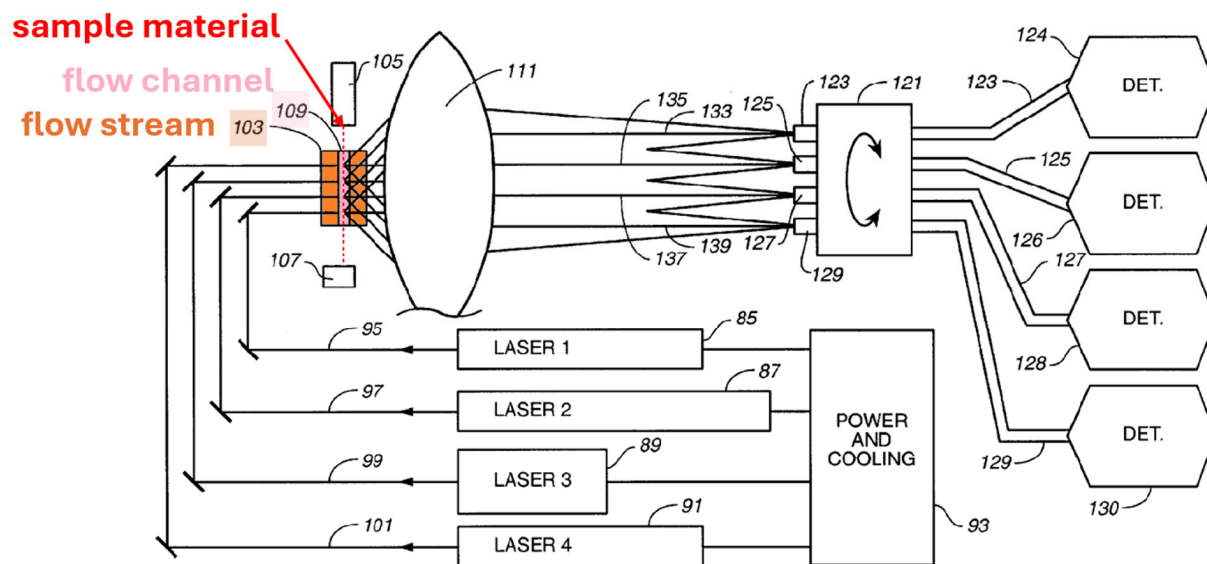


FIG. 4

(Oostman, FIG. 4 (annotated).)

c. Claim 16[b]: “a laser configured to project light into the flow cell;”

296. Oostman discloses “a laser” with respect to its FIG. 4 embodiment, each of “a first laser **85**, a second laser **87**, a third laser **89**, and a fourth laser **91**” that “all produce light with unique wavelength profiles[.]” (Oostman, 5:28-30.) For example, first laser **85** is “**configured to project light into the flow cell.**” Oostman indicates that “[l]ight of different colors intersects the flow stream **103** and interacts with fluid sample causing scattering and fluorescence that is spatially separated along a line parallel to the flow channel **109**.” (*Id.*, 5:58-61 (underlining added).)

297. Oostman's FIG. 4 makes clear that the first laser (in purple) projects light into the flow stream **103** (in orange) and flow channel **109** (in pink) part of the flow cell.

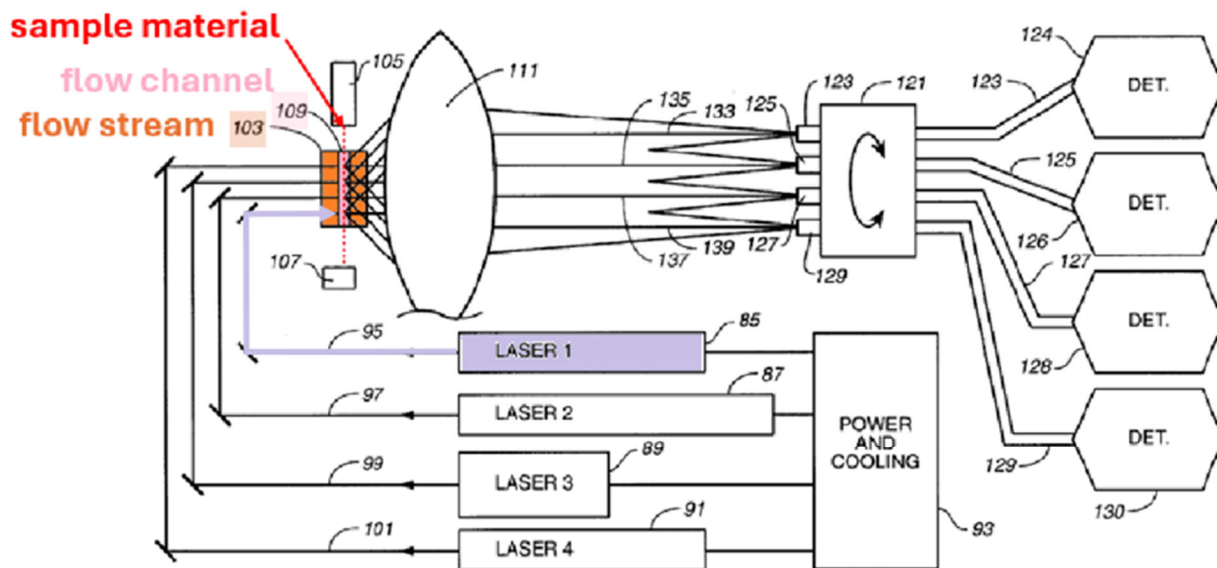


FIG. 4

(Oostman, FIG. 4 (annotated).)

d. Claim 16[c]: “a multimode optical fiber configured to receive light from the flow cell; and”

298. The combination of Oostman and Goodman discloses Claim 16[c] for the reasons I provided for Claim 1[a] of this Ground, incorporated here. Oostman explains that “[t]he focal spots produced by collector **111** enter the tip of each respective fiber **123, 125, 127** and **129**, each of which is a multi-mode fiber” and

then “[l]ight in each of the fibers **123, 125, 127 and 129** is transmitted to a respective detector cluster **124, 126, 128 and 130** which houses an array of detectors” that differentially separates the light into color bands. (Oostman, 6:4-7, 6:26-28, 6:34-39.)

e. Claim 16[d]: “a wavelength division multiplexer (WDM) configured to receive light from the multimode optical fiber, wherein the WDM comprises:”

299. The combination of Oostman and Goodman discloses Claim 16[d] for the reasons I provided for Claim 1[b] of this Ground, incorporated here.

f. Claim 16[e]: “a plurality of mirrors,”

300. Goodman discloses Claim 16[e] for the reasons I provided for Claim 1[c] and Claim 16[e] in Ground 8, incorporated here.

g. Claim 16[e][i]: “wherein at least one of the mirrors is a concave mirror;”

301. Goodman discloses Claim 16[e][i] for the reasons I provided for Claim 3 in Ground 8, incorporated here.

h. Claim 16[f]: “a plurality of filters; and”

302. Goodman discloses Claim 16[f] for the reasons I provided for Claim 1[d] and Claim 16[f] in Ground 8, incorporated here.

- i. **Claim 16[g]: “a plurality of avalanche photodiodes (APDs) configured to receive light that passed through one or more filters of the plurality of filters;”**

303. The combination of Goodman, and Frazier discloses Claim 16[g] for the reasons I provided for Claim 1[e] of this Ground, incorporated here. A POSA would have understood that an “array of avalanche photodiodes (APDs)” as discussed for Claim 1[e] constitutes a plurality.

- j. **Claim 16[h]: “wherein each of the plurality of filters is configured to receive light such that: a portion of light passes through the filter; and another portion of light is reflected; and”**

304. Goodman discloses Claim 16[h] for the reasons I provided for Claim 1[f] in Ground 8, incorporated here.

- k. **Claim 16[i]: “wherein each of the plurality of mirrors is configured to: receive light reflected by a filter of the plurality of filters; and reflect light to another filter of the plurality of filters.”**

305. Goodman discloses Claim 16[i] for the reasons I provided for Claim 1[g] in Ground 8, incorporated here.

17. Dependent Claim 17

306. Claim 17 depends from Claim 16 and further recites “**a plurality of focusing lenses, wherein each of the plurality of focusing lenses is configured to**

focus light that passed through a filter of the plurality of filters to a spot on an APD of the plurality of APDs, wherein the spot has a diameter that is smaller than a diameter of a core of the multimode optical fiber.” The combination of Oostman, Goodman, and Frazier discloses Claim 17 for the reasons I provided for Claim 13 of this Ground, incorporated here.

18. Dependent Claim 18

307. Claim 18 depends from Claim 17 and further recites “**wherein for each of the plurality of focusing lenses, the diameter of the spot is less than 1 mm.**” The combination of Oostman, Goodman, and Frazier discloses Claim 18 for the reasons I provided for Claim 14 of this Ground, incorporated here.

19. Dependent Claim 20

308. Claim 20 depends from Claim 16 and further recites “**wherein the plurality of mirrors includes more than one concave mirror.**” In my opinion, Goodman discloses Claim 20 for the same reasons I provided in my analysis for Claim 20 in Ground 8, fully incorporated here.

20. Dependent Claim 21

309. Claim 21 depends from Claim 20 and further recites “**wherein the WDM is configured such that a portion of an optical path between the plurality**

of mirrors and the plurality of filters forms a zig-zag pattern.” Goodman discloses Claim 21 for the reasons I provided for Claim 5 in Ground 8, fully incorporated here.

21. Dependent Claim 22

310. Claim 22 depends from Claim 21 and recites “**wherein the laser is configured to emit blue light, yellow-green light, violet light, or ultraviolet light.**” Oostman discloses the additional claim elements for Claim 22 for the reasons I provided for Claim 6 of this Ground, incorporated here.

22. Dependent Claim 26

311. Claim 26 depends from Claim 22 and recites that (1) “**the WDM further comprises a block comprising a first surface; and**” (2) “**each of the plurality of filters is coupled to the first surface of the block.**” Goodman discloses Claim 26 for the reasons I provided for Claim 10 in Ground 8, incorporated here.

23. Dependent Claim 27

312. Claim 27 depends from Claim 26 and further recites “**wherein the flow cytometer is a benchtop flow cytometer.**” The combination of Oostman, Goodman, and Frazier discloses Claim 27 for the reasons I provided for Claim 7 of this Ground, incorporated here.

24. Dependent Claim 28

313. Claim 28 depends from Claim 26 and further recites “**wherein the flow cytometer is compact.**” The combination of Oostman, Goodman, and Frazier discloses Claim 28 for the reasons I provided for Claim 8 of this Ground, incorporated here.

25. Dependent Claim 29

314. Claim 29 depends from Claim 28 and further recites “**wherein the WDM is capable of detecting a substantially full spectrum of visible light.**” Oostman discloses the additional claim element in Claim 29 for the reasons I provided for Claim 9 of this Ground, incorporated here.

26. Dependent Claim 30

315. Claim 30 depends from Claim 29 and recites (1) “**wherein: the plurality of mirrors comprise five or more mirrors; and**” (2) “**the plurality of filters comprise six or more filters.**” In my opinion, Goodman discloses Claim 30 for the same reasons I provided in my analysis for Claim 30 in Ground 8, fully incorporated here.

E. Ground 11: Oostman in View of Goodman, Frazier, and Hamamatsu Render Obvious Claims 13, 14, 17, and 18

1. Motivation to Combine Oostman, Goodman, and Frazier with Hamamatsu and Reasonable Expectation of Success

316. A POSA would have been motivated to combine Oostman, Goodman, and Frazier with Hamamatsu for the same reasons I provided in my motivation to combine analysis with respect to Ground 9, incorporated here.

2. Dependent Claim 13

317. Claim 13 depends from Claim 6 and further recites that the WDM additionally comprises “**an array of focusing lenses, wherein each of the focusing lenses in the array of focusing lenses is configured to focus light that passed through a filter in the array of filters to a spot on an APD in the array of APDs, wherein the spot has a diameter that is smaller than a diameter of a core of the optical fiber.**” The combination of Oostman, Goodman, and Frazier discloses Claim 13 for the same reasons I provided for Claim 13 in Ground 10, fully incorporated here. Hamamatsu merely makes express what would have been well-known to a POSA at the time of invention, and I further incorporate my analysis for Claim 13 in Ground 9 related to Hamamatsu and its disclosures on small-area APDs.

3. Dependent Claim 14

318. Claim 14 depends from Claim 13 and further recites “**wherein for each of the focusing lenses in the array of focusing lenses, the diameter of the spot is less than 1 mm.**” The combination of Oostman, Goodman, Frazier, and Hamamatsu discloses Claim 14 for the same reasons I provided for Claim 14 in Ground 10, fully incorporated here (but also incorporating my analysis for Claim 13 in Ground 9 related to Hamamatsu’s small-area APD disclosures).

4. Dependent Claim 17

319. Claim 17 depends from Claim 16 and further recites “**a plurality of focusing lenses, wherein each of the plurality of focusing lenses is configured to focus light that passed through a filter of the plurality of filters to a spot on an APD of the plurality of APDs, wherein the spot has a diameter that is smaller than a diameter of a core of the multimode optical fiber.**” The combination of Oostman, Goodman, Frazier, and Hamamatsu discloses Claim 17 for the same reasons I provided for Claim 17 in Ground 10, fully incorporated here (but also incorporating my analysis for Claim 13 in Ground 9 related to Hamamatsu’s small area APD disclosures).

5. Dependent Claim 18

320. The combination of Oostman, Goodman, Frazier, and Hamamatsu discloses Claim 18 for the same reasons I provided for Claim 18 in Ground 10, fully incorporated here (but also incorporating my analysis for Claim 13 in Ground 9 related to Hamamatsu's small-area APD disclosures).

X. NO SECONDARY CONSIDERATIONS OF NONOBVIOUSNESS

321. I understand from counsel that, while Patent Owner in the underlying district court litigation purports to have identified evidence with respect to secondary considerations of non-obviousness, Patent Owner has not shown any correlation of said evidence to '107 patent's claims.

322. To the extent Patent Owner cites any evidence of sales or any praise or any industry recognition of products that Patent Owner asserts to implement the claimed invention, I am not aware of any information demonstrating that any increased sales, commercial success, praise, or any other secondary factor (that Patent Owner may assert) was a result of the particular features recited in the '107 patent's claims. Since Patent Owner has not yet identified any evidence of secondary considerations, Patent Owner cannot demonstrate that the limitations of the claimed invention in particular, as opposed to other features of the products at

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issue, were the factors that caused any increased sales, praise, or any other asserted secondary considerations.

323. Thus, based on my review of the evidence to date, I can summarize my opinions regarding any alleged secondary considerations of non-obviousness relating to the '107 patent, as follows:

324. **No commercial success of the claimed invention.** Patent Owner has not cited any evidence of particular commercial success of products embodying the '107 patent as opposed to products that do not embody the '107 patent. Patent Owner has not cited any evidence that any commercial success of any products is particularly a result of the claimed inventions recited in the '107 patent's claims and not due to any other facts.

325. **No long-felt but unsolved need.** Patent Owner has not cited any evidence of any long-felt need that remained unsolved in the prior art before the '107 patent. To the contrary, as discussed above, the prior art solved the problems that the '107 patent purported to address.

326. **No failure of others.** Patent Owner has not cited any evidence of anyone who tried, but failed, to solve the problems addressed by the '107 patent. As shown by my analysis above, there existed prior art references that successfully

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disclosed and rendered obvious the subject matter claimed by the '107 patent.

327. **No copying of the claimed invention.** Patent Owner has not cited any evidence that any other party (including Petitioner or third parties) ever copied from the '107 patent and its claimed invention.

328. **No unexpected results of the claimed invention.** Patent Owner has not cited any evidence of unexpected results achieved by the '107 patent's claimed invention. To the contrary, the prior art disclosed the predictable, expected results that show why the '107 patent's claims are obvious as discussed in my Declaration.

329. **No praise for the claimed invention.** Patent Owner has not cited any evidence of praise for the claimed invention recited in the '107 patent.

330. **No surprise or skepticism at the claimed invention.** Patent Owner has not cited any evidence that observers were surprised by, or skeptical of, the claimed invention recited in the '107 patent.

331. **No departure from the wisdom of the prior art.** Patent Owner has not cited any evidence that the claimed inventions of the '107 patent departed from the wisdom of the prior art. The '107 patent claims subject matter that was already present in the prior art, including in the references discussed in my Declaration.

332. Moreover, with respect to the considerations discussed above, I also

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refer to and incorporate my opinions stated throughout this Declaration, including my analysis showing that the '107 patent is directed to techniques known in the prior art and does not provide any inventive technology.

333. To the extent Patent Owner at a later date cites or provides any other evidence regarding secondary considerations, including any expert opinions, I reserve the right to supplement my analysis and opinions to comment on it.

XI. CONCLUSION

334. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in this proceeding. If required, I will appear for cross-examination at the appropriate time.

335. I hereby declare that all statements made herein of my own knowledge are true and that all statements are made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

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Petition for Post-Grant Review of
U.S. Patent No. 12,174,107 B2

Dated: September 23, 2025

Respectfully submitted,

Fedor Ilkov

Fedor A. Ilkov, Ph.D.

Appendix A

Fedor A. Ilkov Ph.D.

737 Opal Dr. Apt.5, San Jose CA 95037 ; cell : (408) 887-4105 ; email : fedor.ilkov@gmail.com
ORCID <https://orcid.org/0000-0002-3700-7033>; www.linkedin.com/in/fedor-teo-ilkov-phd-20b260/

Expertise in

- Flow Cytometers, Cell Sorters, DNA Sequencers, Super-Resolution Microscopy - Optical Cores Designing
- Lasers and Laser Engine design for high precision instrumentation
- Optical design, development, packaging, prototyping and production of complex optical systems in biotechnology, MEMS-light modulators, spectroscopy and telecommunication
- Imaging and non-imaging optics, tolerance analysis in ZEMAX and CODE-V
- Stray-light analysis, illumination and light-collection systems design in ASAP
- Micro-optics for MEMS based optical and laser systems
- Beam shaping and light delivery systems
- Time-Resolved Diffused Reflection Spectroscopy of biological objects
- Non-invasive metabolites monitoring
- Bio-sensors

Hands-on experience in

- Taking concept to full scale production of Flow Cytometers, Cell Sorters, DNA sequencers, Super-Resolution microscopy stations
 - Development, characterization and optimization of coherent and non-coherent light sources
 - Instrumentation and testing techniques: laser characterization, spectroscopy, interferometry, radiometry, photometry, colorimetry, microscopy and mass-spectrometry
 - Technical investigation, performance trade-offs, technological analysis for biotech and medical applications
 - Industrial optical product design, development and volume manufacturing FDA, ISO 9001.
 - Management, technical leadership and supervisory roles; strong interpersonal skills
- =====

Employment History in US and Canada

Head of Optics, Sr.Director	Cellanome	4/23-10/24
Director, Optical Engineering	Eikon Therapeutics Inc.	9/20-4/23
Optical Systems Architect	BD Biosciences	10/18-9/20
Owner, Principal	RodeF Consulting LLC	5/12- 10/18
Director of Optical Engineering	Zyomed Corp. Altadena, CA	6/14- 7/15
Principal Developer	EMD Millipore. Hayward,CA	5/09 – 4/14
Chief Optical Engineer	Guava Technologies, Inc. Hayward,CA	3/05 – 5/09
Principal Optical Design Engineer	Iolon, Inc.San Jose, CA.	3/01 – 3/05
Manager of Optical Engineering	Reflectivity, Inc. Santa Clara, CA	10/99 – 3/01
Optical Designer/Engineer	Raytheon/ELCAN Opt.Tech.,Ont.,Canada.	4/96– 10/99

Work Experience

4/23 -10/24

Head of Optics/ Sr.Director,
Stealth startup, Palo Alto,CA

- Leading optical part of product development effort.
- Design, characterization and optimization of illumination and imaging paths in high precision instrumentation for cellomics.
- Working with multidisciplinary groups- SW, EE, ME engineers, marketing and sales.

9/20 -4/23

Director, Optical Engineering,
Eikon Technologies Inc., Hayward, CA

- Leading the Development of super-resolution microscopy for Single Particle Tracking application
- Designing and developing novel Lasers Engines
- Working with multidisciplinary groups- SW, EE, ME engineers, marketing and sales

Co-author on the manuscript "Oblique Line Scan Illumination Enables Expansive, Accurate and Sensitive Single Protein Measurements in Solution and in Living Cells" in Nature Methods

10/18 – 9/20

Optical Systems Architect, Advanced
Technologies, **BD Bioscience, San Jose, CA**

- Leading the Development of next generation optical platforms for novel cell analyzers
- Designing and developing Lasers, CW and pulsed; LED light sources; Detectors modules based on PMT, APD, GMAPD, siPM
- Designing, developing and prototyping integrated fluorescence collection optics
- Project Technical Lead in novel detection system development - from idea through concept proving, to pilot production
- Working with multidisciplinary groups- SW, EE, ME engineers, marketing and sales

Patents under my single name 'CLUSTERED WAVELENGTH DIVISION..' US20210247293; 'INTEGRATED LIGHT INTERROGATION' US20220244166A1

05/12 – 10/24

Principal, Owner
RodeF Consulting, San Jose, CA

- Optical Engines for Flow Cytometers, Cell Sorters, DNA sequencer
 - Developing novel bio-sensors and algorithms for well-being monitoring
 - Time-resolved Skin Diffuse Reflection Spectroscopy
- Consulted to companies: Reflectivity, Fluidigm, NanoCollect, IntegenX, 10xGenomics, EMD Millipore, STD Biotools, Cytex, DeepCell.

06/14 – 07/15

Director of Optical Systems Engineering.
Zyomed Corp. Altadena, CA

- System integration
- Miniaturization of noninvasive biomedical sensors
- Lead optical design, characterization and optimization of NIR FT spectrometers, tunable lasers and MEMS-based subsystems from concept to prototype stage
- Set up the characterization laboratories

Fedor A. Ilkov

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- Engineering management

03/05 – 04/14

Chief Optical/ Principal Development Engineer.
Guava Technologies, Inc. (Now part of Merck-Millipore Corp.), Hayward, CA

- Tech. Lead in design, characterization and optimization of optical subsystems from the prototype stage through manufacturing
- Overall technical contributions to the company development program.
- Comprehensive optical modeling of next generation laser powered Optical Engines for Flow Cytometry
- Analysis and optimization of Laser Illumination, Fluorescence collection and Scatter light detection
- Product specifications and certification documents, instructions for opto-mechanical assembly and testing processes
- Instrument definition and specification; electro-optical system analysis; system engineering and modeling; project management; interaction with electronic, mechanical, and software engineering; interaction with vendors
- Specification and purchase of lasers, optics, coatings and optical test equipment
- Manufacturing and marketing technical support
- Training manufacturing and field service personnel, supervision of optical assembly and test processes.
- Project management

*Multiple Patents; **Patents under my single name** 'INCREASING COLLECTION EFFICIENCY IN CAPILLARY BASED FLOWCYTOMETRY' US 8,922,778 B2; 'ASYMMETRIC CAPILLARY FOR CAPLLARY-FLOW CYTOMETERS' US 7,564,542 B2*

Co-author on the manuscript " " in

03/01 – 03/05

Principal Optical Design Engineer.
Iolon, Inc. San Jose, CA.

- Design, prototyping and test of novel photonics devices
- Instrument definition and specification; electro-optical system analysis; system engineering and modeling; project management; interaction with electronics, mechanical, and software engineering teams; system integration
- Development of widely tunable Laser, Optical Filters and OADM for telecommunication application. Modeling, building prototypes, characterizing optical performance
- Optical modeling and tolerance analysis of Tunable Laser, Filter and Wavelength Locker using ZEMAX
- Stray light and back reflection analysis using ASAP
- Production and marketing support. interaction with vendors
- Specification and purchase of optics, coatings and test equipment
- Supervision of optical test processes.

Multiple Patents;

10/99 – 03/01

Manager of Optical Engineering.

Reflectivity, Inc. Santa Clara, CA.

- In charge of optical design, illumination and imaging analysis for front and rear projection systems; planning and leading assembly of high-resolution multi-element projection systems, integrating and testing micro-displays
 - Managing optical part of projects on application of innovative MEMS micro-mirror technology in high-definition displays and optical switches. Responsible for taking projects from product definition to market introduction. Working on several multi-disciplinary projects integrating semiconductor physics, MEMS, automation and optics
 - Run presentations and optical tutorials for investors and end users
 - Work with state-of-the-art scientific equipment and software, including: semiconductor processing equipment, high-precision mechanical assemblies and scanning stages, optical detection and metrology hardware, optical assembly tools, and optical design and modeling software, photo-resist modeling software
 - In charge of specifying and ordering optics, coatings and opto-mechanical components
- Multiple Patents;*

12/97 – 10/99

Optical Designer.

Raytheon, ELCAN Optical Technologies, Ont., Canada.

- Multi-element lens design and tolerance analysis using CODE V
- Illumination systems design and stray-light analysis using ASAP
- Explicit characterization and computer modeling of HID lamps, including arcs and reflectors; verification of models and test data
- Design and analysis of projection systems including lenses, illumination systems and complex optical assemblies
- Optics specification and evaluation; taking design from concept to production, hence requires working with prototypes as well as production design
- Identification and resolving of complex optical design and mechanical configuration issues
- Development of alignment and measurement systems to assess optical performance and work with test and development engineers to port these capabilities into manufacturing equipment
- Research and development of techniques for future applications

04/96 - 12/97

Assembly and Test Process Planner/ Manufacturing Engineer Hughes, ELCAN Optical Technologies, Ont., Canada.

- Assembly and test planning of multiple projects conforming to the ISO9001 quality standard.
- Manufacturing and test equipment procuring
- Assembly and test tooling design (using AutoCAD), system tolerance analysis, optimization of fabrication methods
- Preparation of bills of tooling, assembly plans and detailed work instructions
- Responsible for prototype development, acceptance test plans, first article testing
- Responsible for manufacturing processes troubleshooting
- Development of optical calibration procedures
- Examination and approval of production drawings

Fedor A. Ilkov

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- Monitoring of technology trends and management of lamp/light source development efforts for video projection application
- Specification and purchase of optical test equipment
- Supervision of test and assembly process

01/91 - 04/96

Lead. Research Scientist

Center for Optics, Photonics and Lasers, Laval University, Quebec City, Canada

- Laser, optics and spectroscopy specialist in a research team of 12 people. Research areas included Plasma Physics. Tunnel ionization of atoms, Dissociative ionization of diatomic molecules in an intense near and mid-IR laser field, Self-action of ultrashort intense laser pulses in gases and liquids.
- Design and implementation of experiments in the following areas:
 - Optical strength of medium: optical damage; breakdown threshold dependence on laser pulse duration and wavelength in various media
 - Optical spectroscopy: emission, absorption and scattering
 - Non-linear optical effects: self-focusing, self-phase modulation, harmonic generation, multiphoton excitation, ionization and dissociation
- Operation, support and characterization of state-of-art Dye, Ti:Sapphire, Nd:YAG and CO₂ laser systems
- Specification and purchase of laboratory equipment
- Research proposals writing; M.Sc. and Ph.D. students supervision

01/81 - 08/90

Director of Research Laboratory

Thermo-Physics Institute, Tashkent, Uzbekistan,

- Lead a Scientific Lab with five researchers in investigating multiphoton transitions in atomic vapors.
- Design and build high-vacuum chambers for laser interaction with the atomic beams
- Design and build custom ultraviolet, visible and infrared lasers with tunable wavelength.
- Design and build custom ultraviolet, visible and infrared lasers with tunable wavelength
- Lead a scientific research in investigating multiphoton spin-forbidden transition in two electron atoms.
- Directed M.Sc. and Ph.D. projects
- Wrote Research proposals

Education

Ph.D., Non-Linear Spectroscopy, Molecular and Atomic Physics

General Physics Institute, (IOFAN) Moscow, USSR

M.Sc., with distinction, Nuclear Physics, State University of Tashkent, USSR

B.Sc., Physics, State University of Tashkent, USSR

Extensive continuing education in work-related topics

Additional Details

- **US** Citizen
- 6 invited talks at international conferences
- 50+ publications in international journals (Opt.Lett., Opt.Com., JOSA B, Laser.Phys., Phys.Rev.Lett., Phys.Rev.A, J.Phys.B, Chem.Phys.Lett.) and in conference proceedings
Details are in <http://scholar.google.com/scholar?q=+Ilkov+F.&hl=en&lr=&start=0&sa=N>
- Co-author of three manuscripts
- 20+ patents in the areas of microdisplays, fiber optics, telecommunications and biotechnology
Details are in <https://patents.google.com/?inventor=Fedor+Ilkov&oq=Fedor+Ilkov+>
- Merck 2013 Innovation Award for MUSE Cell Analyzer
- Wrote and published book '*Diet to Live - Diet to Die/The Zen of Eating*' under pen name Rodef Vokli

FEDOR ILKOV,

List of Publications

<https://scholar.google.com/citations?user=Bo1rFFQAAAAJ&hl=en>

A - Articles in refereed journals

1. T.D.G.Walsh, **F.A.Ilkov**, S. L. Chin, F. Châteauneuf, T. Nguyen-Dang S. Chelkowski, A. D. Bandrauk, O. Atabek.
“Laser-induced processes during the Coulomb explosion of H₂ in Ti-sapphire laser pulse”
Phys. Rev. A 58,3922, 1998.
2. A. Brodeur, O.G. Kosareva, **F.A. Ilkov**, S.L. Chin
“Self-focusing and plasma defocusing of powerful ultrashort laser pulses/
Moving focus in the propagating of ultrashort laser pulses in air”
Optics Letters, 22,304, 1997.
3. A. Brodeur, **F.A. Ilkov**, S.L. Chin
“Beam filamentation and the white light continuum divergence”
Optics Communications 129, 193, 1996
4. M.Ivanov, T.Seideman, P.Corkum, **F.A.Ilkov**, P.Dietrich
"Explosive ionization of molecules in intense laser fields"
Phys. Rev. A 54,1541, 1996.
5. P. Dietrich, M.Yu. Ivanov, **F.A. Ilkov**, P.B. Corkum
“Two-electron ionization of H₂ and D₂ in infrared laser fields”
Phys.Rev.Lett. 77,4150, 1996
6. **F.A.Ilkov**, S.Turgeon, T.D.G.Walsh, S.L.Chin
"Behaviours of D₂ in a strong CO₂-laser field"
Chem.Phys. Lett., V247,1, 1995
7. **F.A.Ilkov**, T.D.G.Walsh, S.Turgeon, S.L.Chin
"Dissociative tunnel ionization of H₂ in an intense mid-IR laser field"
Phys. Rev. A 51,R2695, 1995.
8. T.D.G.Walsh, **F.A.Ilkov**, S.L.Chin
"The tunnel ionization of atoms, diatomic and triatomic molecules using intense 10.6 μm radiation"
J. of Phys. B: At., Mol., Opt. Phys., V27,p.3767, 1994.

9. T.D.G.Walsh, M.V.Ammosov, **F.A.Ilkov**, S.L.Chin
"Coulomb expansion of a two-component ion bunch: Influence on high field ionization experiments"
J. of Phys. B: At., Mol., Opt. Phys., V.27,p.1115, 1994.
10. TDG Walsh, **FA Ilkov**, SL Chin
"The dynamical behaviour of and in a strong, femtosecond, titanium: sapphire laser field"
Journal of Physics B: Atomic, Molecular and Optical Physics 30 (9), 2167
11. SL Chin, **FA Ilkov**
"Our personal and scientific encounter and collaboration with Delone (or a story of the development of multiphoton and tunnel ionization)"
Laser physics 19 (8), 1494-1499
- 12 **F.A.Ilkov**, L.Sh.Ilkova, S.L.Chin
"Supercontinuum generation versus optical breakdown in CO₂"
Optics Letters,V.18,681,1993.
13. SL Chin, Y Liang, JE Decker, **FA Ilkov**, MV Ammosov
"Tunnel ionization of diatomic molecules by an intense CO₂ laser"
Journal of Physics B: Atomic, Molecular and Optical Physics 25 (10), L249
14. M Ivanov, T Seideman, P Corkum, **F Ilkov**, P Dietrich
"Explosive ionization of molecules in intense laser fields"
Physical Review A 54 (2), 1541
15. A.A.Zhuk, **F.A.Ilkov**, M.G.Malakhov
"Experimental determination of two-photon matrix elements of bound-bound transitions in a calcium atom" *Laser Physics*,V.3,583,1993.
16. D.T.Alimov, **F.A.Ilkov**, A.Z.Ismailov, A.A.Zhuk
"Investigation of quadrupole transition in Ca atoms"
Laser Physics,V.3,651,1993.
17. V.François, **F.A.Ilkov**, S.L.Chin
"Experimental study of the supercontinuum spectral width evolution in CO₂ gas"
Optics Communications,V.99,241,1993.
18. **F.A.Ilkov**, J.E.Decker, S.L.Chin
"Ionization of atoms in the tunnelling regime with Hg as an experimental evidence"
J. of Phys. B:At., Mol., Opt. Phys.,V.25,4005,1992.
19. S.L.Chin, Y.Liang, J.E.Decker, **F.A.Ilkov**, M.V.Ammosov
"Tunnel ionization of diatomic molecules by an intense CO₂ laser"
J. of Phys. B: At., Mol., Opt. Phys.,V.25,L249,1992.

20. V.François, **F.A.Ilkov**, S.L.Chin
"Supercontinuum generation in CO₂ gas accompanied by optical breakdown"
J. of Phys. B: At., Mol., Opt. Phys., V.25,2709,1992.
21. Z.G.Melikishvili, D.T.Alimov, **F.A.Ilkov**
"Polarization dependence of direct three-photon ionization for Ca, Sr and Ba atoms"
J. of Phys. B: At., Mol., Opt. Phys., V.24,1949,1991.
22. D.T.Alimov, **F.A.Ilkov**
"Experimental studies of two-photon intersystem crossings in alkaline-earth atoms"
Optical & Acoustical Review, V.1, p.53, 1990.
23. M.V.Ammosov, **F.A.Ilkov**, M.G.Malakhov, Ch.K.Mukhtarov
"Space-charge influence on the spectra of the ions and electrons formed by laser gas ionisation" *JOSA Ser.B*, V.6, p.1961, 1989.
24. D.T.Alimov, I.I.Bondar, **F.A.Ilkov**
"Forbidden-transition excitation in resonant alkaline-earth atoms multiphoton ionisation"
Bull.Acad.Scienn.USSR, Ser.Phys. V.52, p.72, 1988. (Allerton Press Inc.,New York,1988).

B – Articles in topical collection books

1. **F.A.Ilkov** et al (**Invited paper**)
"Experimental study of tunnel ionisation of atoms and simple molecules by an intense CO₂ laser" in
"Multiphoton Processes" eds D.K.Evans and S.L.Chin, *Series in Optics and Photonics Vol.6*, p.435,
1993.
2. T.D.G.Walsh, M.V.Ammosov, **F.A.Ilkov**, S.L.Chin
"Artificial double peak formation during high field ionisation"
in "Multiphoton Processes" eds D.K.Evans and S.L.Chin, *Series in Optics and Photonics Vol.6*,
p.217, 1993.
3. D.T.Alimov, A.A.Zhuk, A.Z.Ismailov, **F.A.Ilkov**
"Ionisation spectroscopy of Sr autoionizing states"
in "Atoms and Molecules in Strong Field of Laser Radiation" eds. F.V.Bunkin and I.I.Tugov, Wiley
Scientific Publishers, Moscow, 1992, p.271.
4. David King, Amedeo Cappione, **Fedor Ilkov**, Bruce Goldman, Ray Lefebvre, Rick Pittaro
and G. J. Dixon
Chapter 5: Progress in Capillary Flow Cytometry
The Microflow Cytometer, by Frances Ligler, Jason Kim
Pan Stanford Publication 2010 ISBN: 9789814267410

5. S.L.Chin, J.E.Decker, **F.A.Ilkov**, W.Xiong
"Tunnel ionisation of ground state atoms and molecules by an intense CO₂ laser"
in “ *Atoms and Molecules in Strong Field of Laser Radiation*” eds. *F.V.Bunkin and I.I.Tugov*, Wiley Scientific Publishers, Moscow, 1992, p.21.
6. **F.A.Ilkov**, D.T.Alimov, M.Yu.Ivanov,
"Observation of the electric quadruple transition $4s^2\ ^1S_0-4s3d\ ^1D_2$ in Ca during three-photon ionisation"
in “*Nonlinear Spectroscopy of Atoms and Diatomic Molecules*”, ed.,N.B.Delone, Moscow,1988, p.5.
7. D.T.Alimov, **F.A.Ilkov**, V.P.Krainov, Z.G.Melikishvily
"Polarization effects in nonresonant multiphoton ionization of atoms"
in “*Fundamental Processes in a Laser Radiation Field*, Moscow”, ed., N.B.Delone, Moscow, 1987, p.154.
8. **F.A.Ilkov**, D.T.Alimov, A.N.Belkovsky, A.A.Zhuk,
"Experimental investigation of forbidden transitions in processes of the three-photon resonant ionisation of alkaline-earth atoms"
in “*Fundamental Processes in a Laser Radiation Field*”, ed., N.B.Delone, Moscow, 1987, p.92.
9. **F.A.Ilkov** ,D.T.Alimov, A.N.Belkovsky, A.A.Zhuk, , V.M.Medvedeva, M.A.Tursunov
"Multiphoton ionisation of Mg in the presence of a static electric field"
in “*Atomic Energy Levels and Transitions Probability*”, Moscow, ed., N.B.Delone, 1987, p.220.

C – Patents

1. **FA Ilkov** “Asymmetric capillary for capillary-flow cytometers”
US Patent 7,564,542, US Patent 7,978,318
2. **F Ilkov** “Apparatus and method for increasing collection efficiency in capillary based flowcytometry
US Patent 8,605,283, US Patent 8,922,778
3. **F Ilkov** “Clustered wavelength division light detection systems and methods of using the same”
US Patent 11,821,830, US Patent 12,038,373, US Patent 12,313,520
4. **F Ilkov** “Integrated light interrogation modules and methods of use thereof”
US Patent 11,994,458
5. **F Ilkov**, S Bhaban “Apparatus and method for quantitative characterization of a light detector” US Patent 11,781,963; US Patent 11,486,812

6. **F Ilkov** "Apparatus and method for increasing collection efficiency in capillary based flowcytometry" US Patent 8,922,778
7. **Ilkov F.A.**, Patel S, Richards P., Stockton "Mirror Elements for Improved Contrast Ratio", Reflectivity, Inc, Santa Clara, CA, filed August 2000;
8. FA Ilkov, SR Patel, PW Richards, JK Stockton
"Projection system and mirror elements for improved contrast ratio in spatial light modulators"
US Patent 6,523,961
9. **Ilkov F.A.**, Patel S., Richards P., Stockton "Improved Contrast Ratio in Spatial Light Modulators", Reflectivity, Inc, Santa Clara, CA, filed December 2000;
10. **Ilkov F.A.**, Steward J., Reid J "Substrate Gap Uniformity Analysis System", Reflectivity, Inc, Santa Clara, CA, filed May2001;
11. Huibers A., **Ilkov F.A.**, Patel S., Richards P., Stockton "Projection System and Mirror Elements", Reflectivity, Inc, Santa Clara, CA, filed August 2001.
12. **Ilkov F.A.**, Tavernier H. King D. "MEMS- based optical filter incorporated a position-tuned filter element", Iolon, Inc. filed October 15, 2001
13. JD Berger, DW Anthon, FA Ilkov, DA King
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