Cisco Systems, Inc., Ciena Corporation, Coriant Operations, Inc., Coriant (USA) Inc., and Fujitsu Network Communications, Inc.,
Petitioner
v.

Capella Photonics, Inc.
Patent Owner

PATENT NO. RE42,368 (IPR2014-01166)
FILING DATE: JUNE 15, 2010
REISSUE DATE: MAY 17, 2011
&
PATENT NO. RE42,678 (IPR2014-01276)
FILING DATE: JUNE 15, 2010
REISSUE DATE: SEPTEMBER 6, 2011

* All cites to exhibit page numbers refer to the stamped exhibit page numbers and not to the original page numbering
** Highlighting provided for convenience.

Table of Contents

Priority to Smith '683 Provisional

'941 Smith Patent Priority: Smith Claim 1

1. An optical switching system comprising:

at least one movable mirror for selectively coupling an optical signal from an input port to any of a plurality of output ports according to a position of said mirror;

an optical detector receiving a portion of light coupled to one of said output ports to measure an intensity of said light; and

a controller receiving an output of said optical detector and in response adjusting said position of said mirror to effect control of said intensity.

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Claim 1)

Only Priority Dispute: Movable Mirror

at least one movable mirror for selectively coupling an optical signal from an input port to any of a plurality of output ports according to a position of said mirror;

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Claim 1)

‘683 Smith Provisional: “Rotated”

According to a preferred embodiment of the invention, the optical throughput of each wavelength channel may be controlled by using a mirror array with elements that can be rotated in an analog fashion about two orthogonal axes. Angular displacement in a first, switching plane, is used to perform an OXC, ADM or other switching function while angular displacement about the orthogonal axis is used for power control. MEMS switches with single axis mirror

(Ex. 1005 (IPR2014-01166, -01276), ‘683 Smith Provisional, Page 7, Lines 3-7)

‘683 Smith Provisional: MEMS OADM

Example: OADM 3-D Design

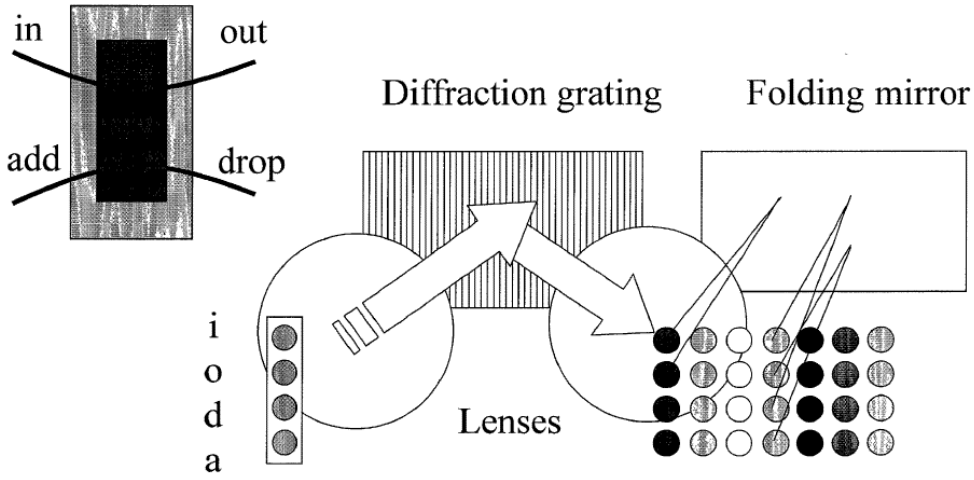
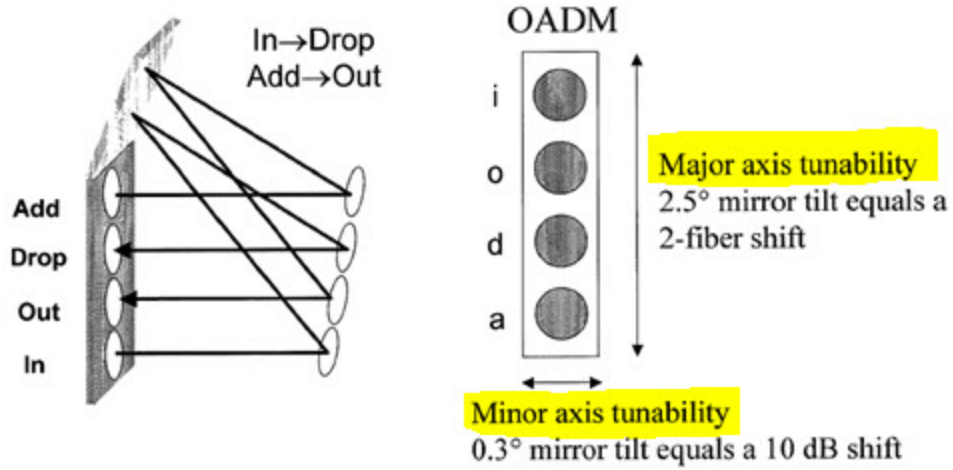


Figure 6

(Ex. 1005 (IPR2014-01166, -01276), ‘683 Smith Provisional, Fig. 6, Page 19)

‘683 Smith Provisional: MEMS OADM

Figure 7 Mirror Tuning



Note: Multiple-LAN OADM needs only 3.8° range

(Ex. 1005 (IPR2014-01166, -01276), ‘683 Smith Provisional, Fig. 7, Page 20)

‘683 Smith Provisional: Definitions

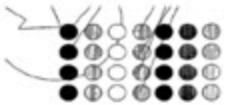
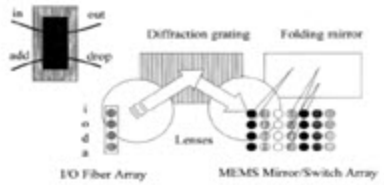
MEMS: MEMS (micro-electro-mechanical systems)

(Ex. 1005 (IPR2014-01166, -01276), ‘683 Smith Provisional, Page 4, Line 15)

OADM: Optical add/drop multiplexers (OADM’s)

(Ex. 1005 (IPR2014-01166, -01276), ‘683 Smith Provisional, Page 5, Line 9)

'941 Smith Patent Priority: Smith Claim 1

Smith Claim 1 Element	Smith Provisional Disclosure (all cites to Exhibit 1005, U.S. Provisional Appl. No. 60/234,683)
1[a]: at least one movable mirror for selectively coupling an optical signal from an input port to any of a plurality of output ports according to a position of said mirror	p. 7; Fig. 6:  MEMS Mirror/Switch Array p. 7 ("[a]ccording to a preferred embodiment of the invention, the optical throughput of each wavelength channel may be controlled by using a mirror array with elements that can be rotated in an analog fashion about two orthogonal axes. Angular displacement in a first, switching plane, is used to perform an OXC, ADM or other switching function while angular displacement about the orthogonal axis is used for power control."); emphasis added.) p. 8, Fig. 6: Example: OADM 3-D Design  Figs. 2, 5, 9.

(Paper 34 (IPR2014-01166), Petitioner's Briefing in Response to PTAB Questions, Attached Chart; Paper 30 (IPR2014-01276), Petitioner's Briefing in Response to PTAB Questions, Attached Chart)

'941 Smith Patent Priority: Smith Claim 28

28. A method for controlling an optical cross connect which includes a plurality of individually controllable transmissive elements comprising:

adjusting said transmissive elements to effect selective optical coupling between a plurality of input beams to a plurality of output beam

monitoring optical powers on said plurality of output beams; and

in response to said monitoring step, adjusting a transmission of said transmissive elements to achieve a predetermined relationship of optical powers between said plurality of output beams.

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Claim 28)

'941 Smith Patent Claim 28: No Dispute Raised

support. It discusses only a single claim and argues that the Smith patent's claim 1 had some corresponding disclosure in the '683 Provisional. (Paper 34, New Chart,

(Paper 37 (IPR2014-01166), PO's Response to Petitioner's Br., Page 5; Paper 33 (IPR2014-01276), PO's Response to Petitioner's Br., Page 5)

‘941 Smith Patent Claim 28: “Adjusting”

adjusting said transmissive elements to effect selective optical coupling between a plurality of input beams to a plurality of output beam

(Ex. 1004 (IPR2014-01166, -01276), ‘941 Smith Patent, Claim 28)

'683 Smith Provisional: "Adjusting"

According to a preferred embodiment of the invention, the optical throughput of each wavelength channel may be controlled by using a mirror array with elements that can be rotated in an analog fashion about two orthogonal axes. Angular displacement in a first, switching plane, is used to perform an OXC, ADM or other switching function while angular displacement about the orthogonal axis is used for power control. MEMS switches with single axis mirror

(Ex. 1005 (IPR2014-01166, -01276), '683 Smith Provisional, Page 7, Lines 3-7)

'941 Smith Patent Claims 1 & 28: No Claimed "Gimbaled Mirror"

1. An optical switching system comprising:

at least one movable mirror for selectively coupling an optical signal from an input port to any of a plurality of output ports according to a position of said mirror;

an optical detector receiving a portion of light coupled to one of said output ports to measure an intensity of said light; and

a controller receiving an output of said optical detector and in response adjusting said position of said mirror to effect control of said intensity.

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Claim 1)

28. A method for controlling an optical cross connect which includes a plurality of individually controllable transmissive elements comprising:

adjusting said transmissive elements to effect selective optical coupling between a plurality of input beams to a plurality of output beam

monitoring optical powers on said plurality of output beams; and

in response to said monitoring step, adjusting a transmission of said transmissive elements to achieve a predetermined relationship of optical powers between said plurality of output beams.

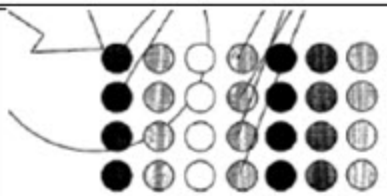
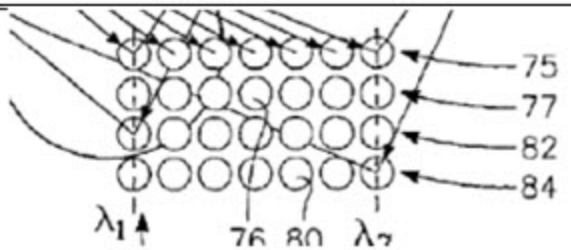
(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Claim 28)

Only Priority Dispute: Movable Mirror

subject matter was carried over from the '683 Provisional. As previously argued, the Smith patent's claim features, *e.g.*, "movable mirror," were not carried over from the '683 Provisional. (Paper 19, pp. 56-59.) Rather, they were carried over

(Paper 37 (IPR2014-01166), PO's Response to Petitioner's Br., Page 5; Paper 33 (IPR2014-01276, PO's Response to Petitioner's Br., Page 5; Paper 19 (IPR2014-01166),PO's Response, Pages 56-59; Paper 15 (IPR2014-01276), PO's Response, Pages 58-60)

Relevant Disclosure Carried Through: Movable Mirror

Claimed '368 subject matter	Smith provisional	Smith patent
Claims 1, 15, 16, 17: Spatial array of beam-	Fig. 6:	Fig. 5:
deflecting elements Claim 13: beam-deflecting elements are micro-machined mirrors	 MEMS Mirror/Switch Array p. 6	 7:1-4, 7:32-44, Fig. 14, 12:29-42, Fig. 9, 9:6-57, 10:37-43, 11:2-11, 14:49-65, 16:8-51.

(Ex. 1028 (IPR2014-01166), Marom Decl., Pages 81-82; Ex. 1028 (IPR2014-01276), Marom Decl., Page 98)

Relevant Disclosure Carried Through: Moveable Mirror

Claimed '368 subject matter	Smith provisional	Smith patent
Claims 1, 15, 16, 17: individually and continuously controllable in two dimensions	p. 6 ("[a]ccording to a preferred embodiment of the invention, the optical throughput of each wavelength channel may be ***controlled by using a mirror array with elements that can be rotated in an analog fashion about two orthogonal axes***. Angular displacement in a first, switching plane, is used to perform an OXC, ADM or other switching function while angular displacement about the orthogonal axis is used for power control.") (emphasis added.)	Abstract ("multi-wavelength…optical switch including an array of mirrors tiltable about two axes, both to control the switching and to provide variable power transmission."), 7:1-3 (describing "switching elements controllable in two different scales or dimensions"), 7:32-44, Fig. 14, 8:19-20 ("FIG. 14 is plan view of two-axis tiltable mirror usable with the invention."), 14:49-65, 7:1-4, 7:32-44, Fig. 14, 12:29-42, Fig. 9, 9:6-57, 10:37-43, 11:2-11, 16:8-51. 15:5-42 ("The ***structure is controllably tilted in two independent dimensions by a pair of electrodes*** 274 under the mirror plate 268 and another pair of electrodes 276 under the frame 262….Any voltage applied across opposed electrodes exerts a positive force acting to overcome the torsion beams **266, 272** and to close the variable gap between the electrodes. ***The force is***
		approximately linearly proportional to the magnitude of the applied voltage.") (emphasis added), 17:1-23.

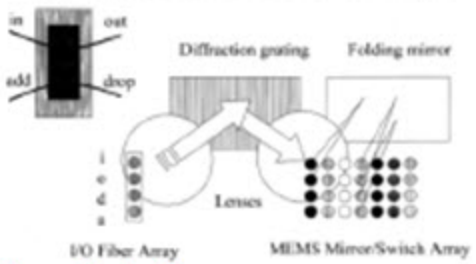
(Ex. 1028 (IPR2014-01166), Marom Decl., Pages 82-83; Ex. 1028 (IPR2014-01276), Marom Decl., Page 103-104)

Relevant Disclosure Carried Through: Port

at least one movable mirror for selectively coupling an optical signal from an input port to any of a plurality of output ports according to a position of said mirror;

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Claim 1)

Relevant Disclosure Carried Through: Port

Claimed '368 subject matter	Smith provisional	Smith patent
Claims 1, 15, 16, 17: In/out/add/drop ports (also, claim	p. 7, Fig. 6 (showing in/add/out/drop ports):	8:47-62 ("This architecture applies as well to a WDM add/drop multiplexer (WADM) in which the input ports IN_1, IN_2 are associated respectively with the
10 "an add port and a drop port" for adding/ dropping)	Example: OADM 3-D Design  Figs. 2, 5, 9.	input (IN) port of the transmission fiber and the DROP port to the local node and the output ports OUT_1, OUT_2 are associated respectively with the output (OUT) port of the transmission fiber and the ADD port from the local node"), Figs. 8, 9.

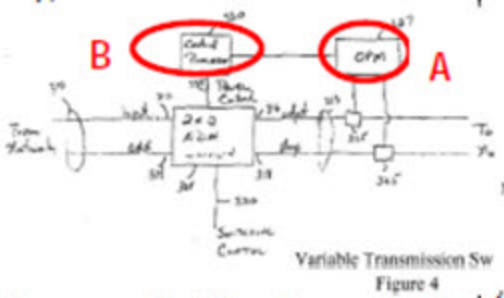
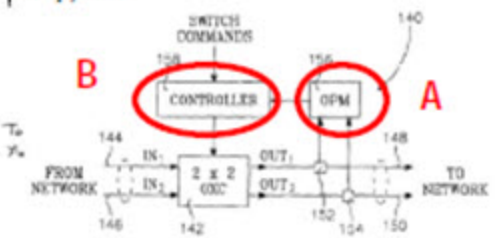
(Ex. 1028 (IPR2014-01166), Marom Decl., Pages 80-81; Ex. 1028 (IPR2014-01276), Marom Decl., Page 99-100)

Relevant Disclosure Carried Through: Controller

a controller receiving an output of said optical detector and in response adjusting said position of said mirror to effect control of said intensity.

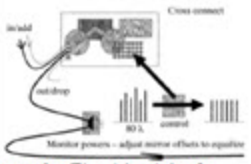
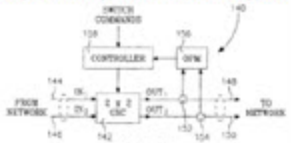
(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Claim 1)

Relevant Disclosure Carried Through: Controller

Claimed '368 subject matter	Smith provisional	Smith patent
Claims 2 & 3: "control unit," "wherein the control unit further comprises a servo-control assembly," "spectral monitor"	Fig. 4  Figure 4 (annotated), Fig. 11, pp. 6, 11.	Fig. 8:  FIG. 8 (annotated), Figs. 9:42-49, 11:39-45, 8, 12, 8:3-4, 9:29-10:13, 13:20-14:15.

(Ex. 1028 (IPR2014-01166), Marom Decl., Page 84;
Ex. 1028 (IPR2014-01276), Marom Decl., Page 107)

Relevant Disclosure Carried Through: Controller

Claimed '368 subject matter	Smith provisional	Smith patent
Claims 1, 15, 16, 17: to control power Claim 22: monitoring power in spectral channels, and controlling an alignment input signal and corresponding beam-deflecting elements in response to monitoring	p. 6, 9 ("the percentage of the drop beam that is coupled into the power drop channel 230 of the optical concentrator 235 may be varied by tilting the individual array elements about their horizontal or vertical axes"), Figs. 7, 9, 11, Fig. 10: OXC Patent: Power Equalization  *see also* Fig. 4 in claim 2, below. p. 10 ("***Displacement of the beam from a condition of perfect alignment decreases the percentage of light coupled into the concentrator's drop channel, reducing the amount of power leaving the switch.*** In the preferred operation of the switch, optimal alignment will be performed by optimal positioning of the beam on the appropriate concentrator element, specifically by controlling the horizontal alignment. Vertical misalignment is the preferred method of reducing power coupling to the chosen output channel.")	16:9-51 ("The above describes the principal switching operations using the one mirror tilt axis. The other mirror tilt axis, the minor axis, can be used for power adjustment"); 17:53-18:25: Fig. 8:  FIG. 8 10:27-43, 13:38-55, 16:36-18:67, 18:11-21 ("the major axis tilt can be used for both channel switching and power equalization. However, power detuning about the major axis incurs the possible problem of increasing cross talk. ***Moving a beam off maximum alignment with its waveguide*** in the direction of a closely neighboring waveguide may increase the cross talk") (emphasis added).

(Ex. 1028 (IPR2014-01166), Marom Decl., Pages 83-84; Ex. 1028 (IPR2014-01276), Marom Decl., Pages 105-106)

Construction of "Port"

'368 Claims 1, 15, 16

'678 Patent Claims 1, 21, 44, 61

'368 Patent Claim 1: "Ports"

an input port for an input multi-wavelength optical signal having first spectral channels;
one or more other ports for second spectral channels; an output port for an output multi-wavelength optical signal;

(Ex. 1001 (IPR2014-01166), '368 Patent, Claim 1)

Bouevitch Patent Figure 11: "Ports" in Context

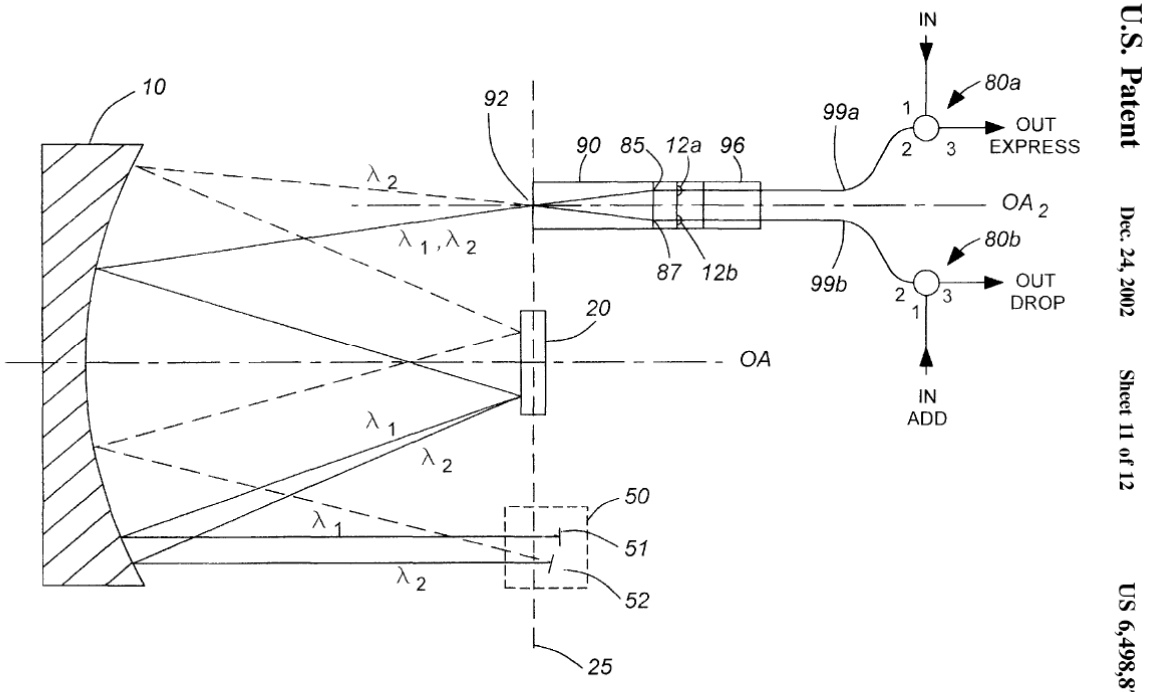


FIG. 11

U.S. Patent Dec. 24, 2002 Sheet 11 of 12 US 6,498,872 B2

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Fig. 11)

Bouevitch Patent Fig. 11: "Ports" in Context

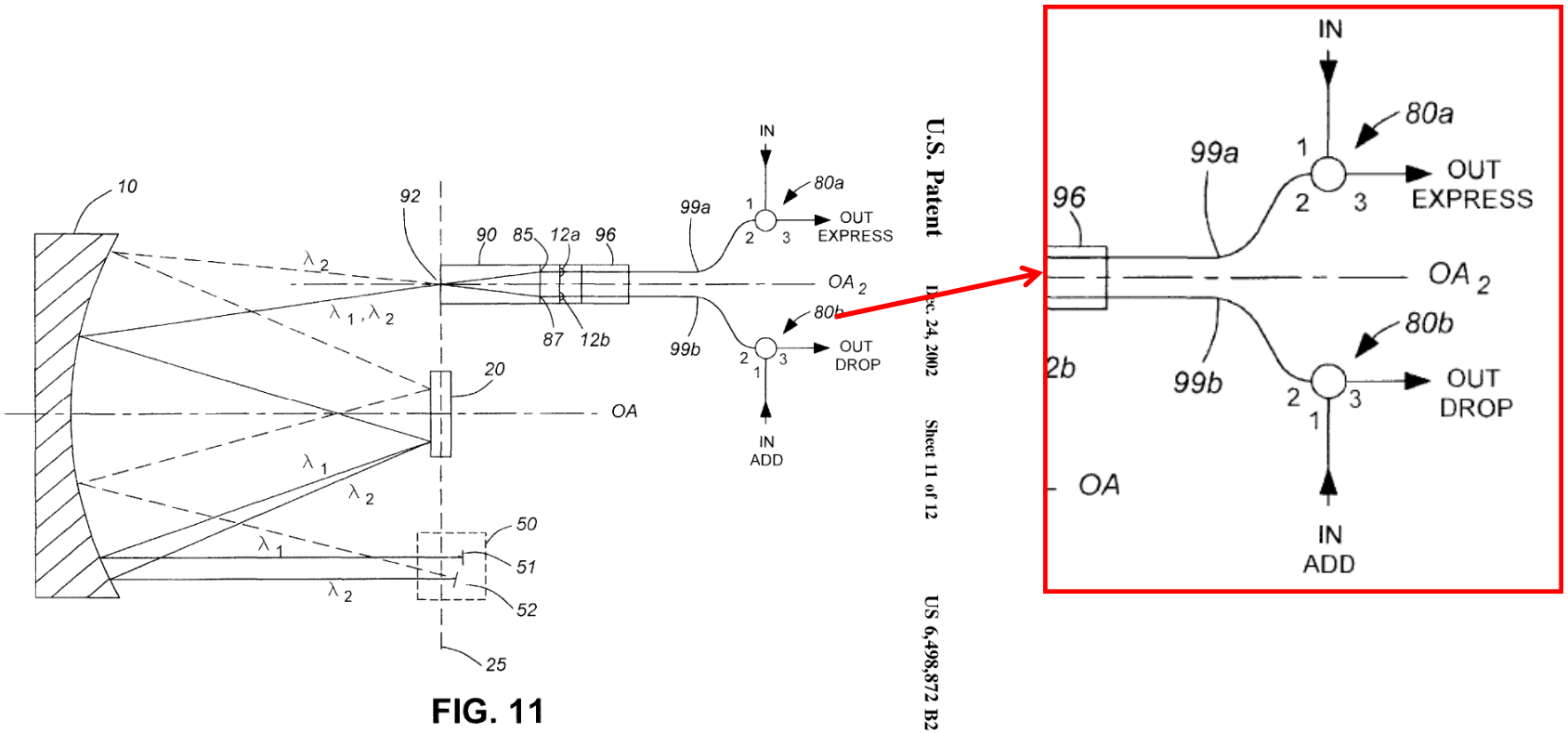
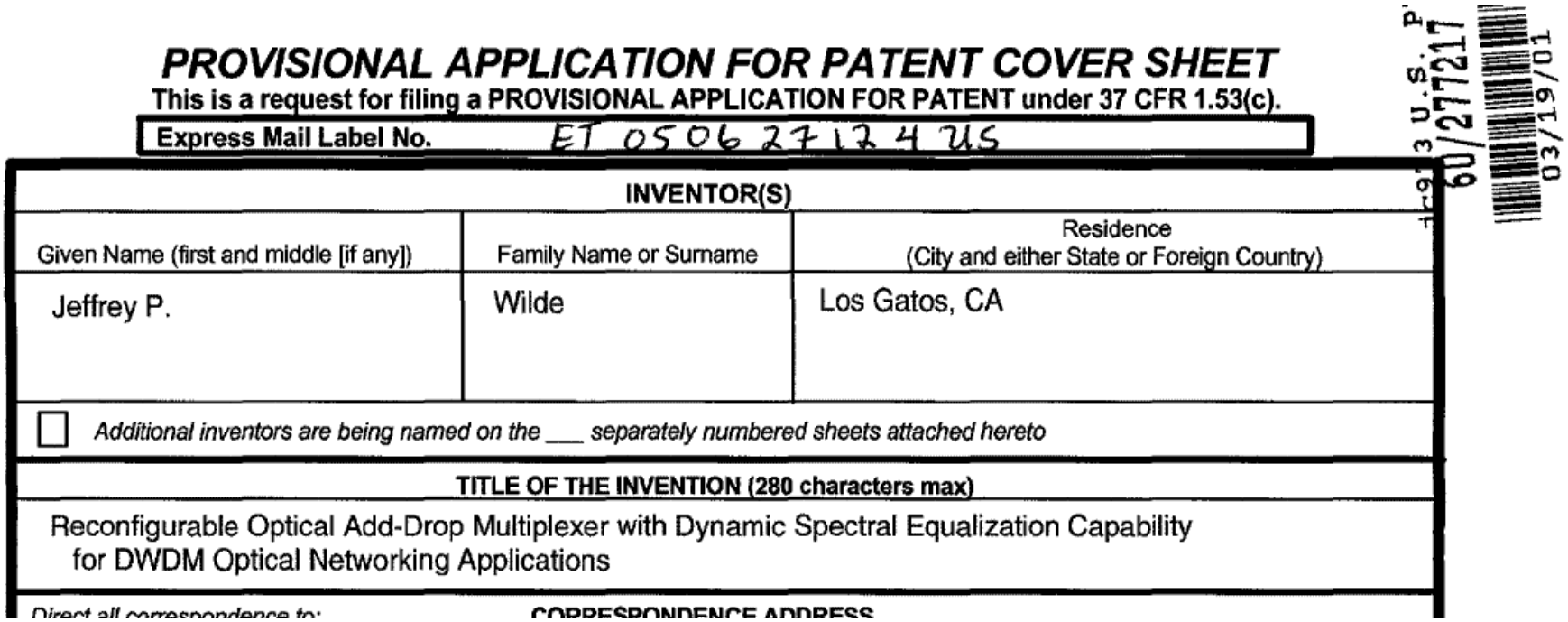


FIG. 11

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Fig. 11 (annotated))

Patent Owner's '217 Provisional: Overview



PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EL 050627124 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Jeffrey P.	Wilde	Los Gatos, CA

☐ *Additional inventors are being named on the ___ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

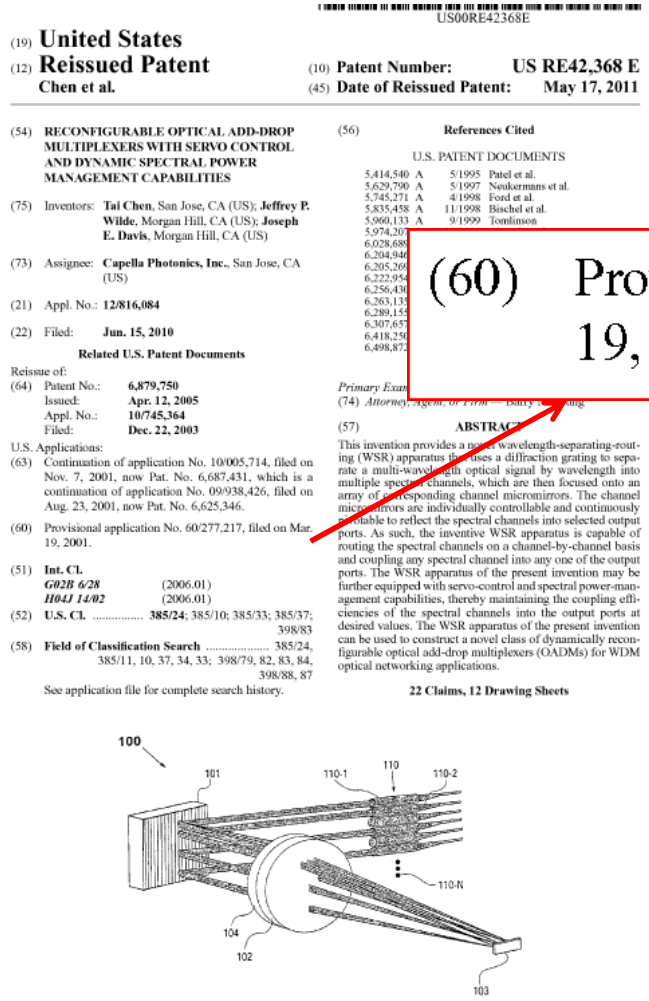
Reconfigurable Optical Add-Drop Multiplexer with Dynamic Spectral Equalization Capability for DWDM Optical Networking Applications

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

U.S. PTO 60/277217 03/19/01

(Ex. 1008 (IPR2014-01166), PO's '217 Provisional, Page 1)

‘368 and ‘678 Patents Claim Priority to the ‘217 Provisional



US00RE42368E

(19) **United States**

(12) **Reissued Patent**
Chen et al.

(10) **Patent Number: US RE42,368 E**
(45) **Date of Reissued Patent: May 17, 2011**

(54) **RECONFIGURABLE OPTICAL ADD-DROP MULTIPLEXERS WITH SERVO CONTROL AND DYNAMIC SPECTRAL POWER MANAGEMENT CAPABILITIES**

(75) Inventors: **Tai Chen**, San Jose, CA (US); **Jeffrey P. Wilde**, Morgan Hill, CA (US); **Joseph E. Davis**, Morgan Hill, CA (US)

(73) Assignee: **Capella Photonics, Inc.**, San Jose, CA (US)

(21) Appl. No.: **12/816,084**

(22) Filed: **Jun. 15, 2010**

Related U.S. Patent Documents

Reissue of:
(64) Patent No.: **6,879,750**
Issued: **Apr. 12, 2005**
Appl. No.: **10/745,364**
Filed: **Dec. 22, 2003**

U.S. Applications:
(63) Continuation of application No. 10/005,714, filed on Nov. 7, 2001, now Pat. No. 6,687,431, which is a continuation of application No. 09/938,426, filed on Aug. 23, 2001, now Pat. No. 6,625,346.

(60) Provisional application No. 60/277,217, filed on Mar. 19, 2001.

(51) **Int. Cl.**
G02B 6/28 (2006.01)
H04J 14/02 (2006.01)

(52) **U.S. Cl.** **385/24**; 385/10; 385/33; 385/37; 398/83

(58) **Field of Classification Search** 385/24, 385/11, 10, 37, 34, 33; 398/79, 82, 83, 84, 398/88, 87
See application file for complete search history.

(56) **References Cited**

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6,222,958
6,256,430
6,263,135
6,289,155
6,307,657
6,418,250
6,498,872

Primary Exam
(74) *Attorney, Agent, or Firm* — Barry

(57) **ABSTRAC**

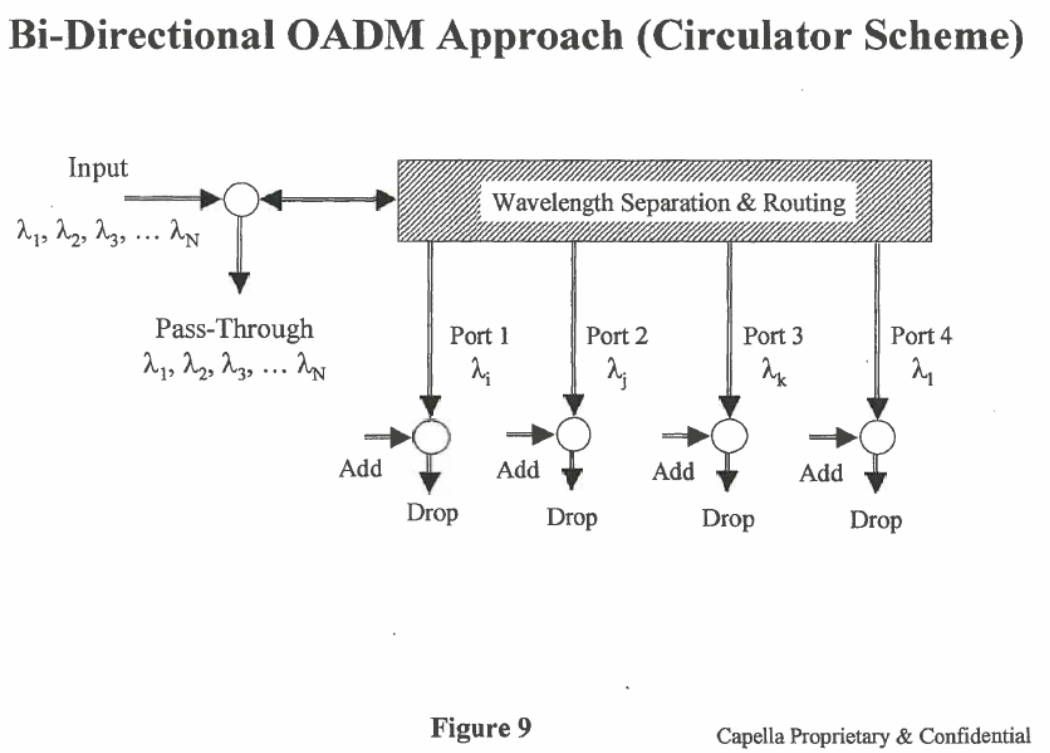
This invention provides a novel wavelength-separating-routing (WSR) apparatus that uses a diffraction grating to separate a multi-wavelength optical signal by wavelength into multiple spectral channels, which are then focused onto an array of corresponding channel micromirrors. The channel micromirrors are individually controllable and continuously movable to reflect the spectral channels into selected output ports. As such, the inventive WSR apparatus is capable of routing the spectral channels on a channel-by-channel basis and coupling any spectral channel into any one of the output ports. The WSR apparatus of the present invention may be further equipped with servo-control and spectral power-management capabilities, thereby maintaining the coupling efficiencies of the spectral channels into the output ports at desired values. The WSR apparatus of the present invention can be used to construct a novel class of dynamically reconfigurable optical add-drop multiplexers (OADMs) for WDM optical networking applications.

22 Claims, 12 Drawing Sheets

(60) Provisional application No. 60/277,217, filed on Mar. 19, 2001.

(Ex. 1001 (IPR2014-01166), ‘368 Patent, Page 1 (annotated); Ex. 1001 (IPR2014-01276), ‘678 Patent, Page 1)

Patent Owner's Use of "Port"



(Ex. 1008 (IPR2014-01166, -01276), PO's '217 Provisional, Fig. 9; Paper 25 (IPR2014-01166), Petitioner's Reply, Page 12; Paper 20 (IPR2014-01276), Petitioner's Reply, Page 11)

Patent Owner's Use of "Port" (cont.)

The third architecture (Fig. 9) is also bi-directional, but uses only one WSR unit. Circulators are situated on all of the physical input/output ports, allowing for two-way optical propagation. This design has the restriction that at each of the add/drop ports, the add and drop wavelengths must be the same.

(Ex. 1008 (IPR2014-01166, -01276), PO's '217 Provisional, Page 4)

Common Usage of "Port"

A *circulator* is similar to an isolator, except that it has multiple ports, typically three or four, as shown in Figure 3.3. In a three-port circulator, an input signal on port 1 is sent out on port 2, an input signal on port 2 is sent out on port 3, and an input signal on port 3 is sent out on port 1. Circulators are useful to construct optical add/drop elements, as we will see in Section 3.3.4. Circulators operate on the same principles as isolators; therefore we only describe the details of how isolators work next.

(Ex. 1042 (IPR2014-01166), Ramaswami Textbook, Page 10;
Ex. 1052 (IPR2014-01276), Ramaswami Textbook, Page 10)

Patent Owner Did Not Disavow Scope

160. Additionally, a POSA would read the '368 patent as teaching away from or at the least discouraging the use of circulators. For example, the earliest priority provisional application in the family of the '368 patent describes existing add/drop architectures that had a number of problems. ('217 Provisional, FIGS. 5, 6.) The problems included requiring all the add and drop wavelengths to enter and exit the device on single fibers (*i.e.,* two ports), each coupled to a circulator. (*Id.* at p. 2.) Since the prior art systems required all add and drop wavelengths to enter and exit the device on single fibers, an additional means (*e.g.,* circulator) was required to add channels to a single fiber and to drop channels from the single fiber output. (*Id.*) As the inventors recognized, the additional means (*e.g.,* circulator) "can lead to significant additional expense." (*Id.*)

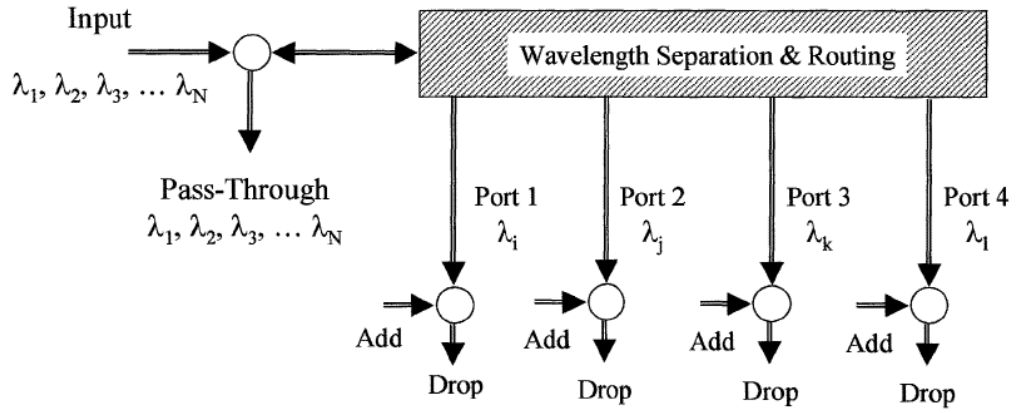
(Ex. 2004 (IPR2014-01166), Sergienko Decl., Para. 160;
Ex. 2004 (IPR2014-01276), Sergienko Decl., Para. 160)

Patent Owner Did Not Disavow Scope

160. Additionally, a POSA would read the '368 patent as teaching away from or at the least discouraging the use of circulators. For example, the earliest

(Ex. 2004 (IPR2014-01166), Sergienko Decl., Para. 160;
Ex. 2004 (IPR2014-01276), Sergienko Decl., Para. 160)

Patent Owner Did Not Disavow Scope



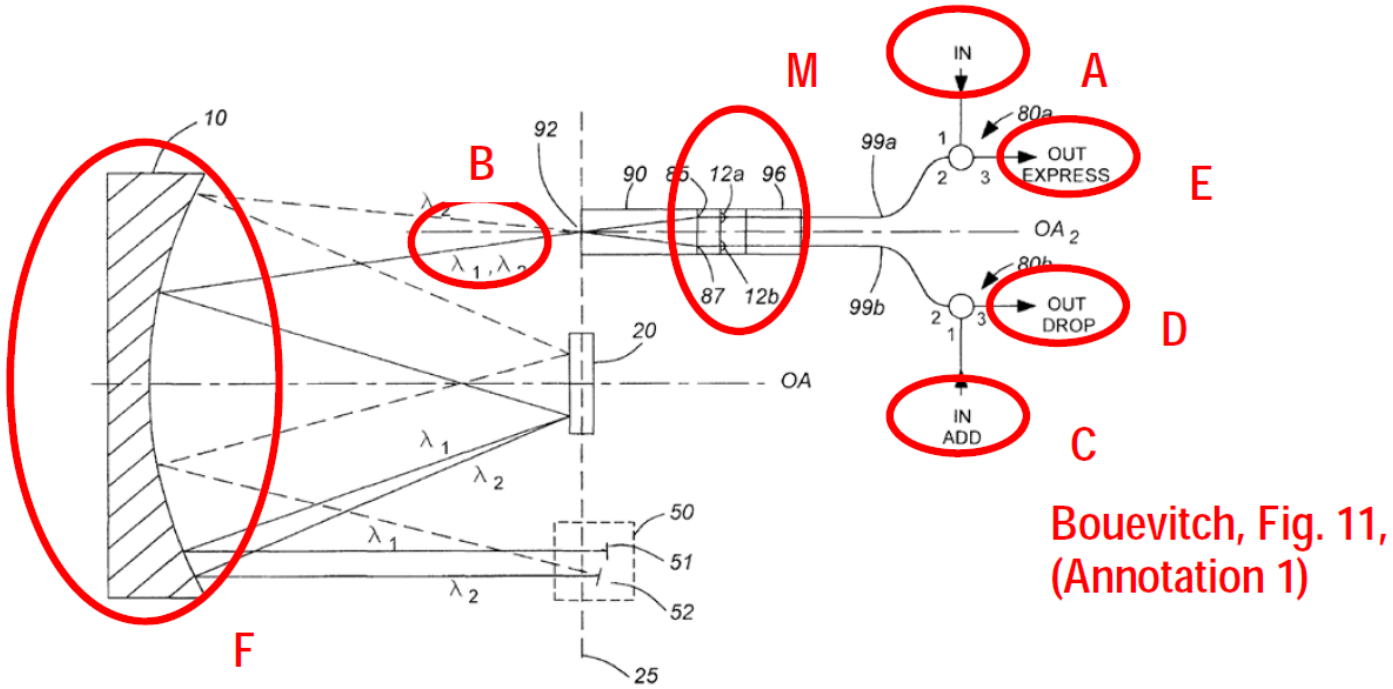
(Ex. 1008 (IPR2014-01166, -01276), PO's '217 Provisional, Fig. 9)

'368 Patent Claim 1: Use of "Port"

an input port for an input multi-wavelength optical signal having first spectral channels;
one or more other ports for second spectral channels; an output port for an output multi-wavelength optical signal;

(Ex. 1001 (IPR2014-01166), '368 Patent, Claim 1)

Bouevitch Patent Figure 11: "Ports"



Bouevitch, Fig. 11, (Annotation 1)

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Fig. 11 (annotated); Paper 2 (IPR2014-01166), Petition, Pages 26-27; Paper 2 (IPR2014-01276), Petition, Pages 24-25)

'678 Patent Claim 1: Use of "Collimators"

a) multiple fiber collimators, providing an input port for a multi-wavelength optical signal and a plurality of output ports;

(Ex. 1001 (IPR2014-01276), '678 Patent, Claim 1)

Providing: Patent Owner's Expert

Q So if something is providing something, it helps to deliver whatever it is that it's providing. Is that fair?

A That's correct.

DR. TUMINARO: Objection, form.

(Ex. 1049 (IPR2014-01276), Sergienko Tr., Page 95, Lines 14-18; Paper 20 (IPR2014-01276), Petitioner's Reply, Pages 8-9)

No One-to-One Requirement

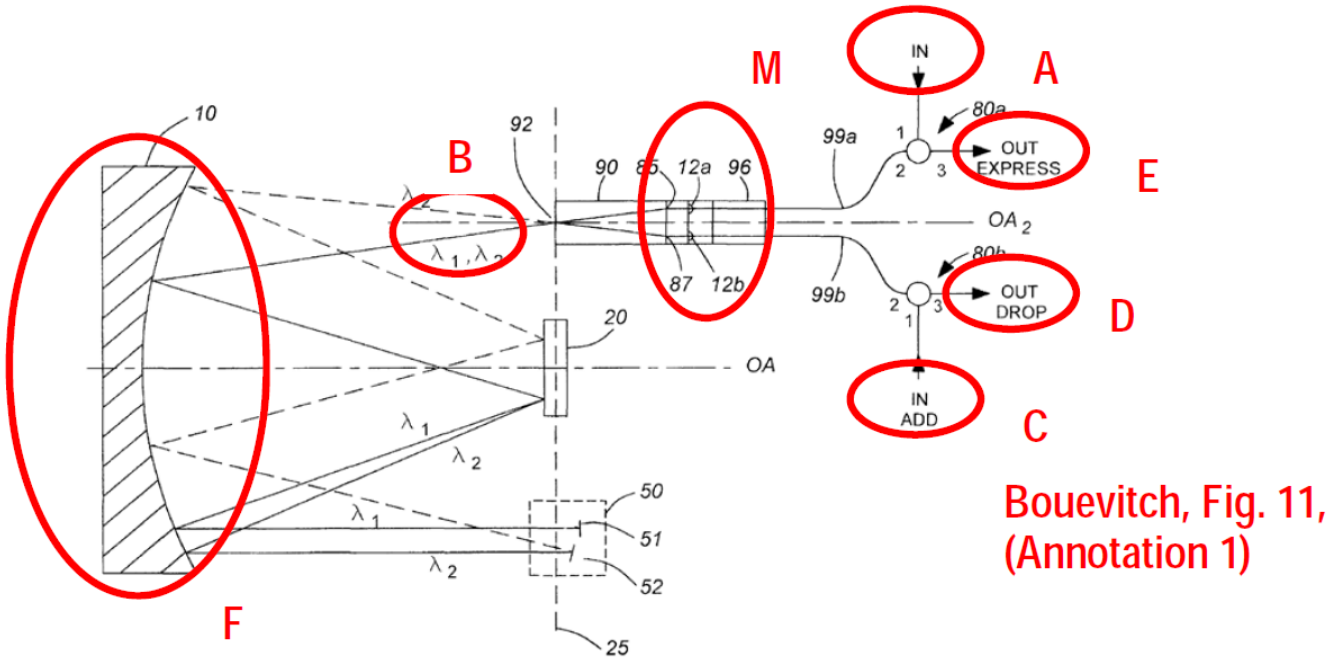
1. An optical add-drop apparatus comprising
an input port for an input multi-wavelength optical signal having first spectral channels;
one or more other ports for second spectral channels; an output port for an output multi-wavelength optical signal;
. . .

(Ex. 1001 (IPR2014-01166), '368 Patent, Claim 1)

8. The optical add-drop apparatus of claim **7** further comprising collimators associated with said alignment mirrors, and imaging lenses in a telecentric arrangement with said alignment mirrors and said collimators.

(Ex. 1001 (IPR2014-01166), '368 Patent, Claims 8)

Bouevitch Patent Figure 11: "Collimators"



Bouevitch, Fig. 11, (Annotation 1)

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Fig. 11 (annotated); Paper 2 (IPR2014-01166), Petition, Pages 26-27; Paper 2 (IPR2014-01276), Petition, Pages 24-25)

Instituted '368 Patent Claims Do Not Recite "Collimator"

1. An optical add-drop apparatus comprising
an input port for an input multi-wavelength optical signal having first spectral channels;
one or more other ports for second spectral channels; an output port for an output multi-wavelength optical signal;
a wavelength-selective device for spatially separating said spectral channels; **[**and**]**
a spatial array of beam-deflecting elements positioned such that each element receives a corresponding one of said spectral channels, each of said elements being individually and continuously controllable *in two dimensions* to reflect its corresponding spectral channel to a selected one of said ports *and to control the power of the spectral channel reflected to said selected port*.

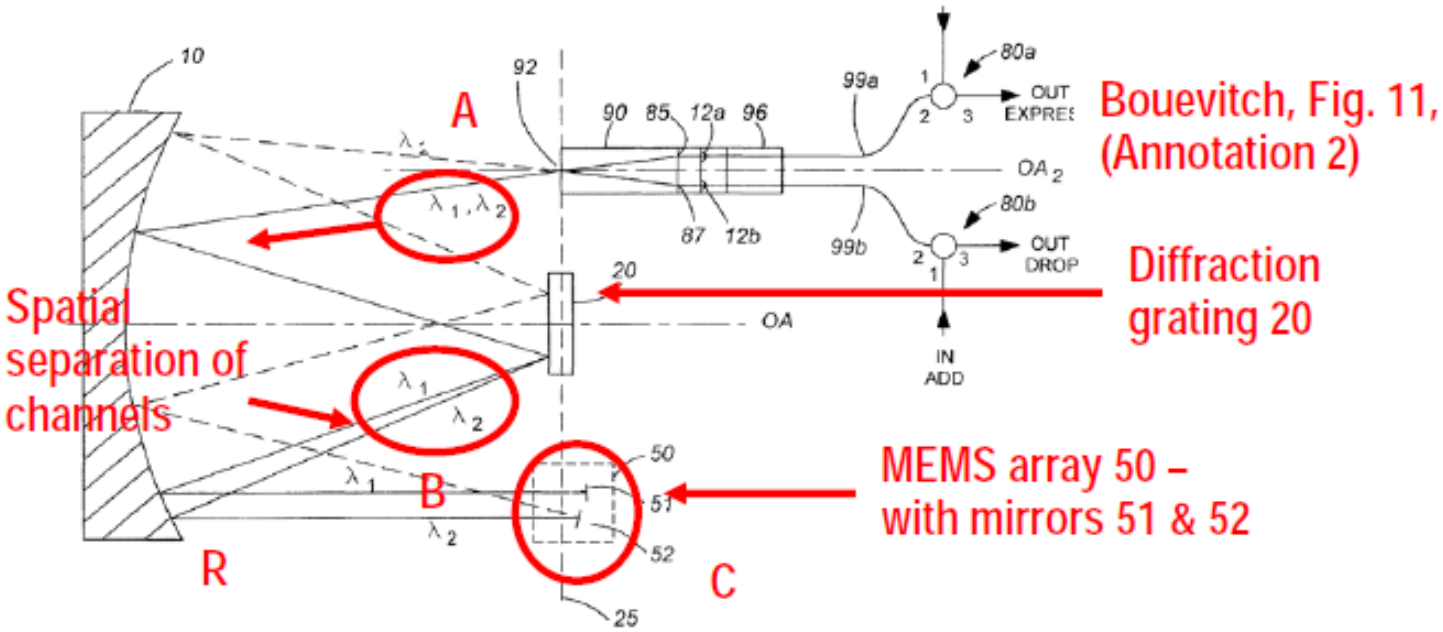
(Ex. 1001 (IPR2014-01166), '368 Patent, Claim 1)

Two-Axis Mirror Movement

‘368 Patent Claims 1, 15, 16, 17

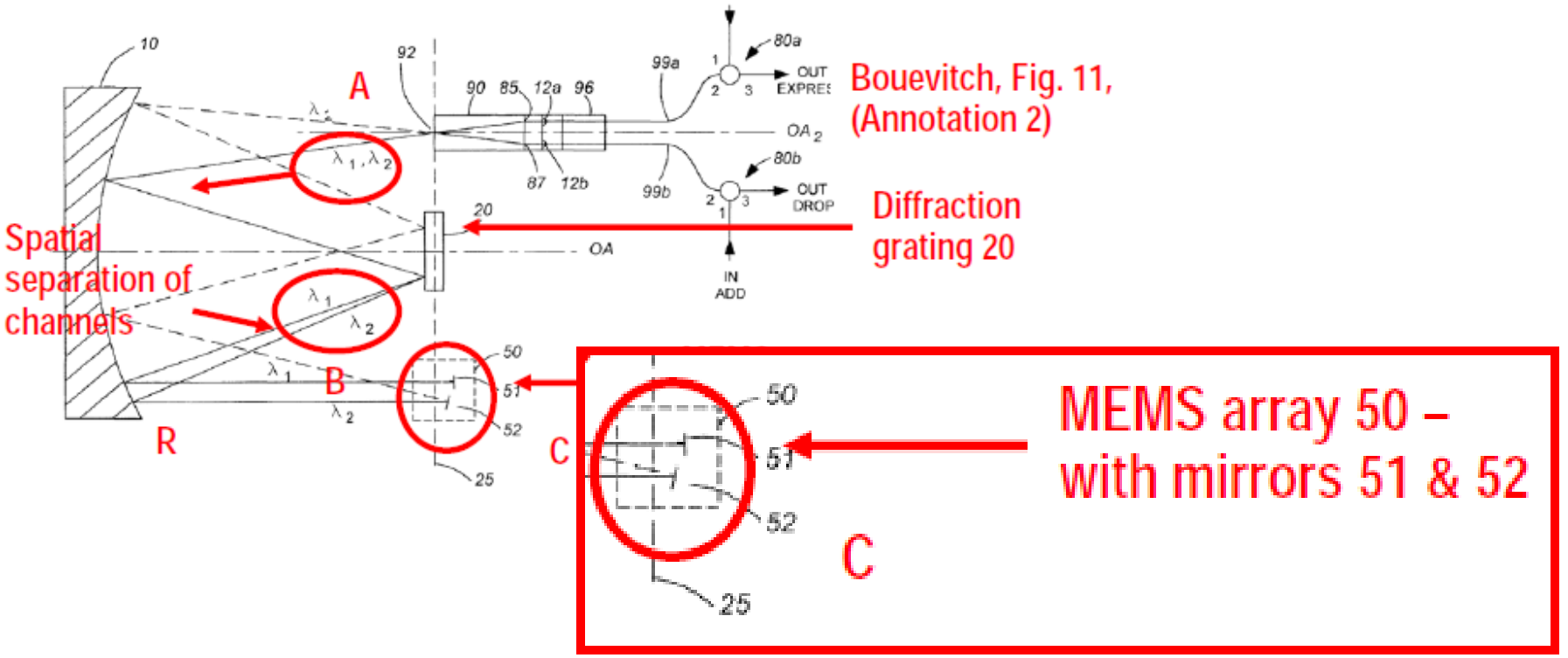
‘678 Patent Claims 1, 44, 61

Bouevitch Figure 11 (51, 52): Movable Mirrors



(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Fig. 11 (annotated); Paper 2 (IPR2014-01166), Petition, Pages 23-24, 27-28; Paper 2 (IPR2014-01276), Petition, Pages 26, 27-28)

Bouevitch Figure 11 (51, 52): Movable Mirrors



(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Fig. 11 (annotated); Paper 2 (IPR2014-01166), Petition, Pages 23-24, 27-28; Paper 2 (IPR2014-01276), Petition, Pages 26, 27-28)

Bouevitch Figure 11 (51, 52): Movable Mirrors

λ_1 and λ_2, respectively. Each sub-beam of light is transmitted to a lower portion of the spherical reflector **10**, is reflected, and is transmitted to separate reflectors **51** and **52** of the MEMS array **50**. Referring to FIG. **11**, reflector **51** is

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Col. 14, Lines 52-63; Paper 2 (IPR2014-01166), Petition, Pages 26-28; Paper 2 (IPR2014-01276), Petition, Pages 26, 27-28)

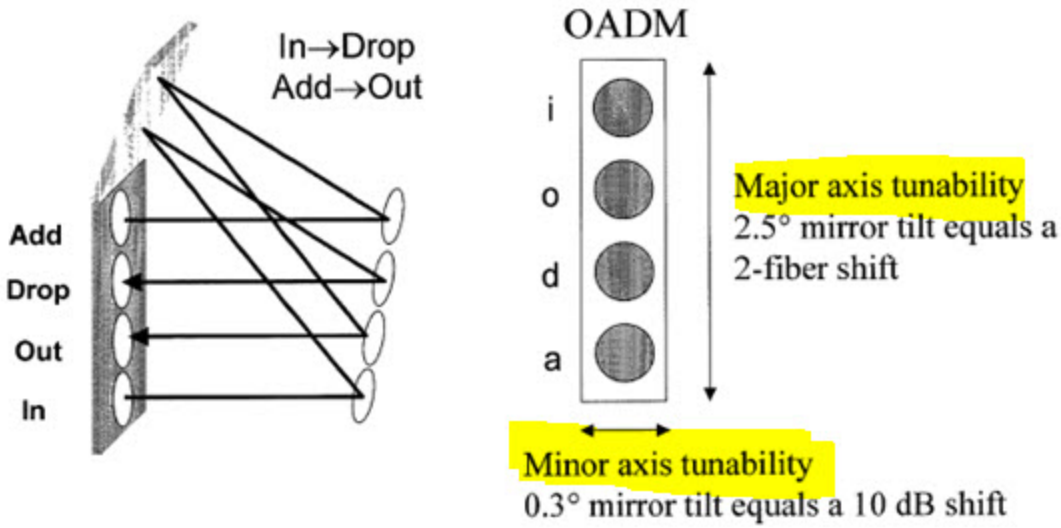
'683 Smith Provisional: 2-Axis Mirror Rotation

According to a preferred embodiment of the invention, the optical throughput of each wavelength channel may be controlled by using a mirror array with elements that can be rotated in an analog fashion about two orthogonal axes. Angular displacement in a first, switching plane, is used to perform an OXC, ADM or other switching function while angular displacement about the orthogonal axis is used for power control. MEMS switches with single axis mirror arrays may also be used for output power control. In this case, the coupling of each beam to a designated output port is adjusted by variations in the switching angle.

(Ex. 1005 (IPR2014-01166, -01276), '683 Smith Provisional, Page 7, Line 3-9)

'683 Smith Provisional: 2-Axis Mirror Rotation

Figure 7 Mirror Tuning



Note: Multiple-LAN OADM needs only 3.8° range

(Ex. 1005 (IPR2014-01166, -01276), '683 Smith Provisional, Fig. 7, Page 20)

'941 Smith Patent: 2-Axis Mirror Rotation

(57) **ABSTRACT**

A multi-wavelength or white-light optical switch including an array of mirrors tiltable about two axes, both to control the switching and to provide variable power transmission through the switch, both for optimization and for power equalization between wavelength channels in a multi-wavelength signal. The output power of a channel is

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Abstract)

No Bodily Incorporation Requirement

e.g., *id.*; S. Tr., 36:18-38:17. The law is just the opposite. "The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference." IPR2013-00107, Paper 21 at 19 (citing *In re Keller*, 642 F.2d 413, 425 (CCPA 1981)). PO's "redesign"

(Paper 25 (IPR2014-01166), Petitioner's Reply, Page 6;
Paper 20 (IPR2014-01276), Petitioner's Reply, Page 5)

No Bodily Incorporation Requirement

"The test for obviousness is not whether the features of a secondary reference may be incorporated bodily into the structure of a primary reference."

Honeywell Int'l Inc. v. Int'l Controls and Measurements Corp., Case No. IPR2014-00219, Paper 43 (P.T.A.B. April 1, 2015)

Bouevitch + Smith: Combination

With respect to a rationale for combining Bouevitch and Smith, Petitioner contends the use of the two-axis mirror of Smith in Bouevitch: (1) is a simple substitution of one known element for another yielding predictable results, (2) is the use of a known technique to improve similar devices, (3) would be obvious to try as there are only two options for tilting MEMS mirrors: one-axis and two-axis mirrors, and (4) would be motivated to reduce crosstalk in attenuation and to increase port density. Pet. 20–21.[6]

(Paper 8 (IPR2014-01166), Institution Decision, Pages 17-18;
Paper 8 (IPR2014-01276), Institution Decision, Pages 17)

'683 Smith Provisional: Substitution / Interchangeability

output is port is adjusted by translating the beam in the switching plane. In comparison to the two-axis embodiment, single axis systems may be realized using simpler, single axis MEMS arrays but suffer from increased potential for crosstalk between channels.

(Ex. 1005 (IPR2014-01166, -01276), '683 Smith Provisional, Page 12, Lines 24-26)

'941 Smith Patent: Substitution / Interchangeability

arrangement as the fibers. If desired, tilting about the second axis is not required if equalization is performed about the first, channel switching axis. However, the second axis tilting is nonetheless desired for optimization. It is noted that

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Col. 16, Lines 55-58)

Substitution / Interchangeability: Dr. Marom

40. First, PHOSITA knew that 2-axis mirrors could be used in place of 1-axis mirrors. Both the Smith provisional and patent acknowledge this interchangeability. The provisional states that "in comparison to the two-axis

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 39;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 40)

Substitution / Interchangeability: Dr. Marom (cont.)

43. Second, the devices disclosed in both Bouevitch and Smith are similar devices, and PHOSITA would know that techniques used in one reference would likely be directly applicable in the other. PHOSITA would know that the 2-axis mirrors of the Smith ROADM could be used as a replacement for the 1-axis mirrors in the similar Bouevitch ROADM.

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 42;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 43)

Substitution / Interchangeability: Dr. Marom (cont.)

combinable. Because the behavior of both 2-axis and 1-axis mirrors were known at the time of the '678 patent, PHOSITA would also expect that using 2-axis mirrors for power control instead of 1-axis mirrors would yield the same predictable result for power control if used in the MEMS-based switch of Bouevitch. Rotation about either 1 or 2 axes would result in controllable misalignment to alter power because any intentional misalignment from fiber location, in any direction, would result in reduced coupling to fiber. (*See, e.g.*, **[Ex. 1037]**, R.E. Wagner and W.J. Tomlinson, *Coupling Efficiency of Optics in Single-Mode Fiber Components*, Applied Optics, Vol. 21, No. 15, pp. 2671-2688 (August 1982).)

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 43;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 44)

Obvious to Try / Limited Number of Solutions: Dr. Marom

46. Third, it would be obvious for PHOSITA to try Smith's 2-axis mirrors in Bouevitch because 2-axis mirrors were among a small number of well known and predictable solutions to beam-steering, and PHOSITA would expect to have success building devices using either type of mirror. There are only two options for tilting MEMS mirrors: tilting about 1-axis and tilting about 2-axis.

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 45;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 46)

Other Motivations: Reduce Crosstalk

However, power detuning about the major axis incurs the possible problem of increasing cross talk. Moving a beam off maximum alignment with its waveguide in the direction of a closely neighboring waveguide may increase the cross talk between the two channels. On the other hand, minor axis tuning seems to affect the pass band. An optimization technique, rather than equalization, involves aligning the minor axis to improve angular alignment arising from mirror offset.

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Col. 18, Lines 17-25)

Other Motivations: Increased Port Density

scaling. These systems make use of the fact that it is possible to use optical steering around in two directions to increase the optical fiber count. Recently, optical switches that use such mirrors have been announced. The systems use piezoelectric elements or magnetically or electrostatically actuated micromirrors. The actuation method for these approaches is often imprecise. To achieve a variable switch, it is typically necessary to use a very high level of optical feedback.

What is needed is a micromachine that enables steering of optical signals from at least one input to a number of alternative outputs, where the arrangement of the outputs is not limited to a linear configuration. What is further needed is a method of fabricating and arranging arrays of the micromachines such that the switching is accurate and repeatable.

(Ex. 1009 (IPR2014-01166, -01276), Hoen Patent, Col. 2, Lines 1-16; Paper 2 (IPR2014-01166), Petition, Pages 22, 32; Paper 2 (IPR2014-01276), Petition, Pages 22, 32)

Continuously Controllable

‘368 Patent Claims 1, 15, 16, 17

‘678 Patent Claim 1, 44, 61

'368 Patent Claim 1: Continuously Controllable

a spatial array of beam-deflecting elements positioned such that each element receives a corresponding one of said spectral channels, each of said elements being individually and continuously controllable *in two dimensions* to reflect its corresponding spectral channel to a selected one of said ports *and to control the power of the spectral channel reflected to said selected port.*

(Ex. 1001 (IPR2014-01166), '368 Patent, Claim 1)

'678 Patent Claim 1: Continuously Controllable

d) a spatial array of channel micromirrors positioned such that each channel micromirror receives one of said spectral channels, said channel micromirrors being **pivotal about two axes and being** individually and continuously controllable to reflect **[[**said**]] corresponding received** spectral channels into **any** selected ones of said output ports **and to control the power of said received spectral channels coupled into said output ports**.

(Ex. 1001 (IPR2014-01276), '678 Patent, Claim 1)

‘368 and ‘678 Patents: Analog Rotation

The channel micromirrors **103** are individually controllable and movable, e.g., pivotable (or rotatable) under analog (or continuous) control, such that, upon reflection, the spectral

(Ex. 1001 (IPR2014-01166), ‘368 Patent, Col. 7, lines 6-8;
Ex. 1001 (IPR2014-01276), ‘678 Patent, Col. 7, lines 6-8)

'683 Smith Provisional: Analog Rotation

According to a preferred embodiment of the invention, the optical throughput of each wavelength channel may be controlled by using a mirror array with elements that can be rotated in an analog fashion about two orthogonal axes. Angular displacement in a first, switching

(Ex. 1005 (IPR2014-01166, -01276), '683 Smith Provisional, Page 7, Line 3-5)

‘941 Smith Patent: Analog Rotation

between the electrodes. The force is approximately linearly proportional to the magnitude of the applied voltage, but non-linearities exist for large deflections. If an AC drive

(Ex. 1004 (IPR2014-01166, -01276), ‘941 Smith Patent, Col. 15, Lines 40-42)

'941 Smith Patent: Analog Rotation

signal. In practice, the precise voltages needed to achieve a particular tilt are experimentally determined.

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Col. 15, Lines 47-48)

Lin Patent: Mirror

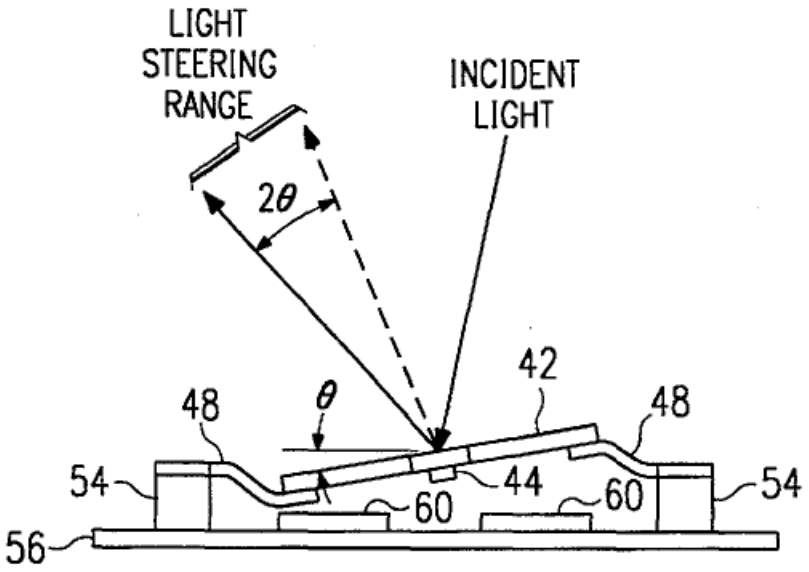


FIG. 3A

(Ex. 1010 (IPR2014-01166, -01276), Lin Patent, Fig. 3)

Lin Patent: For Switching Applications

mirror position, light is directed to a light absorber. The DMD may also be monostable and operated in the analog mode, and finds use as a light switch, pixel steerer, optical shutter, scanner, and the like.

(Ex. 1010 (IPR2014-01166, -01276), Lin Patent, Col. 2, Lines 7-9)

Lin Patent: Continuously Controllable

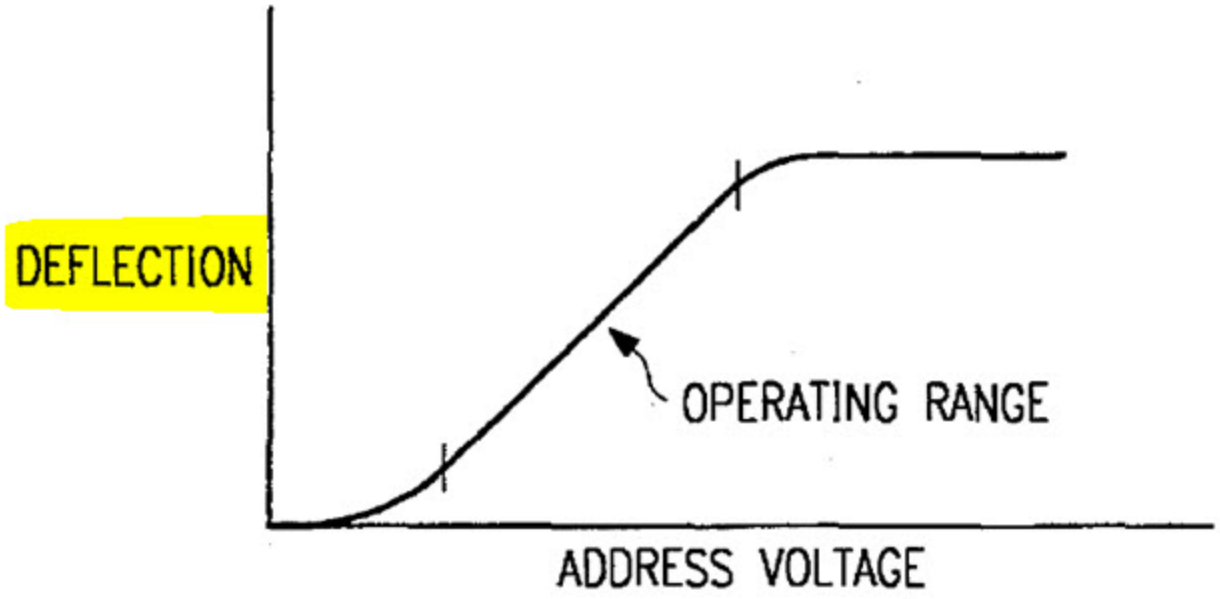


FIG. 3B

(Ex. 1010 (IPR2014-01166, -01276), Lin Patent, Fig. 3B)

Lin Patent: Continuously Controllable

the range of steering light is 20°. The response curve of mirror **42** as a function of address voltage is shown in FIG. **3B**.

With an address voltage being applied to one address electrode **60** being from 0 to 20 volts, mirror **42** is deflected proportional to the address voltage. When SLM **40** is

(Ex. 1010 (IPR2014-01166, -01276), Lin Patent, Col. 7, Lines 10-15)

Bouevitch + Smith/Lin: Combination

It also would have been obvious to substitute Smith's or Lin's continuous, analog, control into the Bouevitch ROADM. (Marom Decl., ¶ 67.) The PHOSITA would combine the teachings of these references at least for the reasons that (1) continuously controlled mirrors were known to be interchangeable with discrete-step mirrors; (2) continuously controlled mirrors allow arbitrary positioning of mirrors and can more precisely match the optimal coupling value; and (3) Lin specifically teaches that its analog, continuous MEMS mirrors would be useful in optical switching applications like Bouevitch's and Smith's ROADM devices. (Ex. 1010, 2:6-9; Marom Decl., ¶ 67.)

(Paper 2 (IPR2014-01276), Petition, Pages 30-31;
Paper 2 (IPR2014-01166), Petition, Page 30)

Bouevitch + Smith/Lin: Limited Options & Predictable Results

In addition, analog (continuous) control of the mirrors would be obvious to try because there are only two general options for such control—either analog (continuous) or discrete (step-wise) control. (*See* Marom Decl., ¶ 68.) For example, Lin discusses analog control as the alternative to binary (discrete) control of mirrors to increase the precision of the mirror placement. (Ex. 1010, 2:7-9; 3:41-57; Marom Decl., ¶ 70.) With only two options, both of which were known in the prior art, and both of which were suggested as working solutions for control, the PHOSITA would have expected that trying analog control would work well in the device of Bouevitch. (Marom Decl., ¶¶ 68-70.)

(Paper 2 (IPR2014-01276), Petition, Page 31; Paper 2 (IPR2014-01166), Petition, Pages 30-31)

Other Motivations: Known Interchangeability

67. To the extent Bouevitch does not fully disclose continuous (analog) mirror control, it also would have been obvious to substitute one control method for the other, including substituting either Smith's or Lin's continuous, analog control into the COADM of Bouevitch. PHOSITA would do so for at least for the reasons that (1) continuously controlled mirrors were known to be interchangeable with discrete-step mirrors; (2) continuously controlled mirrors allow arbitrary positioning of mirrors and can be used to achieve optimal coupling value or deviations from angle to lead to controllable attenuation; and (3) Lin specifically teaches that its analog, continuous MEMS mirrors would be useful in optical switching applications like Bouevitch's and Smith's ROADM devices. (**[Ex. 1010]**, 2:6-9.)

(Ex. 1028 (IPR2014-01276), Marom Decl., Para. 67; Ex. 1028 (IPR2014-01166), Marom Decl., Para. 62)

‘683 Smith Provisional for Power Control—Not Bouevitch Patent Figure 5

The PHOSITA would be motivated to use the 2-axis system of Smith within the system of Bouevitch for power control. (Ex. 1028 at ¶ 73.) First, power control

(Paper 2 (IPR2014-01166), Petition, Page 34;
Paper 2 (IPR2014-01276), Petition, Page 34)

'683 Smith Provisional: Power Control

According to a preferred embodiment of the invention, the optical throughput of each wavelength channel may be controlled by using a mirror array with elements that can be rotated in an analog fashion about two orthogonal axes. Angular displacement in a first, switching plane, is used to perform an OXC, ADM or other switching function while angular displacement about the orthogonal axis is used for power control. MEMS switches with single axis mirror arrays may also be used for output power control. In this case, the coupling of each beam to a designated output port is adjusted by variations in the switching angle.

(Ex. 1005 (IPR2014-01166, -01276), '683 Smith Provisional, Page 7, Lines 3-9)

Reflect

‘678 Patent Claims 1, 21, 41, 66

'678 Patent Claim 1: Reflect

d) a spatial array of channel micromirrors positioned such that each channel micromirror receives one of said spectral channels, said channel micromirrors being **pivotal about two axes and being** individually and continuously controllable to reflect **[[**said**]] corresponding received** spectral channels into **any** selected ones of said output ports **and to control the power of said received spectral channels coupled into said output ports**.

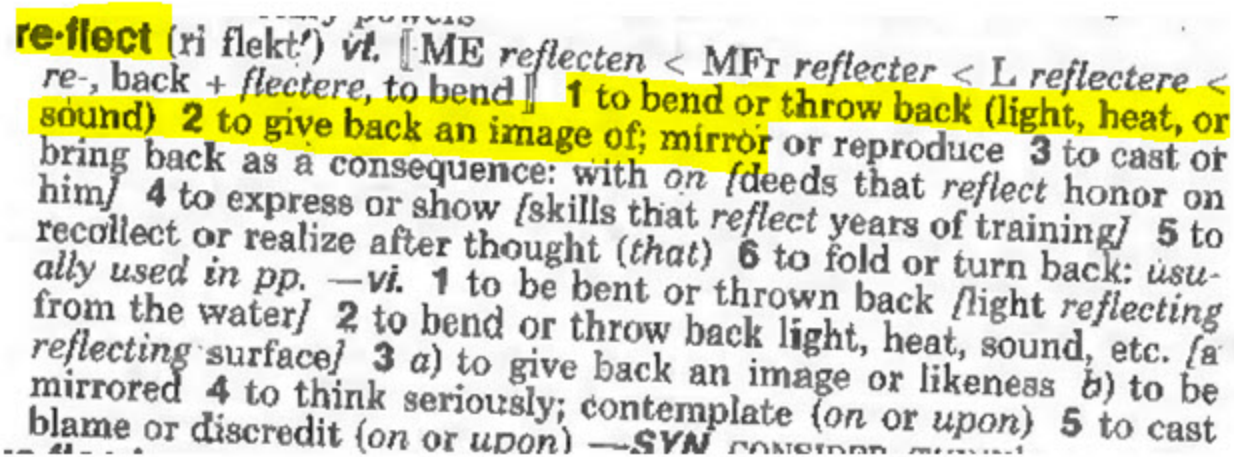
(Ex. 1001 (IPR2014-01276), '678 Patent, Claim 1)

Reflect: Broadest Reasonable Interpretation

The ordinary meaning of "reflect" is to "bend or throw back light" or to "mirror" that light. Ex. 1057 at 1127. Under that BRI, Petitioner showed that

(Paper 20 (IPR2014-01276), Petitioner's Reply, Page 17)

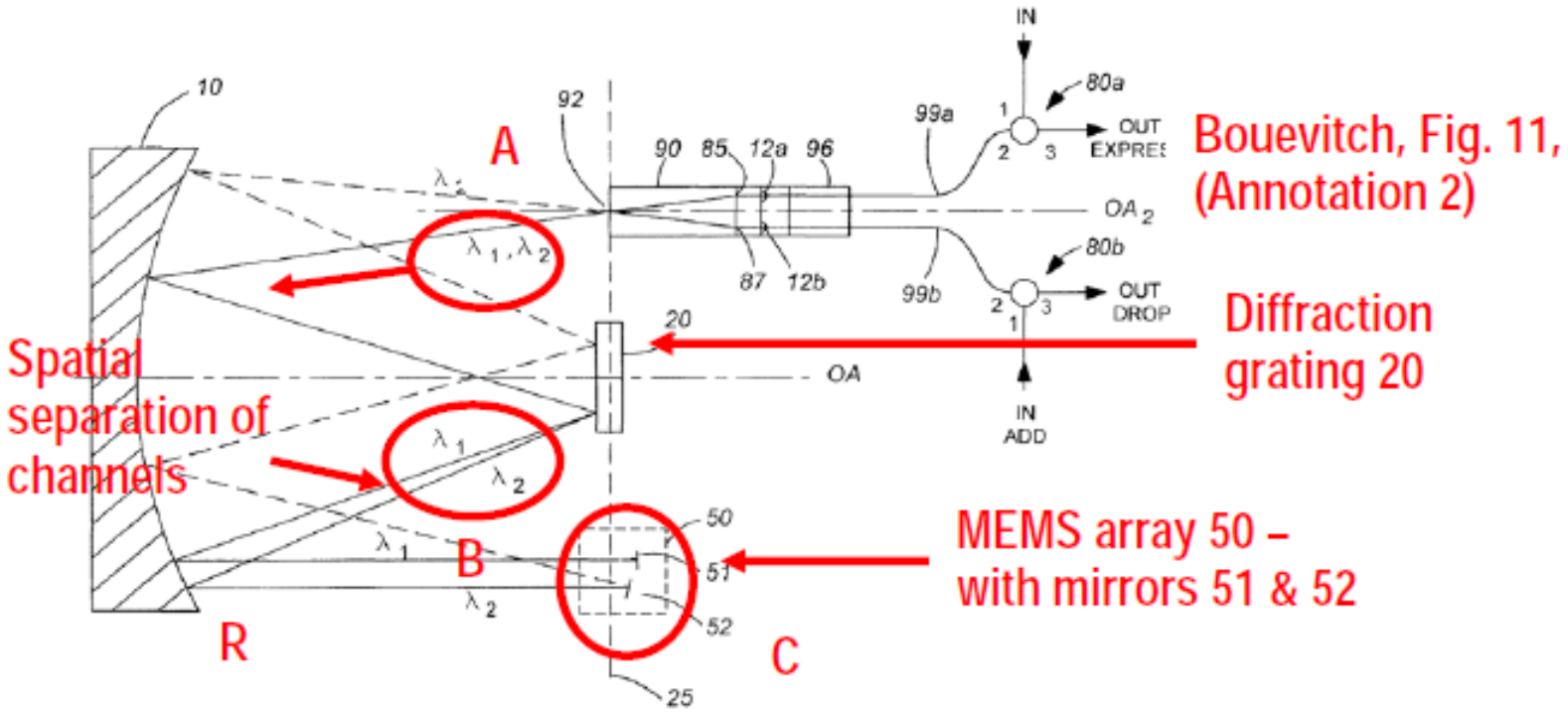
Reflect: Broadest Reasonable Interpretation



re·flect (ri flekt') *vt.* [ME *reflecten* < MFr *reflecter* < L *reflectere* < *re-*, back + *flectere*, to bend] **1** to bend or throw back (light, heat, or sound) **2** to give back an image of; mirror or reproduce **3** to cast or bring back as a consequence: with *on* [deeds that *reflect* honor on him] **4** to express or show [skills that *reflect* years of training] **5** to recollect or realize after thought (*that*) **6** to fold or turn back: *usually used in pp.* —*vi.* **1** to be bent or thrown back [light *reflecting* from the water] **2** to bend or throw back light, heat, sound, etc. [a *reflecting* surface] **3** *a)* to give back an image or likeness *b)* to be mirrored **4** to think seriously; contemplate (*on* or *upon*) **5** to cast blame or discredit (*on* or *upon*) —*SYN*

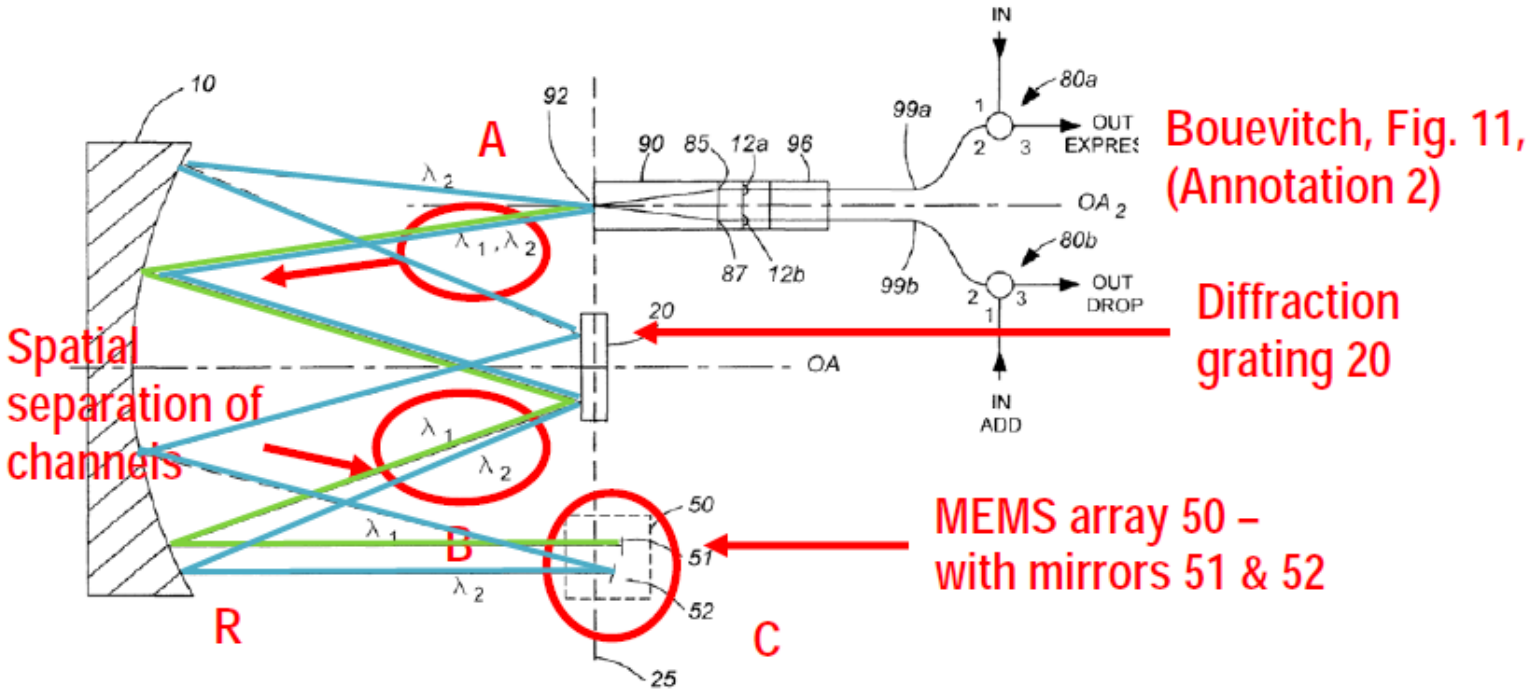
(Ex. 1057 (IPR2014-01276), Webster's New World Dictionary, Page 3; Paper 20 (IPR2014-01276), Petitioner's Reply, Page 17)

Bouevitch Patent Figure 11 (Annotation 2)



(Ex. 1003 (IPR2014-01276), Fig. 11 (annotated); Paper 2 (IPR2014-01276), Petition, Pages 26, 27-29; Paper 20 (IPR2014-01276), Petitioner's Reply, Pages 17-18)

Bouevitch Patent Figure 11 (Annotation 2)



(Ex. 1003 (IPR2014-01276), Fig. 11 (annotated); Paper 2 (IPR2014-01276), Petition, Pages 26, 27-29; Paper 20 (IPR2014-01276), Petitioner's Reply, Pages 17-18)

Diffraction Gratings

‘368 Patent Claim 12

‘678 Patent Claims 17, 29, 53

Markush Group

12. The optical add-drop apparatus of claim **1**, wherein said wavelength-selective device comprises a device selected from the group consisting of ruled diffraction gratings, holographic diffraction gratings, echelle gratings, curved diffraction gratings, and dispersing prisms.

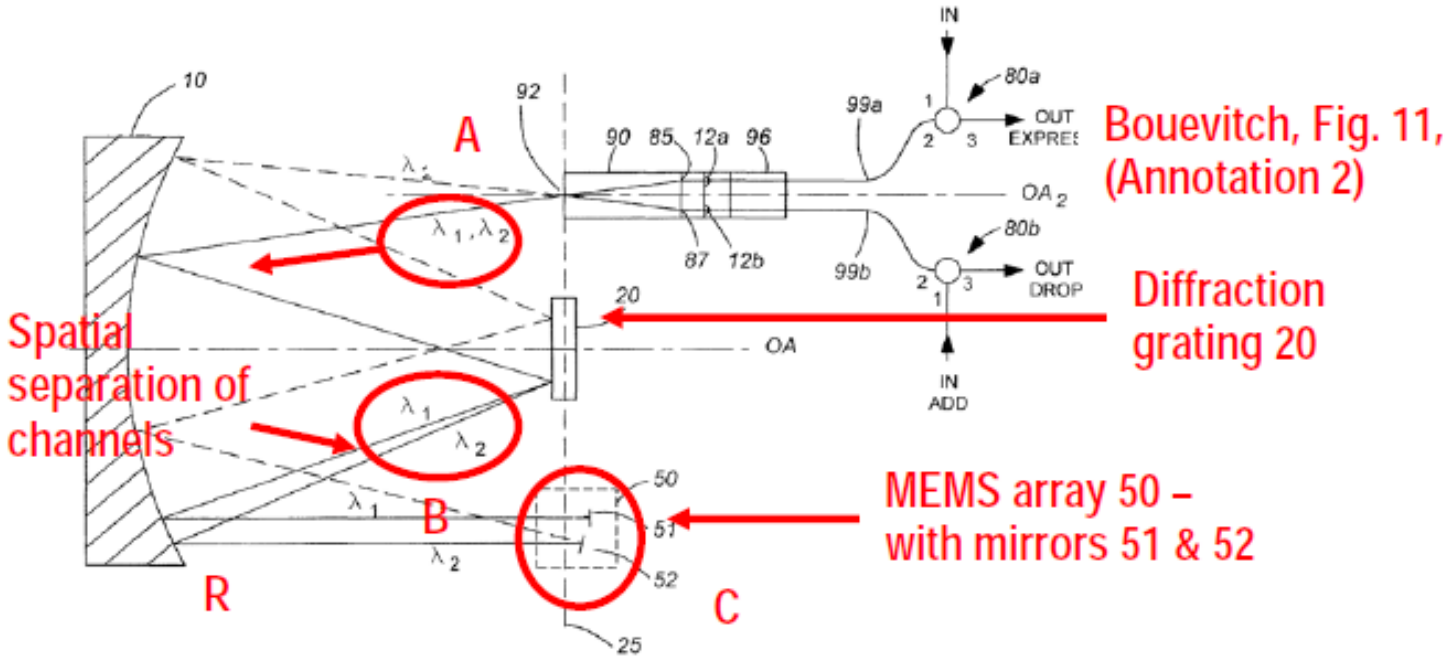
(Ex. 1001 (IPR2014-01166), '368 Patent, Claim 12)

Markush Group

17. The wavelength-separating-routing apparatus of claim 1 wherein said wavelength-separator comprises an element selected from the group consisting of ruled diffraction gratings, halographic diffraction gratings, echelle gratings, curved diffraction gratings, and dispersing gratings.

(Ex. 1001 (IPR2014-01276), '678 Patent, Claim 17)

Bouevitch Patent: Diffraction Gratings



(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Fig. 11 (annotated); Paper 2 (IPR2014-01166), Petition, Pages 26, 47-49; Paper 25 (IPR2014-01166), Petitioner's Reply, Pages 23-24; Paper 2 (IPR2014-01276), Petition, Pages 26, 45-47, 51-52, 59; Paper 20 (IPR2014-01276), Petitioner's Reply, Page 23)

Dr. Marom: Diffraction Gratings

104. Alternatively, it was also obvious to combine Bouevitch+Smith (or Bouevitch+Smith+Lin) with other known teachings of specific types of wavelength-selective device for WDM devices. For example, Dueck discusses "ruled diffraction gratings," and Ranalli discusses grating prisms. ([**Ex. 1021**], *Id.*, 6:26-30; [**Ex. 1027**],Ranalli, 6:33-36.) I will refer to the combination of Bouevitch+Smith+Dueck as Ground 3 and Bouevitch+Smith+Lin+Dueck as Ground 4. All these elements are known to disperse wavelengths. Diffraction

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 104;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 113)

Dr. Marom: Diffraction Gratings

Ground 4. All these elements are known to disperse wavelengths. Diffraction gratings, whether in the form of ruled, holographic, or Echelle are all conforming to the same diffraction formula and same physics. They only differ in their manufacturing technique. It would be obvious to try such a ruled diffraction

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 104;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 113)

Dr. Marom: Diffraction Gratings

manufacturing technique. It would be obvious to try such a ruled diffraction grating in the devices of Bouevitch and Smith under Grounds 3 or 4, and PHOSITA would be motivated to do so because Dueck describes its grating as part of the "best mode" of separating wavelengths in WDM devices, which include the Bouevitch and Smith devices. (*Id.*)

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 104;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 113)

Dueck Patent: Diffraction Gratings

technologies well-known in this art. The ruled diffraction grating **22** could be formed directly on the exit surface **20***b* or formed in a separate planar material such as polymer, glass, silicon, etc., that is secured to the end of the coupler element **20**, again, by an optical cement.

(Ex. 1021 (IPR2014-01166, -01276), Dueck Patent, Col. 6, Lines 26-30)

Ruled Diffraction Gratings

17. The wavelength-separating-routing apparatus of claim 1 wherein said wavelength-separator comprises an element selected from the group consisting of ruled diffraction gratings, halographic diffraction gratings, echelle gratings, curved diffraction gratings, and dispersing gratings.

(Ex. 1001 (IPR2014-01276), '678 Patent, Claim 17)

Patent Owner's Expert: Diffraction Gratings

Q Could you have used a ruled diffraction grating as element 20 and had figure 11 function as intended?

A Yes. Diffraction grating is kind of a generic term in science. It's used everywhere. There are multiple varieties of diffraction gratings, but there's -- unless you have a special need to use special type of grating, the usual one is just the flat surface with metal stripes. That will do the job.

(Ex. 1039 (IPR2014-01166), Ex. 1049 (IPR2014-01276), Sergienko Tr., Page 257, Line 17-Page 258, Line 2; Ex. 1028 (IPR2014-01166), Marom Decl., Para. 104; Ex. 1028 (IPR2014-01276), Marom Decl., Para. 113)

Patent Owner's Expert: Diffraction Gratings

Q Is there any indication to you in the Bouevitch patent that element 20 had some need for a special type of grating?

A Not as I can see in this configuration. It's very straightforward configuration.

Q Could you have used a holographic diffraction grating as well?

A Yes, it will do the same job.

Q How about a, is it an echelette grating?

A Echelette grating.

Q Echelette grating.

A Yes. You can do use anything. The purpose is to send light of all frequencies of all wavelengths in one direction and then spread them in the space depending on their wavelengths. And if this system is capable of doing this, then you can use it.

(Ex. 1039 (IPR2014-01166), Ex. 1049 (IPR2014-01276), Sergienko Tr., Page 258, Lines 3-22; Ex. 1028 (IPR2014-01166), Marom Decl., Para. 104; Ex. 1028 (IPR2014-01276), Marom Decl., Para. 113)

Patent Owner's Expert: Diffraction Gratings

Q Any of those, at least for the purposes of figure 11, would have been reasonable substitutes for one another?

A That's correct.

Q And one of skill in the art would have expected those to probably work?

A Yes. Yes. So the distances maybe will be different slightly or whatever, but it will be minor alignments, but the major principles will not change.

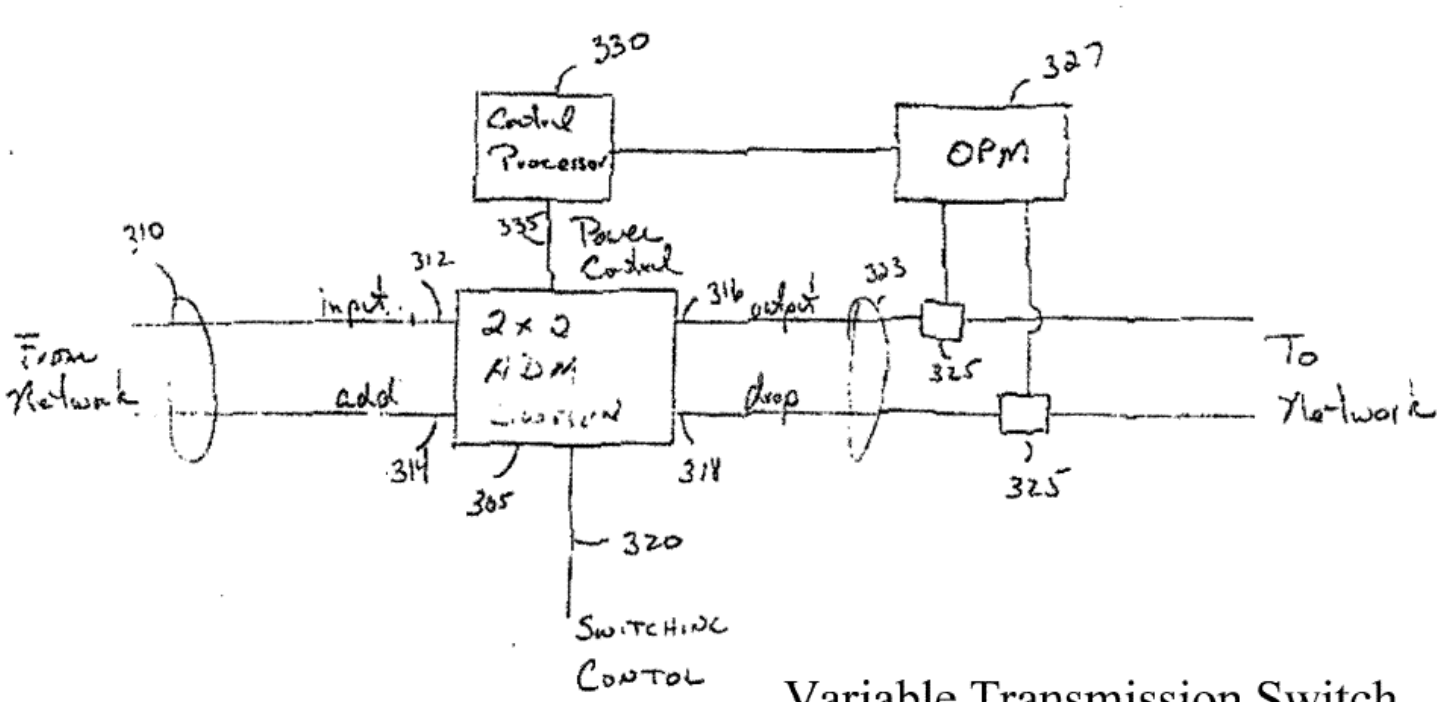
(Ex. 1039 (IPR2014-01166), Ex. 1049 (IPR2014-01276), Sergienko Tr., Page 258, Line 23-Page 259, Line 7; Ex. 1028 (IPR2014-01166), Marom Decl., Para. 104; Ex. 1028 (IPR2014-01276), Marom Decl., Para. 113)

Servo Control

‘368 Patent Claims 3, 22

‘678 Patent Claims 2-4, 21-23, 45, 62, 63

‘683 Smith Provisional: Servo Control



Variable Transmission Switch
Figure 4

(Ex. 1005 (IPR2014-01166, -01276), ‘683 Smith Provisional, Fig. 4, Page 17)

‘941 Smith Patent: Servo Control

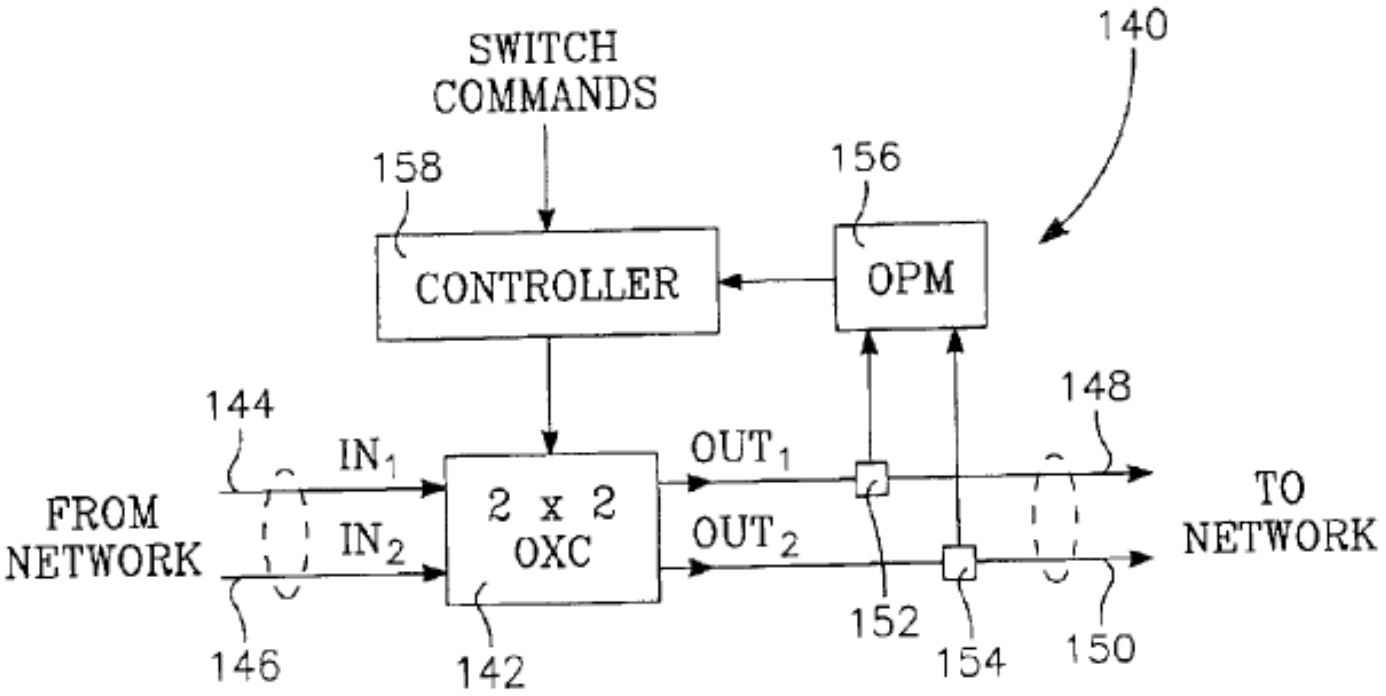


FIG. 8

(Ex. 1004 (IPR2014-01166, -01276), ‘941 Smith Patent, Fig. 8)

Bouevitch Patent: DGE / COADM

US006498872B2

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

(10) **Patent No.: US 6,498,872 B2**
(45) **Date of Patent: Dec. 24, 2002**

(54) **OPTICAL CONFIGURATION FOR A DYNAMIC GAIN EQUALIZER AND A CONFIGURABLE ADD/DROP MULTIPLEXER**

(75) Inventors: **Oleg Bouevitch**, Gloucester (CA); **Thomas Ducellier**, Ottawa (CA); **W. John Tomlinson**, Princeton, NJ (US); **Paul Colbourne**, Nepean (CA); **Jacques Bismuth**, Ottawa (CA)

(73) Assignee: **JDS Uniphase Inc.**, Ottawa (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 17 days.

(21) Appl. No.: **09/729,270**

(22) Filed: **Dec. 5, 2000**

(65) **Prior Publication Data**

US 2002/0009257 A1 Jan. 24, 2002

Related U.S. Application Data

(60) Provisional application No. 60/183,155, filed on Feb. 17, 2000.

(51) **Int. Cl.**[7] **G02B 6/28**; H04J 14/02

(52) **U.S. Cl.** **385/24**; 385/37; 359/130; 359/246; 359/247; 359/301; 359/302; 359/128

(58) **Field of Search** 340/193, 196; 359/115, 122, 128, 124, 130, 131, 245–247, 301–302; 385/16, 18, 24, 31, 37, 39, 47

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5,477,350	A	12/1995	Rita et al.	359/39
5,526,155	A	6/1996	Knox et al.	359/130
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5,880,190	A	3/1999	Li	
5,936,752	A	8/1999	Bishop et al.	
5,943,158	A	8/1999	Ford et al.	
5,960,133	A	9/1999	Tomlinson	
6,038,044	A	1/2000	Lundgren et al.	
6,081,335	A	6/2000	Teichmann	
6,134,359	A	10/2000	Keywoth et al.	
6,415,080	B1 *	7/2002	Nappey et al.	

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Primary Examiner—Hemang Sanghavi
Assistant Examiner—Omar Rojas
(74) *Attorney, Agent, or Firm*—Lacasse & Asso

(57) **ABSTRACT**

An optical device for rerouting and modifyin signal that is capable of operating as a dy equalizer (DGE) and/or a configurable optic multiplexer (COADM) is disclosed. The optical design includes a front-end unit for providing a collimated beam of light, an element having optical power for providing collimating/focusing effects, a diffraction element for providing spatial dispersion, and modifying means which in a preferred embodiment includes one of a MEMS array and a liquid crystal array for reflecting and modifying at least a portion of a beam of light. The modifying means functions as an attenuator when the optical device operates as a DGE and as a switching array when the optical device operates as a COADM. Advantageously, this invention provides a 4-f system wherein a preferred embodiment the element having optical power is a concave reflector for providing a single means for receiving light from the front-end unit, reflecting the received light to the dispersive element, receiving light from the dispersive element, and providing dispersed light to the modifying means. Conveniently and advantageously, this same concave reflector is utilized on a return path, obviating the requirement of matching elements. In one embodiment a single focussing/collimating lens is provided substantially at a focal plane of the element having optical power.

41 Claims, 12 Drawing Sheets

(54) **OPTICAL CONFIGURATION FOR A DYNAMIC GAIN EQUALIZER AND A CONFIGURABLE ADD/DROP MULTIPLEXER**

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Title)

Bouevitch Patent: DGE / COADM

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

(10) **Patent No.: US 6,498,872 B2**
(45) **Date of Patent: Dec. 24, 2002**

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(58) **Field of Search** 349/193, 196; 359/115, 122, 128, 124, 130, 131, 245–247, 301–302; 385/16, 18, 24, 31, 37, 39, 47

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5,414,540	A *	5/1995	Patel et al.	349/196
5,477,350	A	12/1995	Riza et al.	359/39
5,526,155	A	6/1996	Knox et al.	359/130
5,740,288	A	4/1998	Pan	385/11
5,745,271	A	4/1998	Ford et al.	359/130
5,847,831	A	12/1998	Tomlinson, III et al.	356/364
5,867,264	A	2/1999	Hinnrichs	356/310
5,881,199	A	3/1999	Li	385/140
5,936,752	A	8/1999	Bishop et al.	359/124
5,943,158	A	8/1999	Ford et al.	359/295
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6,018,603	A	1/2000	Lundgren et al.	385/33
6,081,331	A	6/2000	Teichmann	356/328
6,134,359	A	10/2000	Keyworth et al.	385/33
6,415,080	B1 *	7/2002	Sappey et al.	359/127

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Primary Examiner—Hemang Sanghavi
Assistant Examiner—Omar Rojas
(74) *Attorney, Agent, or Firm*—Lacasse & Associates, LLC

(57) **ABSTRACT**

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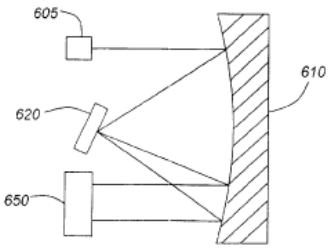
41 Claims, 12 Drawing Sheets



An optical device for rerouting and modifying an optical signal that is capable of operating as a dynamic gain equalizer (DGE) and/or a configurable optical add/drop multiplexer (COADM) is disclosed. The optical design

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Abstract)

Bouevitch Patent Figures 9 and 11

A preferred embodiment is illustrated in FIG. **11**, wherein an arrangement similar to that shown in FIG. **9** designed to operate as a COADM, is shown. Optical circulators **80***a* and

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Col. 14, Lines 14-16)

Bouevitch Patent: DGE / COADM

FIG. **9** is a schematic diagram of a DGE/COADM in accordance with the instant invention including a lens having a single port for launching and receiving light from the concave reflector;

(Ex. 1003 (IPR2014-01166, -01276), Bouevitch Patent, Col. 4, Lines 50-54)

'683 Smith Provisional: Need for Servo Control

distribution functions and generates power control signals to correct the deviations. These signals are transported to the ADM switch on the power control signal line 335 which controls the tilt angle of the individual MEMS elements about the power control axis. This resulting feedback loop may be used to actively optimize the power spectra of the signals leaving the ADM switch. Note – optimizing the output powers should be construed generally. As a rule, one would prefer to maximize the power on each channel, but, for reasons of system uniformity, it is preferred to equalize the powers of all channels which are within a specified range of power (some too-low or too-high power signals may need correction outside the proposed means – e.g. dead lasers) which means adjusting all channel powers until the equal the weakest acceptable channel power – this is common in the current art. For other system reasons, exact equalization

(Ex. 1005 (IPR2014-01166, -01276), '683 Smith Provisional, Page 12, Lines 9-18)

'941 Smith Patent: Need for Servo Control

There are several criteria for adjusting relative power between channels. One straightforward criterion is that all wavelength channels on either output fiber **148, 150** should have the same intensity so that optical receivers and other components located downstream will detect wavelength channels of equal intensity. In another method, the wavelength-differentiated signals are pre-emphasized to have different intensities to, for example, compensate for non-flat wavelength response of a downstream component.

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Col. 9, Lines 58-66)

'941 Smith Patent: Need for Servo Control

The cross connects are also subject to environment and aging effects in which their absorption changes over time. The signal absorption across the cross connect may vary according to the path selected and additionally according to the wavelength channel. The optical input signal may

(Ex. 1004 (IPR2014-01166, -01276), '941 Smith Patent, Col. 10, Lines 17-21)

'678 Patent: Servo Control "Known in the Art"

values. The electronic circuitry and the associated signal processing algorithm/software for such processing unit in a servo-control system are known in the art. A skilled artisan will know how to implement a suitable spectral monitor along with an appropriate processing unit to provide a servo-control assembly in a WSP-S apparatus according to the present invention, for a given application.

(Ex. 1001 (IPR2014-01166), '368 Patent, Col. 12, Lines 9-15;
Ex. 1001 (IPR2014-01276), '678 Patent, Col. 12, Lines 9-15)

Dr. Marom: Servo Control

wavelengths are separated. It would be obvious to PHOSITA to try the internal feedback loop in Smith for use in Bouevitch as an alternative to the "external feedback" for power control that Bouevitch explains should be eliminated. (*Id.* at 10:17-21.) This was obvious because the only alternatives to provide such feedback would be the use of (1) internal or (2) external feedback. Using the

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 85;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 84)

Dr. Marom: Servo Control

feedback would be the use of (1) internal or (2) external feedback. Using the Smith internal feedback technique was known, and one of skill would be motivated to do so to avoid burdening the network controller with additional communication between network elements which would otherwise be required with external control. (*Id.*; *see also* **[Ex. 1001]**, 12:9-15 ("The electronic circuitry and the associated signal processing algorithm/software for such processing unit in a servo-control system are known in the art.")) Bouevitch also suggests placing a photodiode array to intercept part of the light after the beam modifying means, where the wavelengths are separated, to get an internal feedback source (my interpretation) for eliminating the need for external feedback (Bouevitch patent 10:17-20).

(Ex. 1028 (IPR2014-01166), Marom Decl., Para. 85;
Ex. 1028 (IPR2014-01276), Marom Decl., Para. 84)

Imaging

‘368 Patent Claim 17

Focusing

‘368 Patent Claims 11, 21

‘368 Patent Claim 17: Imaging

imaging each of said spectral channels onto a corresponding beam-deflecting element; and

(Ex. 1001 (IPR2014-01166), ‘368 Patent, Claim 17)

‘368 Patent Claim 21: Focusing

21. The method of claim **17**, wherein said imaging comprises focusing said spectral channels onto said beam-deflecting elements.

(Ex. 1001 (IPR2014-01166), ‘368 Patent, Claim 21)

Patent Owner's Expert: Imaging and Focusing

Q So you don't disagree, do you, that Bouevitch figure 11 shows imaging of spectral channels on to a beam-deflecting element, correct?

DR. TUMINARO: Objection, form.

Q That's not a point of contention, I don't believe.

A No, I just want to verify that -- so the beam, it is focused on the mirror -- on beam defecting element 50, in particular, mirrors 51 and 52. This design assumes that.

(Ex. 1039 (IPR2014-01166), Sergienko Tr., Page 246, Lines 2-12; Paper 25 (IPR2014-01166), Petitioner's Reply, Pages 22-23)

Patent Owner's Expert: Imaging and Focusing

Q Because it's focused it's also imaged, correct?

DR. TUMINARO: Objection, form.

A Well, it is in -- this is the extreme form of imaging, focusing, yes. You can say both. When you highlight that this is imaging with the very small size, it become just focusing.

(Ex. 1039 (IPR2014-01166), Sergienko Tr., Page 246, Lines 13-20; Paper 25 (IPR2014-01166), Petitioner's Reply, Pages 22-23)

Combine

‘368 Patent Claim 17

'368 Patent Claim 17: Combine

controlling dynamically and continuously said beam-deflecting elements *in two dimensions* so as to combine selected ones of said spectral channels into an output multi-wavelength optical signal *and to control the*

(Ex. 1001 (IPR2014-01166), '368 Patent, Claim 17)

Patent Owner's Expert: COADM

14 Q And the A in either of those
15 two terms, the capital A, stands for add,
16 correct?
17 A That's correct.
18 Q One point of a COADM or a ROADM
19 is to combine one of the selected signals into
20 the multiwavelength output of the device; is
21 that correct?
22 A That's correct.

(Ex. 1039 (IPR2014-01166), Sergienko Tr., Page 96, Lines 14-22; Paper 25 (IPR2014-01166), Petitioner's Reply, Page 23)

Bouevitch Patent: COADM

It is a further object of the instant invention to provide an optical configuration for rerouting and modifying an optical signal that can be used as a dynamic gain equalizer and/or configurable add/drop multiplexer.

(Ex. 1003 (IPR2014-01166), Bouevitch Patent, Col. 2, Lines 22-25)

Bouevitch Patent: Multiplexer

US006498872B2

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

(10) **Patent No.: US 6,498,872 B2**
(45) **Date of Patent: Dec. 24, 2002**

(54) **OPTICAL CONFIGURATION FOR A DYNAMIC GAIN EQUALIZER AND A CONFIGURABLE ADD/DROP MULTIPLEXER**

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(58) **Field of Search** 349/193, 196; 359/115, 122, 128, 124, 130, 131, 245–247, 301–302; 385/16, 18, 24, 31, 37, 39, 47

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Primary Examiner—Hemang Sanghavi
Assistant Examiner—Omar Rojas
(74) *Attorney, Agent, or Firm*—Lacasse & Asso

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41 Claims, 12 Drawing Sheets

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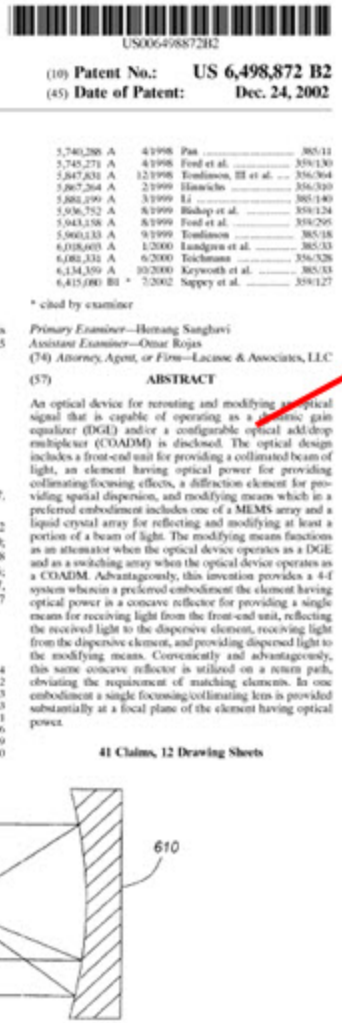
(Ex. 1003 (IPR2014-01166), Bouevitch Patent, Title)

Bouevitch Patent: Multiplexer



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6,134,359	A	10/2000	Keyworth et al.	385/33
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An optical device for rerouting and modifying an optical signal that is capable of operating as a dynamic gain equalizer (DGE) and/or a configurable optical add/drop multiplexer (COADM) is disclosed. The optical design includes a front-end unit for providing a collimated beam of light, an element having optical power for providing collimating/focusing effects, a diffraction element for providing spatial dispersion, and modifying means which in a preferred embodiment includes one of a MEMS array and a liquid crystal array for reflecting and modifying at least a portion of a beam of light. The modifying means functions as an attenuator when the optical device operates as a DGE and as a switching array when the optical device operates as a COADM. Advantageously, this invention provides a 4-f system wherein a preferred embodiment the element having optical power is a concave reflector for providing a single means for receiving light from the front-end unit, reflecting the received light to the dispersive element, receiving light from the dispersive element, and providing dispersed light to the modifying means. Conveniently and advantageously, this same concave reflector is utilized on a return path, obviating the requirement of matching elements. In one embodiment a single focussing/collimating lens is provided substantially at a focal plane of the element having optical power.

41 Claims, 12 Drawing Sheets

An optical device for rerouting and modifying an optical signal that is capable of operating as a dynamic gain equalizer (DGE) and/or a configurable optical add/drop multiplexer (COADM) is disclosed. The optical design

(Ex. 1003 (IPR2014-01166), Bouevitch Patent, Abstract)

Bouevitch Patent Figure 11: Add / Drop

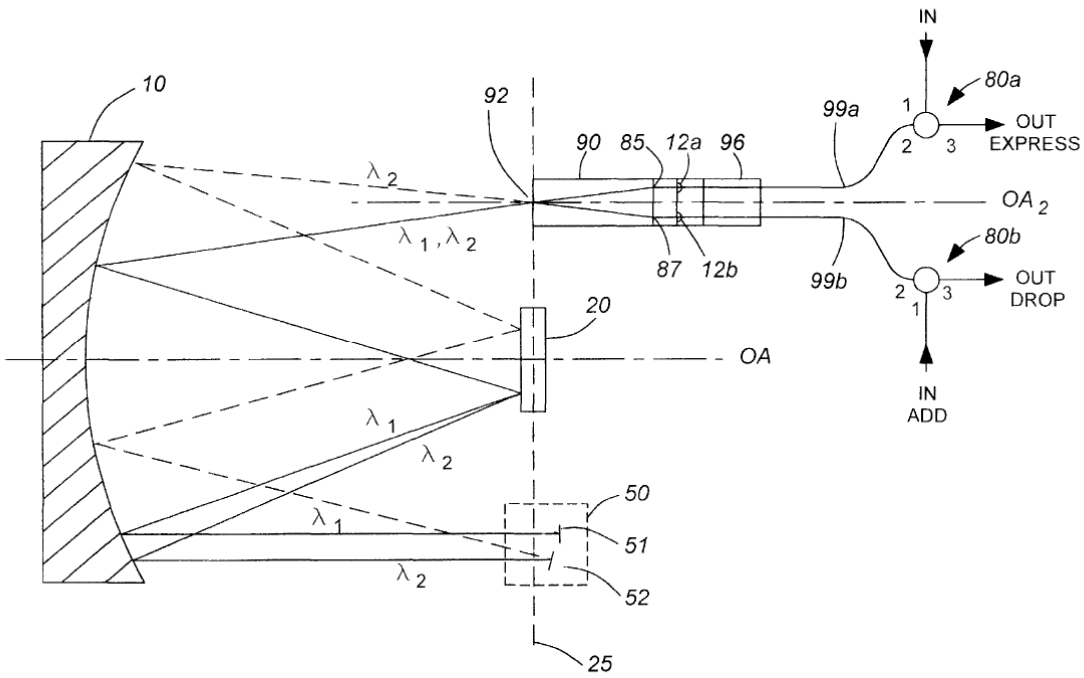

FIG. 11

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(Ex. 1003 (IPR2014-01166), Bouevitch Patent, Fig. 11)