

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CISCO SYSTEMS, INC.,
Petitioner

IPR2025-00241
U.S. Patent No. 8,441,721

**PETITION FOR *INTER PARTES* REVIEW
UNDER 35 U.S.C. § 312 AND 37 C.F.R. § 42.104**

TABLE OF CONTENTS

PETITIONER’S EXHIBIT LIST	5
I. INTRODUCTION	6
II. GROUNDS FOR STANDING.....	7
III. NOTE.....	7
IV. TECHNOLOGY BACKGROUND.....	7
A. Optical Communication	7
B. Wavelength Division Multiplexing (WDM).....	8
C. Optical Pumping.....	9
D. Raman Pump Optimization	12
E. Linear Algebra and Matrix Multiplication.....	13
V. OVERVIEW OF THE ’721 PATENT	15
A. Summary of the ’721 Patent.....	15
B. Prosecution History of the ’721 Patent.	22
VI. LEVEL OF ORDINARY SKILL IN THE ART.....	22
VII. CLAIM CONSTRUCTION	23
VIII. RELIEF REQUESTED AND THE REASONS FOR THE REQUESTED RELIEF	23
IX. DISCRETIONARY DENIAL WOULD BE INAPPROPRIATE.....	23
A. Discretionary denial under the <i>Fintiv</i> factors is not appropriate.....	23
1. No evidence regarding a stay	23

2.	Parallel proceeding trial date	24
3.	Investment in the parallel proceeding	24
4.	Overlapping issues with the parallel proceeding	25
5.	Identity of parties	25
6.	Other circumstances	25
B.	Discretionary denial under 35 U.S.C. § 325(d) is not appropriate. ...	26
X.	IDENTIFICATION OF HOW THE CLAIMS ARE UNPATENTABLE....	27
A.	Challenged Claims and Statutory Grounds for Challenge	27
B.	Ground 1: Claims 1, 2, 4, 6, 19, and 21 are rendered obvious by Sugaya.	28
1.	Summary of Sugaya.	28
2.	Claim 1	32
3.	Claim 2	45
4.	Claim 4	47
5.	Claim 6	48
6.	Claim 19	48
7.	Claim 21	53
C.	Ground 2: Claims 1, 2, 4, 6, 19, and 21 are rendered obvious by Sugaya in view of Farmer.	53
1.	Summary of Farmer.	53
2.	Reasons to Combine Farmer with Sugaya	57
3.	Claim 1	61

4.	Claim 2.....	68
5.	Claim 4.....	69
6.	Claim 6.....	69
7.	Claim 19.....	69
8.	Claim 21	72
XI.	CONCLUSION.....	72
XII.	MANDATORY NOTICES	73
A.	Real Party-in-Interest	73
B.	Related Matters.....	73
C.	Lead and Back-up Counsel and Service Information	73
	CERTIFICATE OF WORD COUNT.....	75
	CERTIFICATE OF SERVICE	76

PETITIONER’S EXHIBIT LIST

Ex.1001	U.S. Patent No. 8,441,721 to White et al.
Ex.1002	Prosecution History of U.S. Patent No. 8,441,721.
Ex.1003	Declaration of Dr. Daniel Blumenthal under 37 C.F.R. § 1.68.
Ex.1004	<i>Curriculum Vitae</i> of Dr. Blumenthal.
Ex.1005	U.S. Patent Publication No. 2004/019615 to Sugaya et al. (“Sugaya”).
Ex.1006	U.S. Patent No. 6,069,719 to Mizrahi (“Mizrahi”).
Ex.1007	“Optical Pump Control of Broadband Raman Amplifiers via Linear Programming,” Roland W. Freund, Bell Labs Technical Memorandum, 2003 (“Freund”).
Ex.1008	“Optimal Design of Flat-Gain Wide-Band Fiber Raman Amplifiers,” Victor E. Perlin et al. Journal of Lightwave Technology, Vol. 20, No. 2, February 2002 (“Perlin”).
Ex.1009	“Flat-Gain Fiber Raman Amplifiers Using Equally Spaced Pumps,” Jonathan Hu et al. Journal of Lightwave Technology, Vol. 22, No. 6, June 2004 (“Hu”).
Ex.1010	“Linear Algebra and its Applications,” David C. Lay, 1997 (“Linear Algebra”).
Ex.1011	“McGraw Hill Dictionary of Scientific and Technical Terms, Fifth Edition,” 1994 (“Technical Dictionary”).
Ex.1012	U.S. Patent No. 6,907,051 to Farmer (“Farmer”).
Ex.1013	Complaint, <i>WSOU Investments, LLC v. Cisco Systems, Inc.</i> , No. 2-24-cv-00332 (E.D. Tex. May, 6, 2024).
Ex.1014	Docket Control Order - <i>WSOU Investments, LLC v. Cisco Systems, Inc.</i> , No. 2-24-cv-00332 (E.D. Tex. May, 6, 2024).
Ex.1015	Federal Court Trial Statistics – September 30, 2024.

I. INTRODUCTION

The prior art presented in this Petition teaches the same technique for determining Raman pump power settings that is claimed in U.S. Patent No. 8,441,721 (“the ’721 patent,” Ex.1001). The ’721 patent relates to determining the power setting for a set of Raman pumps that amplify a set of optical signals at various frequencies as they pass through an optical fiber. The purported novelty of the ’721 patent is a matrix multiplication technique in which a vector of deviations (between measured values and a target value) is multiplied by a Raman gain matrix. Claim 1, for example, recites “*projecting the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers.*” The ’721 patent explains that the “projection is enabled by expressing the basic Raman physics as a matrix vector multiplication.” Ex.1001, 3:17-20.

However, the Sugaya reference (Ex.1005) shows that it was already known to multiply deviations (ΔP_{S1} , ΔP_{S2} and ΔP_{S3}) by a gain matrix (B_{ij}^{-1}) to create projected deviations for determining the Raman pump settings.

$$\begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} \quad (2.12)$$

“projected deviations”
 “space that defines Raman gain profiles”
 “deviations”

Ex.1005, Equation 2.12 (annotated); Ex.1003, ¶88.

Accordingly, pursuant to 35 U.S.C. §§ 311, 314(a), and 37 C.F.R. § 42.100, Cisco Systems, Inc. (“Petitioner”) respectfully requests that the Board review and cancel as unpatentable under (pre-AIA) 35 U.S.C. §103(a) claims 1, 2, 4, 6, 19, and 21 (the “Challenged Claims”) of the ’721 patent.

II. GROUNDS FOR STANDING

Petitioner certifies that the ’721 Patent is eligible for IPR and that Petitioner is not barred or estopped from requesting IPR challenging the patent claims. 37 C.F.R. § 42.104(a).

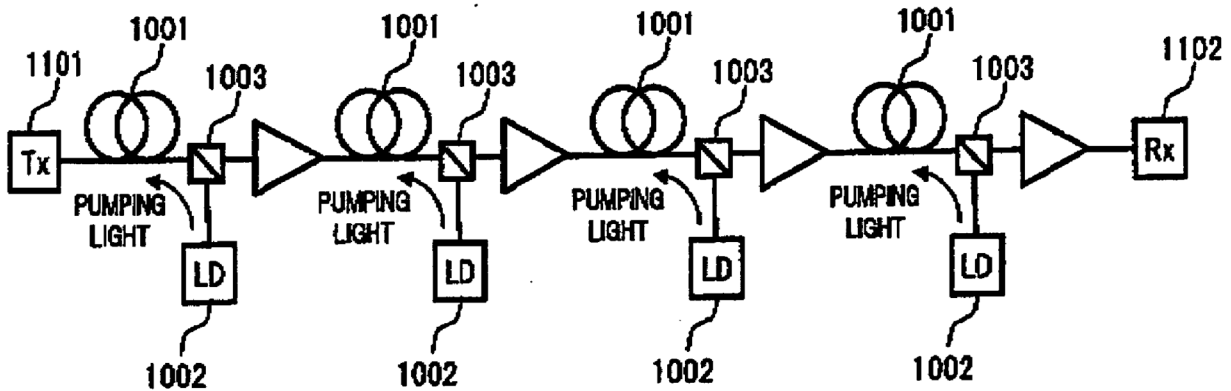
III. NOTE

Petitioner cites to exhibits’ original page numbers. Emphasis in quoted material has been added.

IV. TECHNOLOGY BACKGROUND

A. Optical Communication

Optical communication systems use fiber optic cables to transmit data between a transmitter and a receiver. *See* Ex.1005, [0005]-[0007]. For example, as shown in the figure below, transmission path fibers 1001 extend between a transmission station (Tx) 1101 and a reception station (Rx) 1102. *See* Ex.1005, [0005].



Ex.1005, Fig. 38.

“A transmission path fiber 1001 is an optical transmission medium propagating the WDM light therethrough.” Ex.1005, [0006]. It is known that “[o]ver appreciable distances, the optical signals become significantly attenuated. To address the attenuation, optical signals are amplified.” Ex.1012, 1:21-24. One type of amplifier is a Raman amplifier. *See* Ex.1012, 1:26; Ex.1003, ¶¶28-29.

B. Wavelength Division Multiplexing (WDM)

It was known in the prior art to employ “a wavelength division multiplexing (WDM) technology for achieving a large capacity and a high speed in a trunk optical transmission.” Ex.1005, [0004]. “Wavelength division multiplexing (WDM) is one technique used to increase the capacity of optical communication systems.” Ex.1006, 1:15-18. “A wavelength division multiplexed optical communication system employs plural optical channels, each channel being assigned a particular channel wavelength.” Ex.1006, 1:25-28. “In a WDM system,

optical channels are generated, multiplexed to form an optical signal comprised of the individual optical channels, transmitted over a waveguide [e.g., optical fiber], and demultiplexed such that each channel wavelength is individually routed to a designated receiver.” Ex.1006, 1:28-33; Ex.1003, ¶¶30-33.

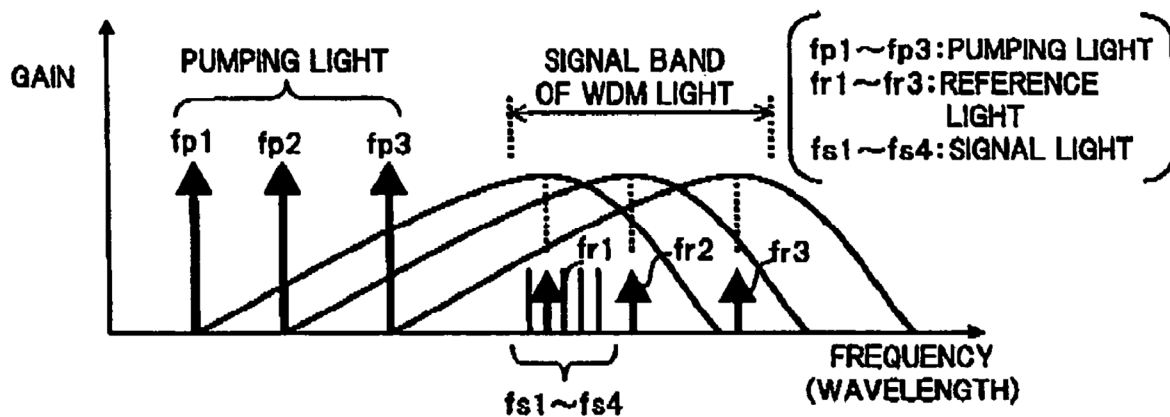
C. Optical Pumping

One type of optical amplifier is a Raman pump: “a core technique of WDM transmission technology, an optical amplification technique, such as a ... Raman amplifier and the like, has been in practical use.” Ex.1005, [0004]. “A Raman amplifier relies upon the Raman scattering effect. The Raman scattering effect is a process in which light is frequency downshifted in a material. The frequency downshift results from a nonlinear interaction between light and the material.” Ex.1012, 1:26-30.

The Raman scattering effect is stimulated “[w]hen photons of two different wavelengths are present in an optical fiber.” Ex.1012, 1:34-36. “This process is referred to as stimulated Raman scattering (SRS). In the SRS process, longer wavelength photons stimulate shorter wavelength photons to experience a Raman scattering event.” Ex.1012, 36-39. “The shorter wavelength photons are destroyed and longer wavelength photons, identical to the longer wavelength photons present initially, are created.” Ex.1012, 1:39-41. “The excess energy is conserved as an optical phonon (a lattice vibration). This process results in an increase in the

number of longer wavelength photons and is referred to as Raman gain.” Ex.1012, 1:41-45.

The Raman scattering effect “is useful for generating optical gain.” Ex.1012, 1:66-67. As an example, light is pumped into the optical fiber at a shorter wavelength (higher energy) than the wavelength intended for amplification, as shown in the figure below.¹



Ex.1005, Fig. 6.

To generate optical gain, a Raman pump may include a “pumping light source (LD) 1002, which is formed by multiplexing by a multiplexer or the like, for example, transmission light from a laser diode or a plurality of laser diode, generates a pumping light for amplifying the WDM light.” Ex.1005, [0006]. “Here,

¹ The x-axis, which is labeled “frequency (wavelength)” shows increasing wavelengths from left to right. Ex.1003, ¶36.

the pumping light generated in the pumping light source 1002 contains a plurality of lights having wavelengths different from each other. A WDM coupler 1003 introduces the pumping light generated in the pumping light source 1002 to the transmission path fiber 1001.” Ex.1005, [0006].

The background section of the ’721 patent explains that Raman amplification is well-known. “Raman scattering, which is a well-known physical phenomenon, can be employed to build amplifiers to compensate for fiber loss in optical transmission systems.” Ex.1001, 1:36-38. “Raman amplification advantageously uses the fiber itself as the amplification medium. Specifically, the output from high-power (Raman) optical pumps lasers are launched into an optical fiber at a wavelength shorter (i.e., higher energy) than that of the signal(s) to be amplified.” Ex.1001, 1:39-43. “Amplification then occurs when the pump photons are converted by the stimulated Raman effect into new photons at the signal wavelength(s).” Ex.1001, 1:44-46.

The background section of the ’721 patent further explains some of the challenges of Raman amplification. “Because the process of Raman amplification is inherently non-linear, control of a Raman amplifier should take into account not only the target channel power, but also the distribution of input channel and pump powers.” Ex.1001, 1:49-52. In other words, pumping power into one channel will also affect other channels. “[T]he addition of a single channel can significantly

affect the gain profile applied to the original channel set.” Ex.1001, 1:53-55.

Accordingly, “[t]he complicated, non-linear nature of the Raman process requires a measurement and feedback based control scheme.” Ex.1001, 1:64-66; Ex.1003, ¶¶34-39.

D. Raman Pump Optimization

Optimizing the Raman pump powers has long been an endeavor of optical engineering. *See generally*, Ex.1007, 1-2. Raman pumps are preferred because they “increase the transmission bandwidth” and “have better noise performance.”

Ex.1009, 1. It is known that “[o]ne of the main difficulties is that pump-to-pump and signal-to-signal Raman interactions make the system highly nonlinear.”

Ex.1008, 1. “While multiple pumps can be used to equalize gain over a large bandwidth, it has been a challenge to design FRAs [fiber Raman Amplifiers] with flat gain.” Ex.1009, 1. Accordingly, optimization procedures have been developed to choose pump powers that “achieve the best possible gain flatness over a specified signal bandwidth.” Ex.1009, 1. In other words, “[t]he powers of these pumps need to be adjusted dynamically, so that signal powers are as flat as possible, relative to some given power target.” Ex.1007, 2.

Solving the optimization problem often involves modeling the relationship between the Raman pump powers and the optical signal powers. For example, the Raman pump powers are represented by a vector. The channel powers are also

represented by a vector. Because each of the pump powers affects multiple channels, the relationship between the pump powers and the channel signal powers is represented by a matrix. For example, a system having m pumps and n channels may be represented by an n by m matrix as shown below.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}$$

Ex.1007, 3.

The R matrix shown above is “the $n \times m$ Raman gain matrix whose entries R_{ij} are nominal values for the Raman gain provided for channel i by pump j .” Ex.1007, 5; *see also* Ex.1005. Such a gain matrix, which represents the capabilities of the Raman pumps, can be used to determine what pump powers should be used to achieve specific channel powers. *See generally* Ex.1005; Ex.1003, ¶¶40-43.

E. Linear Algebra and Matrix Multiplication

Those of skill in the art would have been familiar with the use of linear algebra to solve a system of linear equations. Ex.1003, ¶44. “A system of linear equations (or a linear system) is a collection of one or more linear equations involving the same variables.” Ex.1010, 3.

$$\begin{aligned} 2x_1 - x_2 + 1.5x_3 &= 8 \\ x_1 - 4x_3 &= -7 \end{aligned} \tag{2}$$

Ex.1010, 3.

“The essential information of a linear system can be recorded compactly in a rectangular array called a matrix.” Ex.1010, 4.

$$\begin{aligned} x_1 - 2x_2 + x_3 &= 0 \\ 2x_2 - 8x_3 &= 8 \\ -4x_1 + 5x_2 + 9x_3 &= -9 \end{aligned} \tag{3}$$

with the coefficients of each variable aligned in columns, the matrix

$$\begin{bmatrix} 1 & -2 & 1 \\ 0 & 2 & -8 \\ -4 & 5 & 9 \end{bmatrix}$$

Ex.1010, 4.

“A fundamental idea in linear algebra is to view a linear combination of vectors as the product of a matrix and a vector.” Linear Algebra, 39. A vector is essentially a matrix with a single column or a single row. *See* Linear Algebra, 27.

If A is an $m \times n$ matrix, with columns $\mathbf{a}_1, \dots, \mathbf{a}_n$, and if $\mathbf{x}$ is in $\mathbb{R}^n$, then the **product of A and $\mathbf{x}$** , denoted by $A\mathbf{x}$, is **the linear combination of the columns of A using the corresponding entries in $\mathbf{x}$ as weights**, that is,

$$A\mathbf{x} = [\mathbf{a}_1 \quad \mathbf{a}_2 \quad \cdots \quad \mathbf{a}_n] \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} = x_1\mathbf{a}_1 + x_2\mathbf{a}_2 + \cdots + x_n\mathbf{a}_n$$

Ex.1010, 39.

The example below shows the product of a matrix with a vector.

Solution From the definition,

$$\begin{aligned} \begin{bmatrix} 2 & 3 & 4 \\ -1 & 5 & -3 \\ 6 & -2 & 8 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} &= x_1 \begin{bmatrix} 2 \\ -1 \\ 6 \end{bmatrix} + x_2 \begin{bmatrix} 3 \\ 5 \\ -2 \end{bmatrix} + x_3 \begin{bmatrix} 4 \\ -3 \\ 8 \end{bmatrix} \\ &= \begin{bmatrix} 2x_1 \\ -x_1 \\ 6x_1 \end{bmatrix} + \begin{bmatrix} 3x_2 \\ 5x_2 \\ -2x_2 \end{bmatrix} + \begin{bmatrix} 4x_3 \\ -3x_3 \\ 8x_3 \end{bmatrix} \\ &= \begin{bmatrix} 2x_1 + 3x_2 + 4x_3 \\ -x_1 + 5x_2 - 3x_3 \\ 6x_1 - 2x_2 + 8x_3 \end{bmatrix} \end{aligned} \quad (7)$$

Ex.1010, 43.

As shown in the figure above, a 3x3 matrix multiplied by a 3x1 vector results in a 3x1 vector.

Because matrices are useful for representing systems of linear equations, they are useful for representing a Raman system. As explained above, the power applied to a single Raman pump affects multiple channels. Thus, a matrix can be used to represent how various Raman pump powers produce certain output powers over the channels. Ex.1003, ¶¶44-50.

V. OVERVIEW OF THE '721 PATENT

A. Summary of the '721 Patent

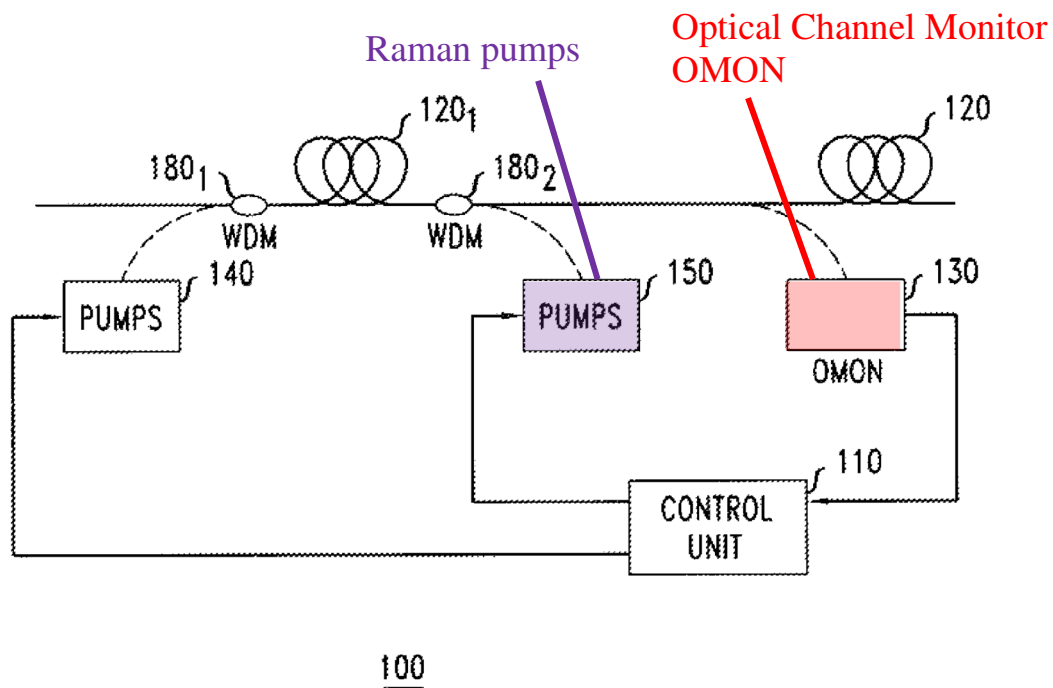
The '721 patent describes and claims a matrix multiplication technique for optimizing Raman pump settings. The '721 patent “relates to Raman amplification,

and more specifically to the control of Raman amplification via the adjustment of the power levels of Raman pump lasers which may be used to compensate for fiber loss in broadband optical transmission systems.” Ex.1001, 1:6-10. The ’721 patent seeks to “enhance the stability and convergence of Raman amplifier control methodologies as compared to conventional embodiments.” Ex.1001, 2:61-63.

The purported novelty of the ’721 patent a matrix multiplication technique that multiplies (e.g., projects) a measured error vector with a gain matrix (e.g., space) that represents the capabilities of the Raman pumps. As the ’721 patent explains, “a measured error vector is projected into the space of correctable deviations.” Ex.1001, 3:16-17. “The projection is enabled by expressing the basic Raman physics as a matrix vector multiplication.” Ex.1001, 3:17-19. The “matrix defines the space of possible Raman gain profiles achievable given a set of channels and pump lasers.” Ex.1001, 3:21-22. This matrix multiplication technique is thus used to optimize the pump settings for a Raman pump system.

The ’721 patent’s matrix multiplication technique is applied to a conventional Raman pump system. Fig. 1, for example, illustrates “a Raman-pumped Dense Wavelength-Division-Multiplexed (DWDM) system 100 employing Raman amplification.” Ex.1001, 5:52-54. “As can be seen from FIG.1, all entering optical signals pass through fiber span 120, where they may be amplified by the three forward Raman pumps 140 and the six backward Raman

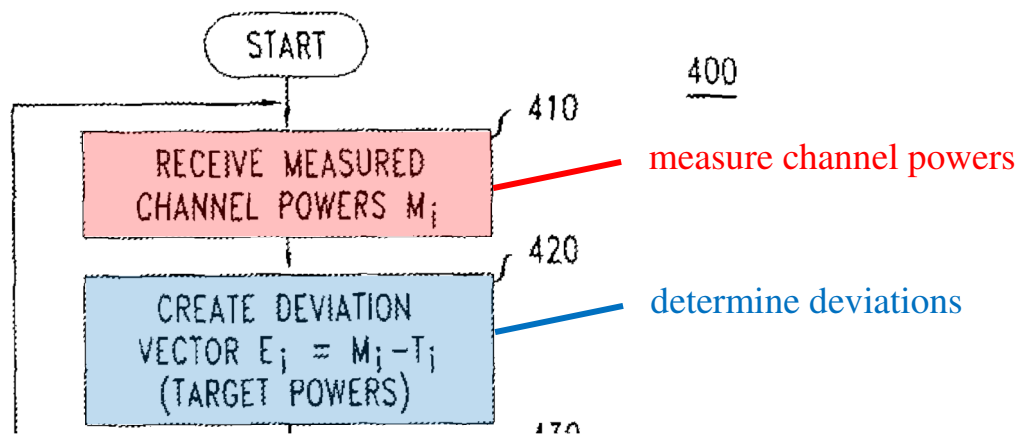
pumps 150.” Ex.1001, 6:6-9. “The Raman pump waves of the Raman pump sets 140 and 150 are coupled into the fiber span by WDMs 180 and 180.” Ex.1001, 6:9-11. “After the optical signal is amplified, a first gain profile is determined by the OMON 130.” Ex.1001, 6:14-16. The system 100 is shown in Fig. 1 below.



Ex.1001, Fig. 1 (annotated); Ex.1003, ¶53.

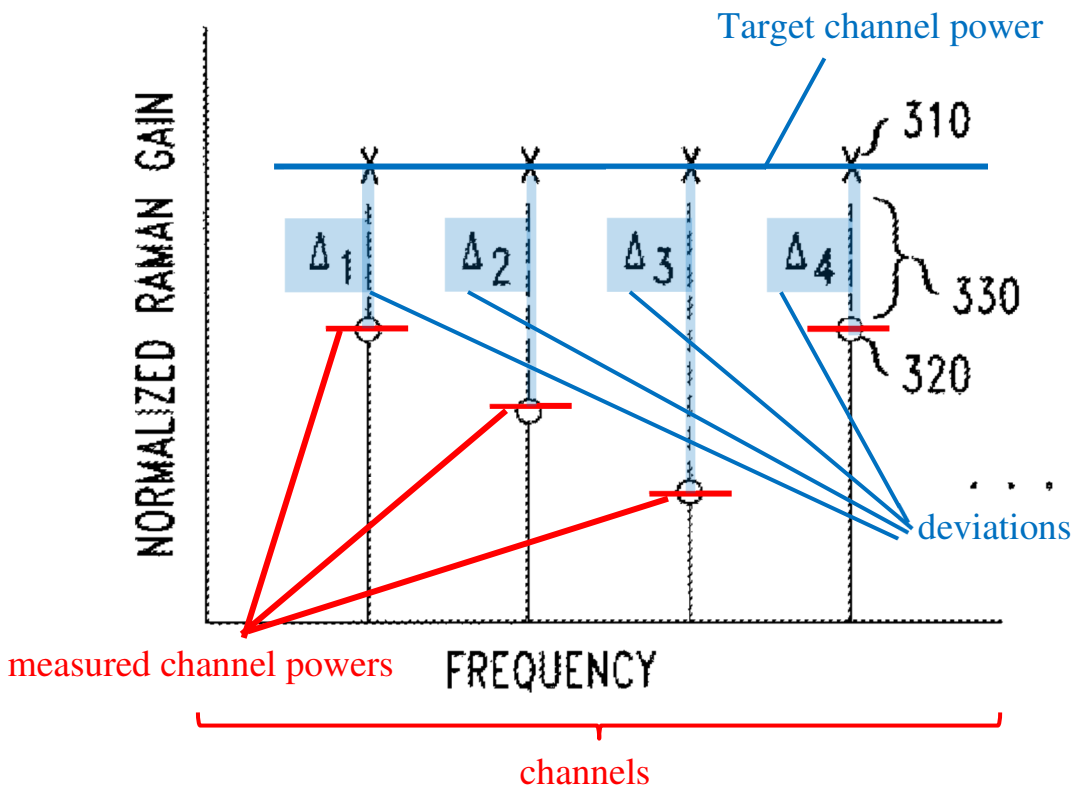
The OMON is used to measure the power levels within each channel: “[T]he control unit 110, receives power measurements (M_i) for a plurality of optical channels. The power measurement may be made by an OMON and provided to the control unit.” Ex.1001, 10:7-11. The control unit then determines the deviations between the measured power values and target values: “At step 420, deviation measurements (E_i) representing a difference between respective power

measurements and corresponding power targets (T_i) for the plurality of optical channels are created ($E_i = M_i - T_i$). The deviation vector E , may be calculated by subtracting measured channel powers from target channel powers.” Ex.1001, 10:11-16. The measuring step, and deviation vector step are illustrated in Fig. 4 below.



Ex.1001, Fig. 4 (partial, annotated); Ex.1003, ¶54.

The '721 patent provides an illustration of the deviations between the measured power values and the target power values. “FIG. 3 is a graphical illustration of target and measured power for a plurality of channels in an example embodiment.” Ex.1001, 9:43-45. Fig. 3 is shown below.



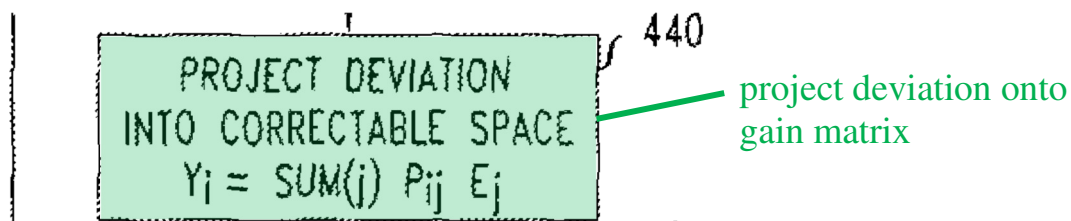
Ex.1001, Fig. 3 (annotated); Ex.1003, ¶55.

Fig. 3 is described as follows: “For each channel of a plurality of channel noted in the frequency domain, the illustrated Raman gain profile has a target power 310 (indicated by an X).” Ex.1001, 9:45-48. “For each channel of the plurality of channels, a measured power 320 (indicated by an ‘O’) is determined, for example through use of the OMON as illustrated in FIG.1.” Ex.1001, 9:48-51. “There is a deviation 330 (Δ_1 , Δ_2 , Δ_3 , Δ_4 , etc.) between the measured power and the target power for each channel (four channels being shown for ease of illustration).” Ex.1001, 9:51-54. The measured deviations can thus be used in the matrix multiplication technique “to minimize the sum of the deviations.” Ex.1001, 9:54-

55.

The measured deviations for each channel, expressed as a vector, are then multiplied by a “gain matrix” that represents the effect of the Raman pumps.

Ex.1001, 10:25-30. “The projection is enabled by expressing the basic Raman physics as a matrix vector multiplication through a manipulation and integration of the basic Raman equations.” Ex.1001, 3:17-20. The ’721 describes this projection technique using the following equation: “ $Y_i = \text{Sum}(j) P_{ij} E_j$ wherein ij , are channel numbers of one of the plurality of channels, P_{ij} is a projector into the subspace represented by the columns of the Raman gain matrix, and E is the deviation measurement for channel j .” Ex.1001, 10:30-35. This step is illustrated as 440 in Fig. 4 below.

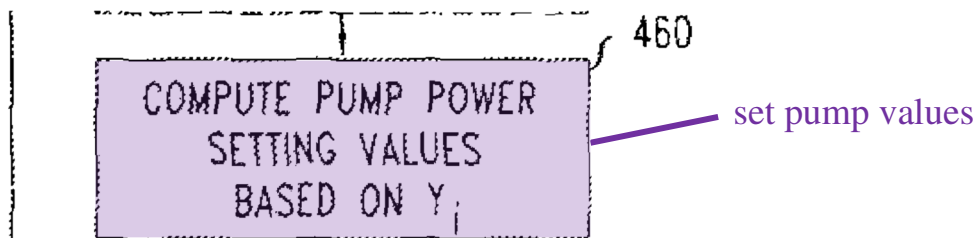


Ex.1001, Fig. 4 (partial, annotated); Ex.1003, ¶57.

The projector P_{ij} represents the gain matrix: “The projector P_{ij} is a square ($m \times m$) matrix which when multiplied with a vector of channel powers (these vectors are of length m) will produce a new vector (also of length m) of the channel powers which are correctable via pump changes.” Ex.1001, 11:63-67.

“When a vector (like the error vector E_i) is multiplied by P_{ij} , one finds the portion of that vector which is representable by the set of orthogonal vectors—which is the changes that can be impacted by changing the pumps.” Ex.1001, 12:9-13. “In this manner, the contributions to a deviation vector that are correctable through adjustment of Raman pumps can be utilized as a control.” Ex.1001, 12:13-16.

The '721 patent then describes using the result of the matrix projection—which it refers to as the projected deviations—to determine the pump power settings. “At step 460, a pump setting for a plurality of pumps is determining based upon the correctable deviations for each channel (Y_i).” Ex.1001, 10:46-48. This step is illustrated as step 460 in Fig. 4 below.



Ex.1001, Fig. 4 (partial, annotated); Ex.1003, ¶60.

However, as will be explained in detail below, it was already known to multiply an error vector (differences between measured and target powers) with a gain matrix that represents the effect of the Raman pumps to determine the Raman pump settings that will bring the actual power levels closer to a target power level. Ex.1003, ¶¶51-61.

B. Prosecution History of the '721 Patent.

The '721 patent was filed December 30, 2009. The original patent included claims 1-20. In the first Office Action, the Examiner allowed claims 1-12 and 19, rejected claims 13-17 and 20, and objected to claims 15 and 18. Ex.1002, 27. The rejected claims were found to be anticipated by U.S. Patent No. 6,590,700 to Seydnejad et al. Ex.1002, 28.

The Applicant then amended claims 13 and 20 and added new claims 21-23. The Office then allowed the remaining claims and the '721 patent issued on May 14, 2013.

The Challenged Claims in this proceeding were thus all allowed in the first office action. For the reasons explained below, the subject matter recited within those claims was already known, as evidenced by Sugaya. Ex.1003, ¶¶62-64.

VI. LEVEL OF ORDINARY SKILL IN THE ART

A Person of Ordinary Skill in The Art (“POSITA”) on December 30, 2009 would have been someone knowledgeable and familiar with fiber optic communication technologies. That person would have a master’s degree in electrical engineering, physics, computer science, or equivalent training, and approximately two years of experience working in the field of optical communication systems. Lack of work experience can be remedied by additional education, and vice versa. Ex.1003, ¶¶21-23.

VII. CLAIM CONSTRUCTION

Claim terms in IPR are construed according to their “ordinary and customary meaning” to those of skill in the art. 37 C.F.R. § 42.100(b). *Phillips v. AWH Corp.*, 415 F.3d 1303, 1313 (Fed. Cir. 2005) (en banc). Petitioner submits that, for the purposes of this proceeding and the grounds presented herein, no claim term requires express construction. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). Ex.1003, ¶¶65.

VIII. RELIEF REQUESTED AND THE REASONS FOR THE REQUESTED RELIEF

Petitioner asks that the Board institute a trial for *inter partes* review and cancel the Challenged Claims in view of the analysis below.

IX. DISCRETIONARY DENIAL WOULD BE INAPPROPRIATE

A. Discretionary denial under the *Fintiv* factors is not appropriate.

The six factors considered for § 314 discretionary denial strongly favor institution given Petitioner’s prompt filing and the compelling merits of this case. *See Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (PTAB Mar. 20, 2020) (precedential).

1. No evidence regarding a stay

No motion to stay has been filed, so the Board should not infer the outcome of such a motion. *Sand Revolution II LLC v. Continental Intermodal Group – Trucking LLC*, IPR2019-01393, Paper 24 at 7 (PTAB June 16, 2020)

(informative); *see also Dish Network L.L.C. v. Broadband iTV, Inc.*, IPR2020-01359, Paper 15 (Feb. 12, 2021) (“It would be improper to speculate, at this stage, what the Texas court might do regarding a motion to stay...”). Thus, this factor is neutral on discretionary denial.

2. Parallel proceeding trial date

The co-pending district court case was filed in the Eastern District of Texas on May 6, 2024. Ex.1013. Trial is currently scheduled for January 26, 2026, and the most recent statistics currently available for the Eastern District of Texas show a median time-to-trial of 21.9 months, consistent with the scheduled trial date. Ex.1014; Ex.1015, 35. The Board’s final written decision is expected in June of 2026. While this is approximately four to five months after the scheduled trial date, this factor is outweighed by both the compelling merits of this case (factor 6) and Petitioner’s stipulation (factor 4).

3. Investment in the parallel proceeding

The co-pending litigation is in its early stages, with major activities including a *Markman* hearing and the close of discovery scheduled for after the Board’s expected decision on institution. *See* Ex.1014, 4 (Claim Construction hearing on September 3, 2025; close of fact discovery on October 14, 2025; close of expert discovery on November 17, 2025). Moreover, Petitioner has acted with diligence to prepare this Petition approximately seven months after Petitioner was

served with a complaint. Under *Fintiv*, Petitioner’s prompt filing “weigh[s] against exercising the authority to deny institution.” *Fintiv*, Paper 11 at 11 (“If the evidence shows that the petitioner filed the petition expeditiously, such as promptly after becoming aware of the claims being asserted, this fact has weighed against exercising the authority to deny institution under NHK”).

4. Overlapping issues with the parallel proceeding

To mitigate any overlap, Petitioner offers the following stipulation: Petitioner stipulates that if trial is instituted, it will not pursue the same grounds in the district court litigation. *See Sand Revolution II, LLC v. Cont’l Intermodal Group-Trucking LLC*, IPR2019-01393, Paper 24 at 12 (PTAB June 16, 2020). Consequently, this factor favors institution.

5. Identity of parties

Petitioner is a defendant in the litigation. That is true of most Petitioners in IPR proceedings. Accordingly, this factor should not be a basis for denying institution.

6. Other circumstances

The prior art presented in this Petition presents a compelling case on the merits. Both Sugaya (Ex.1005) and Farmer (Ex.1012) describe the same matrix multiplication technique for optimizing Raman pumps as recited in the claims of the ’721 patent. As explained above at V.A, in the ’721 patent, “a measured error

vector is projected into the space of correctable deviations.” Ex.1001, 3:16-17.

“The projection is enabled by expressing the basic Raman physics as a matrix vector multiplication.” Ex.1001, 3:17-19. As will be explained in the analysis for Grounds 1 and 2, both Sugaya and Farmer describe a similar matrix multiplication technique, as illustrates below.

$$\begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} \quad (2.12)$$

pump setting gain matrix Measured differences
changes

Ex.1005 (Sugaya), Equation 2.12 (annotated); Ex.1003, ¶74.

$$\Delta I_i = \delta_{ij}^{-1} \Delta P'_j,$$

pump setting gain matrix Measured differences
changes

Ex.1012 (Farmer), 9:30-35 (annotated); Ex.1003, ¶125.

Accordingly, the evidence of unpatentability is compelling here, and the PTAB should not deny institution under *Fintiv*.

B. Discretionary denial under 35 U.S.C. § 325(d) is not appropriate.

Denial under § 325(d) is not warranted because the challenges presented in this petition are neither cumulative nor redundant to the prosecution of the '721

patent. The Examiner did not consider any of the references relied upon in this petition. Accordingly, the Board should not exercise its discretion to deny this petition under § 325(d).

X. IDENTIFICATION OF HOW THE CLAIMS ARE UNPATENTABLE

A. Challenged Claims and Statutory Grounds for Challenge

Grounds	Claims	Basis
#1	1, 2, 4, 6, 19, and 21	35 U.S.C. § 103 (Pre-AIA) over Sugaya
#2	1, 2, 4, 6, 19, and 21	35 U.S.C. § 103 (Pre-AIA) over Sugaya in view of Farmer

U.S. Patent Publication No. 2004/0196158 to Sugaya et al. (“Sugaya”) was filed on March 12, 2004. Sugaya was published on October 7, 2004 and is thus prior art to the ’721 patent under (pre-AIA) 35 U.S.C. 102(b).

U.S. Patent No. 6,907,051 to Farmer (“Farmer”) was filed on August 31, 2001. Farmer issued on June 14, 2005. Farmer is thus prior art to the ’721 patent under (pre-AIA) 35 U.S.C. 102(b).

Petitioner also cites below to additional prior art as evidence of the background knowledge of a POSITA and to provide contemporaneous context to support Petitioner’s assertions regarding what a POSITA would have understood from the prior art in the grounds. *See Yeda Research v. Mylan Pharm. Inc.*, 906 F.3d 1031, 1041-1042 (Fed. Cir. 2018) (affirming the use of “supporting evidence

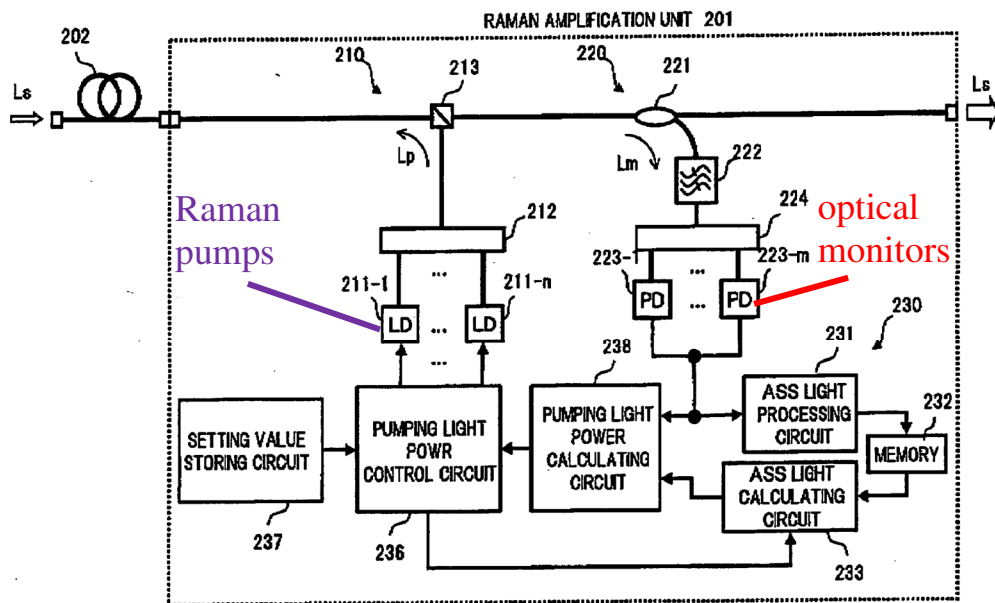
relied upon to support the challenge”); 37 C.F.R. § 42.104(b); *see also K/S HIMPP v. Hear-Wear Techs., LLC*, 751 F.3d 1362, 1365-66 (Fed. Cir. 2014); *Arendi S.A.R.L. v. Apple Inc.*, 832 F.3d 1355, 1363 (Fed. Cir. 2016)).

B. Ground 1: Claims 1, 2, 4, 6, 19, and 21 are rendered obvious by Sugaya.

1. Summary of Sugaya.

Sugaya describes the same matrix multiplication technique for solving the same Raman pump optimization problem recited in the Challenged Claims of the '721 patent. *Compare* Ex.1001 *with* Ex.1005; Ex.1003, ¶69. Like the '721 patent, Sugaya “relates to an optical amplifier which supplies a pumping light to an optical amplification medium to amplify a signal light, and an optical transmission system using the same, and in particular, to a technology for controlling a supply condition of pumping light in the optical amplifier.” Ex.1005, [0002].

Sugaya describes a conventional Raman pump system for pumping light power into a fiber optic medium. Ex.1005, Fig. 38, [0005]-[0007]. One example of a Raman pump system is shown in Fig. 17 below. As shown in Fig. 17, a Raman amplification unit 201 includes Raman pumps LD and optical monitors PD.



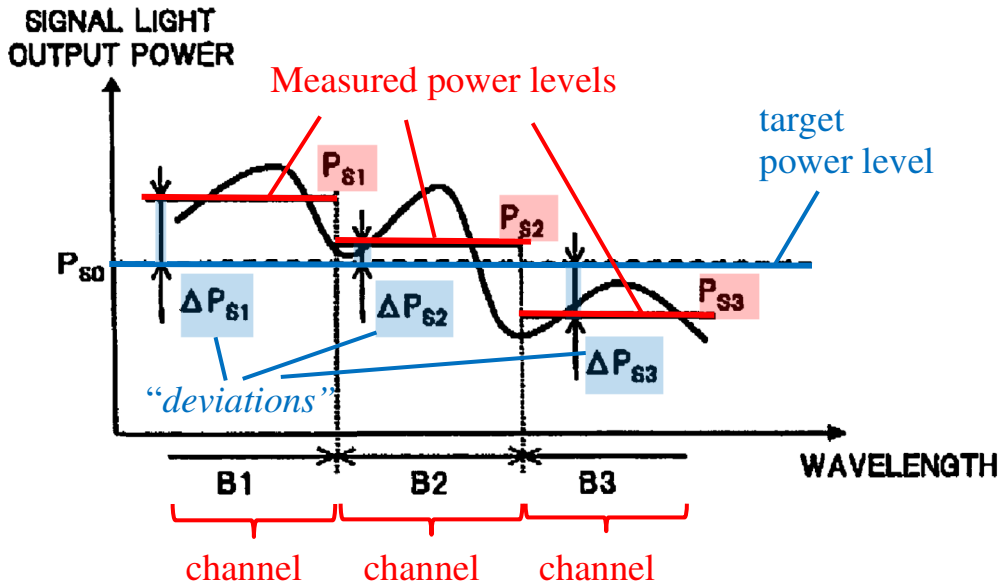
Ex.1005, Fig. 17 (annotated); Ex.1003, ¶70.

The Raman pumps 211 are used to amplify the optical signals passing through the fiber. “The pumping light supply section 210 comprises, for example, in pumping light sources (LD) 211-1 to 211-n.” Ex.1005, [0129]. “The respective pumping light sources 211-1 to 211-n generate lights of required wavelength bands capable of Raman amplifying a signal light L_s transmitted over the optical transmission path 202.” Ex.1005, [0129].

The Raman amplification unit 201 also includes optical monitors for measuring the optical powers at various channels. *See* Ex.1005, [0168]. “The output light monitoring section 220 comprises, for example, a branching device 221, an optical filter 222 and a light receiving element (PD) 223.” Ex.1005, [0131]. In Fig. 17, there are “m light receiving elements 223-1 to 223-m” which “are

provided so that the monitor light Lim passed through the optical filter 221 can be divided into m wavelength blocks to be monitored.” Ex.1005, [0168]. “In step 213, the pumping light sources 211-1 to 211-n are driven for each group corresponding to each wavelength block, and the signal light average output power for each wavelength block is measured.” Ex.1005, [0175]. “Here, the signal light average output powers” are expressed as “ P_{S1} , P_{S2} and P_{S3} .” Ex.1005, [0175].

Sugaya also describes determining the difference between the signal light average output powers and a target power level P_{S0} . “[D]ifferences between the signal light average output powers P_{S1} , P_{S2} and P_{S3} , and the target power level P_{S0} are ΔP_{S1} , ΔP_{S2} and ΔP_{S3} .” Ex.1005, [0181]. The deviations between the measured channel powers and the target channel powers are illustrated in Fig. 19 shown below.



Ex.1005, Fig. 19 (annotated); Ex.1003, ¶73.

The differences between the measured values and the target values are expressed as a vector containing ΔP_{S1} , ΔP_{S2} and ΔP_{S3} . This vector is then multiplied by a gain matrix to determine the pump setting changes that will minimize those differences. This matrix multiplication is shown below.

$$\begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} \quad (2.12)$$

pump setting changes
gain matrix
Measured differences

Ex.1005, Equation 2.12 (annotated); Ex.1003, ¶74.

As Sugaya explains, “the reduction of wavelength characteristic deviation of

the Raman amplified WDS signal light means that, as shown in FIG. 19 for example, the signal light average output powers P_{S1} , P_{S2} and P_{S3} corresponding to the respective wavelength blocks B_1 , B_2 and B_3 approach a desired target power level P_{S0} .” Ex.1005, [0181]. “If differences between the signal light average output powers P_{S1} , P_{S2} and P_{S3} and the target power level P_{S0} are ΔP_{S1} , ΔP_{S2} and ΔP_{S3} **differences of the pumping light power necessary for making up the differences** ΔP_{S1} , ΔP_{S2} and ΔP_{S3} **are ΔP_{P1} , ΔP_{P2} and ΔP_{P3}** .” Ex.1005, [0181].

Accordingly, Sugaya shows that it was known to multiply an error vector (differences between measured and target powers) with a gain matrix that represents the effect of the Raman pumps to determine the Raman pump settings that will bring the actual power levels closer to a target power level. Ex.1003, ¶¶69-77.

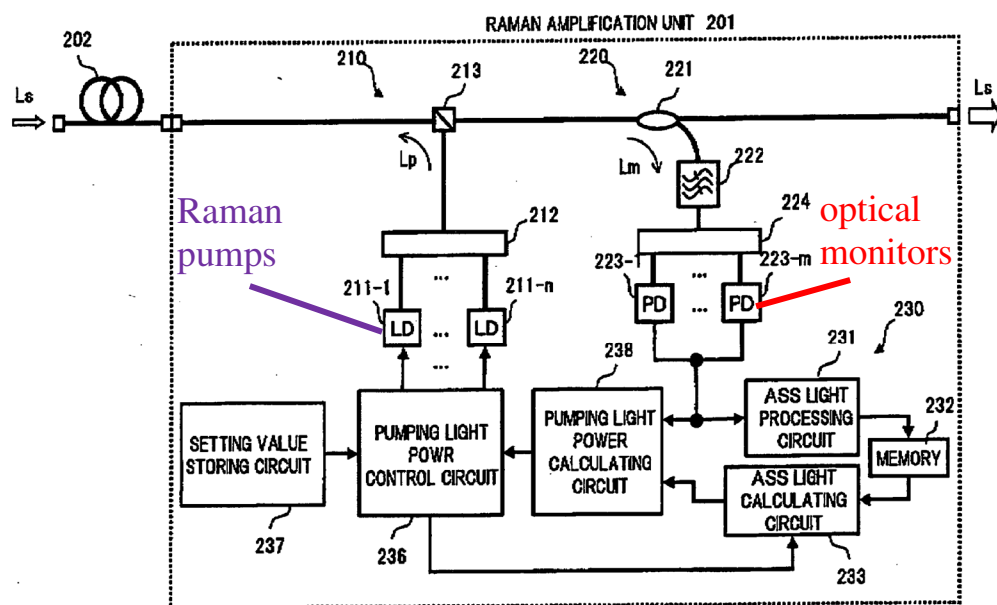
2. Claim 1

[1.0] *A method comprising:*

Sugaya describes a “method” for operating an optical amplifier that supplies pumping light to an optical amplification medium. Sugaya “relates to an optical amplifier which **supplies a pumping light to an optical amplification medium to amplify a signal light**, and an optical transmission system using the same, and in particular, to a technology for **controlling a supply condition of pumping light in the optical amplifier**.” Ex.1005, [0002].

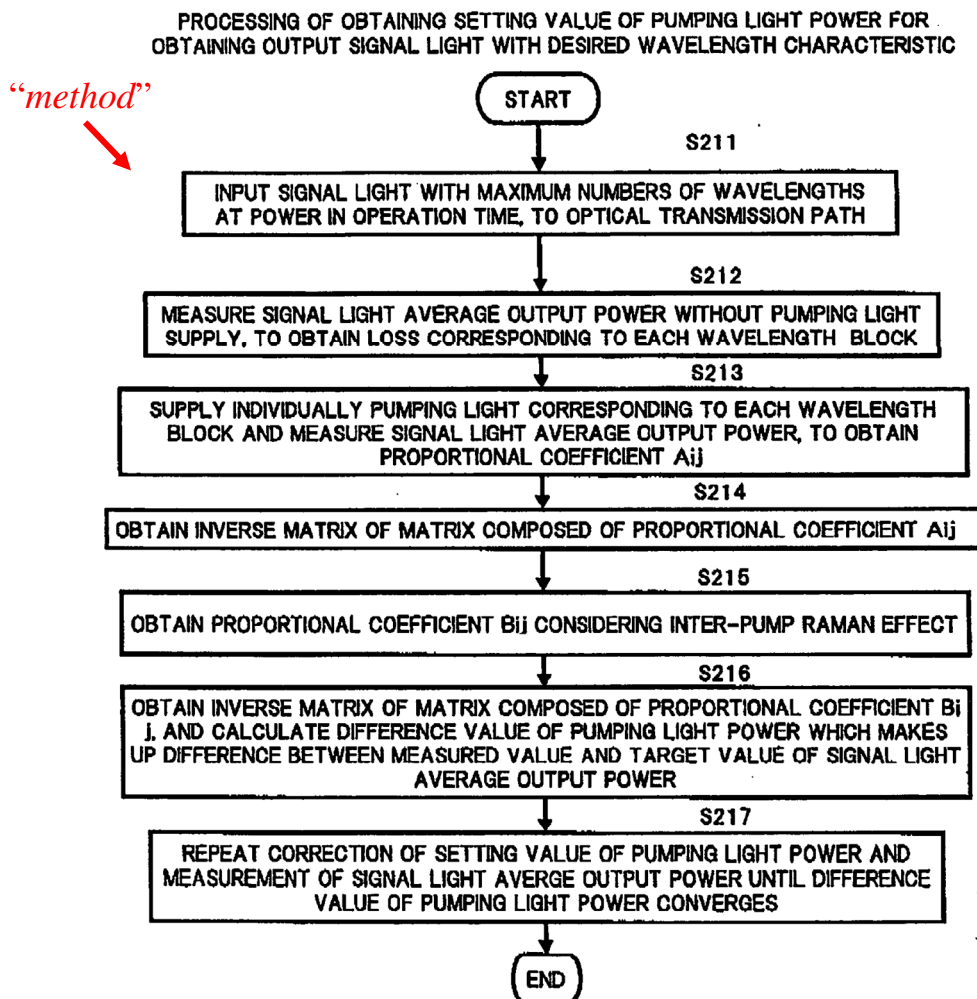
Sugaya illustrates one example of such an optical amplifier in Fig. 17. The amplifier includes Raman pumps 211: “The pumping light supply section 210 comprises, for example, n pumping light sources (LD) 211-1 to 211-n.” Ex.1005, [0129]. “The respective pumping light sources 211-1 to 211-n generate lights of required wavelength bands capable of Raman amplifying a signal light LS transmitted over the optical transmission path 202.” Ex.1005, [0129].

Sugaya’s Raman amplifier also includes optical monitors: “m light receiving elements 223-1 to 223-m are provided so that the monitor light Lm passed through the optical filter 221 can be divided into m wavelength blocks to be monitored.” Ex.1005, [0168]. The Raman pumps and optical monitors are shown in Fig. 17 below.



Ex.1005, Fig. 17 (annotated); Ex.1003, ¶79.

Sugaya describes a method for the operation of the Raman amplifier with respect to Fig. 18. “Here, a specific setting method of the pumping light power will be described referring to a flowchart of FIG. 18.” Ex.1005, [0172]. “In the following description, consideration is made on the case where the output signal light L_s is divided into three wavelength blocks, to calculate the setting value of the pumping light power.” Ex.1005, [0172].



Ex.1005, Fig. 18 (annotated); Ex.1003, ¶80.

Thus, because Sugaya describes a method for controlling pumping light to an optical amplifier, Sugaya renders obvious “*a method*” as claimed. Ex.1003, ¶¶78-81.

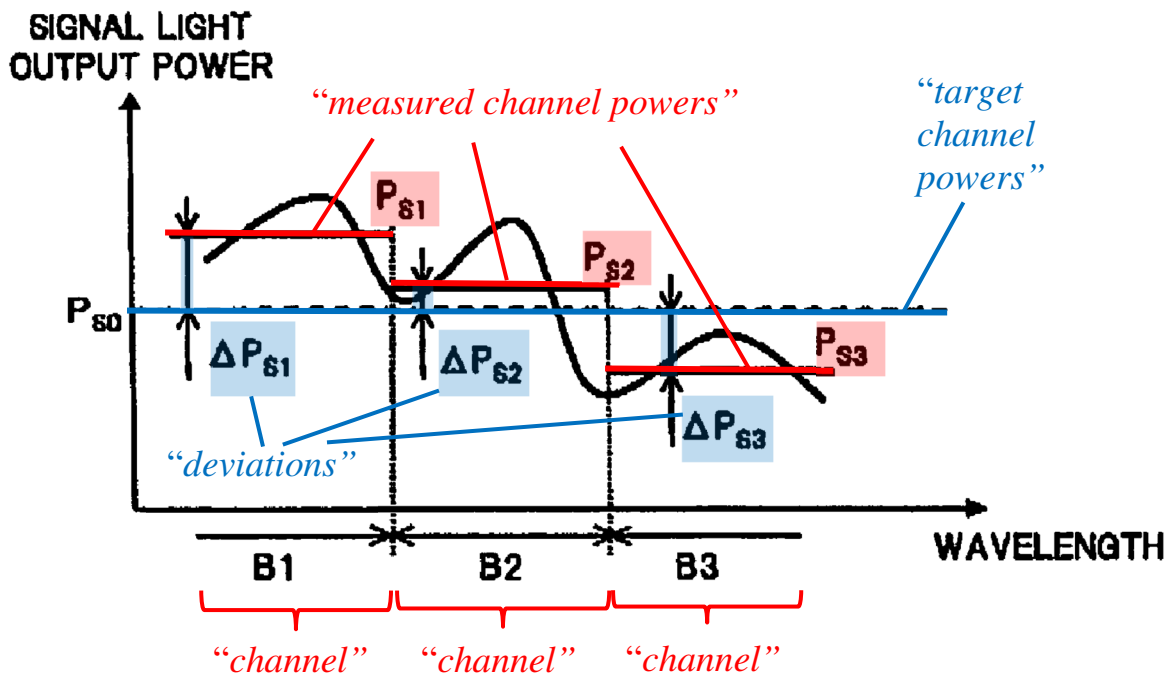
[1.1] receiving measured channel powers;

First, Sugaya’s method includes measuring the average signal power received at each wavelength block (“*channel*”). “In step 213, the pumping light sources 211-1 to 211-n are driven for each group corresponding to each wavelength block, **and the signal light average output power for each wavelength block is measured**.” Ex.1005, [0175]. “Here, the signal light average output powers ... are P_{S1} , P_{S2} and P_{S3} .” Ex.1005, [0175]. Because the measured average signal powers P_{S1} , P_{S2} , and P_{S3} correspond to different wavelength blocks, they are “*measured channel powers*” as claimed. Ex.1003, ¶83.

Second, the measured average signal powers P_{S1} , P_{S2} , and P_{S3} (“*measured channel powers*”) are measured by the light receiving elements 223-1, 223-2, and 223-3 respectively and are thus *received* by the pumping light power calculating circuitry 238. “The respective light receiving elements 223-1 to 223-n, which are connected with the respective output ports of the demultiplexer 224, each converts the monitor light L_m demultiplexed for each wavelength block by the demultiplexer 224 into an electric monitor signal, to output it.” Ex.1005, [0169]. “The monitor signal output from each of the respective light receiving elements

respective target channel powers;

First, Sugaya determines the difference between the measured signal powers and a target level P_{S0} . These differences (“*deviations*”) are expressed in Sugaya as ΔP_{S1} , ΔP_{S2} and ΔP_{S3} . The “differences between the signal light average output powers P_{S1} , P_{S2} and P_{S3} and the target power level P_{S0} are ΔP_{S1} , ΔP_{S2} and ΔP_{S3} .” Ex.1005, [0181]; *see also* Ex.1005 [0179] (“By this measurement, ... a relationship of the change amounts ΔP_{S1} , ΔP_{S2} and ΔP_{S3} of the signal light average output powers to the change amounts ΔP_{P1} , ΔP_{P2} and ΔP_{P3} of the pumping light powers, is obtained.”). Fig. 19 below illustrates the deviations (in blue) between the target channel powers and the measured channel powers (in red).



Ex.1005, Fig. 19 (annotated); Ex.1003, ¶87.

Thus, because Sugaya describes calculating the deviations ΔP_{S1} , ΔP_{S2} and ΔP_{S3} between the measured signal powers P_{S1} , P_{S2} and P_{S3} and a target power P_{S0} , Sugaya renders obvious “*determining deviations of respective measured channel powers from respective target channel powers*” as claimed. Ex.1003, ¶87-88.

[1.3] projecting the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed; and

Sugaya describes the same matrix multiplication technique described and claimed in the ’721 patent. Ex.1003, ¶89. The measured deviations (ΔP_{S1} , ΔP_{S2} and ΔP_{S3}) (“*deviations*”) are expressed in vector format and multiplied by (projected onto) the gain matrix B_{ij} representing the Raman pump profiles (“*space that defines Raman pump capabilities*”) to determine a set of pump power differences (ΔP_{P1} , ΔP_{P2} and ΔP_{P3}) (“*projected deviations*”). This matrix multiplication is illustrated in equation 2.12 below.

$$\begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} \quad (2.12)$$

“*projected deviations*”
“*space that defines Raman gain profiles*”
“*deviations*”

Ex.1005, Equation 2.12 (annotated); Ex.1008, ¶89.

First, the measured error vector (ΔP_{S1} , ΔP_{S2} and ΔP_{S3}) (in blue) represents “*deviations*” as claimed. As explained above at [1.2], Sugaya describes measuring the optical powers at each wavelength block (“*channel*”) and comparing them with a target power P_{S0} . Accordingly, the values ΔP_{S1} , ΔP_{S2} and ΔP_{S3} represent “*deviations*” from that target power level.

Second, the gain matrix B_{ij}^{-1} (in green) represents the inter-pump Raman effect of the system’s Raman pump wavelengths collectively on the set of channel wavelengths (“*space that defines Raman gain profiles achievable with a set of channels and pump lasers*”). This gain matrix B_{ij}^{-1} represents the relationship between a change in light provided by the Raman pumps (ΔP_{P1} , ΔP_{P2} and ΔP_{P3}) and deviations from the target power (ΔP_{S1} , ΔP_{S2} and ΔP_{S3}). Ex.1003, ¶91.

Sugaya describes the manner in which the gain matrix B_{ij}^{-1} is obtained. First, Sugaya obtains the (non-inverted) B_{ij} matrix. To obtain the B_{ij} matrix, “the pumping light powers P_{P1} , P_{P2} and P_{P3} of the respective wavelength blocks are obtained in accordance with (2.10) formula shown in the above, to supply the pumping light corresponding to all of the wavelength blocks in the power setting described above.” Ex.1005, [0179]. “Then, the power of the pumping light corresponding to all of the wavelength blocks is changed by 10 mW, for example, and a change amount of the signal light average output power relative to the change amount of the pumping light power, is measured.” Ex.1005, [0179]. “By

this measurement, a proportional coefficient **B_{ij} (i, j=1, 2, 3)** expressing **a relationship of the change amounts ΔP_{S1} , ΔP_{S2} and ΔP_{S3} of the signal light average output powers to the change amounts ΔP_{P1} , ΔP_{P2} and ΔP_{P3} of the pumping light powers, is obtained.**” Ex.1005, [0179].

The matrix B_{ij}^{-1} represents the gains that are “*achievable*” using a specific set of Raman pumps on a specific set of channels (“*gain profiles achievable with a set of channels and pump lasers*”). These gains are known to be achievable because they are obtained by applying power levels to the specific set of Raman pumps and measuring the specific set of channel output powers. In other words, Sugaya obtains the matrix B_{ij}^{-1} by measuring the changes in deviations with respect to changes in Raman pump powers. First, Sugaya uses the measurements to create matrix B_{ij} . This results in “a proportional coefficient B_{ij} (i, j=1, 2, 3) expressing a relationship of the change amounts ΔP_{S1} , ΔP_{S2} and ΔP_{S3} of the signal light average output powers to the change amounts ΔP_{P1} , ΔP_{P2} and ΔP_{P3} of the pumping light powers.” This relationship is shown in equation 2.11 below.

$$\begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix} \begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} \quad (2.11)$$

Ex.1005, Equation 2.11.

Thus, the matrix B_{ij} provides a prediction of how much deviation between

the output powers and a target level will occur at different pump powers. The inverse of matrix B_{ij} (which is B_{ij}^{-1}) allows one to predict the reverse—how much change in the Raman pump powers is needed to achieve a desired change in the output powers. See Ex.1005, [0180]. Doing so allows one to determine how to control the Raman pump powers to achieve the desired minimal deviations across the different channels. “In step 216, an inverse matrix of a matrix composed of the proportional coefficient B_{ij} obtained in step 215, is calculated, to lead out a relational expression considering the inter-pump Raman effect as shown in (2.12) formula.” Ex.1005, [0180].

$$\begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} \quad (2.12)$$

“projected deviations”
“space that defines Raman gain profiles”
“deviations”

Ex.1005, Equation 2.12 (annotated); Ex.1003, ¶93.

Accordingly, Sugaya’s matrix B_{ij}^{-1} represents the capabilities of the Raman pumps across multiple channels, considering the inter-pump Raman effect. In other words, matrix B_{ij}^{-1} represents “a space that defines Raman gain profiles achievable with a set of channels and pump lasers.” A POSITA would have understood that

this matrix multiplication technique is not limited to case where the number of measurements is equal to the number of Raman pumps. *See e.g.*, Ex.1012, 9:8-11 (“It shall be appreciated that the differential gain matrix, δ_{ji} is not typically a square matrix, since the number of emitters 59-i does not necessarily equal the number of signal wavelengths.”); Ex.1003, ¶94. It was known for Raman pump systems to support “typically over 100 channels.” Ex.1003, ¶31. It was also known for Raman pump systems to use fewer pumps than there are signal channels. *See e.g.*, Ex.1005, Fig. 6; Ex.1003, ¶¶36-37. Accordingly, when the number of measured wavelength blocks is greater than the number of Raman pumps, then the matrix multiplication technique will result in a smaller vector than the measured error vector. Ex.1003, ¶94.

A POSITA would have understood that a matrix is a “*space*” in mathematical terms because the term space refers to an ordered set of data. *See* Technical Dictionary, 1873; Ex.1003, ¶95.

Third, the result vector (in purple) of Sugaya’s matrix multiplication technique (ΔP_{P1} , ΔP_{P2} and ΔP_{P3}) represents “*projected deviations*” as claimed. Because the values ΔP_{P1} , ΔP_{P2} and ΔP_{P3} result from the matrix multiplication (i.e., projection), they are “***projected*** *deviations*” as claimed. Additionally, because they represent changes in the Raman pump powers, they are “*projected **deviations***” as claimed. Ex.1003, ¶96.

The claimed step of “*projecting*” the deviations onto the space that defines Raman gain profiles refers to the matrix multiplication operation described in Sugaya. Ex.1003, ¶ 97. Indeed, the ’721 describes this projecting step as a matrix multiplication operation. “The projection is enabled by expressing the basic Raman physics as a matrix vector multiplication through a manipulation and integration of the basic Raman equations. Within this formulation, the matrix defines the space of possible Raman gain profiles achievable given a set of channels and pump lasers.” Ex.1001, 3:16-22.

Accordingly, Sugaya describes the same matrix multiplication technique described and claimed in the ’721 patent. A measured error vector (ΔP_{S1} , ΔP_{S2} and ΔP_{S3}) (“*deviations*”) is multiplied by (projected onto) the gain matrix B_{ij}^{-1} representing the Raman pump profiles (“*space that defines Raman pump capabilities*”) to determine a set of pump power differences (ΔP_{P1} , ΔP_{P2} and ΔP_{P3}) (“*projected deviations*”).

$$\begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} \quad (2.12)$$

“*projected deviations*”
“*space that defines Raman gain profiles*”
“*deviations*”

Ex.1005, Fig. 17 (annotated); Ex.1003, ¶98.

Thus, because Sugaya describes a multiplication technique that projects the measured pump power deviations from a target power onto a gain matrix that defines the capabilities of the Raman pumps, Sugaya renders obvious “*projecting the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed*” as claimed. Ex.1003, ¶¶89-99.

[1.4] determining power setting values for the pump lasers based on the projected deviations.

First, as described above at [1.3], Sugaya performs a matrix multiplication technique to determine the adjustments in the pump powers that are needed to cause the measured powers to be closer to target values. These adjustments are defined as (ΔP_{P1} , ΔP_{P2} and ΔP_{P3}). These values are the “*projected deviations*” as claimed. Ex.1003, ¶100.

Second, Sugaya describes using these values (“*projected deviations*”) to change the Raman pump settings. Indeed, the purpose of the method described in Fig. 18 is to determine the power setting values for the Raman pumps. “Here, **a specific setting method of the pumping light power will be described** referring to a flowchart of FIG. 18.” Ex.1005, [0172]. “By performing the series of processing shown in step 211 to step 217, based on the measurement result using the optical transmission path 202 to be actually used, the setting values of the

pumping light powers for obtaining the output signal light L_S having the desired wavelength characteristic are obtained.” Ex.1005, [0183]. In other words, the pump settings are adjusted based on the calculated changes (ΔP_{P1} , ΔP_{P2} and ΔP_{P3}). Ex.1003, ¶101. Accordingly, the new, adjusted pump settings are “*based on the projected deviations*” as claimed.

Thus, because Sugaya uses the result of the matrix multiplication technique to determine the power settings for the Raman pumps, Sugaya renders obvious “*determining power setting values for the pump lasers based on the projected deviations*” as claimed. Ex.1003, ¶¶100-02.

3. Claim 2

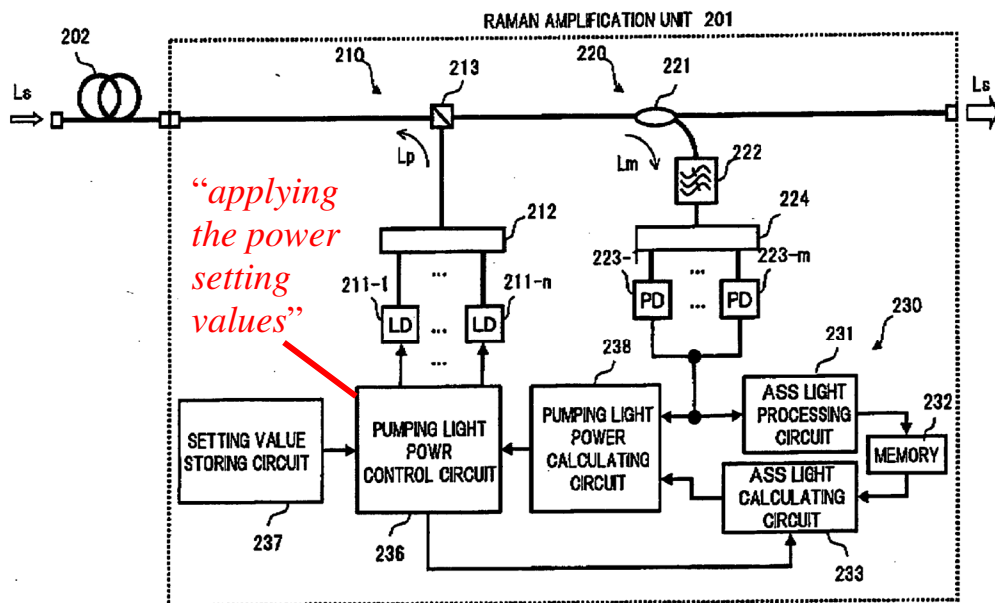
[2.1] *The method of claim 1 further comprising: applying the power setting values determined to the pump lasers.*

First, as explained above at [1.4], Sugaya’s technique describes determining the power settings for the Raman pumps.

Second, Sugaya explicitly describes using the determined settings. “Further, it is also possible that the calculation processing of the setting values of the pumping light powers is executed after starting the operation, and then the wavelength characteristic of the output signal light L_S is controlled sequentially.” Ex.1005, [0183]. “Thus, it becomes possible to execute reliably the control of the wavelength characteristic of the output signal light L_S with excellent accuracy.”

Ex.1005, [0183].

For example, Sugaya's control section 230 includes "a pumping light power control circuit 236 and a setting value storing circuit 237." Ex.1005, [0132]. "The pumping light power control circuit 236 is for adjusting drive conditions of the respective pumping light sources 211-1 to 211-n to control the power of the pumping light L_p to be supplied to the optical transmission path 202." Ex.1005, [0134]. Accordingly, the pumping light power control circuit 236 is "*applying the power setting values*" received from the pumping light power calculating circuit to the Raman pumps as illustrated in Fig. 17 below.



Ex.1005, Fig. 17 (annotated); Ex.1003, ¶103.

Thus, because Sugaya describes executing control of the output signals using the calculated Raman power settings, Sugaya renders obvious "*applying the power*

setting values determined to the pump lasers” as claimed. Ex.1003, ¶¶102-04.

4. Claim 4

[4.1] The method of claim 1 further comprising: compensating the deviations for fiber propagation loss.

Sugaya’s technique takes into account the power loss from the optical transmission path. The process of obtaining the gain matrix B_{ij} includes measuring the fiber loss. “In step 212, ... average losses L1, L2 and L3 in the optical transmission path 202 corresponding to the respective wave length blocks are calculated.” Ex.1005, [0174]. The measured signal powers (P_{S1} , P_{S2} , P_{S3}) factor in these losses, as shown in the equation below. Ex.1005, [0175].

$$\begin{bmatrix} P_{S1} \\ P_{S2} \\ P_{S3} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \begin{bmatrix} P_{P1} \\ P_{P2} \\ P_{P3} \end{bmatrix} + \begin{bmatrix} L_1 \\ L_2 \\ L_3 \end{bmatrix} \quad (2.9)$$

“fiber propagation losses”

Ex.1005, Equation 2.9; Ex.1003, ¶106.

Accordingly, Sugaya’s measured signal powers P_{S1} , P_{S2} , and P_{S3} take into account the fiber propagation loss. Because the measured error vector (“deviations”) represent the differences between the target values and the measured values (which consider the fiber propagation loss), Sugaya is “*compensating the deviations for fiber propagation loss*” as claimed. Ex.1003, ¶107

Thus, because Sugaya’s measurement of the optical signal powers considers

the losses in the fiber optic transmission lines, Sugaya renders obvious

“compensating the deviations for fiber propagation loss” as claimed. Ex.1003,

¶¶105-08.

5. Claim 6

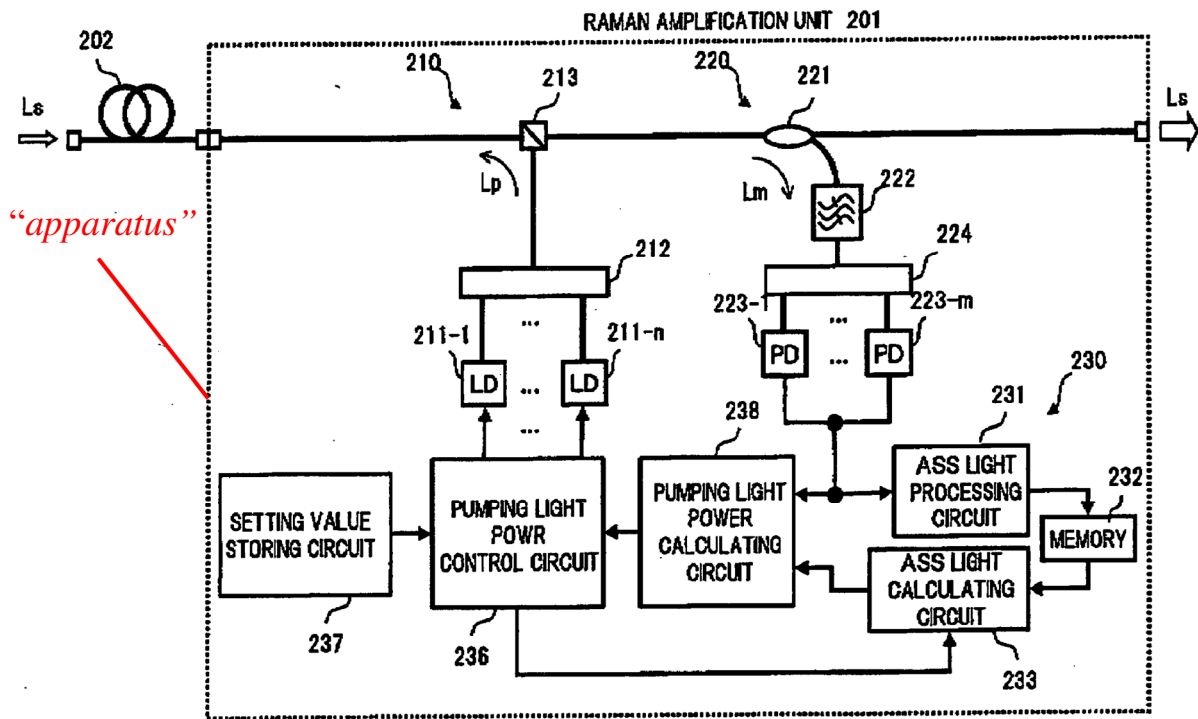
[6.1] *The method of claim 1 further comprising: measuring channel power for a plurality of channels.*

As explained above at [1.1] and [1.2], Sugaya describes measuring channel powers for a plurality of wavelength blocks. Accordingly, Sugaya renders obvious *“measuring channel power for a plurality of channels”* as claimed. Ex.1003, ¶109.

6. Claim 19

[19.0] *An apparatus comprising:*

As explained above at [1.0], Sugaya describes a Raman amplification unit 201 (*“apparatus”*).

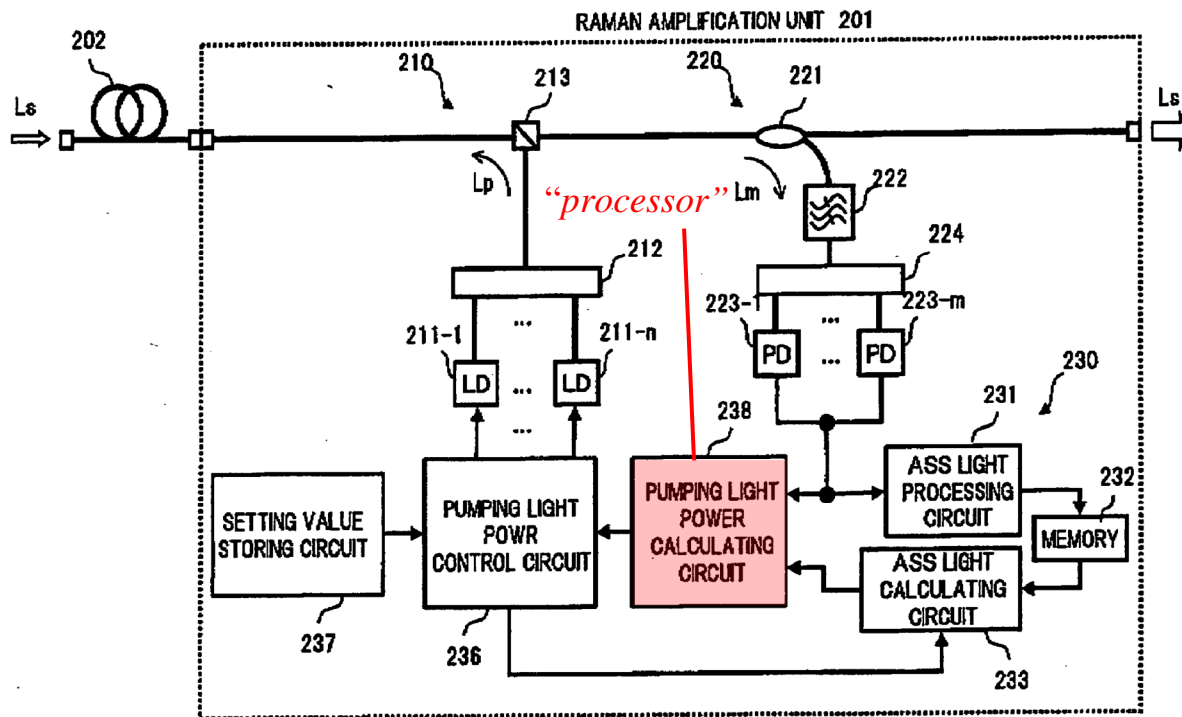


Ex.1005, Fig. 17 (annotated); Ex.1003, ¶110.

Thus, Sugaya's Raman amplification unit 201 teaches "*an apparatus*" as claimed. Ex.1003, ¶¶110-11.

[19.1] a processor configured to receive measured channel powers and,

First, as explained above at [1.1], Sugaya's Raman amplification unit 201 includes pumping light power calculating circuitry 238 ("*a processor*").



Ex.1005, Fig. 17 (annotated); Ex.1003, ¶112.

Second, for the reasons explained above at [1.1], Sugaya’s pumping light power calculating circuit 238 receives measured channel powers.

Thus, because Sugaya describes a pumping light power calculating circuit 238 that receives measured channel powers, Sugaya renders obvious “a processor configured to receive measured channel powers” as claimed. Ex.1003, ¶¶113-14.

[19.2] to determine deviations of respective measured channel powers from respective target channel powers,

First, for the reasons explained above at [1.2], Sugaya teaches “determine deviations of respective measured channel powers from respective target channel powers” as claimed. Ex.1003, ¶115.

Second, Sugaya's determining of the deviations is part of the process for determining power pump settings. *See* Ex.1005, Fig. 18, [0172]-[0183]. Sugaya also explains that calculating the power pump settings is performed by a light power calculating circuit 238 ("processor"): "The pumping light power calculating circuit 238 receives the monitor signal corresponding to each wavelength block ... and based on these signals, calculates the setting value of the pumping light power capable of achieving the output signal light LS having the desired wavelength characteristic." Ex.1005, [0170].

Thus, Sugaya's light power calculating circuit 238 "*determine[s] deviations of respective measured channel powers from respective target channel powers*" as claimed. Ex.1003, ¶¶115-17.

[19.3] wherein the processor is further configured to project the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed, and

First, for the reasons explained above at [1.3], Sugaya teaches "*project the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed*" as claimed. Ex.1003, ¶118.

Second, Sugaya's matrix multiplication technique is part of the process for determining power pump settings. *See* Ex.1005, Fig. 18, [0172]-[0183]. Sugaya also explains that calculating the power pump settings is performed by a light

power calculating circuit 238 (“processor”): “The pumping light power calculating circuit 238 receives the monitor signal corresponding to each wavelength block ... and based on these signals, calculates the setting value of the pumping light power capable of achieving the output signal light LS having the desired wavelength characteristic.” Ex.1005, [0170].

Thus, Sugaya’s pumping light power calculating circuit 238 is “*further configured to project the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed*” as claimed. Ex.1003, ¶¶118-20.

[19.4] wherein the processor is further configured to determine power setting values for the pump lasers based on the projected deviations.

First, for the reasons explained above at [1.4], Sugaya teaches “*determine power setting values for the pump lasers based on the projected deviations*” as claimed. Ex.1003, ¶¶124.

Second, Sugaya’s determining of pump setting adjustments is part of the process for determining power pump settings. *See* Ex.1005, Fig. 18, [0172]-[0183]. Sugaya also explains that calculating the power pump settings is performed by a light power calculating circuit 238 (“processor”): “The pumping light power calculating circuit 238 receives the monitor signal corresponding to each wavelength block ... and based on these signals, calculates the setting value of the

pumping light power capable of achieving the output signal light LS having the desired wavelength characteristic.” Ex.1005, [0170].

Thus, For the reasons explained above at [1.4], Sugaya’s pumping light power calculating circuit 238 is “*further configured to determine power setting values for the pump lasers based on the projected deviations*” as claimed. Ex.1003, ¶¶121-23.

7. Claim 21

[21.1] *The apparatus of claim 19 wherein the processor is configured to compensate the deviations for fiber propagation loss.*

For the reasons explained above at [4.1], Sugaya’s pumping light power calculating circuit 238 is “*configured to compensate the deviations for fiber propagation loss*” as claimed. Ex.1003, ¶124.

C. Ground 2: Claims 1, 2, 4, 6, 19, and 21 are rendered obvious by Sugaya in view of Farmer.

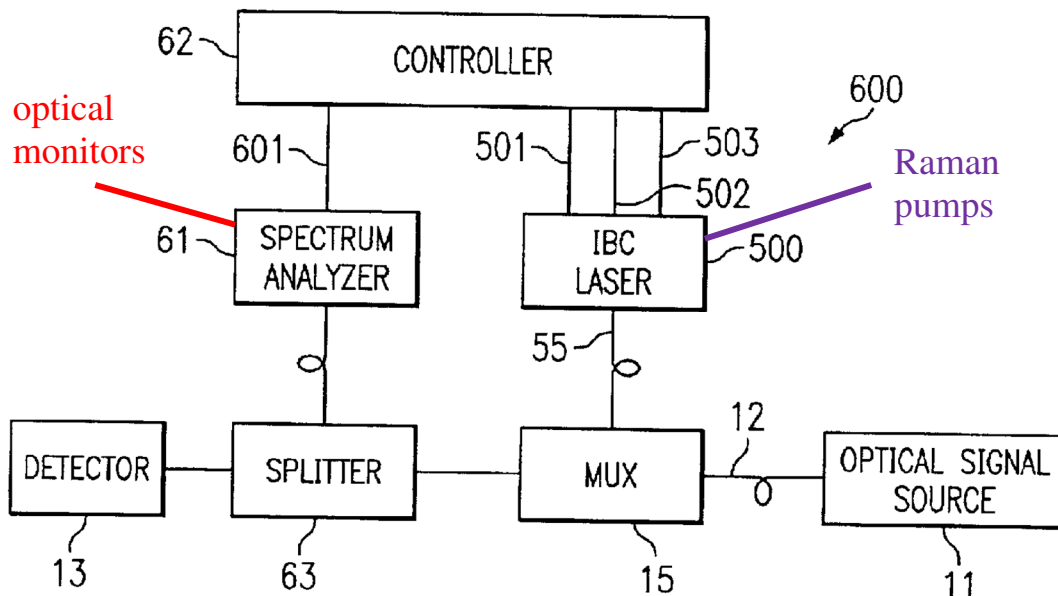
To the extent it is argued that Sugaya’s disclosure of wavelength blocks is insufficient to render obvious measuring the power of individual wavelengths, this idea is rendered obvious by the combination of Sugaya and Farmer. Farmer expressly teaches measuring individual signal wavelengths. *See* Ex.1012, 9:13-35; Ex.1003, ¶125.

1. Summary of Farmer.

Farmer also describes using a matrix multiplication technique to solve the

Raman pump optimization problem addressed in the Challenged Claims of the '721 patent. *Compare* Ex.1001 *with* Ex.1012; Ex.1003, ¶126. Like the '721 patent, Farmer “is directed to a system and method which provide a Raman pump which is spectrally tailored in response to feedback from control structure associated with the Raman pump source.” Ex.1012, abstract.

Farmer describes a conventional Raman pump system for pumping light power into a fiber optic medium. Ex.1012, Fig. 6, [0005]-[0007]. One example of a Raman pump system is shown in Fig. 6 below. As shown in Fig. 6, an optical system 600 includes an “IBC laser 500 which can be adapted to produce a tailored Raman pump spectrum.” Ex.1012, 5:25-26. The system 600 also includes a “Spectrum analyzer 61 [that] analyzes the spectral content of the amplified optical signal,” thus serving as an optical monitor. Ex.1012, 7:32-33; Ex.1003, ¶127.



Ex.1012, Fig. 6 (annotated); Ex.1003, ¶127.

The Raman pumps of the IBC laser are used to amplify the optical signals passing through the fiber. “IBC laser 500 is shown as incorporating emitter device 50. Emitter device 50 comprises a plurality of emitters 59-1 through 59-N.” Ex.1012, 5:27-29. “By controlling the wavelengths and output power of emitters 59-1 through 59-N, IBC laser 500 can be utilized to provide a dynamically spectrally tailored Raman pump.” Ex.1012, 6:56-59.

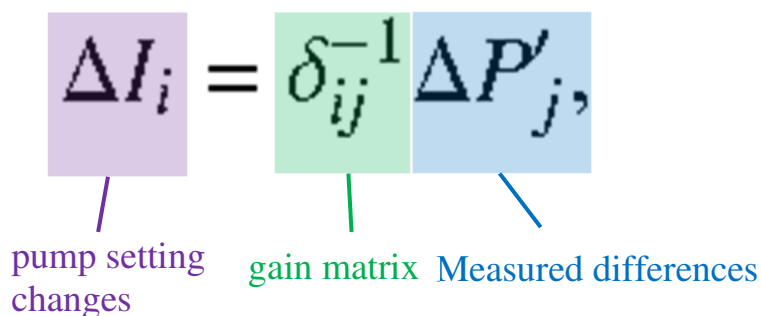
The optical system 61 also includes optical monitors in the form of the spectrum analyzer. *See* Ex.1012, 7:4-29. “Spectrum analyzer 61 analyzes the spectral content of the amplified optical signal.” Ex.1012, 7:21-22. “Utilizing the power information from cables 502 and 503 and the spectral information from cable 601, controller 62 varies the drive currents to emitters 59-1 through 59-N as

necessary to maintain Raman gain flatness.” Ex.1012, 7:24-27. Using the spectrum analyzer, the “processor 91 of controller 62 actuates changes in current supplied to emitters 59-1 through 59-N through cable 501 to measure accompanying changes in the power of signal wavelengths through input cable 601.” Ex.1012, 8:46-49.

Farmer also describes determining the difference between the measured signal power and a target power. “[T]he desired change in power for each signal wavelength is determined that will result in reasonably flat Raman gain. This can be determined by measuring the deviation of power of each signal wavelength from a desired power.” Ex.1012, 9:13-17.

The differences between the measured values and the target values are expressed as a vector: “The desired change in power for each signal wavelength is represented by $\Delta P'_j$.” Ex.1012, 9:19-20. This vector is then multiplied by a gain matrix to determine the pump setting changes that will minimize those differences. Ex.1012, 9:30-35. This matrix multiplication is shown below.

$$\Delta I_i = \delta_{ij}^{-1} \Delta P'_j,$$



pump setting changes gain matrix Measured differences

Ex.1012, 9:30-35 (annotated); Ex.1003, ¶131.

As Farmer explains, this matrix multiplication “provides the change in emitter currents that will result in the desired change in signal wavelength power.” Ex.1012, 36-37.

Accordingly, like Sugaya, Farmer shows that it was known to multiply an error vector (differences between measured and target powers) with a gain matrix that represents the effect of the Raman pumps to determine the Raman pump settings that will bring the actual power levels closer to a target power level. Ex.1003, ¶¶126-33.

2. Reasons to Combine Farmer with Sugaya

A POSITA would have found it obvious for Sugaya’s optimization technique to optimize at individual signal wavelengths as taught by Farmer. Ex.1003, ¶134

Sugaya describes a known technique in which the signal powers at discrete wavelength blocks are measured and compared to a target power: “The differences between the signal light average output powers P_{S1} , P_{S2} and P_{S3} and the target power level P_{S0} are ΔP_{S1} , ΔP_{S2} and ΔP_{S3} .” Ex.1005, [0181]. The deviations between the measured signal powers and the target power are then represented by a vector and multiplied by a gain matrix. *See* Ex.1005, Equation 2.12. By multiplying that vector with a gain matrix, the system determines the Raman pump settings that will flatten the spectrum (i.e., bring the signal powers closer to the

target power) can be determined. *See* Ex.1005, [0183]; Ex.1003, ¶135.

Farmer describes a similar technique in which the signal powers at specific “signal wavelengths” are measured. Farmer describes “measuring the deviation of power of each **signal wavelength** from a desired power.” Ex.1012, 9:13-17. The differences between the measured signal powers at each signal wavelength and a target power are then expressed as a vector. Ex.1012, 9:19-20. Like in Sugaya, Farmer’s vector is similarly multiplied by a gain matrix to determine the Raman pump settings that will flatten the signal powers. Ex.1012, 9:30-36; Ex.1003, ¶136.

Accordingly, to the extent Sugaya’s “wavelength blocks” do not correspond to signal wavelengths, it would have been obvious for Sugaya’s system to measure and optimize the powers at individual signal wavelengths as taught by Farmer. A POSITA would have found it beneficial to optimize at specific wavelengths as taught by Farmer. Ex.1003, ¶137. As Farmer explains, “embodiments of the present invention may monitor spectral information associated with signal wavelengths. When Raman gain associated with the signal wavelengths becomes uneven, suitable control algorithms can be employed to **equalize Raman gain across the signal wavelengths**.” Ex.1012, 11:13-18. Farmer’s technique further “allows reasonably flat Raman gain to be dynamically achieved across a broad spectrum of wavelengths.” Ex.1012, 19-25; Ex.1003, ¶137. Moreover, given the “nonlinear interaction between light and the [fiber optic] material,” a POSITA

would have found it beneficial to utilize a more “spectrally tailored Raman pump” such as the one described by Farmer. Ex.1012, 1:30, 2:52.

The proposed combination predictably results in determining the Raman pump settings at specific wavelengths. Ex.1003, ¶138. The results would have been predictable at least because Farmer uses the same matrix multiplication technique used by Sugaya. *Compare* Ex.1005, Equation 2.12 *with* Ex.1012, 9:30-36.

$$\begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} \quad (2.12)$$

pump setting changes gain matrix Measured differences

Ex.1005, Equation 2.12 (annotated); Ex.1003, ¶138.

$$\Delta I_i = \delta_{ij}^{-1} \Delta P'_j,$$

pump setting changes gain matrix Measured differences

Ex.1012, 9:30-35 (annotated); Ex.1003, ¶138.

A POSITA would have had a reasonable expectation of success because Farmer’s gain matrix is obtained in a manner similar to Sugaya’s. Ex.1003, ¶139. Sugaya explains that the gain matrix is obtained by measuring the signal powers at various frequency blocks at various pump powers to create a matrix. Ex.1005,

[0175]-[0179]. The inverse of that matrix is then used in the multiplication technique. Ex.1005, [0180], Equation, 2.12; *see also* [1.3], Ground 1; Ex.1003, ¶139.

Farmer similarly describes measuring the signal powers at various frequency blocks at various pump powers to create a matrix. Ex.1012, 8:53-9:12. Farmer explains that “the current to each emitter 59-i is individually varied by a small amount, ΔI_i . The resulting change in power, ΔP_j , for each signal wavelength is measured each time that current is varied for an individual emitter 59-i. The information gathered in this manner is used to generate the differential gain matrix, δ_{ji} .” Ex.1012, 8:67-9:4. Thus, the “differential gain matrix, δ_{ji} , provides the relationship between the change in signal wavelength power that results from any change in emitter currents.” Ex.1012, 9:6-8. Then, “[b]y finding the inverse of the differential gain matrix, δ_{ji} , the required change in emitter currents that results in the desired change in signal wavelength power can be determined.” Ex.1012, 9:24-27. Like Sugaya, Farmer uses the inverse matrix to determine the desired pump settings. *See* Ex.1005, [0180], Equation 2.12; Ex.1012, 9:30-36. Accordingly, a POSITA would have expected success in using Sugaya’s technique to optimize for individual signal wavelengths as taught by Farmer. Ex.1003, ¶140.

Accordingly, the combination of Sugaya and Farmer is merely applying a known technique (Farmer’s optimization at individual signal wavelengths) to a

known method (Sugaya's matrix multiplication optimization technique) ready for improvement to yield predictable results (optimizing the pump settings to achieve a flattened gain across signal wavelengths). Ex.1003, ¶¶134-40.

3. Claim 1

[1.0] *A method comprising:*

See [1.0], Ground 1. Ex.1003, ¶142

In addition, Farmer similarly describes a “*method*” that “provide[s] a Raman pump which is dynamically spectrally tailored in response to feedback from pump which is dynamically spectrally tailored in response to feedback from control structure.” Ex.1012, abstract. “An error signal can be generated by measuring the power levels of the optical signal as the optical signal exits the amplifier. The power levels can be compared to a desired power level.” Ex.1012, abstract. “By employing suitable control algorithms with this error signal, the desired gain can be maintained dynamically.” Ex.1012, abstract; Ex.1003, ¶143.

[1.1] *receiving measured channel powers;*

First, as explained above in [1.1], Ground 1, Sugaya's method includes measuring the average output power at varying wavelength blocks (“*channel[s]*”). “In step 213, the pumping light sources 211-1 to 211-n are driven for each group corresponding to each wavelength block, **and the signal light average output power for each wavelength block is measured.**” Ex.1005, [0175]. “Here, the signal light average output powers ... are P_{S1} , P_{S2} and P_{S3} .” Ex.1005, [0175].

Because the measured average signal powers P_{S1} , P_{S2} , and P_{S3} correspond to different wavelength blocks, they are “*measured channel powers*” as claimed. Ex.1003, ¶144.

Second, to the extent that it is argued that Sugaya’s wavelength blocks do not correspond to channels, it would have been obvious for Sugaya’s technique to be applied such that individual channels, or signal wavelengths, are measured and optimized, as evidenced by Farmer. Indeed, while Sugaya’s example uses three wavelength blocks, Sugaya explains that “the number of divided wavelength blocks is not limited to the above example.” Ex.1005, [0172]; Ex.1003, ¶145.

Farmer explains that “the desired change in power for each signal wavelength is determined that will result in reasonably flat Raman gain. This can be determined by measuring the deviation of power of each signal wavelength from a desired power.” Ex.1012, 9:13-17. These measurements can then be received by a controller. Ex.1012, 7:22-23 (“The spectral information is provided to controller 62 via cable 601”). Accordingly, it was known to take measurements at each individual signal wavelength (“*channel*”). Ex.1003, ¶146.

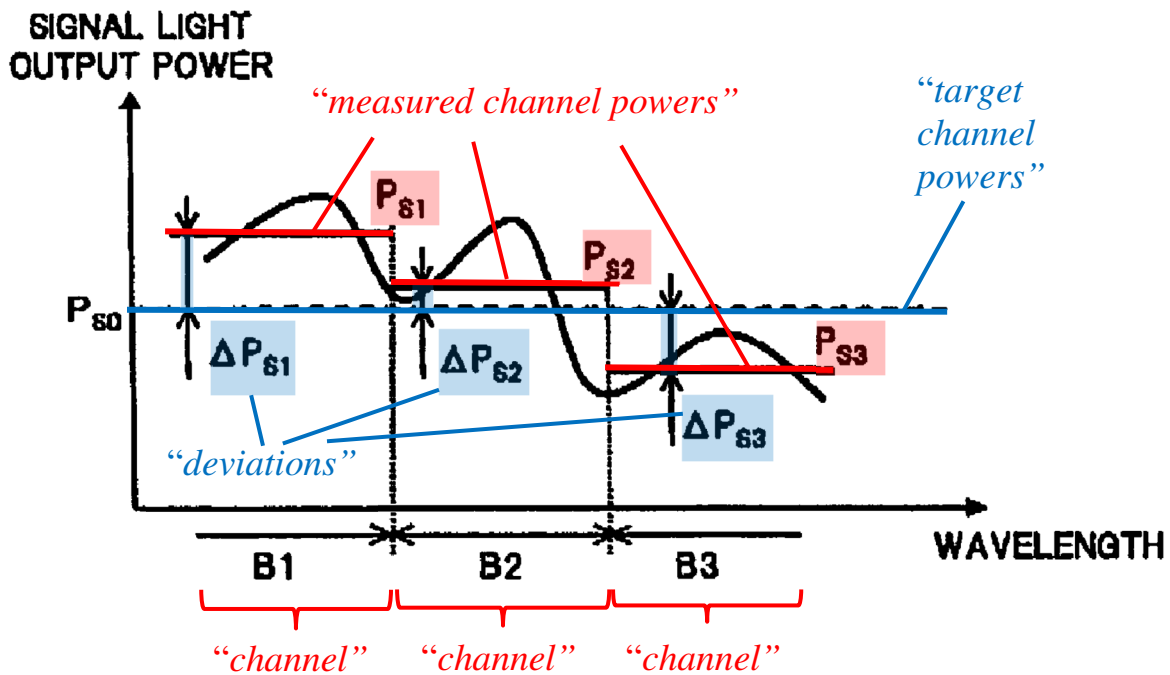
For the reasons explained above at X.C.2, a POSITA would have found it obvious for Sugaya’s technique to apply to individual signal wavelengths. Ex.1003, ¶147. Indeed, Farmer shows that it was known to either measure individual signal wavelengths, or subsets of signal wavelengths: “Additionally, it

shall be appreciated that the preceding matrix algorithm does not require measurement of every wavelength associated with communication channels over a given spectrum. Instead, wavelength power information can be gathered for a subset of wavelengths across the given spectrum.” Ex.1012, 10:11-16.

Thus, because Sugaya describes a pumping light power calculating unit that receives measured average output powers P_{S1} , P_{S2} , and P_{S3} for various wavelength blocks, and Farmer shows that it was known to measure at each individual signal wavelength, Sugaya and Farmer render obvious “*receiving measured channel powers*” as claimed. Ex.1003, ¶¶144-49.

[1.2] *determining deviations of respective measured channel powers from respective target channel powers;*

First, as explained above at [1.2], Ground 1, Sugaya determines the difference between the measured powers and a target level P_{S0} . These differences (“*deviations*”) are expressed in Sugaya as ΔP_{S1} , ΔP_{S2} and ΔP_{S3} . The “differences between the signal light average output powers P_{S1} , P_{S2} and P_{S3} and the target power level P_{S0} are ΔP_{S1} , ΔP_{S2} and ΔP_{S3} .” Ex.1005, [0181]. Fig. 19 below illustrates the deviations (in blue) between the target channel powers and the measured channel powers (in red).



Ex.1005, Fig. 19 (annotated); Ex.1003, ¶150.

Second, Farmer describes a similar process for determining deviations from a target power at individual signal wavelengths (“channels”): “[T]he desired change in power for each signal wavelength is determined that will result in reasonably flat Raman gain. This can be determined by measuring the deviation of power of each signal wavelength from a desired power.” Ex.1012, 9:13-17.

Farmer describes representing the respective deviations for each signal wavelength in a vector: “The desired change in power for each signal wavelength is represented by ΔP_j ’. Obtaining reasonably flat Raman gain involves minimization of the vector norm.” Ex.1012, 9:17-20. Again, for the reasons explained above at X.C.2, a POSITA would have found it obvious for Sugaya’s technique to apply to

individual signal wavelengths. Ex.1003, ¶151. As such, Sugaya's wavelength blocks B1, B2, B3 shown in Fig. 19 would correspond to signal wavelengths.

Thus, because Sugaya describes calculating the deviations ΔP_{S1} , ΔP_{S2} and ΔP_{S3} between the measured values P_{S1} , P_{S2} and P_{S3} and a target level P_{S0} , and Farmer similarly describes measuring deviations at individual signal wavelengths, Sugaya and Farmer render obvious "*determining deviations of respective measured channel powers from respective target channel powers*" as claimed. Ex.1003, ¶¶150-52.

[1.3] *projecting the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed; and*

First, as explained at [1.3], Ground 1, Sugaya describes the same matrix multiplication technique described and claimed in the '721 patent. Ex.1003, ¶153. A measured error vector (ΔP_{S1} , ΔP_{S2} and ΔP_{S3}) ("*deviations*") is multiplied by (projected onto) the gain matrix B_{ij} representing the Raman pump profiles ("*space that defines Raman pump capabilities*") to determine a set of pump power differences (ΔP_{P1} , ΔP_{P2} and ΔP_{P3}) ("*projected deviations*"). This matrix multiplication is illustrated in equation 2.12 below.

$$\begin{bmatrix} \Delta P_{P1} \\ \Delta P_{P2} \\ \Delta P_{P3} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P_{S1} \\ \Delta P_{S2} \\ \Delta P_{S3} \end{bmatrix} \quad (2.12)$$

“projected deviations”
“space that defines Raman gain profiles”
“deviations”

Ex.1005. Equation 2.12 (annotated); Ex.1003. ¶153.

Farmer describes a similar matrix multiplication technique using individual signal wavelengths (“*set of channels*”). Ex.1003, ¶154. “By finding the inverse of the differential gain matrix, δ_{ji} , the required change in emitter currents that results in the desired change in signal wavelength power can be determined. The solution can be obtained by finding the generalized (or pseudo) inverse, δ_{ji}^{-1} .” Farmer’s matrix multiplication is shown below.

$$\Delta I_i = \delta_{ij}^{-1} \Delta P'_j,$$

pump setting changes
gain matrix
Measured differences

Ex.1012, 9:30-35 (annotated); Ex.1003, ¶154.

Again, a POSITA would have understood that this process is not limited to case where the number of measurements is equal to the number of Raman pumps.

See e.g., Ex.1012, 9:8-11 (“It shall be appreciated that the differential gain matrix, δ_{ji} is not typically a square matrix, since the number of emitters 59-i does not necessarily equal the number of signal wavelengths.”). It was known for Raman pump systems to support “typically over 100 channels.” Ex.1003, ¶31. It was also known for Raman pump systems to use fewer pumps than there are signal channels. See e.g., Ex.1005, Fig. 6; Ex.1003, ¶¶36-37. Accordingly, when the number of measured wavelength blocks is greater than the number of Raman pumps, then the matrix multiplication technique will result in a vector that is smaller than the measured error vector. Ex.1003, ¶155.

Thus, because Sugaya describes a multiplication technique that projects the measured pump power deviations from a target power onto a gain matrix that defines the capabilities of the Raman pumps, and Farmer describes a similar technique that optimizes for individual signal wavelengths, Sugaya and Farmer renders obvious “*projecting the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed*” as claimed. Ex.1003, ¶¶153-56.

[1.4] *determining power setting values for the pump lasers based on the projected deviations.*

First, as described above at [1.4], Ground 1, Sugaya describes using the result (“*projected deviations*”) of the matrix multiplication to change the Raman

pump settings. Indeed, the purpose of the method described in Fig. 18 is to determine the power setting values for the Raman pumps. “Here, **a specific setting method of the pumping light power will be described** referring to a flowchart of FIG. 18.” Ex.1005, [0172]. “By performing the series of processing shown in step 211 to step 217, based on the measurement result using the optical transmission path 202 to be actually used, the setting values of the pumping light powers for obtaining the output signal light L_s having the desired wavelength characteristic are obtained.” Ex.1005, [0183].

Farmer, which performs a similar technique using individual signal wavelengths, similarly describes using the results to determine the power settings. Ex.1003, ¶158. The results of Farmer’s matrix multiplication “provide[] the change in emitter currents that will result in the desired change in signal wavelength power.” Ex.1012, 9:36:37.

Thus, because Sugaya uses the result of the matrix multiplication technique to determine the power settings for the Raman pumps, Sugaya renders obvious “*determining power setting values for the pump lasers based on the projected deviations*” as claimed. Ex.1003, ¶¶157-59.

4. Claim 2

[2.1] *The method of claim 1 further comprising: applying the power setting values determined to the pump lasers.*

See [2.1], Ground 1. Ex.1003, ¶160.

5. Claim 4

[4.1] *The method of claim 1 further comprising: compensating the deviations for fiber propagation loss.*

See [4.1], Ground 1. Ex.1003, ¶161.

6. Claim 6

[6.1] *The method of claim 1 further comprising: measuring channel power for a plurality of channels.*

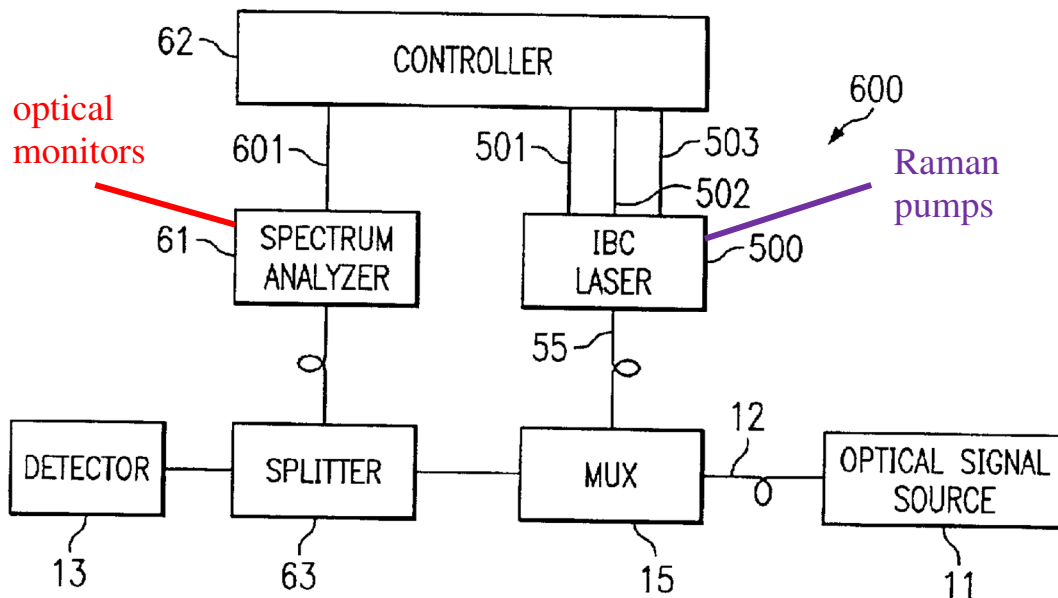
See [6.1], Ground 1. Ex.1003, ¶162.

7. Claim 19

[19.0] *An apparatus comprising:*

As explained above at [19.0] in Ground 1, Sugaya describes a Raman amplification unit 201 (“*apparatus*”). Ex.1003, ¶163.

In addition, Farmer describes a similar apparatus. Farmer describes a Raman pump system. As shown in Fig. 6, an optical system 600 includes an “IBC laser 500 which can be adapted to produce a tailored Raman pump spectrum.” Ex.1012, 5:25-26. The system 600 also includes a “Spectrum analyzer 61 [that] analyzes the spectral content of the amplified optical signal,” thus serving as an optical monitor. Ex.1012, 7:32-33; Ex.1003, ¶164.



Ex.1012, Fig. 6 (annotated); Ex.1003, ¶164.

[19.1] *a processor configured to receive measured channel powers and,*

See [19.1], Ground 1. Ex.1003, ¶165.

As explained above at [19.1], Ground 1, Sugaya’s Raman amplification unit 201 includes pumping light power calculating circuitry 238 (“*a processor*”). In addition, Farmer similarly describes a controller with a processor. The “processor 91 of controller 62 actuates changes in current supplied to emitters 59-1 through 59-N through cable 501 to **measure accompanying changes in the power of signal wavelengths** through input cable 601.” Ex.1012, 8:46-49. Thus, Farmer further renders obvious a “*processor*” as claimed.

For the reasons explained above at [1.1], Ground 1, a POSITA would have found it obvious for Sugaya’s system to receive measured powers at individual

signal wavelengths (“*receive measured channel powers*”) as taught by Farmer.

Ex.1003, ¶¶165-67.

[19.2] to determine deviations of respective measured channel powers from respective target channel powers,

See [19.2], Ground 1. Ex.1003, ¶168.

Additionally, for the reasons explained above at [1.2] Ground 2, it would have been obvious for Sugaya’s pumping light power calculating circuit 238 to determine deviations at individual signal wavelengths, as evidenced by Farmer.

Ex.1003, ¶169.

[19.3] wherein the processor is further configured to project the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed, and

For the reasons explained above at [1.3], Sugaya and Farmer render obvious “*wherein the processor is further configured to project the deviations into a space that defines Raman gain profiles achievable with a set of channels and pump lasers whereby projected deviations are formed*” as claimed. Ex.1003, ¶170.

[19.4] wherein the processor is further configured to determine power setting values for the pump lasers based on the projected deviations.

For the reasons explained above at [1.4], Sugaya and Farmer render obvious “*wherein the processor is further configured to determine power setting values for the pump lasers based on the projected deviations*” as claimed. Ex.1003, ¶171.

8. Claim 21

[21.1] *The apparatus of claim 19 wherein the processor is configured to compensate the deviations for fiber propagation loss.*

For the reasons explained above at [4.1], Ground 2 and [21.1], Ground 1, Sugaya’s pumping light power calculating circuit 238 is “*wherein the processor is further to compensate the deviations for fiber propagation loss*” as claimed.

Ex.1003, ¶172.

XI. CONCLUSION

Accordingly, Petitioner has established a reasonable likelihood that the Challenged Claims are unpatentable.

Respectfully submitted,

Dated: December 2, 2024
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XII. MANDATORY NOTICES

A. Real Party-in-Interest

Pursuant to 37 C.F.R. § 42.8(b)(1), Petitioner certifies that the real party-in-interest is Cisco Systems, Inc.

B. Related Matters

Pursuant to 37 C.F.R. § 42.8(b)(2), to the best knowledge of the Petitioner, the '721 patent is involved in the following cases:

Case Heading	Number	Court	Date
<i>WSOU Investments, LLC v. Cisco Systems, Inc.</i>	2-24-cv-00332	EDTX	May 6, 2024

C. Lead and Back-up Counsel and Service Information

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Please address all correspondence to lead and back-up counsel. Petitioner consents to service in this proceeding by email at the addresses above.

CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), Petitioner hereby certifies, in accordance with and in reliance on the word count provided by the word-processing system used to prepare this Petition, that the number of words in this paper is 11,199.

Pursuant to 37 C.F.R. § 42.24(d), this word count excludes the table of contents, table of authorities, mandatory notices under § 42.8, certificate of service, certificate of word count, appendix of exhibits, and any claim listing.

Dated: December 2, 2024

/Theodore M. Foster/

Theodore M. Foster
Lead Counsel for Petitioner
Registration No. 57,456

CERTIFICATE OF SERVICE

The undersigned certifies that, in accordance with 37 C.F.R. § 42.6(e) and 37 C.F.R. § 42.105, service was made on Patent Owner as detailed below.

Date of service December 2, 2024

Manner of service FEDERAL EXPRESS

Documents served Petition for *Inter Partes* Review Under 35 U.S.C. § 312 and 37 C.F.R. § 42.104 of U.S. 8,441,721; Petitioner's Exhibit List; All Exhibits; Petitioner's Power of Attorney.

Persons served Nokia of America Corporation
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