UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NKT PHOTONICS INC.
and NKT PHOTONICS A/S
Petitioners

v.

OMNI CONTINUUM LLC
Patent Owner

Case No. IPR2025-00839
Patent 7,433,116

DECLARATION OF SCOTT A. DIDDAMS IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,433,116

NKT EXHIBIT 1009
NKT v. Omni Continuum
IPR2025-00839

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A. Shaw (EX1004) 20

B. Islam (EX1005) 24

XI. CLAIMS 1-4, 9, 11-14, 16-25, AND 30-35 ARE ANTICIPATED BY SHAW (GROUND 1) 29

A. Claim 1 (Preamble): An infrared light source, comprising: 29

1. [1.1]: one or more combiners coupled to: 31

2. [1.2]: at least a first pump laser operable to generate a first pump signal and....33

3. [1.3]: a second pump laser operable to generate a second pump signal....34

4. [1.4]: the one or more combiners operable to combine the first pump signal and the second pump signal into a first optical signal, ...35

5. [1.5]: the first pump signal comprising at least a first wavelength and 37

6. [1.6]: the second pump signal comprising at least a second wavelength, ...38

7. [1.7]: wherein the first wavelength of the first pump signal is substantially different than the second wavelength of the second pump signal; and....38

8. [1.8]: a wavelength shifter coupled to the one or more combiners, the wavelength shifter comprising....41

9. [1.9]: a first waveguide structure....44

10. [1.10]: a second waveguide structure, ...45

11. [1.11]: the wavelength shifter operable to receive the first optical signal and 47

12. [1.12]: to wavelength shift at least a portion of the first optical signal based at least in part on a Raman effect,....48

13. [1.13]: wherein the wavelength shifter operates to wavelength shift at least the first wavelength to an intermediate optical wavelength in the first waveguide structure and....50

14. [1.14]: to wavelength shift the intermediate optical wavelength to a longer optical wavelength in the second waveguide structure; 51

15. [1.15]: wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength and 53

16. [1.16]: wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength; and 53

17. [1.17]: wherein the first waveguide structure is substantially different than the second waveguide structure. 54

B. Claim 2: The infrared light source of claim 1, wherein the first pump laser is selected from the group consisting of a continuous wave laser and a pulsed laser. 57

C. Claim 3: The infrared light source of claim 1, wherein the first pump laser is selected from the group consisting of a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a semiconductor laser, and a cladding pump fiber. 57

D. Claim 4: The infrared light source of claim 1, wherein the second pump laser is selected from the group consisting of a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a semiconductor laser, and a cladding pump fiber. 58

E. Claim 9: The infrared light source of claim 1, wherein the longer optical wavelength comprises a pulsed optical signal having a pulse repetition rate in the range of two (2) hertz to one hundred (100) megahertz. 58

F. Claim 11: The infrared light source of claim 1, wherein the longer optical wavelength comprises a pulsed optical signal having a pulse repetition rate in the range of two (2) hertz to one hundred (100) megahertz. 59

G. Claim 12: The infrared light source of claim 1, wherein the one or more combiners are selected from the group consisting of a wavelength division multiplexer and a power coupler. 60

H. Claim 13: The infrared light source of claim 1, wherein the first waveguide structure is selected from the group consisting of a dispersion compensating fiber, a dispersion shifted fiber, a single mode fiber, a chalcogenide fiber, and a fused silica optical fiber.....60

I. Claim 14: The infrared light source of claim 1, wherein at least a portion of the first waveguide structure is selected from the group consisting of an optical fiber, a hollow tube waveguide, an air core waveguide, and a planar waveguide.....61

J. Claim 16: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure is selected from the group consisting of an optical fiber, a hollow tube waveguide, an air core waveguide, and a planar waveguide.....61

K. Claim 17: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure comprises an optical fiber, wherein the optical fiber is selected from the group consisting of a mid-infrared optical fiber, a chalcogenide fiber and a ZBLAN fiber. 62

L. Claim 18: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure is an optical waveguide comprising a material selected from the group consisting of ZBLAN, sulfide, selenide, and telluride.....62

M. Claim 19: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength of approximately 1.7 microns or more. 63

N. Claim 20: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength in the range of two (2) microns to ten (10) microns. 64

O. Claim 21: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength in the range of five (5) microns to seven (7) microns. 64

P. Claim 22: The infrared light source of claim 1, further comprising a wavelength separator coupled to the wavelength shifter and capable of transmitting at least a portion of a selected wavelength from the wavelength shifter. 65

Q. Claim 23: The infrared light source of claim 22, wherein the wavelength separator is selected from the group consisting of a demultiplexer, one or more partially transmissive gratings, one or more partially transmitting mirrors, one or more Fabry Perot filters and one or more dielectric gratings.....68

R. Claim 24: The infrared light source of claim 1, further comprising at least a third waveguide structure coupled to the wavelength shifter, wherein a coupling loss between the third waveguide structure and the wavelength shifter comprises no more than five (5) decibels.....68

S. Claim 25: A method of shifting an optical wavelength to a longer optical wavelength, comprising. 69

1. [25.1]: combining a first pump signal generated by a first pump laser and a second pump signal generated by a second pump laser into a first optical signal, the first pump signal comprising at least a first wavelength and the second pump signal comprising at least a second wavelength, wherein the first wavelength of the first pump signal is substantially different than the second wavelength of the second pump signal;.....70

2. [25.2]: receiving the first optical signal at a wavelength shifter, the wavelength shifter comprising a first waveguide structure and a second waveguide structure, wherein the first waveguide structure is substantially different than the second waveguide structure; 70

3. [25.3]: shifting at least the first wavelength to an intermediate optical wavelength using the first waveguide structure based at least in part on a Raman effect.....70

4. [25.4]: shifting the intermediate optical wavelength to a longer optical wavelength using the second waveguide structure; and....70

5. [25.5]: wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength and wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength. 70

T. Claim 30: The method of claim 25, wherein the longer optical wavelength comprises a wavelength of approximately 1.7 microns or more....71

U. Claim 31: The method of claim 25, wherein the longer optical wavelength comprises a wavelength in the range of two (2) microns to ten (10) microns. 71

V. Claim 32: The method of claim 25, further comprising transmitting at least a portion of a selected wavelength from the wavelength shifter into a third waveguide structure. 71

W. Claim 33: The method of claim 25, wherein the first waveguide structure is selected from the group consisting of a dispersion compensating fiber, a dispersion shifted fiber, a single mode fiber, a chalcogenide fiber, and a fused silica optical fiber....71

X. Claim 34: The method of claim 25, wherein the second waveguide structure is selected from the group consisting of a chalcogenide fiber and a ZBLAN fiber....71

Y. Claim 35: The method of claim 25, wherein at least a portion of the second waveguide structure is an optical waveguide comprising a material selected from the group consisting of ZBLAN, sulfide, selenide, and telluride. 71

XII. CLAIMS 1-4, 9, 11-14, 16-25, AND 30-35 WOULD HAVE BEEN OBVIOUS IN VIEW OF SHAW (GROUND 2)....72

XIII. CLAIMS 1-4, 9, 11-14, 16-25, AND 30-35 WOULD HAVE BEEN OBVIOUS OVER SHAW IN VIEW OF ISLAM (GROUND 3) 73

A. Islam suggests and teaches "the one or more combiners operable to combine the first pump signal and the second pump signal into a first optical signal," as recited by Element [1.4] 75

B. Islam suggests and teaches "a second waveguide structure,… wherein the first waveguide structure is substantially different than the second waveguide structure." as recited by Elements [1.10],[1.17].....77

C. Islam suggests and teaches "a second waveguide structure,… wherein the first waveguide structure is substantially different than the second waveguide structure." as recited by Elements [1.10],[1.17].....80

D. Claims 2-4, 9, 11-14, 16-25, 30-35 84

XIV. OTHER CONSIDERATIONS 86

XV. CONCLUSION.....86

APPENDIX A – LIST OF EXHIBITS

EXHIBIT	DESCRIPTION
1001	U.S. Patent No. 7,433,116, issued on October 7, 2008
1002	File History of U.S. Patent Application No. 10/812,608, filed on March 30, 2004
1003	U.S. Provisional Application No. 60/408,025, filed November 18, 2005
1004	U.S. Patent Publication No. 2003/0012491 ("Shaw")
1005	U.S. Patent No. 6,239,903 ("Islam")
1006	Comparison of U.S. Provisional Application No. 60/408,025 disclosure with U.S. Patent No. 7,433,116 disclosure
1010	*Curriculum Vitae* of Dr. Scott Diddams
1013	P.A. Thielen, et al., "*Raman Amplification in As-Se Fiber*," Proceedings of SPIE Vol. 4628, p. 74, published in 2002
1014	Joint Claim Construction and Prehearing Statement (Docket No. 83) in *Omni Continuum LLC v. NKT Photonics Inc. et al.,* Civil Action No. 1:24-cv-11007-IT, U.S. District Court for the District of Massachusetts
1015	V.I. Karpov et al., "*Laser-diode-pumped phosphosilicate-fiber Raman laser with an output power of 1 W at 1.48 μm,*" Optics Letters, Vol. 24, No. 13, p. 887, published July 1, 1999

I, Scott A. Diddams, hereby state as follows:

I. INTRODUCTION

1. I have been retained by NKT Photonics Inc. and NKT Photonics A/S ("Petitioners") as an independent expert consultant in this *inter partes* review ("IPR") proceeding before the United States Patent and Trademark Office ("PTO").

2. I have been asked by Counsel for Petitioners ("Counsel") to consider whether certain references teach or suggest the features recited in Claims 1-4, 9, 11-14, 16-25, and 30-35 ("the Challenged Claims") of U.S. Patent No. 7,433,116 ("the '116 Patent") (EX1001). My opinions and the bases for my opinions are set forth below.

3. I am being compensated at my ordinary and customary consulting rate for my work, which is $600 per hour. My compensation is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other financial interest in this proceeding.

II. BACKGROUND AND QUALIFICATIONS

4. All my opinions stated in this declaration are based on my own personal knowledge and professional judgment. In forming my opinions, I have relied on my

knowledge and experience in designing, developing, researching, and teaching the technology referenced in this declaration.

5. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth herein. I understand that a copy of my current curriculum vitae, which details my education and professional and academic experience, is being submitted as EX1010. The following provides a brief overview of some of my experience that is relevant to the matters set forth in this declaration.

6. I am a professor in the Electrical, Computer and Energy Engineering and Physics Departments at the University of Colorado Boulder. I also serve as a Faculty Director in the Quantum Engineering Initiative and the Robert H. Davis Discovery Learning Endowed Chair in the College of Engineering and Applied Science at the University of Colorado Boulder. Prior to joining the University of Colorado, I was a Physicist, Group Leader, and Fellow of the National Institute of Standards and Technology (NIST) in Boulder Colorado. The position of NIST Fellow is the highest technical position at NIST, held by less than 1% of the scientific staff. Altogether, I have over thirty years of federal research, industry, and academic experience with lasers and optical systems.

7. I have extensive expertise in all aspects of laser and optical systems, such as laser physics, ultrafast and nonlinear optics, supercontinuum generation, fiber optics, precision laser spectroscopy, and nonlinear nano-photonics.

8. As examples of my experience in laser systems, I invented and developed the first carrier-envelope stabilized femtosecond laser system that included supercontinuum generation. This technology has revolutionized the measurement of optical frequencies, is key to the development of optical clocks, and was part of the 2005 Nobel Prize in Physics. Frequency-stabilized mode-locked lasers have also been crucial for the generation of isolated attosecond laser pulses. The first paper on the topic was denoted a "Milestone Letter" at the 50th anniversary of Physical Review Letters (PRL). It and a companion paper in Science and have been cited more than a combined 1,600 times.

9. I built the first femtosecond laser frequency comb technology and demonstrated the first optical clock based on a single Hg^{+} ion. The techniques described in Science and PRL have been cited over 1,500 times and have been adopted by all laboratories pursuing research into advanced optical clocks.

10. I demonstrated optical and microwave frequency synthesis with femtosecond laser frequency combs at the 1×10^{-19} level. Following four years of work, the key paper was published in Science. This paper proved that the frequency

comb was a perfect optical synthesizer and would not be a limitation in future optical clocks or spectroscopy. This research involved supercontinuum generation in nonlinear optical fibers. This paper has been cited over 400 times.

11. I developed and employed novel femtosecond lasers with sub-Hz linewidths to make measurements of absolute atomic frequencies and frequency ratios with 18+ digits of precision. These are now the most precise measurements of any physical quantities. This infrastructure is critical to the comparison of atomic standards for tests of the constancy of fundamental constants and local position invariance. Among many papers co-authored in this area, two of the key ones were published in PRL and Science and have more than 2,300 combined citations.

12. I established new approaches to broadband spectroscopy in which the femtosecond laser frequency comb is itself used as a probe for precision spectroscopy. I introduced a novel 2-dimensional diagnostic for rapid spectral fingerprinting and extended such techniques into the mid-infrared spectral region. The original paper in Nature has been cited over 800 times. Simple and robust broad bandwidth infrared frequency combs in the lab now rival the brightness and bandwidth of an infrared synchrotron beamline. These laser tools involve broad bandwidth spectral generation in nonlinear fibers and are being applied to infrared molecular spectroscopy and hyperspectral imaging.

13. I introduced the technique of optical frequency division and used optically-stabilized frequency combs to generate ultra-low noise microwave signals—possessing phase noise and timing jitter significantly lower than what is achievable with the best conventional electronic sources. Here, a key discovery was the limitations introduced by high-speed photodetection, as well as ways to circumvent and understand the quantum limitations. Key publications in Nature Photonics, Optics Letters and IEEE Photonics Journal have combined citations exceeding 1,000.

14. I introduced gigahertz repetition-rate laser combs that are now critical to the most precise astronomical spectroscopy. Technology platforms include 10-GHz solid state lasers, in addition to electro-optic combs and microresonator combs. This technology includes supercontinuum generation in nanophotonic waveguides and was employed at the Hobby-Eberly telescope where it yielded the first comb-calibrated stellar spectra. It has also been evaluated at the IRTF and Keck telescopes on Mauna Kea. Since 2018, a 30-GHz electro-optic frequency comb runs continuously at the McDonald Observatory. This frequency comb is used nightly for high-precision radial velocity exoplanet searches, and it has enabled more than 25 scientific discoveries by astronomer collaborators.

15. I was involved in the development and application of micro-resonator frequency combs, which enable frequency combs to be fabricated on a silicon chip. This work resulted in the first self-referenced microcomb and the application of these chip-scale devices to optical frequency synthesis, a microcomb optical clock, and chip-scale optical clocks. An early review paper in Science motivated development in the field and has received over 2,500 citations. This work is part of the NIST on a Chip Program and has motivated significant external research efforts across multiple funding agencies.

16. I have more than 305 Peer-reviewed papers, books and proceedings relating to laser systems, including papers in Science (14), Phys. Rev. Lett. (21), Phys. Rev. X (2), Nature (4), Nature Photonics (10), Nature Communications (5), and Optica (14). I have more than 183 invited talks and colloquia, 13 patents granted or submitted, and at least 269 contributed conference papers.

17. In 1989, I received a Bachelor of Art degree in Physics from Bethel College, St. Paul, Minnesota. I earned my Ph.D. in 1996 from the University of New Mexico, Albuquerque in the Department of Physics & Astronomy. My PhD research focused on intracavity phase spectroscopy with modelocked ring lasers, ultrashort pulse characterization, and dispersion measurements. I subsequently served as a Postdoc at JILA, which is a joint institute between the University of Colorado and

the National Institute of Standards and Technology. As a postdoc, I studied nonlinear pulse propagation and supercontinuum generation with ultrashort pulses as well as the development of optical frequency comb generators and their use in precision spectroscopy and optical clocks.

III. INFORMATION CONSIDERED

18. In preparing this declaration, I have reviewed the '116 Patent, its file history, and the exhibits and documents referenced herein. *E.g.*, EXs1001–08, and 1013–15. In addition, my opinions are further based on my education, training, experience, and knowledge in the relevant field.

IV. RELEVANT LEGAL STANDARDS

19. I am not an attorney and offer no legal opinions. For the purposes of this Declaration, I have been informed about certain aspects of the law that are relevant to my analysis, as summarized below.

A. Claim Interpretation

20. I have been informed that during an *inter partes* review proceeding, claims are to be construed in light of the specification as would be read by a person of ordinary skill in the relevant art at the time the application was filed. I have been informed that claim terms are given their ordinary and customary meaning as would be understood by a person of ordinary skill in the relevant art in the context of the entire disclosure. A claim term, however, will not receive its ordinary meaning if the

patentee acted as his own lexicographer and clearly set forth a definition of the claim term in the specification. In that case, the claim term will receive the definition set forth in the patent.

B. Perspective of One of Ordinary Skill in the Art

21. I have been informed that a patent is to be understood from the perspective of a hypothetical "person of ordinary skill in the art" ("POSITA"). Such an individual is considered to possess normal skills and knowledge in a particular technical field (as opposed to being a genius). I have been informed that in considering what the claims of a patent require, what was known prior to that patent, what a prior art reference discloses, and whether an invention is obvious or not, one must use the perspective of such a POSITA.

C. Anticipation

22. I have been informed that a claim is not patentable if it is anticipated. I have been informed that anticipation of a claim requires that every element of a claim is disclosed expressly or inherently in a prior art reference, arranged as in the claim, when considered from the perspective of a person of ordinary skill in the relevant art. I have been informed that when the structure recited in a reference is substantially identical to that of the claims, claimed properties or functions are presumed to be inherent. I have been informed that extrinsic evidence may be used

to explain but not expand the meaning of terms and phrases used in the reference relied upon as anticipatory of the claimed subject matter.

D. Obviousness

23. I have been informed that a patent claim is obvious under 35 U.S.C. §103, and therefore invalid, if the claimed subject matter, as a whole, would have been obvious to a POSITA as of the priority date of the patent based on one or more prior art references and/or the knowledge of a POSITA.

24. I have been informed that an obviousness analysis must consider (1) the scope and content of the prior art, (2) the differences between the claims and the prior art, (3) the level of ordinary skill in the pertinent art, and (4) secondary considerations, if any, of non-obviousness (such as unexpected results, commercial success, long- felt but unmet need, failure of others, copying by others, and skepticism of experts).

25. I have been informed that a prior art reference may be combined with other references to disclose each element of the invention under 35 U.S.C. §103. I have been informed that a reference may also be combined with the knowledge of a POSITA, and that this knowledge may be used to combine multiple references. I have been informed that a POSITA is presumed to know the relevant prior art. I have

been informed that the obviousness analysis may take into account the inferences and creative steps that a POSITA would employ.

26. In determining whether a prior art reference would have been combined with other prior art or other information known to a POSITA, I have been informed that the following principles may be considered:

- whether the references to be combined involve non-analogous art;
- whether the references to be combined are in different fields of endeavor than the alleged invention in the patent;
- whether the references to be combined are reasonably pertinent to the problems to which the inventions of the patent are directed;
- whether the combination is of familiar elements according to known methods that yields predictable results;
- whether a combination involves the substitution of one known element for another that yields predictable results;
- whether the combination involves the use of a known technique to improve similar items or methods in the same way that yields predictable results;

- whether the combination involves the application of a known technique to a prior art reference that is ready for improvement, to yield predictable results;
- whether the combination is "obvious to try";
- whether the combination involves the known work in one field of endeavor prompting variations of it for use in either the same field or a different one based on design incentives or other market forces, where the variations are predictable to a POSITA;
- whether there is some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention;
- whether the combination requires modifications that render the prior art unsatisfactory for its intended use;
- whether the combination requires modifications that change the principle of operation of the reference;
- whether the combination is reasonably expected to be a success; and

- whether the combination possesses the requisite degree of predictability at the time the invention was made.

27. I have been informed that in determining whether a combination of prior art references renders a claim obvious, it is helpful to consider whether there is some teaching, suggestion, or motivation to combine the references and a reasonable expectation of success in doing so. I have been informed, however, that a teaching, suggestion, or motivation to combine is not required.

V. SUMMARY OF OPINIONS

28. It is my opinion that Claims 1-4, 9, 11-14, 16-25, and 30-35 of the '116 Patent are unpatentable under 35 U.S.C. §§102/103 on the following grounds:

Ground	References	Basis	Claims Challenged
1	U.S. Publication 2003/0012491 ("Shaw") (EX1004)	§102(e)	1-4, 9, 11-14, 16-25, 30-35
2	Shaw (EX1004)	§103(a)	1-4, 9, 11-14, 16-25, 30-35
3	Shaw (EX1004) and U.S. Patent 6,239,903 ("Islam") (EX1005)	§103(a)	1-4, 9, 11-14, 16-25, 30-35

VI. THE CHALLENGED '116 PATENT

29. The '116 Patent contains 45 claims. I have been asked to opine on the validity of Claims 1-4, 9, 11-14, 16-25, and 30-35.

VII. LEVEL OF ORDINARY SKILL IN THE ART

30. I have been informed that POSITA is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

31. I believe that a POSITA would have at least a Ph.D. in electrical engineering, optical engineering, or physics (or equivalent course work) and three to four years of work experience in the areas of fiber optics and Raman scattering.

VIII. TECHNICAL BACKGROUND

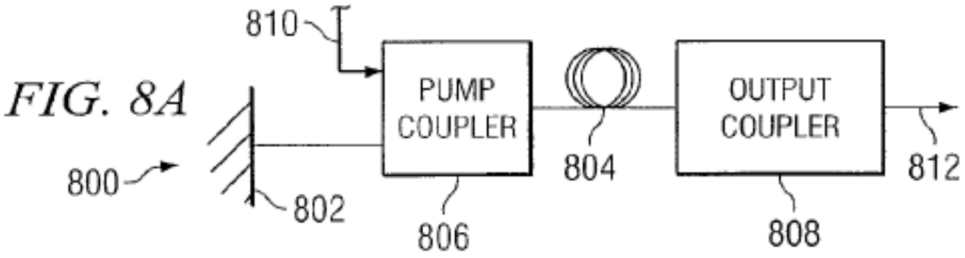
A. The ’116 Patent

32. I have reviewed the ’116 Patent, the provisional patent application to which the ’116 Patent claims priority, and the file history of the ’116 Patent. EXs1001-03.

33. The ’116 Patent purports to provide an infrared light source capable of wavelength shifting at least a portion of an optical signal based in part on a Raman effect. EX1001, Abstract. It purports that the infrared light source can be included with a medical device that facilitates detection/removal of cancerous cells by using an optical signal in the infrared wavelength range. EX1001, 14:35-64. It purports to wavelength shift an optical signal to prevent or reduce damage to tissue during a surgical procedure. EX1001, 14:65-15:53.

34. FIGS. 8-9 of the '116 Patent and the corresponding description in Columns 16-20 of the specification purportedly describe embodiments of the claimed invention.

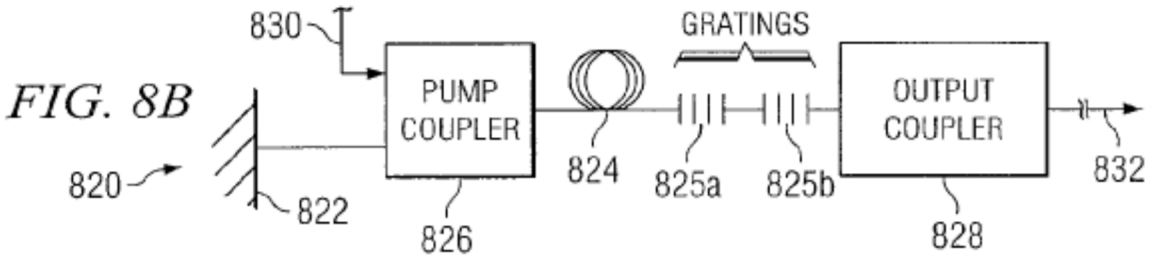
35. In the embodiment shown in FIG. 8A, a pump signal (810) is coupled (or combined) via coupler 806 into a cavity (bounded by reflector 802 and wavelength separator/output coupler 808) that contains gain fiber 804. EX1001, 17:18-49. Wavelength separator 808 partially reflects the wavelength-shifted light (812) to maintain lasing in the cavity. EX1001, 17:37-49. Gain fiber 804 shifts the incoming light from pump signal 810 via the Raman effect as this shifted light 812 bounces back and forth between reflector 802 and wavelength separator 808. EX1001, 15:1-6, 17:18-27.



36. Using the nomenclature of the claims, embodiment 800 is a Raman wavelength shifter (or just wavelength shifter) because it is the device coupled to pump laser 810 to shift the shorter pump wavelength to a longer infrared wavelength.

EX1001, 14:65-15:6. Gain fiber 804 is a waveguide structure because it is an optical fiber. EX1001, Abstract, 14:38-41,17:20-22.

37. FIGS. 8B-8D describe variations on this embodiment. FIG. 8B describes another cavity configuration with additional selecting elements 825a and 825b (*e.g.*, gratings or Fabry-Perot filters) that preferentially transmit only a portion of a desired wavelength to be outputted from the device. EX1001, 18:5-20.



38. FIGS. 8C and 8D describe configurations in which the selecting elements (845, 847, 865, 867) act as reflectors at certain wavelengths to form separate cavities to allow multiple wavelength shiftings to occur in gain fibers 844 and 864. EX1001, 18:21-19:39. Each pair of selecting elements (*e.g.*, 845a and 847a) forms a separate cavity that will shift the wavelength of the incoming pump laser by successive amounts. EX1001, 18:45-59. In this way, a cascade occurs that allows the incoming pump laser light to be successively shifted to even longer wavelengths. EX1001, 18:45-59.

FIG. 8C

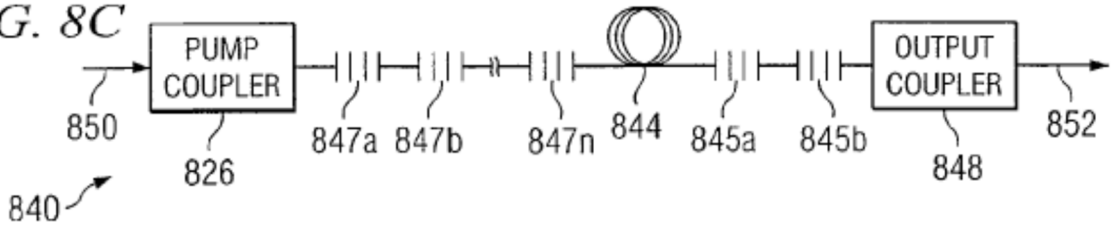
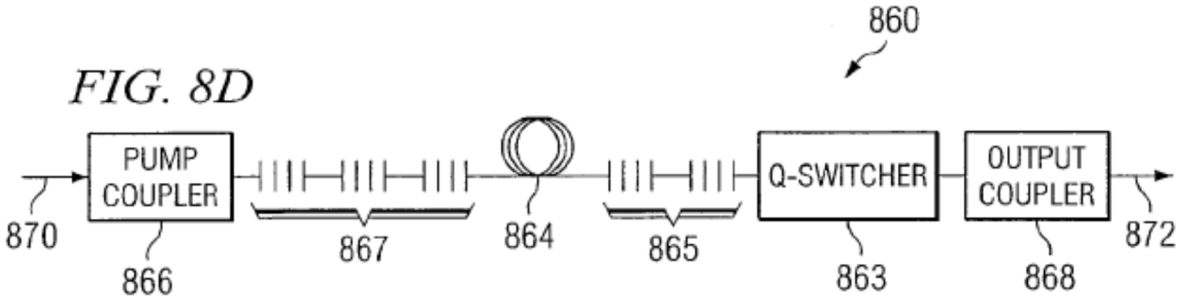


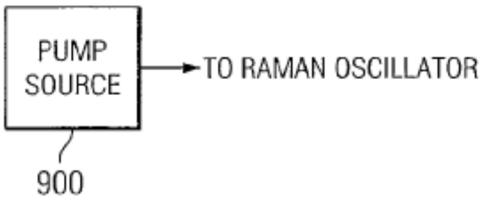
FIG. 8D



39. FIGS. 9A-9C describe embodiments of the pump sources (810, 830, 850, 870) that can be used with the configurations described in FIGS. 8A-8D. EX1001, 19:40-43.

40. The simplest, FIG. 9A, describes a single pump source 900 (such as a solid-state laser, laser diode, or fiber laser) that can produce an optical signal at a desired wavelength and power. EX1001, 19:47-59.

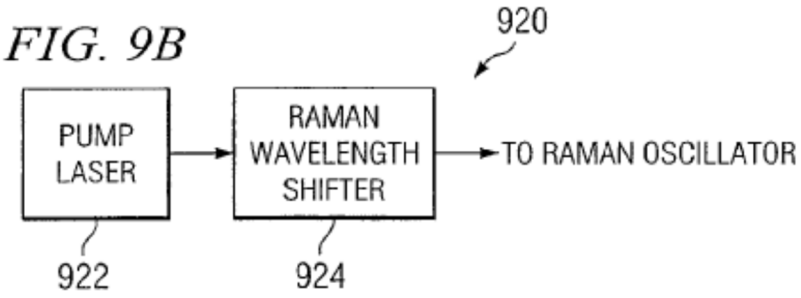
FIG. 9A



41. The "Raman oscillator" shown in these figures can be the Raman wavelength shifters 800, 820, 840, and 860 shown in FIGS. 8A-8D. EX1001, 19:55-59.

42. FIG. 9B adds an intermediate stage (Raman wavelength shifter) 924 after pump laser 922 but before the Raman oscillator to produce a first wavelength shift before the pump laser light is sent to the Raman oscillators described in FIGS. 8A-8D. EX1001, 19:60-66. This intermediate stage 924 produces a first wavelength shift of the pump laser signal 922 before the subsequent Raman oscillator shifts it further. EX1001, 20:8-20.

FIG. 9B



43. Finally, FIG. 9C describes an embodiment where light generated by multiple pump lasers 942a and 942b at the same wavelength are combined via a multiplexer 944 (combiner) before being sent to the Raman oscillator. EX1001, 20:23-41.

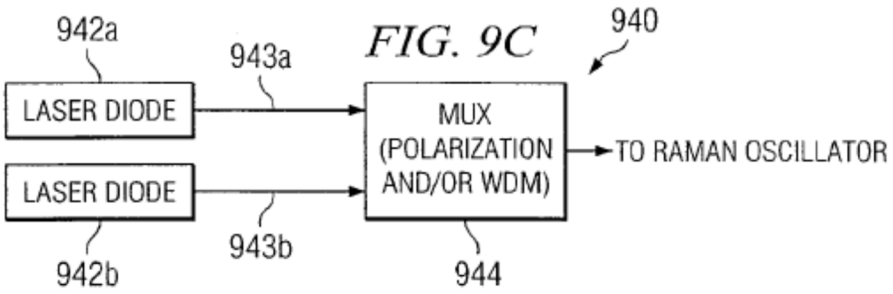


FIG. 9C

B. Priority Date for the '116 Patent

44. The '116 Patent states that it was filed on March 30, 2004 as U.S. Patent Application No. 10/812,608 ("'608 Application"), claiming priority to (a) U.S. Patent Application No. 10/757,341; (b) U.S. Patent Application No. 10/652,276 ("'276 Application"); and (c) U.S. Provisional Application No. 60/408,025 ("'025 Provisional"). EX1001. I have been informed that a patent document claiming subject matter cannot properly claim priority to an earlier filed patent document if that earlier filed patent document lacks adequate disclosure for that claimed subject matter.

45. It is my opinion that the '116 Patent claims subject matter that is not adequately disclosed in the '025 Provisional (EX1003). EX1006 is a comparison of the '025 Provisional disclosure with that of the '116 Patent. The '116 Patent issued with only two independent claims, which are Claim 1 and 25. Independent Claim 1 of the '116 Patent recites a "wavelength shifter operable to receive the first optical signal and to wavelength shift at least a portion of the first optical signal based at

least in part on a Raman effect,…." Independent Claim 25 of the '116 Patent recites "receiving the first optical signal at a wavelength shifter, the wavelength shifter comprising a first waveguide structure and a second waveguide structure,…shifting at least the first wavelength to an intermediate optical wavelength using the first waveguide structure based at least in part on a Raman effect…." Yet the '025 Provisional is devoid of any discussion related to wavelength shifting, let alone use of Raman effects to induce/facilitate wavelength shifting.

46. In my opinion, there is nothing within the '025 Provisional that would provide guidance to a POSITA to perform any type of wavelength shift, let alone use Raman effects for doing the same.

IX. CLAIM CONSTRUCTION

47. For purposes of my analysis in this IPR proceeding, I have been informed that terms that appear in the claims of the '116 Patent should be interpreted according to their plain and ordinary meaning under the *Phillips* standard unless otherwise stated below.

48. In determining the ordinary and customary meaning, I have been informed that the words of a claim are first given their plain meaning that those words would have had to a POSITA at the time of the alleged invention. I also have been informed that the claims, specification, and file history may be used to better

construe a claim insofar as the plain meaning of the claims cannot be understood. I have been informed that even treatises and dictionaries may be used under limited circumstances to determine the meaning attributed by a POSITA to a claim term at the time of filing.

49. I have reviewed the ’116 Patent and its prosecution history as well as additional documents to construe the terms in the claims for performing my validity analysis. I further considered the constructions proposed by Petitioner and the Patent Owner in the currently pending litigation in the United States District Court for the District of Massachusetts. EX1014.

50. Unless otherwise discussed in sections below, I have considered each term recited Claims 1-4, 9, 11-14, 16-25, and 30-35 in according with their plain and ordinary meaning under the *Phillips* standard.

X. OVERVIEW OF THE PRIOR ART REFERENCES

A. Shaw (EX1004)

51. Shaw discloses an optical device configured to wavelength shift optical signals in a waveguide structure based on a Raman effect. EX1004, Abstract, ¶[0010]. Shaw’s technique uses stimulated Raman scattering to improve Raman fiber lasers and amplifiers operating in the infrared spectrum by shifting optical signals to longer wavelengths. EX1004, ¶[0010]. Shaw contemplates this improved

technology to have useful applications with laser surgical devices. EX1004, ¶¶[0002],[0038].

52. Shaw provides two examples (Examples 1 and 2) of exemplary implementations of its techniques. EX1004, ¶¶[0040]-[0043].

53. Shaw's Example 1 includes an infrared light ("IR") source (EX1004, ¶[0020], "[t]his invention describes a new approach for achieving high efficiency Raman glass fiber lasers and amplifiers in the infrared region") having a combiner (labelled as 216 in FIG. 8) coupled to pump lasers (labelled as 212, 214 in FIG. 8) that combines light from the two pump lasers (*id.*, ¶[0041], "The signal source 214 was a 1.56 μm diode laser that was mixed with the pump laser using a 2×2 coupler 216") into an optical fiber or series of fibers (*id,* ¶¶[0036],[0041]). An annotated version of Shaw's FIG. 8 is shown below:

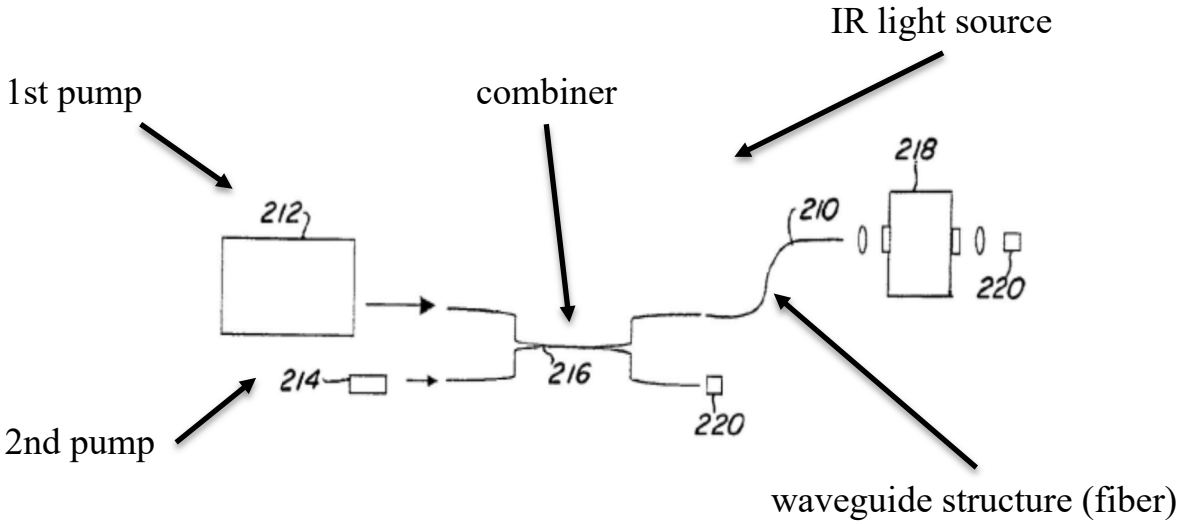


FIG. 8

54. Shaw's Example 1 includes a pump laser 212 that generates a first pump signal: "[t]he device was pumped with Continuum Mirage OPO 212 at 1.5 μm with about 8 W of peak power in a 5 ns pulse." EX1004, ¶[0041].

55. Example 1 also has a signal laser diode 214: "[t]he signal source 214 was a 1.56 μm diode laser that was mixed with the pump laser using a 2x2 coupler 216." EX1004, ¶[0041]. This signal is a second pump laser that generates a second pump signal at a wavelength that differs from the wavelength of the first pump signal—e.g., 1.5 μm (first pump signal) is different from 1.56 μm (second pump signal).

56. Example 1 uses coupler 216 to mix (combine) the pump laser signal with the signal laser signal to generate a combined optical signal—the 2x2 coupler is a beam combiner that couples two different input sources. EX1004, ¶[0041]. The optical signal from coupler 216 is sent to fiber 210 where wavelength shifting occurs through the Raman effect. EX1004, ¶¶[0028], [0029], [0041].

57. Fiber 210 is an optical fiber (specifically an As-Se fiber optical fiber) having waveguide structure(s) for guiding direction of light waves.

> It is noted that the term "glass fiber" is used herein. It should be understood that a person skilled in the art can use a glass waveguide to achieve same or similar purposes. As used herein the term, "waveguide", is used

> to define any device that is designed to confine and direct the propagation of electromagnetic waves. Examples of waveguides include optical fibers, planar waveguides, channel or ridge waveguides, and microstructured fiber.

EX1004, ¶[0021].

58. Shaw discloses exemplary optical fibers to include single-mode fibers, multimode fibers, chalcogenide fibers (with one or more chalcogenide elements), silica fibers, etc. EX1004, ¶¶[0022], [0030]-[0031], [0041].

59. Shaw describes how further wavelength shifting can occur if the light emitted from fiber 210 is sent to one or more subsequent Fabry-Perot cavities (or if fiber 210 itself is comprised of multiple Fabry-Perot cavities). EX1004, ¶[0036]. These Fabry-Perot cavities can be cascaded "such that the output Stokes from one cavity is trapped in the next Fabry Perot cavity that generates and amplifies a second Stokes at longer wavelength." EX1004, ¶[0036]. This is done so that an "initial pump beam may be shifted up in wavelength through several Stokes shifts to generate a high power beam at wavelengths corresponding to multiples of the Raman shift." EX1004, ¶[0036]. This process results in an upshift of the initial pump beam multiple times—e.g., multiple waveguides are used to achieve larger wavelength shifts.

60. Shaw's multiple wavelength-shifting technique includes combining two laser signals at different wavelengths into a single optical signal, shifting the wavelength of part of the optical signal to an intermediate optical wavelength in a first waveguide structure, and shifting the intermediate optical wavelength to a longer wavelength in a second waveguide structure. EX1004, ¶¶[0036]-[0041].

B. Islam (EX1005)

61. Islam discloses devices to improve upon fiber amplifiers by combining cascaded Raman amplification with parametric amplification or four-wave mixing. EX1005, Abstract, 1:63-65, 2:44-62. As an example, Islam utilizes a wavelength shifter (a Raman gain fiber) to cascade pumped laser light through distributed gain mediums at a plurality of Raman orders (including an intermediate orders) to achieve longer wavelength shifting. EX1005, 9:27-35, 12:32-33. Examples of these systems are shown in FIGS. 9-11 of Islam.

62. As shown in FIG. 9, one embodiment of the Islam system includes a first pump (35) at 1240 nm, a second pump at 1430-1530 nm, an input port/combiner (25), and a waveguide structure (30) that shifts the first pump light to the second pump wavelength. EX1005, 9:9-24.

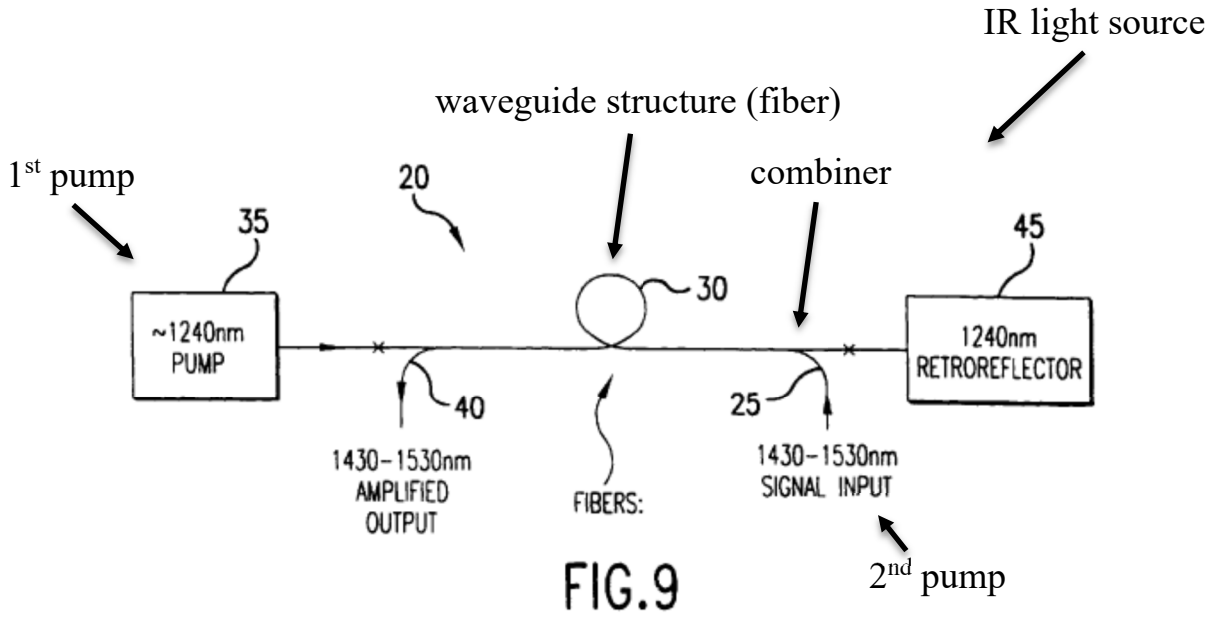


FIG.9

63. As shown in FIG. 10, another embodiment includes an IR source (EX1005, 7:64-67, "To illustrate the cascaded Raman amplification to reach the 1430-1530 nm range of the low-loss window, consider pumping with a commercially available cladding-pumped fiber laser…"), having a combiner (labelled as WDM1/WDM2 in FIG. 10) coupled to pump lasers (labelled as 75,80 in FIG. 10) that combines light from the two pump lasers to generate an optical signal. An annotated version of Islam's FIG. 10 is shown below.

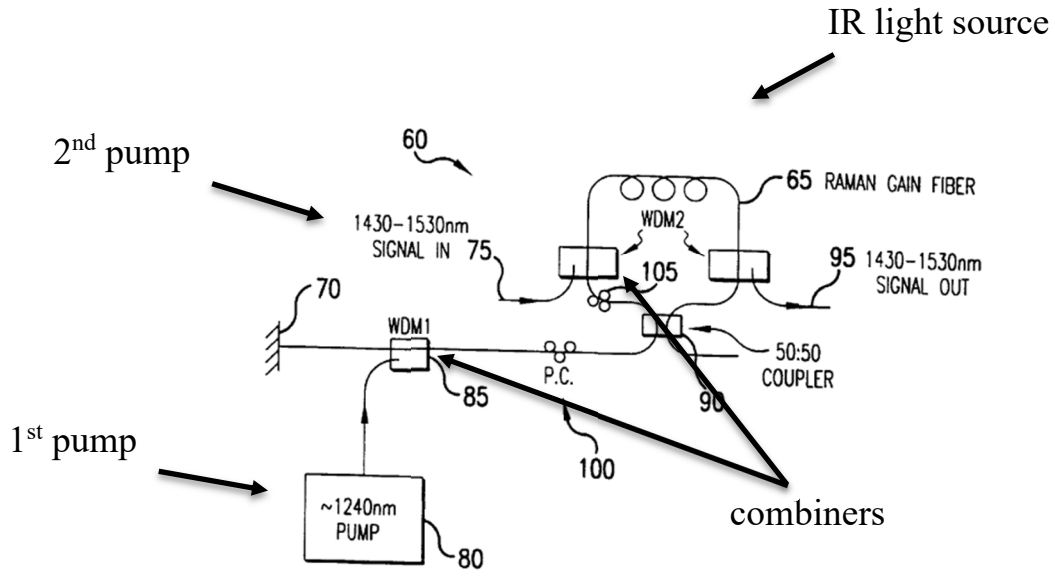


FIG.10

64. Islam's pump laser (item 35 in FIG. 9; item 80 in FIG. 10) generates a first pump signal, and Islam's optical signal (item 25 in FIG. 9; item 75 in FIG. 10) is a second pump signal. "[P]umping laser 35 is operated at a wavelength of about 1240 nm" and "optical signal having a wavelength between 1430 nm and 1530 nm is input from an input port 25." EX1005, 9:15-19.

65. Islam states in relation to the first embodiment (FIG. 9) that "the input port and output port each comprises a WDM coupler which transmits at least at a wavelength between about 1240 nm and 1425 nm." EX1005, 10:16–19. Thus, the ports include a combiner to combine the pump signals to generate an optical signal, which is sent to fiber 30 where wavelength shifting occurs:

> The optical fiber 30 is pumped by a pumping light generated by a pumping laser 35 operated at a wavelength of about 1240 nm. The optical signal is amplified and spectrally broadened in the fiber by nonlinear polarization, and output through an output port 40. The configuration is so arranged that the optical signal has a wavelength greater than the zero-dispersion wavelength of the fiber, which in turn is greater than the pumping wavelength of 1240 nm.

EX1005, 9:17-24.

66. In the second embodiment, WDM1/WDM2 combine the signals, which are sent to fiber 65 (FIG. 10) where wavelength sifting occurs. EX1005, 9:64-10:4.

67. Notably, the Islam fiber 30 (FIG. 9) or 65 (FIG. 10) in each embodiment receives the optical signal (the combined pump signals) and performs wavelength shifting via a Raman effect.

> Raman effect leads to a transfer of energy from one optical beam (the pump) to another optical beam (the signal). The signal is downshifted in frequency (or upshifted in wavelength) by an amount determined by vibrational modes of silica fibers.

EX1005, 4:56–58.

68. Islam indicates that its wavelength shifter can include multiple waveguide structures. EX1005, 30-33. For instance, FIG. 9B illustrates that the

wavelength shifter can include a first waveguide structure and a second waveguide structure. EX1005, 30-33. An annotated version of Islam's FIG. 9b is shown below.

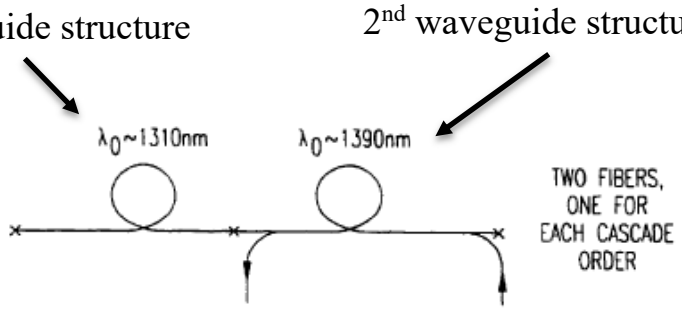


FIG.9b

69. Fiber (λ_0~1310nm) constitutes a first waveguide structure, and fiber (λ_0~1390nm) constitutes a second waveguide structure.

> [D]istributed gain medium comprises first and second optical fibers spliced together, and said optical fibers are used for two different cascaded Raman orders….

EX1005, 14:29–32.

70. The wavelength shifting includes shifting a wavelength of the optical signal to an intermediate optical wavelength in a first waveguide structure and shifting the intermediate optical wavelength to a longer wavelength in a second waveguide structure. For instance, Islam states:

> In this open-loop configuration,…two fibers [are] spliced together with one fiber having a zero-dispersion

> wavelength at about 1310 nm (first cascade) and the other at 1390 nm (second cascade).

EX1005, 9:25–33.

71. Thus, the first cascade happens in the first fiber, and the second cascade happens in the second fiber:

> [S]aid first pumping light cascades through said first distributed gain medium a plurality of Raman orders including an ***intermediate order***….

EX1005, 12:32–34 (emphasis added).

XI. CLAIMS 1-4, 9, 11-14, 16-25, AND 30-35 ARE ANTICIPATED BY SHAW (GROUND 1)

72. In my opinion, claims 1-4, 9, 11-14, 16-25, are 30-35 are anticipated by Shaw.

73. The following sections explain where each element of these claims is found in this prior art.

A. Claim 1 (Preamble): An infrared light source, comprising:

74. I understand that both Petitioners and Patent Owner have agreed for this term to mean at least "a source of light that emits light with a wavelength between approximately 750 nm and 1 mm." EX1014. The '116 Patent describes this technology, and each example within its disclosure falls within a wavelength ranging

from 980 nm to 10 μm. EX1001, 14:54-64, 15:15-58, 16:16-20, 35-37, 55-57, 17:13-17, 53-60, 18:30-35, 64-65, 19:2-7, 20:15-16, 34-35; Claims 8, 28; FIGS. 6B, 7.

75. It is my opinion that the "infrared light source" is properly interpreted as "a source of light that emits light with a wavelength between approximately 750 nm and 1 mm."

76. I understand that Patent Owner has further construed this term as "a preamble term that does not exclude other wavelengths of light. It is my opinion that resolution of Patent Owner's additional language is not necessary to properly apply the prior art to the claims of the '116 Patent.

77. Shaw states that it's "invention pertains to an ***optical device***…to amplify a pump light beam by means of stimulated Raman scattering" (EX1004, Abstract (emphasis added)) and "describes a new approach for achieving high efficiency Raman glass fiber lasers and amplifiers in the ***infrared region***" (EX1004, ¶[0020] (emphasis added)). Shaw further provides a specific example that emits light at 1.56 μm. EX1004, ¶[0041].

78. It is my opinion that to the extent that the preamble is limiting, Shaw discloses an infrared light source ("optical device" operating in "the infrared region").

1. [1.1]: one or more combiners coupled to:

79. I understand the parties have agreed to construe the term combiner as "an optical device that combines two or more separate incoming optical signals into an outgoing optical signal." EX1014. The parties have also agreed to construe the term "coupled to" as "any direct or indirect optical communication between two or more elements, whether or not those elements are in physical contact with one another." EX1014.

80. It is my opinion that the "one or more combiners coupled to" is properly interpreted as "an optical device that combines two or more separate incoming optical signals into an outgoing optical signal," wherein "coupled to" means "any direct or indirect optical communication between two or more elements, whether or not those elements are in physical contact with one another."

81. Shaw describes how his invention includes a 2x2 coupler (combiner), which is an optical device that combines two or more separate incoming signals into an outgoing signal. Shaw states that "[f]iber ***couplers***, WDM splitters, or dichroic beam splitters may also be utilized to ***combine pump beam and the signal beam for launching into and/or coupling out of the fiber***. EX1004, ¶[0027] (emphasis added). Thus, Shaw's couplers are combiners.

82. Shaw's Example 1 has a 2x2 coupler 216 that combines light from two different laser sources: Continuum Mirage OPO[1] 212 and signal source 214. "The ***signal source 214*** was a 1.56 μm diode laser that was ***mixed*** with the ***pump laser*** using a ***2×2 coupler 216***." EX1004, ¶[0041] (emphasis added). This is illustrated in Shaw's FIG. 8 (an annotated version is shown below).

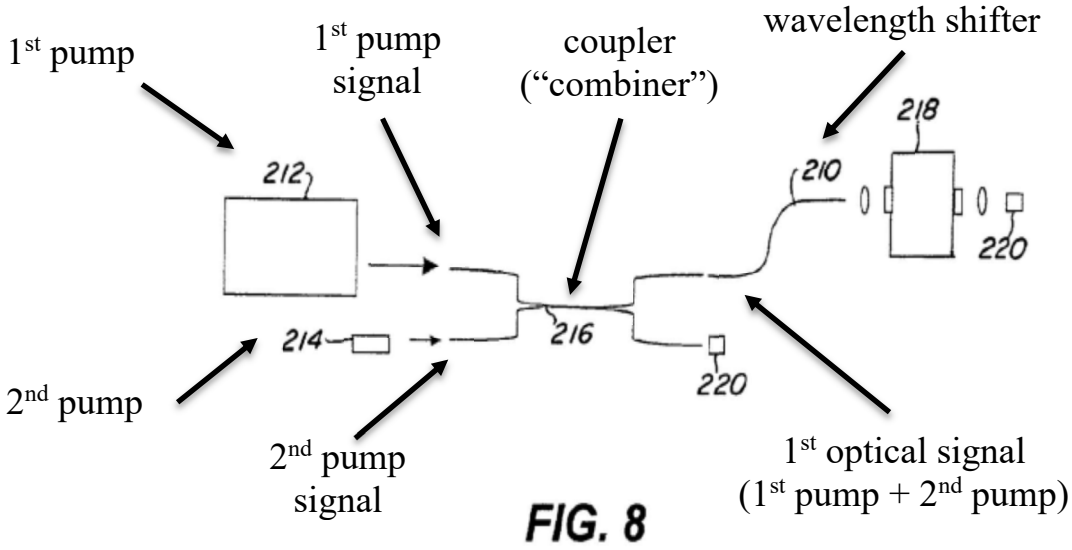


FIG. 8

83. FIG. 6 of Shaw shows a similar, more generalized configuration with coupler 106 as the combiner. EX1004.

84. Claim 1 requires the one or more combiners to be coupled to first and second pump lasers. Shaw's coupler is coupled to (direct or indirect optical communication) its signal source and pump laser.

[1] A Continuum Mirage OPO is an optical parametric oscillator laser.

85. Shaw's coupler combines the two or more separate incoming optical signals into an outgoing optical signal. A 2x2 coupler is a device having two input ports and two output ports, which combines the incoming signals and transmits the combined signals to both output ports. It is my opinion that a POSITA would have understood that Shaw's 2x2 coupler 216 is a combiner operable to combine a first signal generated by a first pump laser 212 with a second signal generated by a second pump laser 214 into a first optical signal and then to couple that combined signal to a subsequent optical element 210.

86. It is my opinion that Shaw discloses one or more combiners (2x2 coupler 216) coupled to a first pump laser (Continuum Mirage OPO 212) and a second pump laser (signal source 214).

2. [1.2]: at least a first pump laser operable to generate a first pump signal and

87. Shaw's Example 1 and FIG. 8 describe an infrared light source having a pump laser (*e.g.*, Continuum Mirage OPO 212) generating a first pump signal. Shaw states that his IR light source "is pumped with Continuum Mirage OPO 212 at 1.5 μm with about 8 W of peak power in a 5 ns pulse." EX1004, ¶[0041]. Shaw refers to laser 212 as a "pump laser." EX1004, ¶[0041].

88. FIG. 6 also shows a first pump laser generating a first pump signal 110. EX1004, ¶[0034].

89. It is my opinion that a POSITA would have understood Shaw's pump laser 212/110 to be a first pump laser operable to generate a first pump signal.

90. It is my opinion that Shaw discloses at least a first pump laser (Continuum Mirage OPO 212 or 110) operable to generate a first pump signal (1.5 μm).

3. [1.3]: a second pump laser operable to generate a second pump signal

91. Shaw's Example 1 and FIG. 8 describe an infrared light source having a laser diode source 214 generating a second pump signal. "The signal source 214 [is] a 1.56 μm diode laser that [is] mixed with the pump laser using a 2×2 coupler 216." EX1004, ¶[0041].

92. FIG. 6 shows a second pump laser 118 generating a second pump signal. EX1004, ¶[0034].

93. It is my opinion that a POSITA would have understood that Shaw's laser diode 214/118 to be a second pump laser operable to generate a second pump signal.

94. It is my opinion that Shaw discloses at least a second pump laser (signal source 214/118) operable to generate a second pump signal (1.56 μm).

4. [1.4]: the one or more combiners operable to combine the first pump signal and the second pump signal into a first optical signal,

95. I understand that the parties have agreed to construe "operable to combine the first pump signal and the second pump signal into a first optical signal" as "receive the first pump signal and the second pump signal and combine them into the first optical signal." EX1014. I understand that Petitioners have construed the term "first optical signal" as "a combined optical signal that simultaneously contains both the first pump signal and the second pump signal propagating in the same direction."

96. While the '116 Patent does not describe the two-differing-wavelength-pump system described in the claims, it does provide a single example in FIG. 9C of a two-pump system (albeit using two pumps of the same wavelength). In that case, the pump signals (943a, 943b) from the two pump lasers (942a, 942b) are sent to a combiner (944), merged into a single signal, and then sent to the Raman wavelength shifter/oscillator to shift its wavelength. EX1001, 20:21–41, FIG. 9C.

97. As a result, the "first optical signal" of Claim 1 must mean that it is an optical signal comprised of the first pump signal and the second pump signal and that those combined signals propagate together in the same direction after being combined so that they can be received by the first waveguide structure.

98. I understand that Patent Owner has construed this term under its plain and ordinary meaning, or in alternative as "combined optical signal that contains at least a portion of the first pump signal and the second pump signal." It is my opinion that resolution of these different constructions is not necessary to properly apply the prior art to the claims of the '116 Patent.

99. Shaw's Example 1 and FIG. 8 describe a 2x2 coupler (a "combiner" or "optical device" operable to receive the first pump signal and the second pump signal and combine them into a first optical signal:

> The ***signal source 214*** was a 1.56 μm ***diode laser*** that was ***mixed*** with the ***pump laser*** using a 2×2 ***coupler*** 216.

EX1004, ¶[0041] (emphasis added).

100. An annotated version of Shaw's FIG. 8 is shown below.

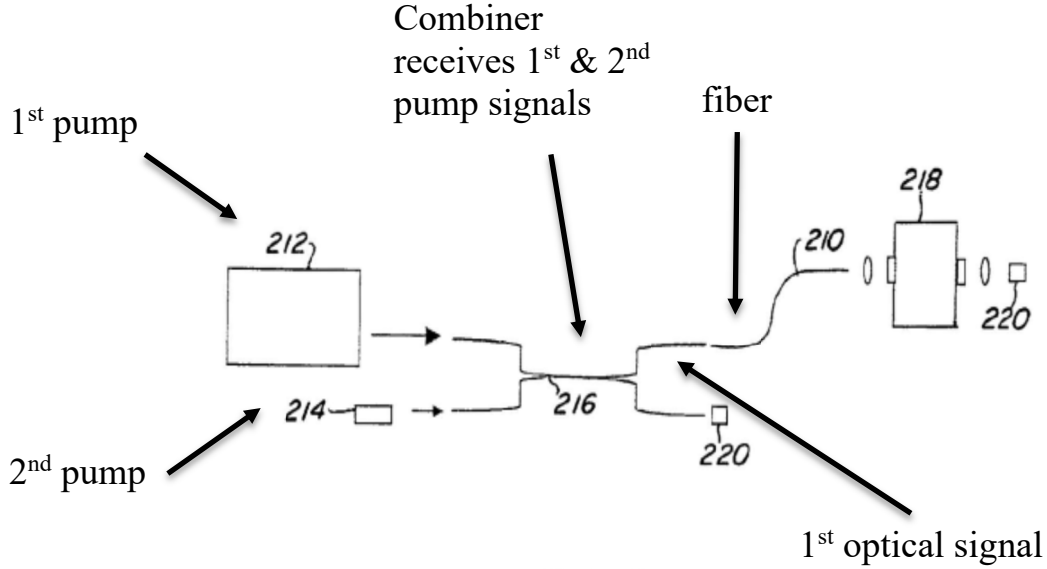


FIG. 8

EX1004, FIG.8. FIG. 6 shows a similar configuration. EX1004, ¶[0034].

101. Shaw's system mixes the first and second pump signals so that they merge or "combine" into an optical signal that is fed to fiber 210. Each of the first pump signal and the second pump signal is an optical signal (*see* §§XI(A)(2)-(3)), and thus when they are mixed, they are combined into a "first optical signal." The first pump signal is at a first wavelength (1.5 μm) and the second pump signal is at a second wavelength (1.56 μm). EX1004, ¶[0041]. The 2x2 coupler 216 receives the first pump signal and the second pump signal and mixes them into a "first optical signal" that includes both the first wavelength (1.5 μm) and the second wavelength (1.56 μm). EX1004, ¶[0041].

102. It is my opinion that Shaw discloses the one or more combiners (2x2 coupler 216) operable to combine the first pump signal (1.5 μm) and the second pump signal (1.56 μm) into a first optical signal ("mixed" signal).

5. [1.5]: the first pump signal comprising at least a first wavelength and

103. In Shaw's Example 1, the first pump signal has a wavelength of 1.5 μm. EX1004, ¶[0041].

104. It is my opinion that Shaw discloses the first pump signal (1.5 μm) comprising at least a first wavelength (1.5 μm).

6. [1.6]: the second pump signal comprising at least a second wavelength,

105. In Shaw's Example 1, the second pump signal has a wavelength of 1.56 μm. EX1004, ¶[0041].

106. It is my opinion that Shaw discloses the second pump signal (1.56 μm) comprising at least a second wavelength (1.56 μm).

7. [1.7]: wherein the first wavelength of the first pump signal is substantially different than the second wavelength of the second pump signal; and

107. I understand that Petitioners have asserted this term to be indefinite because the '116 Patent provides no guidance as to how different the first and second wavelengths must be to be "substantially different." EX1014. Despite not providing a minimum difference, the '116 Patent does distinguish between light as close as 10 nm apart (1390 vs. 1400 nm). EX1001, 21:60-63. At the very least, a 10-nm difference in wavelength would seem to be "substantially different" within the meaning of the patent because the Patent Owner treats the two wavelengths as being different.

108. Given the context of the specification, it is my opinion that a POSITA would have understood that whatever the precise scope of the claim, a first wavelength has a wavelength that "substantially differs" from a second wavelength

when it facilitates a significant shift of the wavelength on the order of tens of nanometers.

109. I have been informed that in certain circumstances if a claim cannot be understood without resort to speculation, then other prior art grounds may not be able to be applied. I understand that this prohibition does not extend to cases where the prior art can be read against the claim in question, as is the case presently.

110. It is my opinion that Patent Owner itself admits that there are differences in wavelength that a POSITA would understand to be substantial. Such differences not only include that which Patent Owner purports to be a substantial difference but also the difference in wavelength disclosed in the prior art Shaw.

111. I understand the Patent Owner has construed this term as "wavelengths with an 80nm difference or more," which lies between the primary invalidity reference cited against the '116 Patent (Shaw) (disclosing a 60-nm difference between the first and second pump wavelengths) and the products the Patent Owner accuses of infringement (allegedly having an 84-nm difference between the first and second pump wavelengths).

112. The '116 Patent is devoid of any specific wavelength range that constitutes a substantial difference, much less an 80-nm or more difference. Indeed, to the extent that the '116 Patent discloses different wavelengths, it discloses

wavelengths that are much closer, such as 10 nm apart. EX1001, 21:60–63. It is my opinion that there is no evidence to support the Patent Owner's 80-nm construction.

113. Nonetheless, in Shaw's Example 1, the first wavelength is unquestionably ***different*** than the second wavelength (1.5 μm vs. 1.56 μm). Neither the '116 Patent specification nor the examination history define the metes and bounds of how different these wavelengths must be to be "substantially different."

114. However, given Patent Owner's contention that enumerated wavelengths differences in the specification are sufficient to be "substantially different" and the specification distinguishes between 1390 nm and 1400 nm, a difference of at least 10 nm would appear to be "substantially different" within the meaning of the claim even if the precise boundary between different and substantially different cannot be reasonably ascertained. The shift of 60 nm (0.06 μm) from the first wavelength to the second wavelength would correspond to a shift of six times the 10-nm difference described in the specification. Thus, it is my opinion that a POSITA would have understood that a difference of wavelength from 1.5 μm to 1.56 μm is enough to be "substantially different."

115. It is my opinion that Shaw, therefore, discloses the first wavelength (1.5 μm) of the first pump signal is substantially different (Δ0.06 μm—6× the minimum

wavelength difference described in the specification) than the second wavelength (1.56 μm) of the second pump signal.

8. [1.8]: a wavelength shifter coupled to the one or more combiners, the wavelength shifter comprising

116. I understand that the parties have agreed to construe the term "coupled to" as "any direct or indirect optical communication between two or more elements, whether or not those elements are in physical contact with one another." EX1014.

117. It is my opinion that "coupled to" is properly interpreted as "any direct or indirect optical communication between two or more elements, whether or not those elements are in physical contact with one another."

118. The '116 Patent broadly defines wavelength shifters to refer to any device that shifts a signal to a longer wavelength, including optical fibers and gratings:

> "Raman wavelength shifter" refers to any device that uses the Raman effect to shift a shorter optical signal wavelength to a longer optical signal wavelength. The Raman wavelength shifters may comprise, for example, one or more reflectors, one or more gratings, an optical fiber, or a combination of these or other elements.

EX1001, 15:1-6.

119. Shaw explains how wavelength shifting occurs via the Raman effect in fibers. EX1004, ¶[0028]. Light at two different wavelengths is sent into a fiber, and light at one wavelength is amplified by transferring (shifting) energy from the other wavelength to it through stimulated Raman scattering:

> pump light beam 450 of wavelength λ_1 and signal light beam 452 of wavelength λ_2 of a lower intensity than the pump light beam 450 are launched into one end of glass fiber 454. Light beam 452 interacts with light beam 450 and the fiber 454 through stimulated Raman scattering and is amplified. At the opposite end of the fiber 454, depleted beam 456 at wavelength λ_1 and amplified light beam 458 at wavelength λ_2 issue forth.

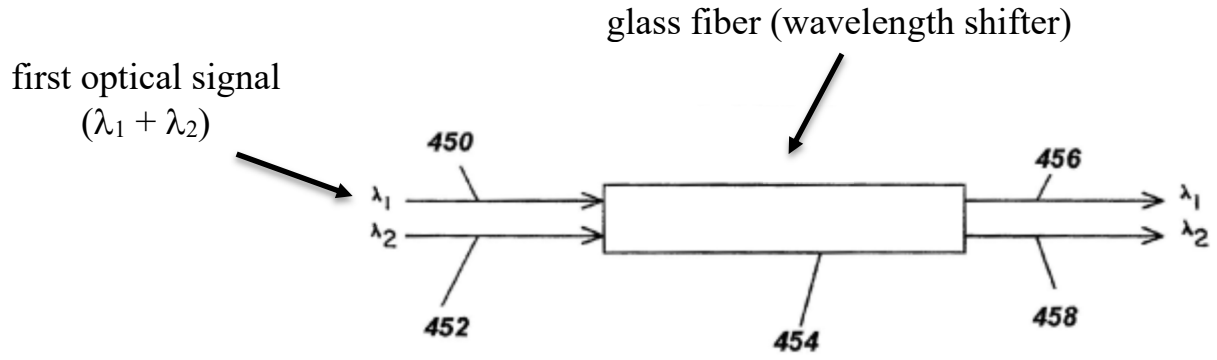


FIG. 4

EX1004, ¶[0028], FIG.4.

120. In Shaw's Example 1, 2x2 coupler 216 (the "combiner") combines the signals from lasers 212 and 214 (*i.e.*, light beams 450 and 452 from FIG. 4) into the

first optical signal, which is then coupled to fiber 210 (*i.e.*, glass fiber 454 from FIG. 4), which operates as a wavelength shifter and shifts light from one wavelength (λ_1) to the other (λ_2). *Id.,* ¶[0041]. Coupler 106 in FIG. 6 similarly combines signals from lasers 110 and 118. EX1004, ¶[0034].

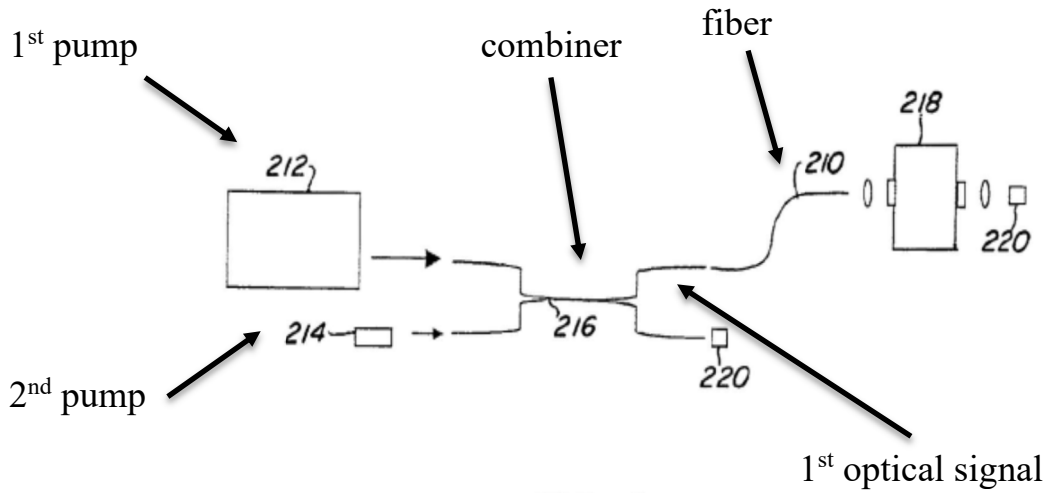


FIG. 8

EX1004, FIG.8.

121. Therefore, fiber 210 is a wavelength shifter coupled to (in direct or indirect optical communication with) the combiner (2x2 coupler 216).

122. The '116 Patent states that its "Raman wavelength shifter includes a gain fiber 804 operable to facilitate shifting pump signal 810 to a desired wavelength," and that its gain fiber can "comprise any waveguide structure capable of ***wavelength shifting pump signal*** 810 ***to a longer wavelength*** or a ***different Raman cascade order***." EX1001, 17:18-22 (emphasis added).

123. Shaw discloses:

> Other configurations of Raman fiber lasers include ring lasers and cascaded Raman fiber lasers….The latter embodiment involves ***cascading several Fabry-Perot cavities*** such that the output Stokes from one cavity is trapped in the next Fabry-Perot cavity that generates and amplifies a second Stokes at ***longer wavelength***. With this process, the ***initial pump beam may be shifted up in wavelength*** through several Stokes shifts to generate a high power beam at wavelengths corresponding to multiples of the Raman shift.

EX1004, ¶[0036].

124. Shaw's Raman wavelength shifter, which is coupled to a combiner (2x2 coupler 216), includes a fiber 210 that shifts a pump signal to a desired wavelength. Its fiber incudes a waveguide structure capable of wavelength shifting the pump signal to a longer wavelength or a different Raman cascade order.

125. It is my opinion that Shaw discloses a wavelength shifter (fiber 210) coupled to the one or more combiners (2x2 coupler 216).

9. [1.9]: a first waveguide structure

126. The '116 Patent states:

> The ***waveguide structure can comprise***, for example, an ***optical fiber***, a hollow tube waveguide, an air core

> waveguide, a planar waveguide, or a combination of these or other devices.

EX1001, 14:38-41 (emphasis added).

> [A]t least a portion of the ***Raman wavelength shifter can be implemented in a waveguide structure.***

EX1001, 16:43-45 (emphasis added).

> Raman wavelength shifter includes a gain fiber 804 operable to facilitate shifting pump signal 810 to a desired wavelength. ***Gain fiber 804 may comprise any waveguide structure capable of wavelength shifting*** pump signal 810 to a longer wavelength or a different Raman cascade order.

EX1001, 17:20-22 (emphasis added).

127. In Shaw's Example 1, the As-Se fiber 210 is an optical fiber, which is one of the enumerated types of waveguide structures. EX1004, ¶[0041]. Amplifier fiber 128 in FIG. 6 is also a waveguide structure. EX1004, ¶[0034].

128. It is my opinion that Shaw discloses the wavelength shifter (fiber 210) comprising…a first waveguide structure ("optical fiber").

10. [1.10]: a second waveguide structure,

129. The '116 Patent provides an example of using two waveguide structures (*e.g.*, multiple fibers or Fabry-Perot cavities) in tandem to achieve multiple

wavelength shifts. EX1001, 18:5-20. The second waveguide structure, therefore, could be a different Fabry-Perot cavity from the first waveguide structure.

130. Shaw discloses a first waveguide structure in the form of As-Se fiber 210. EX1004, ¶[0041]. Shaw further notes that additional fibers can be used in tandem with the first fiber to shift the wavelength through multiple Raman shifts, thereby achieving a longer overall wavelength shift than would be possible with a single fiber. EX1004, ¶[0036]. Shaw specifically shows such a configuration in FIG. 6 with fibers 132 and 138. EX1004, FIG.6.

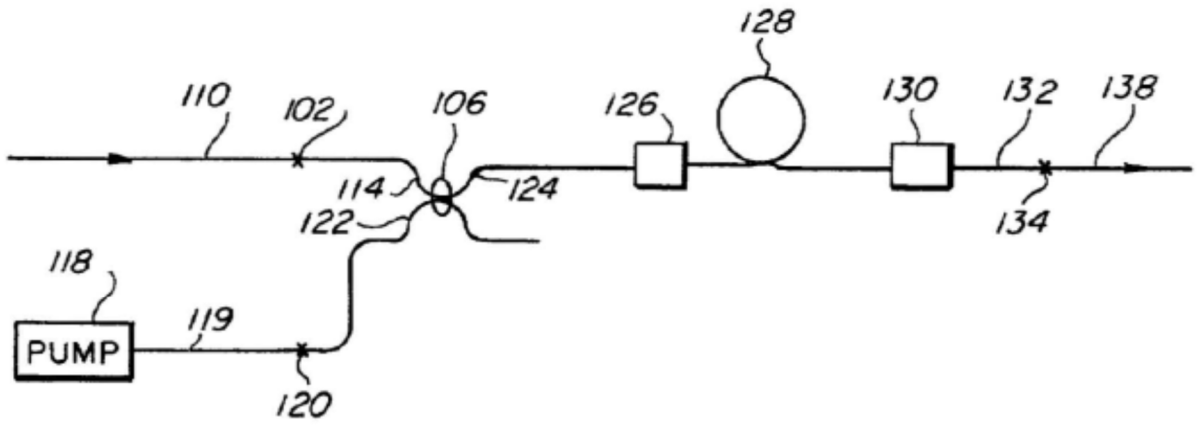


FIG. 6

131. Shaw further states that different fiber materials (*e.g.*, As-Se and As-S) have different Raman bandwidths, which would cause different shifting. EX1004, ¶¶[0024]-[0026], [0032], Fig. 3.

132. Shaw also explains that Fabry-Perot cavities can be made from fibers with a fiber-Bragg grating written into the fiber. EX1004, ¶[0035]. Shaw further notes that such a Bragg grating is uniquely tailored to the specific Stokes wavelength desired. EX1004, ¶[0035]. It will only be reflective at certain wavelengths and transmissive (or partially transmissive) at other wavelengths. EX1004, ¶[0035],[0037]. Thus, in the cascaded approach used by Shaw, each Fabry-Perot cavity necessarily will be different than the other because it will be designed to trap successively longer wavelengths as the light cascades from one cavity to the next. EX1004, ¶[0035].

133. This approach is the same as disclosed in the embodiment shown in FIG. 8C of the ’116 Patent, which also uses multiple Fabry-Perot cavities. EX1001, 18:5-20. Accordingly, Shaw discloses a second, different waveguide structure via these other optical fibers. FIG. 6 shows how successive waveguide structures 132, 138 (fibers) can be coupled to prior waveguide structures 128. EX1004, FIG.6.

134. It is my opinion that Shaw discloses the wavelength shifter (fiber 210) comprising…a second waveguide structure (different fibers or Fabry-Perot cavities).

11. [1.11]: the wavelength shifter operable to receive the first optical signal and

135. Shaw states: “Fiber couplers, WDM splitters, or dichroic beam splitters may also be utilized to combine pump beam and the signal beam [the combined

beams forming the "first optical signal"—*see* §XI(A)(4)] for launching into and/or coupling out of the fiber." EX1004, ¶[0027]. How the Shaw fiber 210 operates as a wavelength shifter is discussed above in §XI(A)(8). In the Shaw system, the fiber 210 (wavelength shifter) is operable to receive the first optical signal, as shown below.

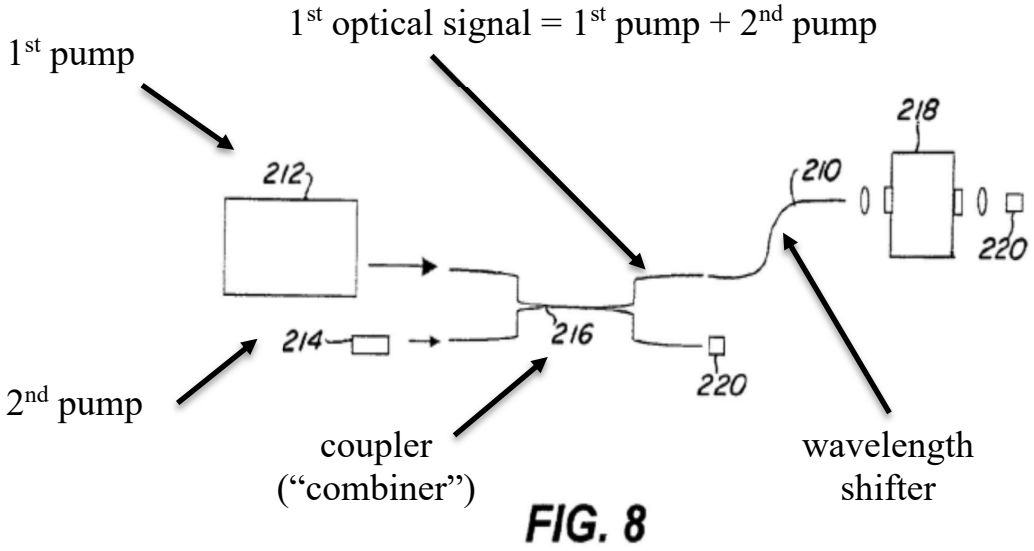


FIG. 8

FIG. 6 also shows a wavelength shifter 128. EX1004, ¶[0034].

136. It is my opinion that Shaw discloses the wavelength shifter (fiber 210) operable to receive the first optical signal ("mixed" signal).

12. [1.12]: to wavelength shift at least a portion of the first optical signal based at least in part on a Raman effect,

137. I understand that Petitioners have construed the term "shift" as "to discretely move from one value to another without broadening." The '116 Patent never specifically defines the term "shift" in the patent, although the term (or the

term "shifting") is used throughout the latter half of the specification. Every example involves a circumstance in which light is discretely shifted from one value to another: *See, e.g.,* EX1001, 14:67-15:3, 15:19-23,16:40-43, 17:18-22. In no instance does the patent suggest that the invention is directed towards creating a broad continuum of wavelengths.

138. I understand that Patent Owner has construed this term as "to change the wavelength of the light." It is my opinion that resolution of these different constructions is not necessary to properly apply the prior art to the claims of the '116 Patent.

139. In Shaw's Example 1, fiber 210 shifts at least a portion of the first optical signal (specifically the second pump signal portion to the first pump signal wavelength) using the stimulated Raman scattering effect. EX1004, ¶¶[0028], [0041]. Shaw states that the first pump signal (212 or 458) is amplified by depleting the second pump signal (214 or 450). EX1004, ¶¶[0028], [0041]. Shaw explains that amplification means that energy from the second pump signal is Raman-shifted to the first pump signal wavelength, which satisfies either construction. The light is either moved or changed from one wavelength (second pump signal) to another (first pump signal). EX1004, ¶[0029].

140. It is my opinion that Shaw discloses the wavelength shifter (fiber 210) operable to…wavelength shift (the first pump signal 212, 458 is amplified/shifted by depleting the second pump signal 214, 450) at least a portion of the first optical signal (1.5 μm) based at least in part on a Raman effect ("stimulated Raman scattering effect").

13. [1.13]: wherein the wavelength shifter operates to wavelength shift at least the first wavelength to an intermediate optical wavelength in the first waveguide structure and

141. Shaw describes the concept of wavelength shifting using Raman scattering from a first wavelength λ_1 to a second wavelength λ_2 (an "intermediate" wavelength). EX1004, ¶[0028]. FIG. 4 is an illustration of a basic laser structure with first pump light beam 452 at wavelength λ_2 and a second pump light beam at wavelength λ_1 entering glass fiber 454. *Id*. Light from the second pump signal (λ_1) is then shifted to the first pump signal wavelength (λ_2) using stimulated Raman scattering. EX1004, ¶[0028].

142. Shaw then describes an example of this technique (Example 1—EX1004, ¶[0041]) in which a signal from a Continuum Mirage OPO 212 at 1.5 μm is combined with a signal from a 1.56-μm signal source 214 in coupler 216 to form a first optical signal. EX1004, ¶[0041]. This "first optical signal" enters fiber 210, wherein 1.5-μm light is shifted to 1.56 μm through stimulated Raman scattering.

EX1004, ¶[0028]. This shift occurs in Shaw's fiber 210, which includes the first waveguide structure (*see* §XI(A)(9)). The claim requires another shift to occur in the second waveguide structure. As will be explained, Shaw discloses a system having a second waveguide structure within which another wavelength shift occurs. With two waveguide structures performing two different shifts, the first shift to the intermediate optical wavelength would occur in the first waveguide structure. Such a structure is also shown in FIG. 6. EX1004, ¶[0034].

143. It is my opinion that Shaw discloses the wavelength shifter (fiber 210) operates to wavelength shift (the first pump signal 212, 458 is amplified by depleting the second pump signal 214, 450) at least the first wavelength (1.5 μm) to an intermediate optical wavelength (1.56 μm) in the first waveguide structure ("optical fiber").

14. [1.14]: to wavelength shift the intermediate optical wavelength to a longer optical wavelength in the second waveguide structure;

144. Shaw's Example 1 further discloses that this intermediate optical wavelength can be further shifted using additional fibers (such as cascaded Raman fiber lasers) to shift the wavelength through several Stokes shifts. EX1004, ¶[0036].

145. Cascading ***several*** Fabry-Perot cavities or fibers to shift through ***several*** Stokes shifts requires more than one wavelength shift—*e.g.*, a shift to one

wavelength in the first fiber and then another shift in the next fiber and so on. EX1004, ¶[0036]. This is the same approach described in the embodiment shown in FIG. 8C of the '116 Patent. EX1001, 18:5-20.

146. Shaw further states that this process can be used to generate wavelengths of 1.91 μm, 5.4 μm, and up to 15 μm. EX1004, ¶[0042], Claim 10.

147. Because each Stokes shift in the subsequent waveguide structures shifts the wavelength of the signal to a longer wavelength, Shaw discloses a shift of the intermediate optical wavelength to a longer optical wavelength in a second waveguide structure (the subsequent Fabry-Perot cavity). Alternatively, separate waveguide structures (132, 138) can be connected in series, as shown in FIG. 6 of Shaw. EX1004, FIG.6.

148. It is my opinion that Shaw discloses wherein the wavelength shifter (fiber 210) operates to…wavelength shift (the first pump signal 212, 458 is amplified by depleting the second pump signal 214, 450) the intermediate optical wavelength (1.56 μm) to a longer optical wavelength ("the initial pump beam may be shifted up in wavelength through several Stokes shifts") in the second waveguide structure ("Fabry-Perot cavities"). With two waveguide structures performing two different shifts, the second shift to the longer optical wavelength would occur in the second waveguide structure.

15. [1.15]: wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength and

149. In Shaw's Example 1, the fiber 210 shifts 1.5-μm light (first wavelength) to 1.56 μm (intermediate wavelength). EX1004, ¶[0028], [0041]. 1.56 μm is an optical wavelength greater than a 1.5 μm.

150. It is my opinion that Shaw discloses wherein at least a portion of the intermediate optical wavelength (1.56 μm) is greater than the first wavelength (1.5 μm).

16. [1.16]: wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength; and

151. Shaw states that his cascaded Raman fiber laser embodiment will cause multiple wavelength shifts, each to a longer wavelength than the previous. EX1004, ¶[0036].

152. By cascading an additional Fabry-Perot cavity to fiber 210 (or using additional fibers), Shaw can shift the 1.56 μm light (the intermediate optical wavelength) to a longer optical wavelength (up to 15 μm). EX1004, ¶¶[0020], [0034], FIG. 6.

153. It is my opinion that Shaw discloses at least a portion of the longer optical wavelength (up to 15 μm via "several Stokes shifts") is greater than the intermediate optical wavelength (1.56 μm).

17. [1.17]: wherein the first waveguide structure is substantially different than the second waveguide structure.

154. I understand that Petitioners have asserted this term to be indefinite because there is no explanation in the ’116 Patent regarding how different the first and second waveguide structures must be to be “substantially different.” EX1014. Again, I understand (as mentioned with respect to Claim element 1.7) that prohibitions against challenging indefinite claim does not extend to cases where the prior art can be read against the claim in question, as is the case presently.

155. Here, given the context of the specification, it is my opinion that a POSITA would have understood the first and second waveguide structures to operate at wavelengths that differ from one another.

156. For instance, the ’116 Patent provides an example with two different waveguide structures (Fabry-Perot cavities) that cause multiple wavelength shifts, and that these fibers were selected because they work at different wavelengths. EX1001, 18:5-20. In another example, the ’116 Patent describes the two waveguide structures as being comprised of different materials—fused silica and different chalcogenide glass—that enable multiple shifts in wavelengths. EX1001, 15:14-24.

157. It is my opinion that a POSITA would have understood that whatever the precise scope of this term “substantial” it at least includes differences in the wavelengths for which the first and second waveguide structures are optimized.

158. I understand that Patent Owner has construed this term as "a waveguide having a different material, shape, or size greater than standard tolerances." But it is my opinion that the '116 Patent is devoid of any reference to waveguide shape or size. There is nothing about use of one size or shape for a first waveguide structure and use of another for a second waveguide structure. The '116 Patent is further devoid of any discussion related to standard tolerances or why a deviation from standard tolerances is desired. There is also no discussion of any baseline waveguide structure to use as a standard. As a result, it is my opinion that there is no support for the Patent Owner's proposed construction.

159. As discussed above, the '116 Patent specification provides one example of an embodiment with two different waveguide structures (Fabry-Perot cavities) that cause multiple wavelength shifts. EX1001, 18:5-20. The '116 Patent states that these fibers were selected because they work at different wavelengths. EX1001, 18:5-20.

160. Shaw notes that the Fabry-Perot cavity/fiber can be formed with Bragg gratings written into the fiber. EX1004, ¶[0035]. Because the gratings would be tailored to the specific output wavelength, they must be different if the wavelengths are different. EX1004, ¶[0035]. Shaw uses the same approach described in the embodiment shown in FIG. 8C of the '116 Patent. EX1001, 18:5-20. Shaw also

discloses that different compositions of fibers can be used to cause different shifts in wavelengths. EX1004, ¶¶[0022], [0025], [0026], [0032], FIG. 3. Claims 19 and 20 in Shaw identify a variety of different types of waveguide structures that work in the infrared to mid-infrared range. It is my opinion that a POSITA would have recognized that the specific type of second fiber/waveguide structure would be tailored differently than the first waveguide structure in order to shift the signal to higher wavelengths.

161. It is my opinion that Shaw discloses that the second waveguide structure is substantially different from the first waveguide structure because it comprises a different type of fiber that works at a different wavelength.

162. As stated above, Patent Owner has construed this term as a waveguide having a different material, shape, or size greater than standard tolerances. Shaw also discloses that different compositions of fibers (*e.g.*, entirely different materials) can be used to cause different shifts in wavelengths. EX1004, ¶¶[0022], [0025], [0026], FIG. 3; Claims 19 and 20. It is my opinion that a POSITA would have understood to use a material composition, concentration, etc. for the first waveguide structure that is entirely different from the material composition, concentration, etc. of the second waveguide structure so as to have two waveguide structures that substantially differ.

163. It is my opinion that Shaw discloses wherein the first waveguide structure ("optical fiber") is substantially different than the second waveguide structure ("Fabry-Perot cavities")—Fabry-Perot cavities/fibers can be formed with or by different Bragg gratings, different compositions of fibers, etc. to effectuate different shifts.

B. Claim 2: The infrared light source of claim 1, wherein the first pump laser is selected from the group consisting of a continuous wave laser and a pulsed laser.

164. As stated above, laser 212 is the first pump laser in Shaw's Example 1. Shaw specifically notes that pump laser 212 is pulsed—"The device was pumped with Continuum Mirage OPO 212 at 1.5 μm with about 8 W of peak power in a 5 ns ***pulse***." EX1004, ¶[0041] (emphasis added).

165. It is my opinion that Shaw discloses the first pump laser (Continuum Mirage OPO 212) is selected from the group consisting of…a pulsed laser ("in a 5 ns pulse").

C. Claim 3: The infrared light source of claim 1, wherein the first pump laser is selected from the group consisting of a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a semiconductor laser, and a cladding pump fiber.

166. The Continuum Mirage OPO 212 of Shaw's Example 1 is a solid-state laser. OPO lasers use solid nonlinear crystals as their gain medium.

167. It is my opinion that Shaw discloses the first pump laser (Continuum Mirage OPO 212) is selected from the group consisting of…a solid state laser (OPO lasers are solid state lasers).

D. Claim 4: The infrared light source of claim 1, wherein the second pump laser is selected from the group consisting of a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a semiconductor laser, and a cladding pump fiber.

168. As stated above, laser 214 is the second pump laser in Shaw's Example 1, which is a laser diode. EX1004, ¶[0041] ("The signal source 214 was a 1.56 μm diode laser…").

169. It is my opinion that Shaw discloses the second pump laser (signal source 214) is selected from the group consisting of…laser diodes ("signal source 214 was a 1.56 μm diode laser").

E. Claim 9: The infrared light source of claim 1, wherein the longer optical wavelength comprises a pulsed optical signal having a pulse repetition rate in the range of two (2) hertz to one hundred (100) megahertz.

170. In Example 1, Shaw's first pump laser 212 is a Continuum Mirage OPO. EX1004, ¶[0041]. A Continuum Mirage OPO operates at 10 Hz, as evidenced by "*Raman Amplification in As-Se Fiber*," SPIE Vol. 4628, published in 2002. EX1013.

171. It is my opinion that Shaw discloses the longer optical wavelength (1.56 μm) comprises a pulsed optical signal ("Continuum Mirage OPO 212…in a 5 ns pulse") having a pulse repetition rate in the range of two (2) hertz to one hundred (100) megahertz (Continuum Mirage OPO operates at 10 Hz).

F. Claim 11: The infrared light source of claim 1, wherein the longer optical wavelength comprises a pulsed optical signal having a pulse repetition rate in the range of two (2) hertz to one hundred (100) megahertz.

172. Neither the '116 Patent nor the examination history provides any guidance as to what Patentee envisioned the technical effect of a variation of the first wavelength would cause on the longer optical wavelength. It is my opinion that a POSITA would have understood that changing the first wavelength would change the subsequent longer wavelength due to how the Raman process works, however. For instance, Shaw discloses that starting with a different wavelength leads to different shifts—*e.g.*, using a 1.83-μm pump to shift to 1.91 μm; using a 5.4-μm pump to shift to 6.2 μm. EX1004, ¶[0042].

173. It is my opinion that Shaw discloses a variation of the first wavelength of the first pump signal causes a variation in the longer optical wavelength—Shaw discloses that starting with a different wavelength leads to different shifts (*e.g.*, using a 1.83-μm pump to shift to 1.91 μm; using a 5.4-μm pump to shift to 6.2 μm).

G. Claim 12: The infrared light source of claim 1, wherein the one or more combiners are selected from the group consisting of a wavelength division multiplexer and a power coupler.

174. The 2x2 coupler 216 of Shaw's Example 1 is a power coupler. In addition, Shaw states: "Fiber couplers, WDM[2] splitters, or dichroic beam splitters may also be utilized to combine pump beam and the signal beam for launching into and/or coupling out of the fiber" EX1004, ¶[0027].

175. It is my opinion that Shaw discloses the one or more combiners (2x2 coupler 216) are selected from the group consisting of a wavelength division multiplexer ("WDM splitters").

H. Claim 13: The infrared light source of claim 1, wherein the first waveguide structure is selected from the group consisting of a dispersion compensating fiber, a dispersion shifted fiber, a single mode fiber, a chalcogenide fiber, and a fused silica optical fiber.

176. Shaw states that its waveguide structure is an "As-Se fiber 210." EX1004, ¶[0041]. Moreover, Shaw classifies such a fiber as a "chalcogenide As-Se glass fiber." EX1004, ¶[0032].

177. It is my opinion that Shaw discloses the first waveguide structure ("optical fiber") is selected from the group consisting of…chalcogenide fiber ("chalcogenide As-Se glass fiber").

[2] "WDM" stands for wavelength division multiplexer.

I. Claim 14: The infrared light source of claim 1, wherein at least a portion of the first waveguide structure is selected from the group consisting of an optical fiber, a hollow tube waveguide, an air core waveguide, and a planar waveguide.

178. The fiber 210 of Shaw's Example 1 is an optical fiber. EX1004, ¶[0041].

179. It is my opinion that Shaw discloses at least a portion of the first waveguide structure ("optical fiber") is selected from the group consisting of an optical fiber ("optical fiber").

J. Claim 16: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure is selected from the group consisting of an optical fiber, a hollow tube waveguide, an air core waveguide, and a planar waveguide.

180. Shaw teaches use of multiple waveguides to achieve larger wavelength shifts—*i.e.*, the Shaw fiber 210 can include a second waveguide structure via additional fiber Bragg gratings written into optical fibers. *See* §XI(A)(10); EX1004, ¶[0035].

181. It is my opinion that Shaw discloses at least a portion of the second waveguide structure ("optical fiber") is selected from the group consisting of an optical fiber ("optical fiber").

K. Claim 17: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure comprises an optical fiber, wherein the optical fiber is selected from the group consisting of a mid-infrared optical fiber, a chalcogenide fiber and a ZBLAN fiber.

182. Shaw teaches that at least a portion of the second waveguide structure comprises an optical fiber. *See* §XI(J). Shaw further discloses use of chalcogenide glass fibers to achieve a wavelength shift. EX1004, ¶[0020] ("The approach involves utilizing Stimulated Raman Scattering (SRS) in infrared transmissive chalcogenide glass fibers to frequency shift a shorter wavelength pump beam to a longer wavelength Stokes beam"), ¶[0022].

183. It is my opinion that Shaw discloses at least a portion of the second waveguide structure ("optical fiber") comprises an optical fiber ("optical fiber"), wherein the optical fiber is selected from the group consisting of…a chalcogenide fiber ("chalcogenide As-Se glass fiber").

L. Claim 18: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure is an optical waveguide comprising a material selected from the group consisting of ZBLAN, sulfide, selenide, and telluride.

184. Shaw teaches that its second waveguide structure comprises a chalcogenide optical fiber. *See* §XI(K). Shaw further discloses use of optical waveguides comprising sulfide, selenide, or telluride. EX1004, ¶[0022]

("Chalcogenide glasses comprise at least one of the chalcogenide elements sulfur (S), selenium (Se), and tellurium (Te)…").

185. As-Se is the chemical name for arsenic selenide. It is my opinion that Shaw discloses that its second waveguide structure comprises an optical waveguide comprising selenide.

186. It is my opinion that Shaw discloses at least a portion of the second waveguide structure ("optical fiber") is an optical waveguide ("optical fiber") comprising a material selected from the group consisting of…selenide ("Chalcogenide glasses comprise at least one of the chalcogenide elements sulfur (S), selenium (Se), and tellurium (Te)…").

M. Claim 19: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength of approximately 1.7 microns or more.

187. Shaw teaches that its technique can create Raman shifts up to 15 μm. EX1004, ¶[0020] ("Raman lasers and amplifiers can be utilized to generate or amplify light in the wavelength region of about 1-15 μm"). Further, Shaw's Example 2 shows how wavelengths of at least 6.2 μm can be obtained using the disclosed technique. EX1004, ¶[0042]. Accordingly, Shaw discloses that its technique can generate the longer optical wavelength having a wavelength of approximately 1.7 microns or more.

188. It is my opinion that Shaw discloses the longer optical wavelength ("amplify light in the wavelength region of about 1-15 μm") comprises a wavelength of approximately 1.7 microns or more (Example 2—wavelengths of at least 6.2 μm can be obtained).

N. Claim 20: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength in the range of two (2) microns to ten (10) microns.

189. Shaw teaches that its technique can "generate or amplify light in the wavelength region of about 1-15 μm." *See* §XI(M).

190. It is my opinion that Shaw discloses the longer optical wavelength ("amplify light in the wavelength region of about 1-15 μm") comprises a wavelength in the range of two (2) microns to ten (10) microns (Example 2—wavelengths of at least 6.2 μm can be obtained).

O. Claim 21: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength in the range of five (5) microns to seven (7) microns.

191. Shaw teaches that its technique can "generate or amplify light in the wavelength region of about 1-15 μm." *See* §XI(M).

192. It is my opinion that Shaw discloses the longer optical wavelength ("amplify light in the wavelength region of about 1-15 μm") comprises a wavelength

in the range of five (5) microns to seven (7) microns (Example 2—wavelengths of at least 6.2 μm can be obtained).

P. Claim 22: The infrared light source of claim 1, further comprising a wavelength separator coupled to the wavelength shifter and capable of transmitting at least a portion of a selected wavelength from the wavelength shifter.

193. In Shaw's Example 1, a wavelength separator 218 is used after the Raman amplifier (*e.g.*, coupled to fiber 210) to remove the unwanted light and only transmit the shifted light:

> The signal source 214 was a 1.56 μm diode laser that was mixed with the pump laser using a 2×2 coupler 216. The amplified 1.56 μm signal ***was spectrally separated from the pump by a Jarrel-Ash ¼ meter monochromator 218*** and detected with an InGaAs detector 220.

EX1004, ¶[0041]) (emphasis added).

194. An annotated version of Shaw's FIG. 8 is shown below to illustrate this feature.

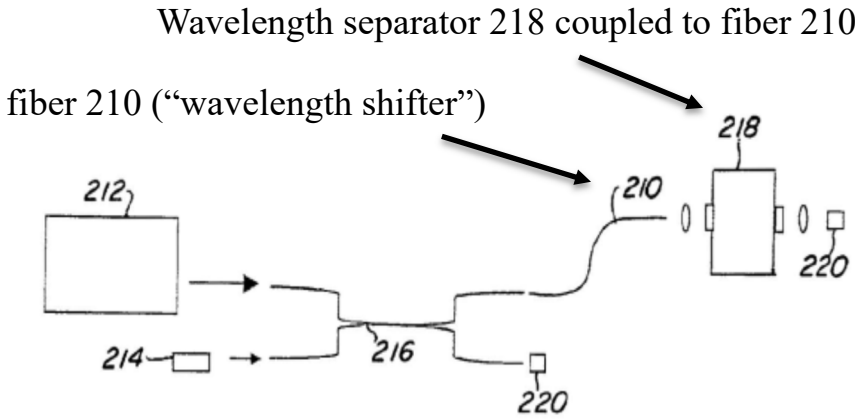


FIG. 8

195. Shaw also describes how the Fabry-Perot cavity (*see* §XI(A)(10)) uses a partially transmissive Bragg grating 156 to transmit part of the shifted light 155 out of the cavity 158, which therefore acts as a wavelength separator:

> FIG. 7 is an illustration of a basic laser structure with pump light beam 150 at wavelength λ_1 entering glass fiber 152. Glass fiber 152, having at both ends thereof mirrors or other reflectors 151, 153, is provided with a pair of spaced fiber Bragg gratings 154, 156 at ends of the fiber creating cavity 158 between the spaced gratings….Gratings 154, 156 reflect light 155 at wavelength λ_2 back and forth in cavity 158 and every time the light at wavelength λ_2 is reflected, it interacts with pump light beam 150 and extracts energy through stimulated Raman scattering….Since grating 156 is

designed so that its reflectivity is not 100%, some of light 155 at wavelength λ_2 in cavity 158 escapes through grating 156 and issues out of fiber 152 as laser light beam 160 at wavelength λ_2.

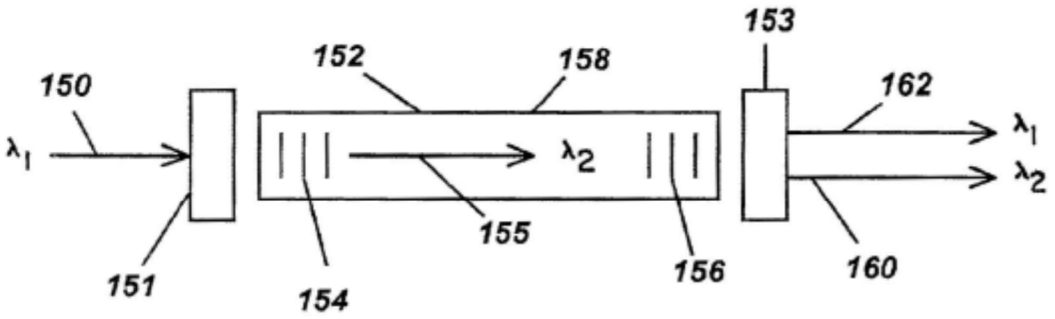


FIG. 7

EX1004, ¶[0037], FIG.7.

196. The '116 Patent describes its wavelength separator as a device "capable of transmitting at least a portion of the desired wavelength from Raman wavelength shifter 800." EX1001, 17:37-40. It is my opinion that a POSITA would have understood that Shaw's monochromator 218 or partially transmissive grating 156 operate to select and transmit a portion of a desired wavelength, and that monochromators and gratings were commonly used as separators in a manner prescribed by Claim 22.

197. It is my opinion that Shaw discloses a wavelength separator (monochromator 218/grating 156) coupled to the wavelength shifter (fiber 210) and capable of transmitting ("amplified 1.56 μm signal was spectrally separated from the

pump by a Jarrel-Ash ¼ meter monochromator 218," "[s]ince grating 156 is designed so that its reflectivity is not 100%, some of light 155 at wavelength λ_2 in cavity 158 escapes through grating 156") at least a portion of a selected wavelength from the wavelength shifter (fiber 210).

Q. Claim 23: The infrared light source of claim 22, wherein the wavelength separator is selected from the group consisting of a demultiplexer, one or more partially transmissive gratings, one or more partially transmitting mirrors, one or more Fabry Perot filters and one or more dielectric gratings.

198. Shaw's Fabry-Perot cavities include a partially transmissive grating 156 that separates and transmits a portion of the shifted wavelength 155 out of the laser. *See* §XI(P); EX1004, ¶[0037], FIG.7.

199. It is my opinion that Shaw discloses wherein the wavelength separator (partially transmissive grating 156) is selected from the group consisting of…one or more partially transmissive gratings.

R. Claim 24: The infrared light source of claim 1, further comprising at least a third waveguide structure coupled to the wavelength shifter, wherein a coupling loss between the third waveguide structure and the wavelength shifter comprises no more than five (5) decibels.

200. Shaw teaches use of multiple waveguides (Fabry-Perot cavities) to achieve larger wavelength shifts. *See* §XI(A)(10). Thus, Shaw's device can include a third waveguide structure (or more).

201. It is my opinion that a POSITA would have recognized that fibers were routinely coupled together at the time with losses less than 5 decibels. EX1015, p. 888 (noting a loss of "only 0.05 db when we spliced these fibers" in a cascaded Raman fiber laser using ~1.0-1.5-μm light). Moreover, Shaw's Example 1 demonstrates a that "the fiber loss was about 0.7 dB/m at 1.5 μm." EX1004, ¶[0041]. Given that the fiber length was 1 meter, this corresponds to a loss of only 0.7 dB. Accordingly, Shaw discloses that a third waveguide structure can be coupled to the wavelength shifter that has a coupling loss of no more than 5 decibels.

202. It is my opinion that Shaw discloses at least a third waveguide structure ("Fabry-Perot cavities") coupled to the wavelength shifter (fiber 210), wherein a coupling loss between the third waveguide structure ("Fabry-Perot cavities") and the wavelength shifter (fiber 210) comprises no more than five (5) decibels ("fiber loss was about 0.7 dB/m").

S. Claim 25: A method of shifting an optical wavelength to a longer optical wavelength, comprising.

203. *See* Claim 1 (Preamble).

1. [25.1]: combining a first pump signal generated by a first pump laser and a second pump signal generated by a second pump laser into a first optical signal, the first pump signal comprising at least a first wavelength and the second pump signal comprising at least a second wavelength, wherein the first wavelength of the first pump signal is substantially different than the second wavelength of the second pump signal;

204. *See* Elements [1.1]; [1.2]; [1.3]; [1.4]; [1.5]; [1.6]; [1.7].

2. [25.2]: receiving the first optical signal at a wavelength shifter, the wavelength shifter comprising a first waveguide structure and a second waveguide structure, wherein the first waveguide structure is substantially different than the second waveguide structure;

205. *See* Elements [1.8]; [1.9]; [1.10]; [1.11]; [1.17].

3. [25.3]: shifting at least the first wavelength to an intermediate optical wavelength using the first waveguide structure based at least in part on a Raman effect

206. *See* Elements [1.12]; [1.13].

4. [25.4]: shifting the intermediate optical wavelength to a longer optical wavelength using the second waveguide structure; and

207. *See* Element [1.14].

5. [25.5]: wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength and wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength.

208. *See* Elements [1.15]; [1.16].

T. Claim 30: The method of claim 25, wherein the longer optical wavelength comprises a wavelength of approximately 1.7 microns or more.

209. *See* Claim 19.

U. Claim 31: The method of claim 25, wherein the longer optical wavelength comprises a wavelength in the range of two (2) microns to ten (10) microns.

210. *See* Claim 20.

V. Claim 32: The method of claim 25, further comprising transmitting at least a portion of a selected wavelength from the wavelength shifter into a third waveguide structure.

211. *See* Claim 24.

W. Claim 33: The method of claim 25, wherein the first waveguide structure is selected from the group consisting of a dispersion compensating fiber, a dispersion shifted fiber, a single mode fiber, a chalcogenide fiber, and a fused silica optical fiber.

212. *See* Claim 13.

X. Claim 34: The method of claim 25, wherein the second waveguide structure is selected from the group consisting of a chalcogenide fiber and a ZBLAN fiber.

213. *See* Claim 17.

Y. Claim 35: The method of claim 25, wherein at least a portion of the second waveguide structure is an optical waveguide comprising a material selected from the group consisting of ZBLAN, sulfide, selenide, and telluride.

214. *See* Claim 18.

XII. CLAIMS 1-4, 9, 11-14, 16-25, AND 30-35 WOULD HAVE BEEN OBVIOUS IN VIEW OF SHAW (GROUND 2)

215. In my opinion, claims 1-4, 9, 11-14, 16-25, are 30-35 would have been obvious in view of Shaw.

216. As indicated above, Shaw discloses each of the features of the challenged claims and thus anticipates the challenged claims. However, to the extent Patent Owner asserts that there are differences such differences would have been minor and thus obvious to a POSITA. For instance, it is my opinion that a POSITA would have understood how to combine the disclosures in FIGS. 4, 6, and 8, as well as ¶¶[0026]-[0032], [0034]-[0037], [0040]-[0043] to achieve each of the requirements of the challenged claims and would have been motivated to do so to create a longer wavelength light source. EX1004, ¶[0002]. As Shaw notes, there was significant interest at that time in generating longer infrared wavelength sources (e.g., 2–12 μm) for high atmospheric transmission, chemical fingerprinting, remote sensing, infrared countermeasures, surgery, and biomedical applications, among other things. EX1004, ¶[0002]

217. I understand that anticipation is the ultimate or epitome of obviousness. Thus, it is my opinion that Claims 1-4, 9, 11-14, 16-25, and 30-35 would have been obvious in view of Shaw.

XIII. CLAIMS 1-4, 9, 11-14, 16-25, AND 30-35 WOULD HAVE BEEN OBVIOUS OVER SHAW IN VIEW OF ISLAM (GROUND 3)

218. In my opinion, claims 1-4, 9, 11-14, 16-25, are 30-35 would have been obvious over Shaw in view of Islam.

219. The following sections explain where each element of Claims 1-4, 9, 11-14, 16-25, and 30-35 are found in the prior art.

220. I understand that the Patent Owner may argue that one or more of the claimed features are not exactly disclosed. It is my opinion that any such argument is untenable but to the extent that there are any minor differences such differences would have been obvious, as discussed below.

221. Each of the '116 Patent (EX1001, Abstract), Shaw (EX1004, Abstract, ¶¶[0010], [0020]), and Islam (EX1005, Abstract; 1:63-65, 2:44-62, 7:64-67, 9:27-35, 12:32-33) is directed toward an infrared light source that wavelength shifts light via a Raman effect.

222. Each of the '116 Patent (EX1001, 16:63-17:17, FIGS. 8A-8D, 9A-9C), Shaw (EX1004, ¶[0041], FIG. 8), and Islam (EX1005, 3:49-53, 7:64-67, 9:15-19, 10:5-8, FIGS. 9, 9a, 9b, 9c, 10) has configurations where two laser pumps generate two different pump signals at different wavelengths, which are combined by a combiner into an optical signal.

223. Each of the ’116 Patent (EX1001, 14:38-41, 17:20-23, 19:60-20:5), Shaw (EX1004, ¶¶[0036], [0041]), and Islam (EX1005, 9:17-24, 9:64-10:4, 10:16-19, 10:24-35, FIGS. 9, 10, 11) send their optical signal to a fiber (“wavelength shifter”) that wavelength shifts via a Raman effect.

224. The wavelength shifting in each of the ’116 Patent (EX1001, 14:38-41, 17:20-23, 19:60-20:5), Shaw (EX1004, ¶¶[0021], [0030]-[0041]), and Islam (EX1005, 4:56–58, 9:25–33, 14:29–32, 12:32–34, FIG. 9B) includes shifting the first wavelength to an intermediate wavelength in a first waveguide structure of the wavelength shifter, and shifting the intermediate wavelength to a longer wavelength in a second waveguide structure of the wavelength shifter.

225. The ’116 Patent purports that its wavelength shifting technology can be used in a medical device to generate an optical signal in the infrared wavelength range to prevent or reduce damage to tissue during surgical procedures. EX1001, 14:35-15:53.

226. Shaw’s wavelength shifting technology is used to improve Raman fiber lasers and amplifiers operating in the infrared spectrum, which can be used for laser surgy applications or telecommunication applications. EX1004, ¶¶[0002], [0003], [0010], [0038].

227. Islam's wavelength shifting technology is used to improve broadband nonlinear polarization amplifiers by broadening the bandwidth of the fiber amplifiers so they can accommodate a larger number of channels, which can be used for telecommunication applications. EX1005, Abstract, 1:17-23,1:63-65, 2:44-62.

A. Islam suggests and teaches "the one or more combiners operable to combine the first pump signal and the second pump signal into a first optical signal," as recited by Element [1.4]

228. I understand that the Patent Owner may argue that Shaw does not describe its coupler forming a first optical signal that includes both the first wavelength of the first pump signal and the second wavelength of the second pump signal. In my opinion, such an argument is untenable.

229. Shaw discloses that its "signal source 214 was a 1.56 μm diode laser that was mixed with the pump laser [1.5 μm] using a 2×2 coupler 216" to generate a first optical signal which is feed to a fiber for wavelength shifting, and therefore Shaw's first optical signal includes both wavelengths. *See* §XI(A)(4). EX1004, ¶[0041].

230. Islam discloses use of wavelength-division multiplexing (WDM) couplers as combiners in its system to generate a first optical signal from two pump sources. EX1004, 10:14-16, FIG.10.

231. It is my opinion that, at a minimum, it would have been obvious to supplant the Shaw coupler with Islam's WDM combiner to generate such a first optical signal as a substitution of a known equivalent, especially since Shaw discloses that a WDM coupler can be used in its system in a similar way. EX1004, ¶[0036].

232. It was well understood by a POSITA that WDM facilitates combining multiple optical signals for subsequent separation of them—*i.e.*, a WDM combines optical input signals to generate an optical output signal that includes both wavelengths of the input signals. A POSITA would have been motivated to use the Islam WDM as the Shaw combiner to ensure that the first optical signal includes a first wavelength from the first pump signal and a second wavelength from the second pump signal at least because when operating the Shaw system one would want to ensure that "pump light beam 450 of wavelength λ_1 and signal light beam 452 of wavelength λ_2…[are] launched into one end of glass fiber 454…[so that] "[l]ight beam 452 interacts with light beam 450…." EX1004, ¶[0028].

233. Shaw contemplates use of a WDM coupler and both Shaw and Islam discuss optical amplification in telecommunications as a practical application of their respective technologies, and therefore a POSITA would have readily applied the teachings of Islam to modify the Shaw system to accommodate the Islam WDM.

To the extent Shaw does not expressly disclose generating such a first optical signal, there would have been motivation to modify Shaw with Islam because a WDM coupler is a standard fiber device to combine signals, and a POSITA would have had a reasonable expectation of success given that Shaw expressly teaches such modifications and uses it to combine signals.

B. Islam suggests and teaches "a second waveguide structure,… wherein the first waveguide structure is substantially different than the second waveguide structure." as recited by Elements [1.10],[1.17]

234. I understand that the Patent Owner may argue that Shaw does not disclose a second waveguide structure, or that if it does then it fails to disclose its first waveguide structure being substantially different from its second waveguide structure. In my opinion, such an argument is untenable.

235. Shaw discloses a wavelength shifter including a second waveguide structure—*e.g.*, "The latter embodiment involves cascading ***several Fabry-Perot cavities***." *See* §XI(A)(10); EX1004, ¶¶[0022], [0030]-[0031], [0036], [0041]. Also, Shaw's first waveguide structure is substantially different from its second waveguide structure. *See* §XI(A)(17); EX1004, ¶¶[0022], [0025], [0026], [0035], FIG. 3.

236. Islam's FIG. 9b (annotated version is shown below) illustrates an exemplary wavelength shifter (*e.g.*, a fiber) having a first waveguide structure and a second waveguide structure. *See* §VIII(A); EX1005, 9:17-24, 9:64-10:4.

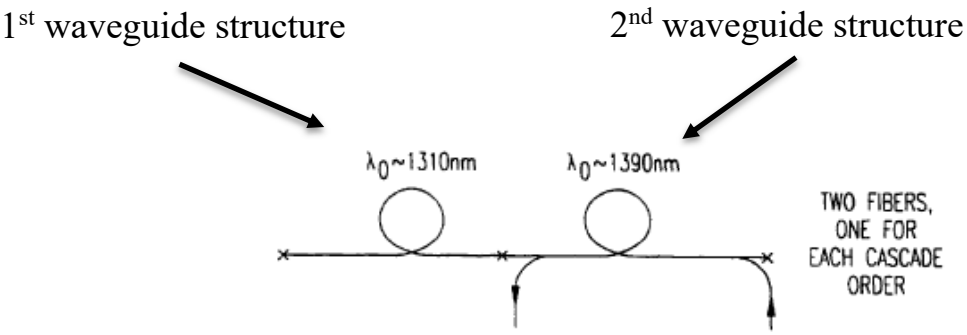


FIG.9b

237. Fiber (λ_0~1310nm) constitutes a first waveguide structure, and fiber (λ_0~1390nm) constitutes a second waveguide structure:

> [D]istributed gain medium comprises first and second optical fibers spliced together, and said optical fibers are used for two different cascaded Raman orders….

EX1005, 14:29–32.

238. Fiber (λ_0~1310nm) and fiber (λ_0~1390nm) are two separate and distinct fibers—*e.g.*, they are substantially different from each other.

239. It is my opinion that, at a minimum, it would have been obvious to use the multiple fibers configuration of Islam as the multiple waveguides in Shaw's system, especially since Shaw discloses multiple waveguides to achieve larger wavelength shifts. *See* §XI(A)(10); EX1004, ¶[0035].

240. It was well understood by a POSITA to use different fibers to generate different wavelength shifting and/or to use multiple fibers to generate larger

wavelength shifts. Islam discloses such a use of multiple fibers for multiple wavelength shifts. EX1005, 9:9-51, FIG. 9b. Shaw discloses that different compositions of fibers can be used to cause different shifts in wavelengths—*e.g.*, Shaw contemplates use of more than one fiber as multiple waveguide structures. *See* §XI(A)(17).

241. It is my opinion that a POSITA would have been motivated to use the two-fiber configuration of Islam in the Shaw system for at least the purpose of providing "successively longer wavelengths." EX1004, ¶[0035]. Shaw discusses that it may be favorable in some applications to provide "amplification over the entire telecom band" which would have motivated a POSITA to use more than one fiber to achieve such amplification. EX1004, ¶[0003]. As Shaw contemplates use of more than one fiber as multiple waveguide structures (*see* §XI(A)(17)), and both Shaw and Islam discuss optical amplification in telecommunications as a practical application of their respective technologies, a POSITA would have readily applied the teachings of Islam to modify the Shaw system to accommodate the Islam two fiber configuration.

242. It is my opinion that to the extent Shaw does not expressly disclose a wavelength shifter comprising a first waveguide structure and a second waveguide structure, there would have been motivation to modify Shaw with Islam because

additional fibers provide additional shifting to other desirable wavelengths, and a POSITA would have had a reasonable expectation of success given that Shaw expressly teaches such modifications and uses additional fibers.

C. Islam suggests and teaches "a second waveguide structure,… wherein the first waveguide structure is substantially different than the second waveguide structure." as recited by Elements [1.10],[1.17]

243. I understand that the Patent Owner may argue that Shaw does not disclose its wavelength shifter operating to: i) wavelength shift at least the first wavelength to an intermediate optical wavelength in the first waveguide structure; ii) wavelength shift the intermediate optical wavelength to a longer optical wavelength in the second waveguide structure; iii) wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength; iv) wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength.

244. The prior art discussed below illustrates why that position is incorrect in my opinion.

245. Shaw's fiber shifts light from the first pump signal (at 1.5 μm—the first wavelength) to the second wavelength (at 1.56 μm—the intermediate wavelength), and this shift occurs in a first waveguide structure. *See* §XI(A)(13); EX1004, ¶¶[0023]-[0024], [0036]-[0041]. Shaw's intermediate optical wavelength (the

second wavelength at 1.56 μm) is shifted to a longer wavelength than the first optical wavelength, and this occurs in a second waveguide structure. *See* §XI(A)(14). Notably, the intermediate optical wavelength (1.56 μm) is longer ("greater") than the first wavelength (1.5 μm). Shaw's use of a second waveguide structure shifts the wavelength of the intermediate optical wavelength to a longer optical wavelength, and thus the output (the longer optical wavelength) from the second waveguide is at a longer ("greater") wavelength than the input (the intermediate optical wavelength) to the second waveguide. *See* §XI(A)(16).

246. Islam states that an option is to have "two fibers spliced together with one fiber having a zero-dispersion wavelength at about 1310 nm (first cascade) and the other at 1390 nm (second cascade)." EX1005, 9:30–33. Islam's first fiber is the first waveguide structure, and the second fiber is the second waveguide structure. *See* §X(B). Accordingly, the first cascade happens in the first fiber, and the second cascade happens in the second fiber. Islam states that the "first pumping light cascades through said first distributed gain medium a plurality of Raman orders including an intermediate order." *See* §X(B); EX1005, 12:32–34.

247. Islam explains "[t]he pumping light cascades through the distributed gain medium a plurality of Raman orders including an intermediate order having a wavelength λ_r, at a close proximity to the zero-dispersion wavelength λ_0…."

EX1005, 10:49-54. This intermediate order of the Raman cascade constitutes an intermediate optical wavelength in the first waveguide structure.

248. Islam explains that "[c]ascading is the mechanism by which optical energy at the pump wavelength is transferred, through a series of nonlinear polarizations, to an optical signal at a longer wavelength.…" (EX1005, 5:14-19), and that "pumping light cascades through said second distributed gain medium a plurality of Raman orders including an intermediate order" (EX1005, 12:52-54). Therefore, the wavelength is shifted to a longer wavelength by a second Raman cascade in the second fiber.

249. Islam continues to explain how at least a portion of the intermediate optical wavelength is greater than the first wavelength and how least a portion of the longer optical wavelength is greater than the intermediate optical wavelength:

> To obtain gain between 1430 nm and 1520 nm, the pump is operated between 1090 nm and 1140 nm, and five cascaded Raman orders are used to reach the desired wavelength. To make use of the broadening from PA or 4WM, a pumping scheme is selected in the middle of this range, i.e., starting with a pump wavelength of 1117 nm. Then, the various Raman orders land at approximately 1175 nm, 1240 nm, 1310 nm, 1390 nm and finally 1480 nm.

EX1005, 8:43–57.

250. In addition, Table 1 of the Islam provides a list of various Raman orders when pumping between 1060 and 1140 nm. EX1005, 8:5-42.

251. Therefore, at least a portion of the intermediate optical wavelength is greater than the first wavelength, and at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength.

252. It is my opinion that, at a minimum, it would have been obvious to use the multiple fibers of Islam with Shaw's system to perform the wavelength shifting scheme prescribed by Elements [1.13]-[1.17], especially since Shaw discloses such wavelength shifting scheme. *See* §§XI(A)(13)-(16).

253. A POSITA would have found it obvious to use the two-fiber arrangement of Islam in the Shaw system for the enhanced shifting. It was well understood by a POSITA to configure optical systems to wavelength shift light to a first order and a second order via first and second waveguide structures, respectively.

254. A POSITA would have been motivated to use the two-fiber configuration of Islam in the Shaw system for at least the purpose of providing two separate and distinct waveguide structures to facilitate a first wavelength shift occurring in the first waveguide structure and a second wavelength shift occurring the second waveguide structure.

255. A POSITA would have obtained guidance from Islam's discussion of Raman cascade through intermediate order(s) via its first and second fibers (first and second waveguide structures) to incorporate the same into a Shaw-Islam two-fiber system. To the extent Shaw does not expressly disclose the wavelength shifting scheme prescribed by Elements [1.13]-[1.17], there would have been motivation to modify Shaw with Islam because using different fibers optimized for different wavelengths was a well-known approach to cascading Raman shifts to reach longer wavelengths, and a POSITA would have had a reasonable expectation of success given that Shaw expressly teaches such modifications and uses cascaded Raman shifting.

D. Claims 2-4, 9, 11-14, 16-25, 30-35

256. Clams 1-4, 9, 11-14, 16-25, and 30-35 have been shown to be anticipated by Shaw. *See* §§XI(A)-(S).

257. Regarding independent Claim 1, to the extent Shaw may not explicitly disclose a feature recited by independent Claim 1, it has been demonstrated that a Shaw-Islam combination would render said feature obvious. (*see* §§XIII(A)-(C)). While independent Claim 25 is not identical to independent Claim 1, the obviousness analysis presented for independent Claim 1 is similarly applicable to independent Claim 25. Therefore, to the extent Shaw does not explicitly disclose a feature recited

by independent Claim 25, it has been demonstrated that a Shaw-Islam combination would have rendered said feature obvious.

258. Regarding dependent Claims 2-4, 9, 11-14, 16-24, and 30-35, each feature recited by these claims is disclosed by Shaw. *See* §§XI(B)-(S). None of the features required by these claims would, when applied to a Shaw-Islam combination of the independent claim from which they depend, frustrate the motivation to combine Islam with Shaw, detract from a POSITA's reasonable expectation of successfully combining Shaw with Islam to generate a predictable result, or render Shaw or Islam inoperable for its intended purpose.

259. For instance, Claims 2-4 specify which type of pump lasers are required. Islam specifically identifies the pump lasers as being cladding-pumped fiber lasers or semiconductor lasers. EX1005, 7:64-67, 9-38-42. Claims 9 and 30-31 specify optical characteristics of the longer optical wavelength. Claim 11 requires a variation of the first wavelength to cause a variation in the longer optical wavelength. Claim 12 specifies which type of combiner is required. Claims 13-14, 16-18, and 33-35 specify which type of waveguide structure(s) is/are required. Claim 22 requires the system to include a wavelength separator, and Claim 23 specifies the type of separator required. Claims 24 and 32 require the system to include a third waveguide structure. Each of these claims requires features that were well known

and commonly used in optical systems at the time, or merely recite inherent properties of elements required by the claims. Implementing them in the Shaw-Islam combination would not have required undue experimentation on a part of a POSITA or required a modification to the Shaw-Islam system beyond which has already been discussed.

260. Thus, Shaw's disclosure of these features set forth in Ground 1 is applicable to the Shaw-Islam combination set forth in Ground 3 to render Claims 2-4, 9, 11-14, 16-24, and 30-35 obvious.

XIV. OTHER CONSIDERATIONS

261. It is my opinion that all elements of Claims 1-4, 9, 11-14, 16-25, and 30-35 are known in the art, and any differences between the claims of the '116 Patent and the prior art would have been obvious to a POSITA based on the disclosures of the applied references and the knowledge in the art.

262. I am not aware of any secondary considerations evidence bearing any nexus to the purported claimed invention.

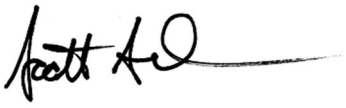
XV. CONCLUSION

263. For at least the foregoing reasons, it is my opinion that claims 1-14, 16-28, 30-35, 38-40, and 43-45 of the '116 Patent are unpatentable.

264. In signing this Declaration, I understand that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

265. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: April 10,2025



Scott A. Diddams