UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NOKIA OF AMERICA CORPORATION,

Petitioner

v.

ALEXANDER SOTO AND WALTER SOTO,

Patent Owner

Case: IPR2023-00680

U.S. Patent No. 9,887,795

DECLARATION OF DR. PAUL R. PRUCNAL

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Exhibit	Short Name	Description
Ex. 1001	’795 Patent	U.S. Patent No. 9,887,795
Ex. 1002	’795 File History	File History of U.S. Patent No. 9,887,795
Ex. 1003	Prucnal Declaration	Declaration of Dr. Paul Prucnal
Ex. 1004	Prucnal CV	*Curriculum Vitae* of Dr. Paul Prucnal
Ex. 1005	Agazzi ’640	U.S. Patent No. 6,879,640
Ex. 1006	Wei	U.S. Patent No. 6,873,800
Ex. 1007	Gans	U.S. Patent No. 5,388,088
Ex. 1008	Eroz	U.S. Patent No. 7,020,829
Ex. 1009	Agazzi ’341	U.S. Patent No. 7,933,341
Ex. 1010	Jiang	U.S. Patent No. 6,665,498
Ex. 1011	Liu	U.S. Patent No. 6,005,694
Ex. 1012	Poplawski	U.S. Patent No. 5,879,173
Ex. 1013	Lavoie	Renaud Lavoie, *The Evolution of the Pluggable Module*, Broadcast Engineering (2012)
Ex. 1014	SFP MSA	SFF Committee, INF-8074i Specification for SFP (Small Formfactor Pluggable) Transceiver, Rev. 1.0 (May 12, 2001)
Ex. 1015	Leon-Garcia	Alberto Leon-Garcia & Indra Widjaja, *Communication Networks Fundamental Concepts and Key Architectures* (2000)
Ex. 1016	Ramaswami	Rajiv Ramaswami & Kumar Sivarajan, *Optical Networks: A Practical Perspective* (2d ed. 2002)

Exhibit	Short Name	Description
Ex. 1017	Senior	John Senior, *Optical Fiber Communications: Principles and Practice* (1985)
Ex. 1018	Papadias	C. B. Papadias & D. T. M. Slock, *On the Decision-Directed Equalization of Constant Modulus Signals*, Proceedings of 1994 28th Asilomar Conference on Signals, Systems and Computers, Pacific Grove, CA, USA, pp. 1423-1427, Vol. 2 (1994)
Ex. 1019	Feldman	U.S. Patent No. 6,295,272
Ex. 1020	Martin	Martin P. Clark, *Wireless Access Networks: Fixed Wireless Access and WLL Networks—Design and Operation* (2000)
Ex. 1021	Wicker	Stephen Wicker & Vijay Bhargava, *Reed-Solomon Codes and Their Applications* (1994)
Ex. 1022	Richardson	Thomas J. Richardson & Rudiger L. Urbanke, *Efficient Encoding of Low-Density Parity-Check Codes*, IEEE Transactions on Information Theory, Vol. 47, No. 2, at p. 638 (2001)
Ex. 1023		[Reserved]
Ex. 1024		[Reserved]
Ex. 1025		[Reserved]
Ex. 1026		[Reserved]
Ex. 1027		[Reserved]
Ex. 1028		[Reserved]
Ex. 1029	Agrawal	Govind P. Agrawal, *Fiber-Optic Communication Systems* (3d. ed. 2002)

DECLARATION OF PAUL PRUCNAL

I, Paul Prucnal, do hereby declare and say as follows:

I. Introduction

1. My name is Dr. Paul Prucnal, and I have been retained as a technical expert by counsel for Petitioner Nokia of America Corporation ("Nokia") to address certain issues regarding U.S. Patent No. 9,887,795 ("the '795 Patent").

2. I have personal knowledge of the facts contained in this Declaration, am of legal age, and am otherwise competent to testify.

3. Unless otherwise stated, the matters contained in this Declaration are of my own personal knowledge and, if called as a witness, I could and would testify completely and truthfully with regard to the matters set forth herein.

4. My opinions are based on my years of education, research, and experience, as well as my study of the relevant materials. A list of materials I considered is included at the beginning of this Declaration.

5. I reserve all available rights to supplement this Declaration if further information becomes available, or if I am asked to consider additional information. This Declaration represents only those opinions I have formed to date.

6. Further, I reserve all available rights to consider and comment on any additional expert statements or testimony of Patent Owner's expert(s) in this matter.

7. I am being compensated at my usual consulting rate of $725 per hour for my time spent working on issues in this matter. My compensation does not depend on the outcome of this matter or the opinions I express.

II. Qualifications

8. A true and correct copy of my curriculum vitae is attached as Ex. 1004 to this Declaration.

9. I have over 40 years of experience in communications and signal processing. I am currently a Professor of Electrical Engineering at Princeton University in Princeton, New Jersey. I graduated *summa cum laude* from Bowdoin College in 1974 with an A.B. in Mathematics and Physics. I then graduated from Columbia University in 1976 with an M.S. in Electrical Engineering. I went on to receive an M.Phil. from Columbia University in 1978 in Electrical Engineering and a Ph.D. from Columbia University in 1979 in Electrical Engineering. The title of my thesis was "Threshold Detection in Optical Communications and Psychophysics." My thesis investigated the quantum nature of light, the optimal detection of photons in optical communication systems, and the question of whether the human visual system, which I postulated could be modeled as a doubly stochastic Poisson point process, is capable of detecting a single photon.

10. Upon graduation from Columbia in 1979, I joined Columbia as an Assistant Professor of Electrical Engineering, and in 1984 I was promoted to Associate Professor.

11. In 1988, I joined the faculty of Princeton University as an Associate Professor of Electrical Engineering. My responsibilities there included teaching and research.

12. In 1989 and until 1991, I was a founding director of the New Jersey Advanced Technology Center for Photonics and Optoelectronic Materials. My responsibilities there included leading a $10 million research program involving approximately thirty faculty members.

13. In 1990, I was promoted to Professor of Electrical Engineering at Princeton University. My teaching responsibilities include courses in circuits, signal processing, quantum electronics, and fiber-optic communications.

14. While at Princeton University, I have received numerous awards and recognitions, including: (a) becoming a Fellow of the National Academy of Engineers, a Fellow of the IEEE, and a Fellow of the Optical Society of America; (b) receiving the Rudolf Kingslake Medal and Prize from the SPIE for the most noteworthy original paper in Optical Engineering; (c) receiving the Gold Medal Award from the Faculty of Mathematics, Physics, and Informatics at the Comenius University for leadership in the field of Optics; (d) receiving the Princeton

University Graduate Mentoring Award; (e) receiving numerous Engineering Council Awards; (f) receiving the Walter Curtis Johnson Prize for Excellence in Teaching; (g) receiving the Princeton School of Engineering and Applied Science Distinguished Teacher Award; and (h) receiving The President's Award for Distinguished Teaching, Princeton University (2015).

15. In 1991, I was a visiting professor in the Research Center for Advanced Science and Technology at the University of Tokyo, where I held the NEC Chair. My responsibilities there included research on optical packet switching and giving lectures on fiber-optic networks.

16. In 1992, I was a visiting professor at the University of Parma. My responsibilities there included research on photonic switching and giving lectures on fiber-optic networks.

17. In addition to the activities, education, and professional experience listed above, I have been involved in several research projects that contribute to my expertise relating to fiber-optic communications.

18. In 1992-1995, I worked with Siemens Corporate Research on a project that involved research on ultrafast optical switching technology. My responsibilities included the investigation of optoelectronic technologies for high-speed multiplexing and switching.

19. In 1998-2001, I worked with Sun Microsystems on a project that involved research on optical backplanes and computer interconnects. My responsibilities included the design of a high-performance multiprocessor interconnection system.

20. In 1999-2000, I worked with SAIC on a project which involved research on fiber-optic network architectures. My responsibilities included the investigation of novel switching and multiplexing techniques.

21. In 2000-2002, I worked with Ultra Fast Optical Systems on a project that involved research and development on optical switching technology. My responsibilities included the design and testing of an all-optical switch.

22. In 2000-2003, I was a member of the advisory board on optical network technology for Alphion, Inc. My responsibilities included providing guidance on the development of technology in the optical networks space.

23. In 2003-2006, I worked with Kailight Inc. on a project that involved research and development on optical switching technology. My responsibilities included the design and testing of a digital optical repeater.

24. In 2004-2011, I worked with NEC Laboratories on a project that involved research on physical layer security in optical networks. My responsibilities included the design and analysis of techniques for optical steganography and data encryption using digital optical logic.

25. My research interests include fiber-optic communications systems and networks. I have extensive experience researching and teaching about optical signal processing and optical communications techniques such as multilevel modulation, equalization, and error-correcting codes. I also have experience with optical transceiver modules, including pluggable-type modules.

26. To date, I have published books on Optical CDMA and Neuromorphic Photonics, and 36 book chapters and reviews in the area of fiber-optic communications systems. In addition, I have published approximately 419 papers in conference proceedings and 329 peer-reviewed journal papers. I am also a named inventor on 28 patents relating to fiber-optic communications.

27. Through my work, I have earned the respect of the optical communication and electrical engineering community more broadly. I am a member of the advisory board on advanced computing and communications research for the Center for Computing Sciences. I have also chaired or served as a member on several dozen boards and committees related to electrical engineering.

III. Scope of the Engagement

28. I have been retained by Alston & Bird LLP on behalf of Nokia to provide various analyses and opinions. Among other tasks, I have been asked to address the technology claimed in the ’795 Patent and to evaluate whether certain

claims of the ’795 Patent would have been obvious to a person of ordinary skill in the art.

29. All of the opinions I express in this Declaration have been made from the standpoint of a person of ordinary skill in the relevant art at the time of the invention of the ’795 Patent, which I am informed is, for purposes of this matter, the earliest claimed priority date of June 10, 2003. With that said, none of my opinions would change if the proper priority date were found to be June 21, 2003.

30. I have been asked to identify the level of skill in the art pertinent to the ’795 Patent. It is my opinion that a person of ordinary skill in the art pertinent to the ’795 Patent would have had at least a bachelor’s degree in electrical engineering, computer engineering, or similar discipline and had at least two years of optical communications, networking and signal processing experience. A person with a different degree but with additional relevant experience could still qualify if the additional experience compensates for the different educational background.

31. I consider myself a person of ordinary skill in the art as of no later than the earliest claimed priority date (June 10, 2003).

32. My opinions are based on my experience and knowledge and the information I have reviewed as of the date of this Declaration. In connection with my analysis, I have reviewed the exhibits listed in the above list of exhibits, as well as each of the items referenced herein. I attest that the foregoing exhibits are true

and accurate copies that I downloaded. My opinions directed to the invalidity of the challenged claims are based, at least in part, on the following prior art publications:

- **"Agazzi '640"** (Ex. 1005), which is U.S. Patent No. 6,879,640, filed on October 20, 2000 and issued on April 12, 2005;
- **"Wei"** (Ex. 1006), which is U.S. Patent No. 6,873,800, filed on September 7, 2000 and issued on March 29, 2005;
- **"Gans"** (Ex. 1007), which is U.S. Patent No. 5,388,088, filed on April 2, 1992 and issued on February 7, 1995;
- **"Eroz"** (Ex. 1008), which is U.S. Patent No. 7,020,829, filed on June 4, 2003 and issued March 28, 2006.
- **"Agazzi '641"** (Ex. 1009), which is U.S. Patent No. 7,933,341, filed on February 28, 2001 and issued on April 26, 2011.

IV. Legal Standards

33. For purposes of this Declaration, counsel for Nokia have instructed me to make the following assumptions:

34. Claims are construed from the perspective of a person of ordinary skill in the art ("POSITA") as of the effective filing date of the patent application. Persons of ordinary skill in the art are deemed to read the claims in the context of the entire patent, including the specification and prosecution history. In other words, the terms are not considered in a vacuum.

35. It is my understanding that information that satisfies one of the categories of prior art set forth in 35 U.S.C. § 102 may be used in an invalidity analysis under §§ 102 or 103. If information is not properly classified as prior art under one of the subsections of § 102 of the Patent Act, then it may not form the basis of an anticipation or obviousness determination. It is also my understanding that, for *inter partes* review, applicable prior art is limited to patents and printed publications.

36. I am also informed and understand that a patent claim is invalid under 35 U.S.C. § 103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time of the invention to a POSITA to which the subject matter pertains. Obviousness, I am informed, is determined based on the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and secondary indications of non-obviousness to the extent they exist.

37. I understand that whether there are any relevant differences between the prior art and the claimed invention is to be analyzed from the view of a POSITA at the time of the invention. A POSITA is a hypothetical person who is presumed to be aware of all of the relevant art at the time of the invention. The POSITA is not an automaton and may be able to fit together the teachings of multiple patents (or other printed publications) by employing ordinary creativity and the common sense

that familiar items may have obvious uses in another context or beyond their primary purposes.

38. In analyzing the relevance of the differences between the claimed invention and the prior art, I understand that I must consider the impact, if any, of such differences on the obviousness or non-obviousness of the invention as a whole, not merely some portion of it. The person of ordinary skill faced with a problem is able to apply his or her experience and ability to solve the problem and also look to any available prior art to help solve the problem.

39. I understand that an invention would have been obvious if a POSITA, facing the wide range of needs created by developments in the field, would have seen an obvious benefit to the solutions tried by the patent applicant. When there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, it would have been obvious to a POSITA to try the known options. If a technique has been used to improve one device, and a POSITA would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

40. I understand that I do not need to look for precise teachings in the prior art directed to the subject matter of the claimed invention. I understand that I may consider the inferences and creative steps that a POSITA would have employed in reviewing the prior art at the time of the invention. For example, if the claimed

invention combines elements that were known in the prior art and if the combination yields results that were predictable to a POSITA at the time of the invention, then this would make it more likely that the claim was obvious. On the other hand, if the combination of known elements yields unexpected or unpredictable results, or if the prior art teaches away from combining the known elements, then this would make it more likely that the claim that successfully combined those elements was not obvious. I understand that hindsight must not be used when comparing the prior art to the invention during an obviousness analysis.

41. I understand that obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the patented invention. Obviousness may also be shown by demonstrating that it would have been obvious to combine the teachings of more than one item of prior art. I understand that a claimed invention may be obvious if some teaching, suggestion, or motivation exists that would have led a POSITA to combine the invalidating references. I also understand that this suggestion or motivation may come from sources such as explicit statements in the prior art, or from the knowledge of a person having ordinary skill in the art. Alternatively, any need or problem known in the field at the time and addressed by the patent may provide a reason for combining elements of the prior art. I also understand that when there is a design need or market pressure, and there are a finite number of predictable solutions,

persons of ordinary skill may be motivated to apply both their skill and common sense in trying to combine the known options in order to solve the problem.

42. I understand that absent evidence of an invention date prior to the filing date of a patent, the invention date of the patent is presumed to be its filing date. A prior invention requires a complete conception of the invention and a reduction to practice of that invention. The patent owner has the burden of establishing by clear and convincing evidence a date of conception earlier than the filing date of the patent.

V. Technical Background

43. In this technical background, I describe the pertinent technology as it existed as of June 2003, the assumed priority date of the '795 Patent.

44. The '795 Patent is generally related to communication over an optical network. Ex. 1001 at Abstract. Specifically, the '795 Patent claims a pluggable optical transceiver module that uses m-ary modulation and signal processing techniques to convert between electrical and optical signals. Ex. 1001 at cl. 1.

45. As I will describe, all these ideas were well known to a POSITA at the time of the alleged invention.

a. Optical Network

46. A fiber-optic network transmits information, in the form of modulated light, from one location to another. The modulated light, called signals, represents bits of data, such as voice, video, or computer data. Ex. 1011 at 1:14-24.

47. Fiber-optic networks have become more and more prevalent since the 1990s, due to an ability to convey significantly more information over longer distances than conventional electrical cables. For example, an optical fiber operating at 10 Gb/s can carry data equivalent to over 128,000 voice calls over hundreds of kilometers. And dozens of fibers may be included in a single cable, thereby multiplying the amount of data that can be transmitted. *Id.* at 1:36-45. Because optical cables can convey considerably more data than conventional electrical cables, fiber-optic networks are used to transmit large amounts of data across cities, states, and continents. *Id.* at 1:24-30.

48. User devices, such as phones, computers, and televisions, use optical signals that traverse the fiber network. But these devices operate using electrical signals, which requires the fiber-optic network to have optical-to-electrical interfaces that convert electrical signals to optical signals, and vice versa. Ex. 1010 at 1:17-46.

b. Pluggable Optical Transceiver Modules

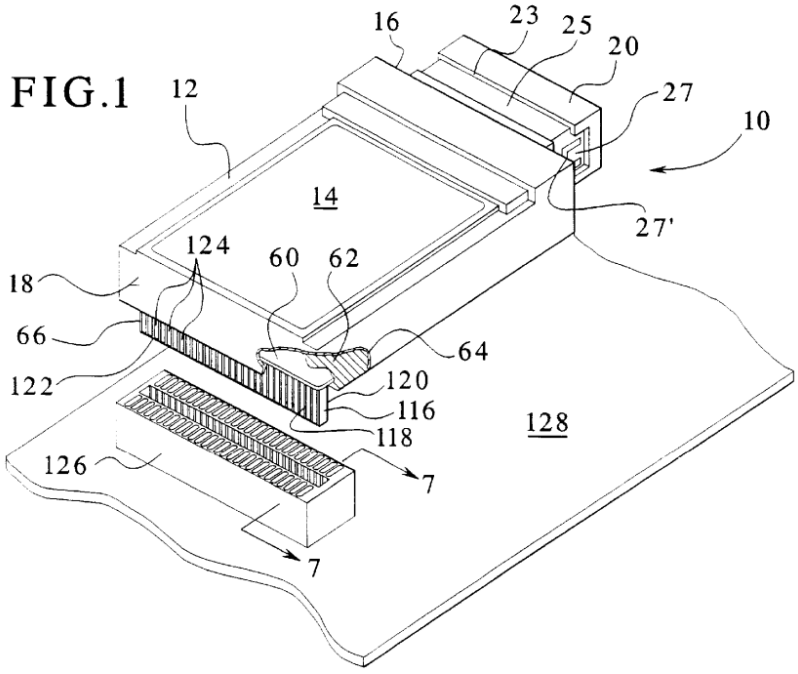
49. The optical-to-electrical interface is where electrical and fiber cables are connected to one another via an optical transceiver module. To allow the electrical and fiber cables to communicate with one another, the optical transceiver module converts signals between the optical and electrical domains. Ex. 1006 at 1:24-59.

50. For example, the transceiver module includes a transmitter system and a receiver system. The transmitter receives digital electrical signals, which includes electronic data (information) typically in the form of binary voltages that drive the optical transmitter. The optical transmitter converts the electrical signals to optical signals, which are emitted onto an optical fiber. Ex. 1017 at 399-403. The receiver includes a light detecting device that receives optical signals and converts them to electrical signals. The transmitter and receiver, which together form the transceiver, thus send signals back and forth across the electrical-to-optical interface, allowing communication between the electrical components and optical fibers. Ex. 1006 at 1:24-59.

51. Traditionally, optical transceiver modules were bulky and mounted in a relatively fixed configuration, such as mounted on a circuit card located in a computer, peripheral device, or on a shelf in an equipment rack. But it was desirable to produce a smaller hot-pluggable optical transceiver that was easily removable.

Ex. 1012 at 2:25-30. In 1995, one of the first such pluggable optical transceivers was produced, called the hot pluggable gigabit interface converter ("GBIC"). Ex. 1013 at 1.

52. Another example, from the late 1990s, of a pluggable "transceiver module which provides for a small, yet robust package, which is inexpensive to manufacture and can easily and quickly be installed and removed" is shown below. Ex. 1012 at Abstract, 2:25-30, Fig. 1.



53. However, because the pluggable optical transceivers were still relatively large, users desired a more compact, high-throughput fiber-optic transceiver in a small form pluggable ("SFP") package. Ex. 1006 at 1:65-2:4. For example, a prior art patent filed in 2000 specifically addresses how "to package the functions of a GBIC into the compact size of an SFP." *Id.*; *Id.* at Fig. 4A.

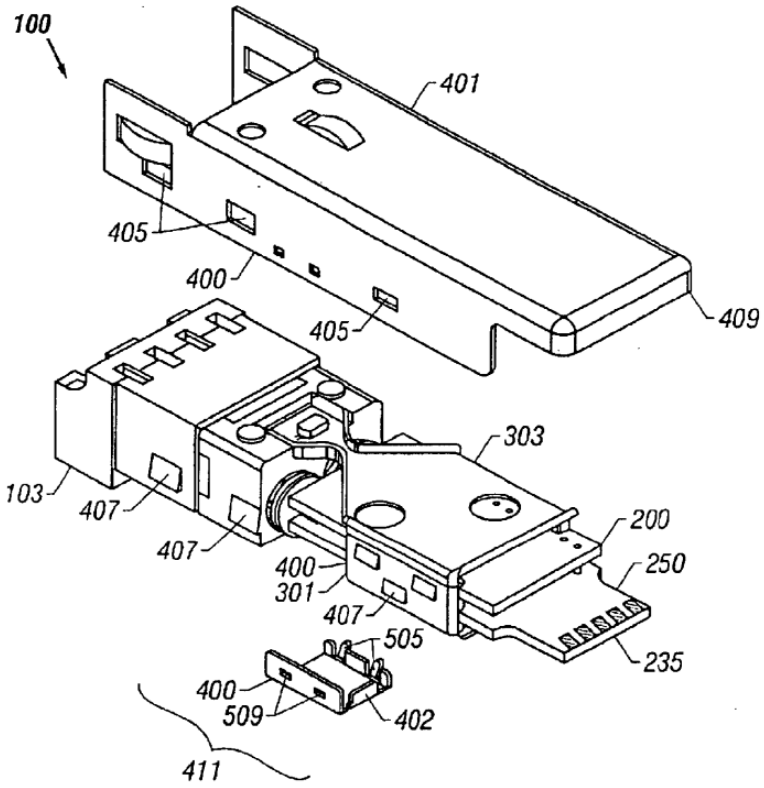


FIG. 4A

54. Around this same time, in the late 1990s and early 2000s, in an effort to standardize the industry, system vendors supported Multi-Source Agreements ("MSA") among several component suppliers to define and specify all the physical and electrical requirements for specific pluggable form factors. *See, e.g.*, Ex. 1014. One such example is the SFP MSA that defines the SFP form factor. *Id.*

c. M-ary Modulation

55. M-ary modulation is a process through which two or more bits of information are transmitted simultaneously. Ex. 1015 at 125-30. There are various schemes that may be employed to perform this modulation, including Quadrature Phase Shift Keying ("QPSK"), Quadrature Amplitude Modulation ("QAM"), and

Pulse Amplitude Modulation ("PAM"), which are some of the more common techniques. Ex. 1015 at 128; Ex. 1005 at 3:12-21, 17:5-8. Each of these modulation techniques was well known to a POSITA by the priority date of the '795 Patent.

56. M-ary modulation is a kind of digital modulation where two or more bits are transmitted simultaneously. The two or more bits are converted into one of M possible symbols for transmission. In general, M possible symbols can carry $\log_2 M$ bits of information. For example, M=4 possible symbols can carry 2 bits, as in QPSK; M=8 possible symbols can carry 3 bits, as in 8-QAM; and M=64 possible symbols can carry 6 bits, as in 64-QAM. For QPSK, QAM, and PAM, these symbols can be modulated onto a carrier signal using a different amplitude and/or phase for each symbol over the symbol duration. These symbols can be represented in a constellation diagram, where each symbol is a constellation point in the complex plane, representing amplitude and phase. In this plane, the distance from the center of the diagram is the amplitude and the angle from the x-axis is the phase. Since the bandwidth of a signal is proportional to the inverse of the symbol duration, and the number of bits in each symbol increases as $\log_2 M$, a key advantage of m-ary modulation with M greater than 2 is that more data can be transmitted in the same bandwidth—typically, $\log_2 M$ times more data—as compared to binary modulation that carries only one bit per symbol (M=2). The main disadvantage of m-ary modulation, compared to binary modulation, is that the transmission power must be

increased to maintain the same spacing of the points in the constellation diagram, and therefore the same bit error rate.

57. With QPSK modulation, M=4 as there are 2 bits per symbol, and each symbol has the same amplitude but one of four different phases. The phases are separated by 90 degrees. Thus, the constellation points are four equally spaced points on a circle.

58. With QAM modulation, each symbol has a different amplitude and/or phase. Although m-ary QAM with M constellation points is referred to as M-QAM, 4-ary QAM, *i.e.*, 4-QAM, is often referred to as just QAM, for short. The typical constellation points for 4-QAM are four equally spaced constellation points with the same amplitude, as this provides the lowest bit error rate in standard cases. Note that QAM differs from QPSK in that the amplitude of the symbols can vary, but QPSK is the same as 4-QAM in its typical constellation.

59. With PAM, each symbol has the same phase but a different amplitude. Binary PAM is often referred to as just PAM, but PAM also covers m-ary PAM, where there are M different amplitudes for the symbols.

d. Equalization

60. I have also been asked to provide an overview of equalization, including blind and non-blind equalization, which are two well-known signal processing techniques used to remove distortion.

61. In communications, equalization is the mitigation of distortion of a signal transmitted through a communications channel. Ex. 1016 at 266-67; Ex. 1017 at 412-14. Equalizers typically attempt to make the frequency response of the channel in combination with the equalizer constant in amplitude and linear in phase across the channel, thus removing signal distortion. Two types of equalizers are linear tapped delay line and decision feedback equalizers, which multiply different versions of the signal with weights, *i.e.*, coefficients, and then sum these weighed signals to form the output signal. For a variable channel, these equalizers require some type of reference signal to be able to adapt the coefficients to mitigate distortion, and these types of reference signals can be split into two basic types: blind and non-blind.

62. In non-blind equalization, a training sequence of symbols known by the equalizer is included in the transmitted signal so that the equalizer can calculate the coefficients based on the distortion in the received training sequence and then correct the distortion in the rest of the transmitted signal. In blind equalizers, the equalizer estimates the coefficients without knowledge of the channel statistics—it uses only the transmitted signal characteristics without a training sequence. Examples of such characteristics are that the signal is constant amplitude, as with QPSK, or consists of digital symbols with a given modulation and symbol duration. For the latter case, the detected, *i.e.*, decided, symbols at the receiver can be used as the reference for

estimating and correcting the distortion, assuming that the bit error rate of the receiver is not too high. A POSITA would have understood that this technique is decision directed equalization, as it is commonly referred to in the literature. Ex. 1018 at Abstract ("Decision-directed (DD) equalization is the most primitive blind equalization (BE) method for the cancelling of inter-symbol-interference (ISI) in data communication systems."). A hybrid approach uses a training sequence to get an initial estimate of the coefficients and then adjusts the coefficients with the changing channel based on the decided data symbols received after the training sequence. A POSITA would have understood that such an equalizer uses both blind and non-blind techniques.

e. Error Correction Techniques

63. Additionally, I have been asked to provide an overview of known error correction techniques. Detection errors in the received signals can be caused by a number of factors, including noise, interference, channel distortion, and decoding issues.

64. There are many ways to correct errors, including repeat requests, forward error correction ("FEC"), and hybrid schemes that utilize both. Repeat requests can be triggered by the detection of errors using, for example, a cyclic redundancy check ("CRC") or other form of error detection. The system then

requests a retransmission of the message that was previously received with an error to attempt to avoid the detection error with the retransmitted message.

65. FEC is the process of using redundant or duplicate data to allow for the receiving side of a system to reconstruct the transmitted data to be nearly error-free, *i.e.*, correcting any errors that occur. Ex. 1020 at 353-58. FEC does not require the retransmission of data, although it does require a larger message (to account for the data redundancy). Ex. 1016 at 267-68.

66. There are two general types of FECs: block codes and convolutional codes. Ex. 1016 at 267-72; Ex. 1015 at 153. In a block code, the message is divided into fixed-size blocks of bits to which redundant bits are added for error correction. *Id.* In a convolutional code, the message comprises data streams of arbitrary length and parity symbols are generated by the sliding application of a Boolean function in the data stream. *Id.*

67. Reed-Solomon and low-density parity-check ("LDPC") codes are types of block codes, whereas a trellis code is a type of convolution code. Ex. 1016 at 270-71; Ex. 1015 at 131. Each of the aforementioned codes was well-known to a POSITA.

68. To implement error correction, encoding and decoding processing is performed by encoders and decoders. Ex. 1015 at 153-54. These techniques allow

for the correction of errors in the detected received signal as long as there are not too many errors in the detected signal before error correction.

VI. The ’795 Patent

69. The ’795 Patent is generally directed towards communications over an optical network. Specifically, the ’795 Patent discloses a pluggable optical transceiver module that uses m-ary modulation and signal-processing techniques to convert between electrical and optical signals. Ex. 1001 at Abstract, cl. 1.

70. I understand the filing date of Provisional Application No. 60/477,845, to which the ’795 Patent claims priority, is June 10, 2003. Ex. 1001.

71. The claims of the ’795 Patent that are being challenged, and that I have been asked to evaluate, are claims 1-3, 5, 10-14, and 16-21. I have reproduced the challenged claims below:

Claim	Recitation
[1.Pre]	A method for m-ary modulation communication by a pluggable optical transceiver module comprising of:
[1.A]	receiving a first electrical binary data signal through a system interface of the pluggable optical transceiver module;
[1.B]	converting the first electrical binary data signal in the pluggable optical transceiver module to a first electrical m-ary modulation signal;
[1.C]	amplifying the first electrical m-ary modulation signal to drive an optical transmitter in the pluggable optical transceiver module;
[1.D]	emitting a first optical signal on a first wavelength responsive to and representative of the amplified first electrical m-ary modulation signal from the optical transmitter in the pluggable optical transceiver module;
[1.E]	receiving a second optical signal on a second wavelength and producing an electrical signal from an optical detector in the pluggable optical transceiver module;
[1.F]	amplifying the electrical signal to facilitate clock and data recovery in the pluggable optical transceiver module;
[1.G]	recovering a clock data information from the amplified electrical signal to produce a second m-ary modulation signal in the pluggable optical transceiver module;
[1.H]	demodulating the second m-ary modulation signal to a second electrical binary data signal in the pluggable optical transceiver module; and
[1.I]	transmitting the second electrical binary data signal through the system interface of the pluggable optical transceiver module.
2	The method of claim 1, whereby the form factor of the pluggable optical transceiver module is a pluggable form factor standard.
3	The method of claim 2, whereby the pluggable form factor standard of the pluggable optical transceiver module is an SFP form factor or SFP+ form factor standard.
5	The method of claim 1, whereby the m-ary modulation is a m-ary pulse amplitude modulation communication method that uses two or more bits per symbol for communication.
10	The method of claim 1, whereby the first electrical binary data signal and second electrical binary data signal are parallel electrical binary data signals.

11	The method of claim 1, whereby the first optical signal emitted by the pluggable optical transceiver module is dual polarized.
12	The method of claim 1, whereby the second optical signal received by the pluggable optical transceiver module is dual polarized.
13	The method of claim 1, whereby the m-ary modulation is a m-ary quadrature amplitude modulation communication method that uses two or more bits per symbol for communication.
14	The method of claim 1, whereby the m-ary modulation is a m-ary quadrature phase shift keying modulation communication method that uses two or more bits per symbol for communication.
16	The method of claim 1, further comprising coding the first electrical binary data signal and decoding the second electrical binary signal according to an error correcting code in the pluggable optical transceiver module.
17	The method of claim 16, whereby the error correcting code is a convolutional code.
18	The method of claim 16, whereby the error correcting code is a forward error correcting (FEC) code.
19	The method of claim 16, whereby the error correcting code is a trellis code.
20	The method of claim 16, whereby the error correcting code is a Reed-Solomon code.
21	The method of claim 16, whereby the error correcting code is a low-density parity-check (LDPC) code.

VII. Prosecution History

72. U.S. Patent Application No. 15/095,137 (the "'137 Application"), which matured into the '795 Patent, was filed on April 10, 2016. Ex. 1001.

73. The '137 Application was filed with five claims. Ex. 1002 at 240-41. Independent claim 1 disclosed a method for m-ary modulation by an optical transceiver module that performed a number of signal processing steps. *Id.* Dependent claim 2 disclosed a number of optical transceiver form factors. *Id.* The

remaining dependent claims (claims 3-5) disclosed m-ary modulation techniques and equalization methods. *Id.* None of the original claims included a "pluggable" limitation. *Id.*

74. During prosecution, the '137 Application was rejected twice. In a first rejection, claims 1 and 3-5 were rejected as anticipated by Brede (U.S. Patent No. 6,603,822). Ex. 1002 at 174-78. Claim 2 was rejected as obvious over Brede in view of Aronson (U.S. Pub. No. 2007/0031153) as Aronson disclosed the specific form factors of the optical transceiver module. *Id*.

75. Applicants amended claims 1-5 to include the "pluggable" limitation, arguing that the HDT disclosed in Brede was an OLT, not a pluggable transceiver. Ex. 1002 at 174-78, 152. For example, Applicants distinguished the OLT in Brede, where the optical elements are separate and distinct from the OLT, from the claimed pluggable optical transceiver module, where the optical elements are included within the module.

> While Applicants' acknowledge that an OLT is a device that transmits and receives and thus can be considered a transceiver, however, the Brede optical elements (14, 16 of Fig. 3) are described as distinct elements that transmit and receive separately and NOT as a transceiver as in Applicants' claims. Additionally, these optical elements (14, 16) are connected to the OLT 12 via a coaxial cable interface (22, 28), again distinguished as distinct from the OLT 12 and again NOT as a pluggable optical transceiver module as in the Applicants' claims.

Ex. 1002 at 153. Applicants' argument for claim 2 was that the secondary reference lacked the network interface of the primary reference. Ex. 1002 at 154.

76. In a second rejection, claims 1, 3-7, 10, 13-16, 18, and 20-21 were rejected as anticipated by Brede. Ex. 1002 at 121-28. Claims 11-12, 17, and 19 were rejected as obvious over Brede. *Id.* Claims 2, 8, and 9, which related to form factors, were rejected as obvious over Brede in view of Sheth (U.S. Patent No. 7,729,617) as Sheth taught that standardized pluggable form factors were well known in the art. *Id.*

77. In response, Applicants reiterated the arguments from the first office action response. Ex. 1002 at 69-74. Specifically, that the HDT (*i.e.*, OLT) disclosed in Brede was not a pluggable transceiver, and the secondary reference lacked the network interface. *Id.* Moreover, Applicants further noted that no reference refers to the rack mounted HDT in Brede as an optical transceiver.

> [T]he HDT is a rack mounted unit that is securely mounted using eight screws to the metal frame of a shelf of a rack … Additionally, it should be noted that Brede's optical transmitters 14 and optical receivers 16 are yet more rack mounted units that connect to the HDT 12 via coaxial cables 22, 28 respectively, and importantly that none of these references refer to [sic] this entirety of rack mounted units as a pluggable optical transceiver, nor even just an optical transceiver as in the Examiner's interpretation, on the contrary these references teach away from this interpretation.

Ex. 1002 at 70.

78. After this response, the Examiner issued an allowance without any further explanation or remarks. Ex. 1002 at 56.

79. As explained in detail below, none of the primary references in this Petition disclose a rack mounted OLT with optical elements separate and distinct from the optical transceiver module. Instead, the primary references disclose optical transmitter and receiver elements that are integrated together within the transceiver module which, according to the Applicants, is what differentiates an optical transceiver module from an OLT. For example, Agazzi '341 discloses an "optical transceiver module" where "the transmitter and receiver sections … are implemented as a transceiver integrated circuit constructed as a single chip" (Ex. 1009 at 3:34-36, 4:61-65) and Agazzi '640 discloses an "optical communications transceiver" where "the receivers and transmitters are integrated on a single integrated circuit" (Ex. 1005 at Abstract, 16:9-14).

80. This would have changed the motivation-to-combine calculus as a POSITA would have understood the small optical transceiver modules with integrated optoelectronics as taught by the primary references in this Petition are more easily implemented in a pluggable form factor. Additionally, the argument raised by the Applicants to differentiate between the prior art OLT in Brede and an optical transceiver module would not apply to the primary references in this Petition because the primary references in this Petition disclose smaller optical transceiver modules with integrated optoelectronics, not OLTs which are larger devices used at

the end of a point-to-point link to multiplex and demultiplex wavelengths. Ex. 1016 at 406.

VIII. Claim Construction

81. Based on my review of the ’795 Patent and its file history, a POSITA would have understood the claim terms in light of the specification, and interpreted them by using their plan and ordinary meaning in accordance with the then current state of the art.

IX. Prior Art References

a. Agazzi ’640 Overview

82. U.S. Patent No. 6,879,640 to Agazzi et al., titled “Method, Apparatus and System for High-Speed Transmission on Fiber Optic Channel,” issued on April 12, 2005, and derives from U.S. Patent Application No. 09/693,709, which was filed on October 20, 2000. Ex. 1005 at 1. Agazzi ’640 was not considered during prosecution of the ’795 Patent.

83. Agazzi ’640 teaches an optical transceiver module that processes signals for an optical channel using m-ary modulation, equalization, and forward error correction codes. *Id.* at 16:7-19, 3:12-49. The goal of the invention in Agazzi ’640 is to use “channel coding and bandwidth efficient modulation techniques to overcome the limitations of low quality optical channels and result in higher transmission rates and reduced system costs.” *Id.* at 1:44-48. Specifically, Agazzi ’640 teaches “complex digital signal processing (DSP) and coding algorithms”

implemented "in a singled monolithic chip" to reduce costs and increase bandwidth. *Id.* at 3:40-4:4. Agazzi '640 further teaches a small optical transceiver module where the "transmitters and receivers can be integrated on a single integrated circuit." *Id.* at Abstract.

b. Wei Overview

84. U.S. Patent No. 6,873,800 to Wei et al. ("Wei"), titled "Hot Pluggable Optical Transceiver in a Small Form Pluggable Package," issued on March 29, 2005, and derives from U.S. Patent Application No. 09/656,779, which was filed on September 7, 2000. Ex. 1006 at 1. Wei was not considered during prosecution of the '795 Patent.

85. Wei teaches a hot pluggable small form factor optical transceiver module. *Id.* 3:29-32. The goal of the invention in Wei is to create a pluggable optical transceiver module that is more compact and has a higher data throughput than other pluggables on the market at the time to allow for easier servicing of communication systems and shorter downtimes. *Id.* at 1:60-2:11. To accomplish this, Wei teaches how to produce a SFP transceiver. *Id.* at 3:29-32. Specifically, Wei teaches "vertically stacked receiver and transmitter printed circuit boards" allows packaging the functions of larger pluggables, Like a GBIC, into smaller form factors. *Id.* At 2:28-35.

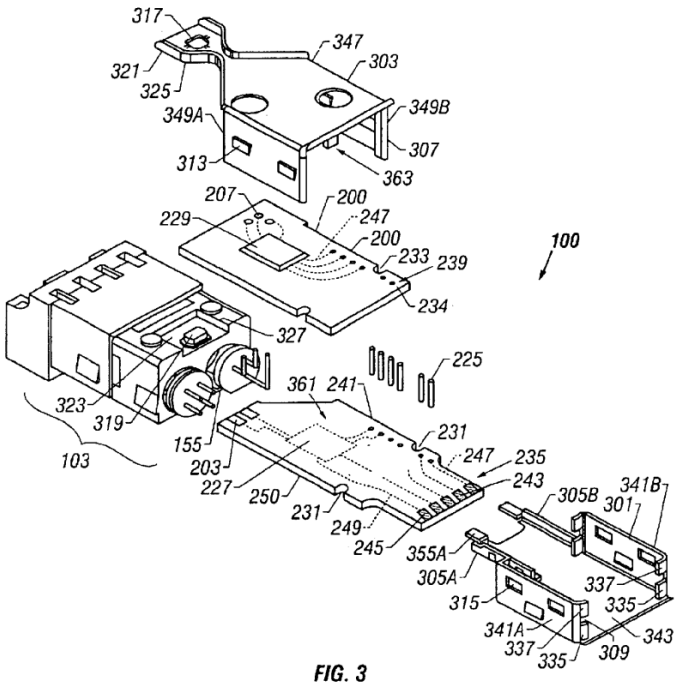


FIG. 3

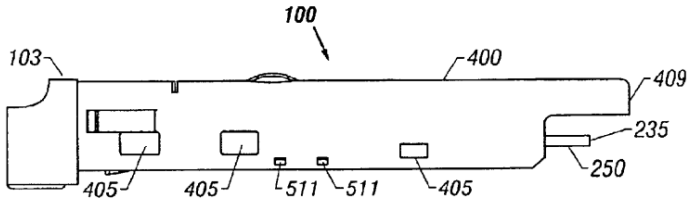


FIG. 6C

c. Gans Overview

86. U.S. Patent No. 5,388,088 to Gans et al. ("Gans"), titled "Multiple Polarization Sensitive Detection Arrangement for Fiber Optic Communications," issued on February 7, 1995, and derives from U.S. Patent Application No. 862,398, which was filed on April 2, 1992. Ex. 1007 at 1. Gans was not considered during prosecution of the '795 Patent.

87. Gans discloses that "[d]emand for bandwidth in lightwave communication systems is ever increasing," but "it is desirable to use existing

systems to maximum capacity" rather than install additional fiber cable, which is costly. *Id.* at 1:14-19. To address this problem, Gans teaches transmitting and receiving dual polarized optical signals. *Id.* at 1:20-27. Gans explains that "[t]ransmission of different data sequences in the same fiber via a separate polarization for each sequence permits more information to pass through the fiber without increasing the bit rate in any particular polarization." *Id.* at 1:23-27.

d. Eroz Overview

88. U.S. Patent No. 7,020,829 to Eroz et al. ("Eroz"), titled "Method and System for Decoding Low Density Parity Check (LDPC) Codes," issued March 28, 2006, and derives from U.S. Patent Application No. 10/454,439, which was filed on June 4, 2003. Ex. 1008 at 1. Eroz was not considered during prosecution of the '795 Patent.

89. Eroz discloses coding optical signals using "Reed-Solomon" or "LDPC" error correction codes "to ensure reliable communication across noisy communication channels." *Id.* at 1:42-50, 7:12-16. Eroz also discloses implementing these error correcting codes in fiber-optic communications. *Id.* at 14:42-47. Eroz further discloses utilizing "codes efficiently to support high data rates, without introducing greater complexity." *Id.* at 2:3-5.

e. Agazzi ’341 Overview

90. U.S. Patent No. 7,933,341 to Agazzi et al. (“Agazzi ’341”), titled “System and Method for High Speed Communications using Digital Signal Processing,” issued on April 26, 2011, and derives from U.S. Patent Application No. 09/797,428, which was filed on February 28, 2001, and published as U.S. Patent Application Publication No. 2001/0035994 on November 1, 2001. Ex. 1009 at 1. Agazzi ’341 was not considered during prosecution of the ’795 Patent.

91. Agazzi ’341 teaches an optical transceiver module that processes signals for an optical channel using m-ary modulation/demodulation, equalization, and forward error correction codes. *Id.* at 2:8-29, 4:33-39.

92. The goal of the invention in Agazzi ’341 is to increase the bandwidth and transfer rate of data across existing communications systems and to do so “in a cost effective manner.” *Id.* at 1:31-51.

93. Agazzi ’341 further teaches a small optical transceiver module with a transmitter and receiver on an “integrated circuit constructed as a single chip.” *Id.* at 4:63-65. For example, “the transmitter and receiver sections 50 and 82 typically would be implemented as a CMOS PHY transceiver integrated circuit.” *Id.* at 14:50-52.

X. Grounds 1-3 render the challenged claims obvious.

a. Ground 1: The combination of Agazzi '640 and Wei render claims 1-3, 5, 10, 13-14, and 16-19 obvious.

94. Both Agazzi '640 and Wei are directed to optical transceiver modules with integrated optoelectronics that interface optical fibers to electronic circuitry by converting between optical signals and electrical signals. Ex. 1006 at 1:24-30; Ex. 1005 at 4:15-32, 12:18-23, 15:7-10, 16:7-14, at Figs. 1D, 2A, 3. Indeed, Agazzi '640 and Wei both teach transceiver modules that include an electrical system interface, an optical transmitter, an optical receiver, and an amplifier. Ex. 1005 at Figs. 1D, 2A, 3, 2:1-11, 7:14-24, 2:66-3:4; Ex. 1006 at 1:24-45, 4:40-55.

95. As explained *supra*, Wei specifically discloses vertically stacked transmitter and receiver printed circuit boards that allow for the functionality of larger GBIC modules to be included inside an SFP package. This accomplishes the stated goal in Wei—creating a smaller, more compact transceiver module that is hot pluggable with "reduce[d] manufacturing costs" in order to allow service technicians to quickly replace damaged transceiver modules with limited down time. Ex. 1006 at 1:53-2:11.

96. Agazzi '640 specifically teaches a transceiver module that performs signal processing, including m-ary modulation, equalization, and error correction. This allows the transceiver module in Agazzi '640 to transmit data at higher rates through existing fiber infrastructure, which is a specific goal of Agazzi '640. Ex.

1005 at 2:66-3:55. Agazzi '640 also teaches that "it is desirable to achieve high levels of chip integration, which requires that all analog processing functions, such as amplifiers, mixers, analog filters and data converters be integrated in a single chip." Ex. 1005 at 4:9-13. Agazzi '640 further teaches that "[a]ll of the electronics illustrated in FIG. 2 and encompassed within the dotted line 225 may be integrated into a single integrated circuit, for example a CMOS integrated circuit chip. By integrating all the electronics within the block 225 on a single chip, the system cost may be reduced. By placing as much of the processing as possible within the integrated circuit 225, costs of assembly, alignment and multiple optical parts may be greatly reduced." Ex. 1005 at 9:33-41.

97. Agazzi '640 does not, however, expressly disclose a pluggable transceiver module in a small form factor package as taught in Wei. Nor does Wei expressly disclose the signal processing techniques taught in Agazzi '640. A POSITA would have understood that the transceiver as contemplated in Agazzi '640, which was taught as constructed as a single chip, would have been implemented in a SFP transceiver as taught in Wei. And a POSITA would have been motivated to combine the transceiver module of Agazzi '640 with the SFP package of Wei to create a smaller transceiver with greater data throughput that was easily removable and cost-effective.

98. There were several reasons a POSITA would have been motivated to combine Agazzi '640 with Wei. First, market pressures were increasing the demand for compact pluggable transceivers with high data throughput rates in a standardized form factor as users desired a high throughput pluggable transceiver which led the industry to standardize the SFP form factor to ensure compatibility across fiber-optic systems. Ex. 1008, 1:66-2:4; Ex. 1014. Accordingly, as a result of consumer preferences and industry standards, a POSITA would have understood that higher throughput pluggable transceivers in an SFP form factor were needed. Second, an m-ary pluggable transceiver module would be easier to install, repair, and replace than a mounted transceiver. Ex. 1006 at 2:5-11. This would decrease the chances for improper installation. It also decreases the likelihood that other components near the transceiver would be damaged during servicing. An m-ary pluggable transceiver would also take less time to install, repair, and/or replace. Ex. 1006 at 2:5-11. This, in turn, means less down time for the fiber-optic system during maintenance or servicing of the transceiver. Ex. 1011 at 1:45-52.

99. Third, an m-ary pluggable transceiver in a SFP package was more compact and takes less room than other transceivers. Decreasing the size was a stated goal in both Agazzi '640 and Wei. Ex. 1005 at 9:33-41; Ex. 1006 at 1:67-2:4. Thus, a POSITA would have been motivated to combine Agazzi '640 with Wei to create a smaller transceiver. This is because Wei discloses how to efficiently

package transceiver components to fit within a pluggable form factor: "separate vertically stacked printed circuit boards allows packaging the functions of [larger modules] within an LC or other small form factor package" like the SFP. Ex. 1006, 2:1-2, 2:28-32. A POSITA would have understood how to package the components of a module like Agazzi '640 into an SFP based on the disclosure in Wei. This was important because OLTs and ONTs often have many components, like switches and routers, located in large racks. Therefore, space was a limiting factor in many cases and smaller optical components were desired.

100. Fourth, an m-ary pluggable transceiver was more cost effective. Decreasing costs was a stated goal in both Agazzi '640 and Wei. Ex. 1005 at 1:45-49; Ex. 1006 at 1:50-69. Thus, a POSITA would have been motivated to combine Agazzi '640 with Wei to create an m-ary pluggable transceiver because pluggable transceivers were easier to install, repair, and replace, which allowed less skilled technicians to be able to service the communication system. Ex. 1006 at 2:5-11. Moreover, technicians did not have to repair and replace larger equipment, like a switch or router, when an optoelectrical component in a mounted transceiver failed. Instead, the technician simply replaced the hot pluggable transceiver with a new transceiver. And manufacturing costs were decreased when transceivers were produced separate from other optoelectrical equipment on printed circuit boards. Ex. 1006 at 1:45-60. Further, the smaller size of the transceiver allowed the optical

equipment to take up less space, thus saving on rent and utilities. And, importantly, the increased data throughput rates of m-ary pluggable transceivers allowed for higher data speeds without the need to replace older fiber channels.

101. Fifth, an m-ary pluggable transceiver would have higher data throughput rates in a small form factor. Increasing the data throughput rate in the transceiver was a stated goal in both Agazzi '640 and Wei. Ex. 1005 at 2:66-3:55; Ex. 1006 at 1:66-2:4. Accordingly, a POSITA who wanted to maintain high data throughput rates, as taught by Agazzi '640's use of m-ary modulation, would have looked to Wei when evaluating how to package a high throughput transceiver in a SFP form factor as Wei also taught high data throughput. This allowed for more data to be transferred in the same channel over the same amount of time as traditional binary modulation and was a simple way to increase data speeds in a communication system because it did not require replacement of older fiber channels which was a costly and resource intensive activity.

102. Moreover, a POSITA would have had a reasonable expectation of success in combing the transceivers in Agazzi '640 and Wei to produce expected results. In fact, many of the expected results of the combination were stated goals in the references.

103. A POSITA also would have been motivated to combine transceivers that perform advanced signal processing, like in Agazzi '640, with a pluggable

transceiver, like in Wei, after reviewing the prior art. For example, U.S. Patent No. 6,665,498 to Jiang discloses a high speed transceiver module that has a transmitter, receiver, amplifier, and clock data recovery unit. Ex. 1010 at 3:34-4:3. In addition to signal processing techniques, Jiang teaches that is it important to provide a smaller transceiver that is capable of conveying information at similar rates to larger transceivers, wherein the transceiver is "inexpensive to manufacture." Ex. 1010 at 1:54-61. Jiang also recommends making the transceiver pluggable, stating: "It is also easier to make the transceiver pluggable." Ex. 1010 at 5:34-41. A POSITA would thus have been motivated to combine signal processing capabilities inside a small pluggable transceiver.

104. As another example, U.S. Patent No. 6,295,272 to Feldman et al. ("Feldman") discloses a pluggable transceiver module in the form of a GBIC (the larger predecessor of the SFP) that conveys m-ary modulated signals from a subcarrier channel to a high speed channel. Ex. 1019 at Abstract, 6:21-29, Fig. 13. Although the m-ary modulation disclosed in Feldman occurs before the signal is conveyed by the GBIC, a POSITA would have understood that the m-ary functionality can be added into the pluggable to reduce the number of components. Moreover, Wei teaches "package[ing] the functions of a GBIC into the compact size of an SFP." Ex. 1006 at 2:1-4.

105. For at least these reasons, in reading Agazzi '640, a POSITA would have been motivated to look to the pluggable transceiver module in Wei and would have had a reasonable expectation of success in combining the two optical transceiver modules.

i. Claim 1: [1.pre] A method for m-ary modulation communication by a pluggable optical transceiver module comprising of:

106. To the extent the preamble is limiting, a POSITA would have understood the combination of Agazzi '640 and Wei discloses this limitation.

107. Agazzi '640 discloses an "optical communications transceiver." Ex. 1005 at 12:18-23. Agazzi '640 further discloses a "receiver module" and a "transmitter module[]." Ex. 1005 at 11:15-16, 14:34, Figs. 2A, 3. A POSITA would have understood that a transceiver includes both transmitting and receiving capabilities.

108. Agazzi '640 also discloses performing multilevel modulation within the transmitter/receiver portions of the optical transceiver, including "Pulse Amplitude Modulation (PAM) or Quadrature Amplitude Modulation (QAM) to encode several bits per transmitted symbol." Ex. 1005 at 3:15-20, Figs. 2A, 3. The modulation techniques disclosed in Agazzi '640 cover m-ary modulation as the '795 Patent identifies PAM and QAM as types of m-ary modulation techniques. Ex. 1001 at 10:11-19.

109. Wei discloses a "fiber optic transceiver module" where the module is a "pluggable optical transceiver in a small form pluggable." Ex. 1006 at 2:17-20, 3:29-32. Specifically, Wei discloses an optical transceiver module "in a small form pluggable (SFP), LC package." Ex. 1006 at 2:1-4, 2:28-35.

110. A POSITA would have been motivated to implement the transceiver in Agazzi '640 in Wei's SFP package for at least the reasons explained in Section X(a) above. Therefore, it is my opinion that a POSITA would have understood that the combination of Agazzi '640 and Wei disclose "[a] method for m-ary modulation communication by a pluggable optical transceiver module." To the extent the pluggable limitation is included in subsequent claim limitations, my above analysis applies.

ii. Claim 1: [1.A] receiving a first electrical binary data signal through a system interface of the pluggable optical transceiver module;

111. A POSITA would have understood the combination of Agazzi '640 and Wei discloses this limitation. Agazzi '640 discloses an optical transceiver module that includes an optical transmitter that receives an electrical data signal through the system interface, performs signal processing, converts it to an optical signal, and then transmits the optical signal onto the optical fiber. *See, e.g.*, Ex. 1005 at Fig. 2A, 10, 8:36-9:41. For example, in Figure 10 below, Agazzi '640 discloses the optical transmitter portion of the transceiver includes an "XGMII (Ten Gigabit

Media Independent Interface) module" that receives electrical signals. Ex. 1005 at 8:36-49. Agazzi '640 further discloses that "[o]ther system interfaces besides the XGMII" can be used including, for example, the XAUI interface. Ex. 1005 at 8:51-65.

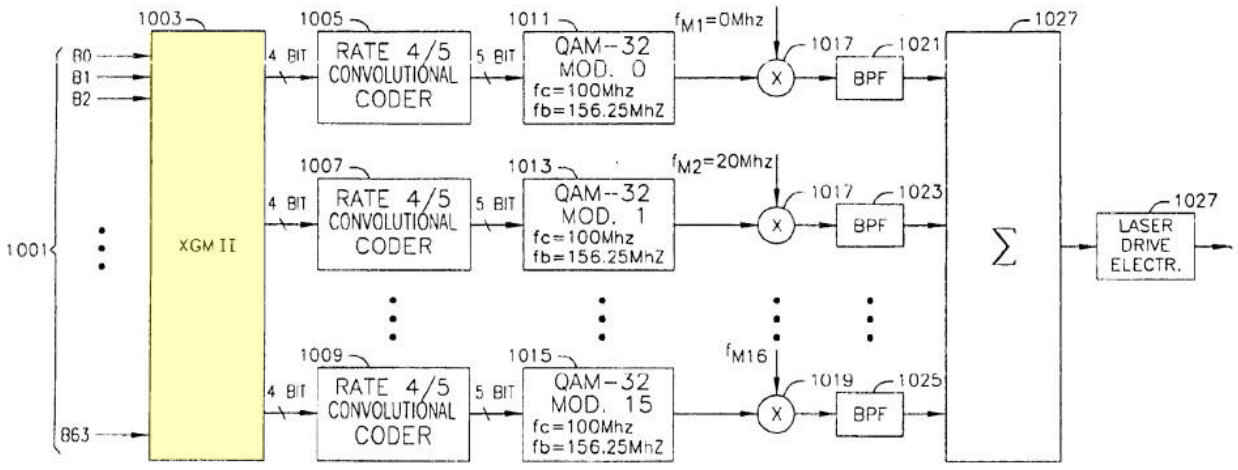


FIG. 10

112. A POSITA would have understood the XGMII interface (in yellow above) to be an interface for the receipt of electrical data signals because the '795 Patent explicitly notes that the XGMII interface is a conventional system interface. Ex. 1001 at 9:13-17. A POSITA would also have understood that the electrical system interface receives many electrical data signals, each one of which is an example of the claimed "first electrical binary data signal." The "first" electrical binary data signal is an arbitrary name for a signal that passes through the electrical system interface. A POSITA would further have understood the electrical data signals are digital which are understood to be binary. Ex. 1005 at 1:52-65. For

example, Leon-Garcia teaches that digital signals "transfer a sequence of 0s and 1s," which is a binary sequence. Ex. 1015, 107.

113. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '640 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei discloses a male electrical connector coupled to an external electrical connector that "allow[s] electrical signals … to be coupled into or out of the fiber optic module." Ex. 1006 at 4:56-62. A POSITA would have understood this coupled area (see red rectangles below) to be an interface for the receipt and transmission of binary electrical data signals. Ex. 1006 at Figs. 3, 6C, 2:5-11.

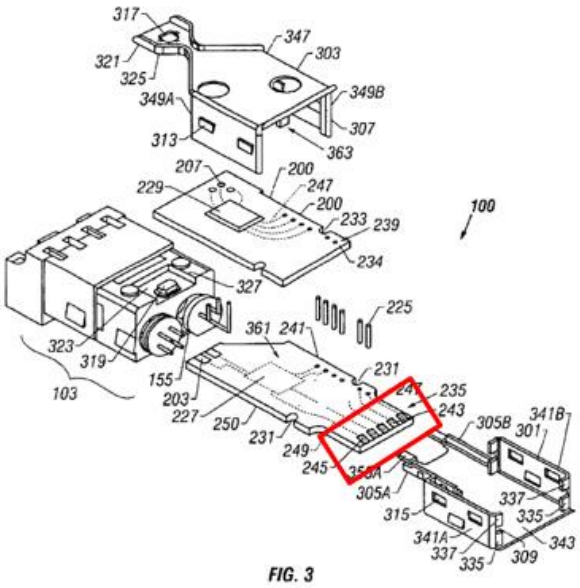


FIG. 3

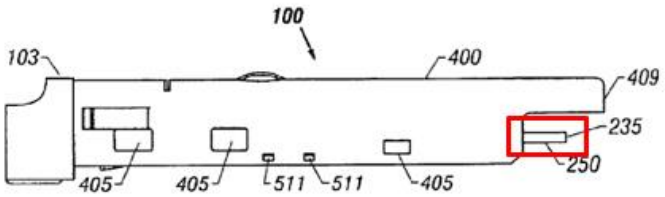


FIG. 6C

iii. Claim 1: [1.B] converting the first electrical binary data signal in the pluggable optical transceiver module to a first electrical m-ary modulation signal;

114. A POSITA would have understood the combination of Agazzi '640 and Wei discloses this limitation. Agazzi '640 discloses a QAM-32 modulator (in yellow below) in the transmitter portion of the transceiver. Ex. 1005 at Fig. 10.

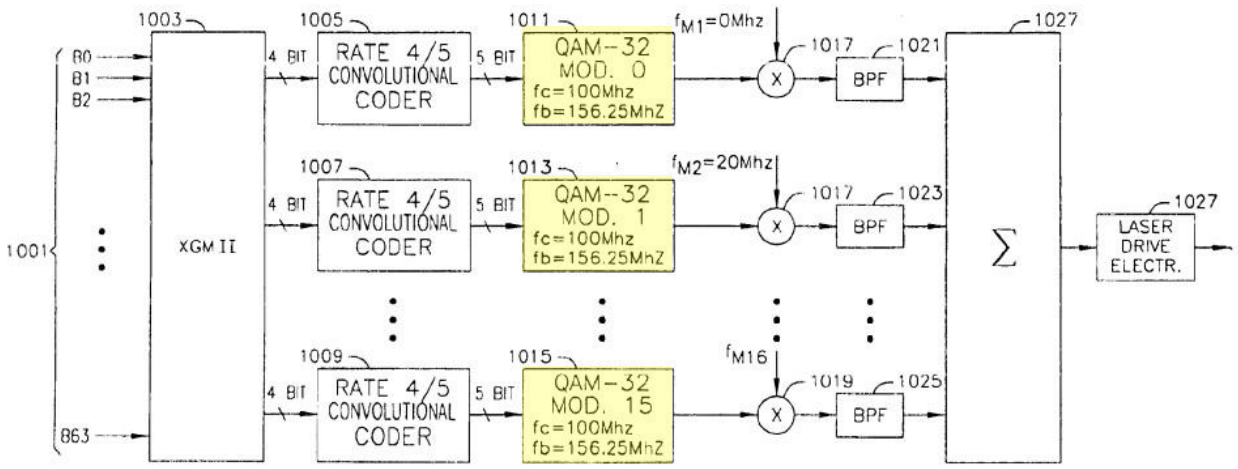


FIG. 10

115. Agazzi '640 teaches that the modulator can perform "Pulse Amplitude Modulation (PAM) or Quadrature Amplitude Modulation (QAM) to encode several bits per transmitted symbol." Ex. 1005 at 3:15-20, Figs. 2A, 3, 10. Agazzi '640 further teaches that the modulator can perform QAM-16, QAM-32, PAM, and QPSK modulation. Ex. 1005 at 3:17, 9:1, 12:9, 17:7.

116. The modulators disclosed in Agazzi '640 include m-ary modulators because the '795 Patent identifies QAM, PAM, and QPSK as examples of m-ary modulation. Ex. 1001 at 10:11-19. A POSITA would have understood that the m-ary modulator in Agazzi '640 converts a received signal (*i.e.*, first electrical binary data signal) to a modulated signal (*i.e.*, first electrical m-ary modulation signal) using m-ary modulation.

117. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in

Agazzi ’640 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

iv. Claim 1: [1.C] amplifying the first electrical m-ary modulation signal to drive an optical transmitter in the pluggable optical transceiver module;

118. A POSITA would have understood the combination of Agazzi ’640 and Wei discloses this limitation. Agazzi ’640 discloses an optical transmitter that includes a laser, and laser drive electronics (in yellow below) which drive the laser. Ex. 1005 at 2:54-55, 7:18-21, 10:14-16, Fig. 10.

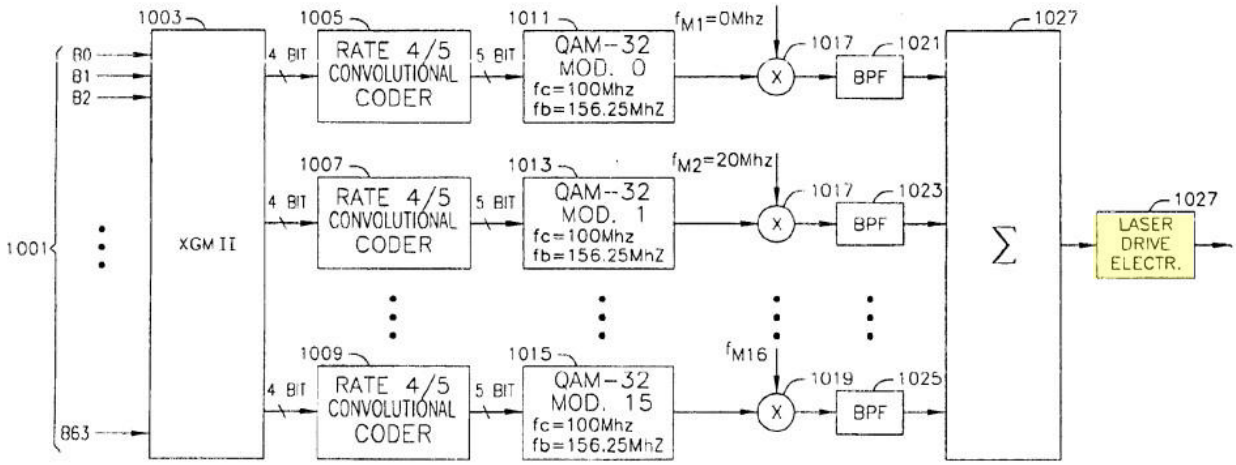


FIG. 10

119. Agazzi ’640 further discloses that “[t]he analog waveform is then coupled into laser drive electronics[] and is used to modulate the laser intensity using drive electronics … [where] the laser drive electronics[] intensity modulates the laser beam.” Ex. 1005 at 11:4-15. A POSITA would have understood that the modulated signals are amplified by the laser drive electronics to ensure the signals are

sufficiently strong to drive the laser, which emits optical signals that must be able to travel long distances through optical fibers. Optical transmitters are based on lasers that must be driven by a sufficient amount of current to cause lasing. Laser drive circuits are designed to amplify the modulated signal so that it exceeds this lasing threshold. Ex. 1017, 399-403. For example, a prior art textbook teaches a "laser drive circuit … consists of two differential amplifiers … The two differential amplifiers provide sufficient modulation current amplitude for the laser." Ex. 1017, 400. The laser drive electronics in Agazzi '640 thus amplifies a received signal (*i.e.*, first electrical m-ary modulation signal) to drive the laser (*i.e.*, optical transmitter).

120. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '640 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei also discloses a laser driver. Ex. 1006 at 4:40-55. A POSITA would have understood that the electrical signals are amplified to ensure the driver receives electrical data signals that are sufficiently strong to drive the optical transmitter.

v. Claim 1: [1.D] emitting a first optical signal on a first wavelength responsive to and representative of the amplified first electrical m-ary modulation signal from the optical transmitter in the pluggable optical transceiver module;

121. A POSITA would have understood the combination of Agazzi '640 and Wei discloses this limitation. Agazzi '640 discloses an "optical transmitter" that

includes a laser that "transmits the data across a fiber optic channel." Ex. 1005, 7:18-19, 10:14-16. As I explain in the technical background section, the optical transmitter produces optical signals based received electrical signals, where the optical signal is representative of the electrical signal. *See supra*, Section V(b). A POSITA would have understood that the laser (*i.e.*, optical transmitter) is driven by (*i.e.*, is responsive to) an electrical signal (*i.e.*, amplified first electrical m-ary modulation signal) from the laser drive electronics, produces a corresponding (*i.e.*, representative) optical signal, and then emits the optical signal (*i.e.*, first optical signal on a first wavelength) onto an optical fiber.

122. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '640 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei also discloses an optical transmitter that emits an optical signal onto an optical fiber that is responsive to and representative of the signal it receives. Ex. 1006 at 1:24-45.

vi. Claim 1: [1.E] receiving a second optical signal on a second wavelength and producing an electrical signal from an optical detector in the pluggable optical transceiver module;

123. A POSITA would have understood the combination of Agazzi '640 and Wei discloses this limitation. Agazzi '640 discloses an optical receiver that includes a photo detector (*i.e.*, optical detector, which is shown in yellow below) that receives

optical signals (*i.e.*, second optical signal on a second wavelength) and converts the optical signals to electrical signals (*i.e.*, electrical signal). Ex. 1005 at Fig. 12.

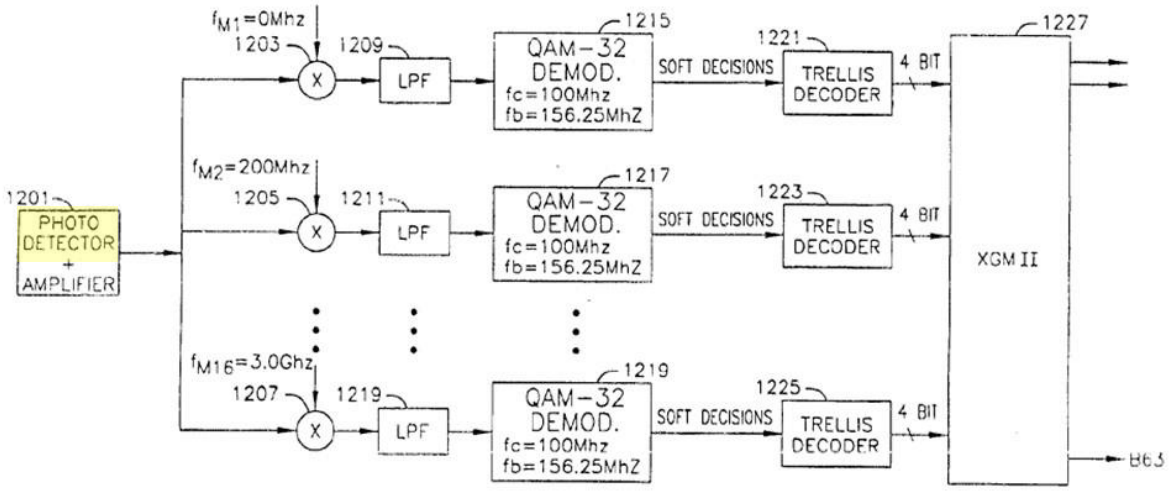


FIG. 12

124. For example, Agazzi '640 discloses "[t]he photo detector and amplifier 501 receive the multi-carrier modulated signal from the fiber optic and convert it into an electrical signal." Ex. 1005 at 11:17-22. A POSITA would have understood that the photodetector (*i.e.*, optical detector) receives the signal when it is an optical signal, then produces an electrical signal that corresponds to the received optical signal. A POSITA would further have understood that the photodetector receives many optical signals, any one of which can be the claimed "second optical signal on a second wavelength."

125. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in

Agazzi ’640 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei discloses a receiver that “includes a photodetector (such as a photodiode) mounted in a package and an optical coupling element for coupling light or photons from the optical fiber into the photodetector.” Ex. 1006 at 1:37-41.

vii. Claim 1: [1.F] amplifying the electrical signal to facilitate clock and data recovery in the pluggable optical transceiver module;

126. A POSITA would have understood the combination of Agazzi ’640 and Wei discloses this limitation. Agazzi ’640 discloses an amplifier (shown in yellow below) that amplifies the electrical signals received from the photodetector. Ex. 1005 at 2:66-3:11, Fig. 3, 12.

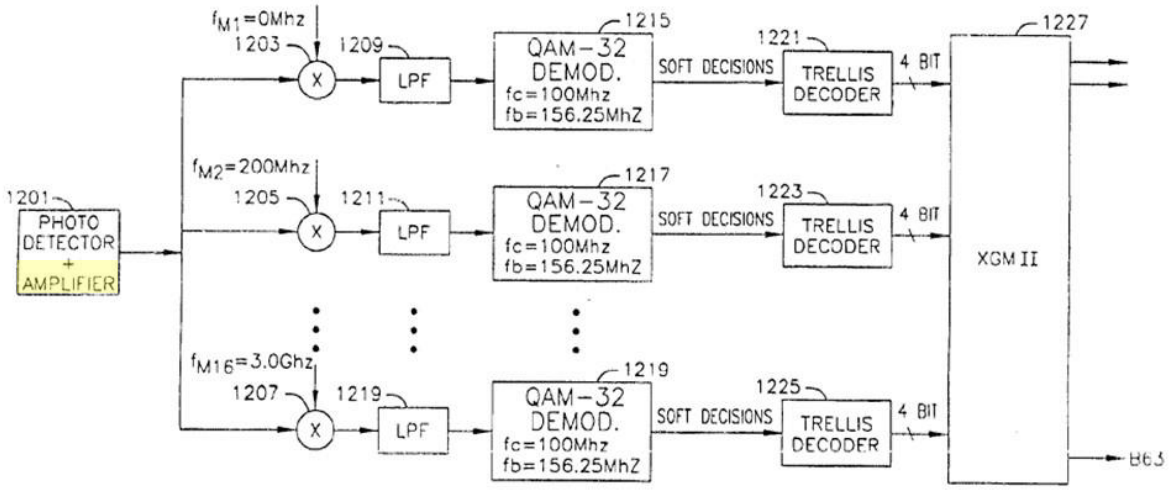


FIG. 12

127. Agazzi ’640 further discloses an optical transceiver with “clock and data recovery circuits.” Ex. 1005 at 3:3-4. A POSITA would have understood that amplification of the electrical output of the photodetector is necessary to ensure that the received signal overcomes the subsequent noise in the electrical circuitry that follows, so that the data can be recovered. To perform data recovery a clock must first be recovered to help synchronize the demodulation process. This clock is typically recovered by isolating a spectral component in the received signal that corresponds to the data rate and is in phase with the data. Ex. 1029, 152-153.

128. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi ’640 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

viii. Claim 1: [1.G] recovering a clock data information from the amplified electrical signal to produce a second m-ary modulation signal in the pluggable optical transceiver module;

129. A POSITA would have understood the combination of Agazzi ’640 and Wei discloses this limitation. Agazzi ’640 discloses “an optical communications transceiver.” Ex. 1005 at 16:10-11. Agazzi ’640 further discloses that “[o]ptical communications systems may achieve very high data rates as a result of the high bandwidth of the optical fibers and the availability of high-speed lasers and photo detectors, as well as wideband laser drivers, transimpedance amplifiers,

postamplifiers, and ***clock and data recovery circuits.***" Ex. 1005 at 2:66-3:4 (emphasis added). In particular, Agazzi '640 depicts recovered clock data information (in yellow below) in the demodulation block. *Id.* at Fig. 12, 13:20-22.

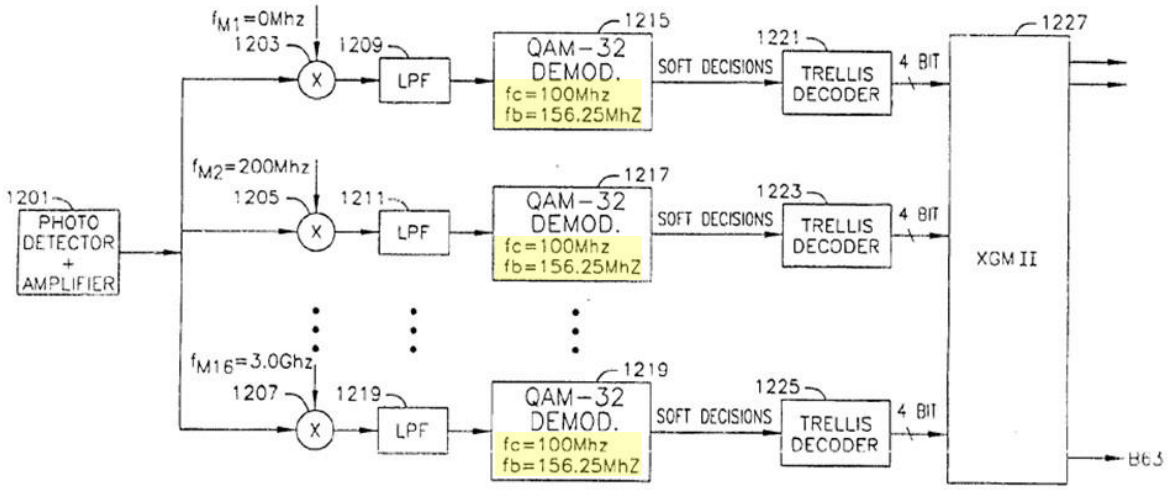


FIG. 12

Moreover, it was well-known to a POSITA that clock recovery was a routine part of the signal processing performed at the receiver, which occurs before data is recovered during demodulation. *See, e.g.*, Ex. 1016 at 265-66. For example, a prior art textbook teaches that "the clock must be extracted from the received signal." *Id.* at 266. And the '795 Patent teaches that clock recovery occurs before demodulation. Ex. 1001, 10:38-65. As depicted in Figure 12 of Agazzi '640, clock data information is recovered from an input signal (*i.e.*, amplified electrical signal) to produce an output signal (*i.e.*, second m-ary modulation signal) that is ready for demodulation.

130. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '640 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

ix. Claim 1: [1.H] demodulating the second m-ary modulation signal to a second electrical binary data signal in the pluggable optical transceiver module; and

131. A POSITA would have understood the combination of Agazzi '640 and Wei discloses this limitation. Agazzi '640 discloses a QAM-32 demodulator (shown in yellow below) in the receiver portion of the transceiver. Ex. 1005 at Fig. 12.

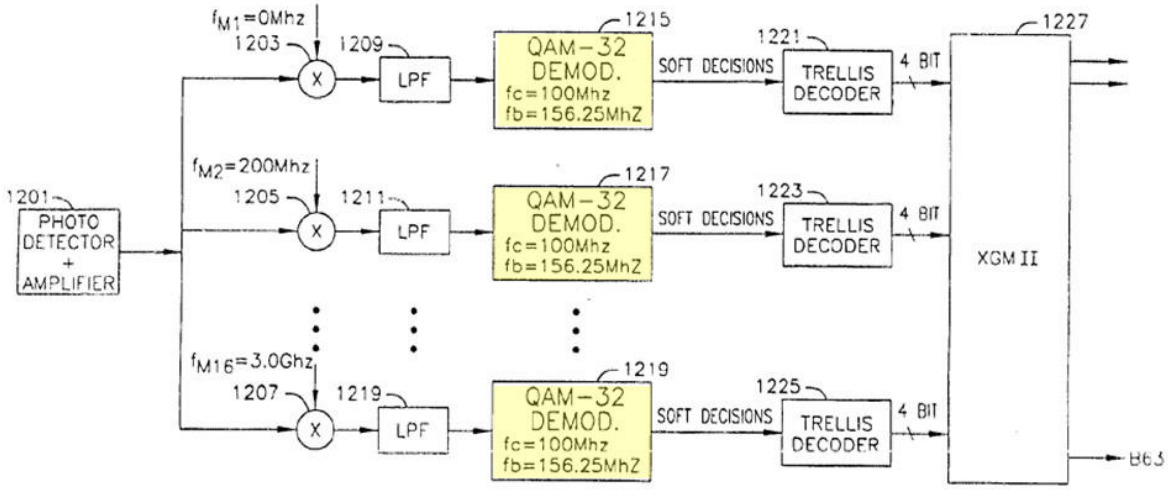


FIG. 12

132. Agazzi '640 further discloses "demodulators, which will demodulate the signal according to the modulation used by the transmit apparatus." Ex. 1005 at 2:1-11, Figs. 3, 12. The QAM-32 demodulators disclosed in Agazzi '640 are m-ary

demodulators because the ’795 Patent identifies QAM, PAM, and QPSK as examples of m-ary modulation techniques. Ex. 1001 at 10:11-19. A POSITA would have understood that the QAM-32 demodulator (*i.e.*, m-ary demodulator) demodulates the input signal (*i.e.*, second m-ary modulation signal) to produce a demodulated output signal (*i.e.*, second electrical binary data signal).

133. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi ’640 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

x. Claim 1: [1.I] transmitting the second electrical binary data signal through the system interface of the pluggable optical transceiver module.

134. A POSITA would have understood the combination of Agazzi ’640 and Wei discloses this limitation. Agazzi ’640 discloses a receiver system that receives an optical signal, converts it to an electrical signal, performs signal processing, and then transmits the electrical signal through the system interface. *See*, *e.g.*, Ex. 1005 at Fig. 3A, 12, 10:14-57. For example, in Figure 12 below, Agazzi ’640 discloses the optical receiver portion of the transceiver includes an “XGMII (Ten Gigabit Media Independent Interface) unit” that transmits digital electrical signals. Ex. 1005 at 10:46-57.

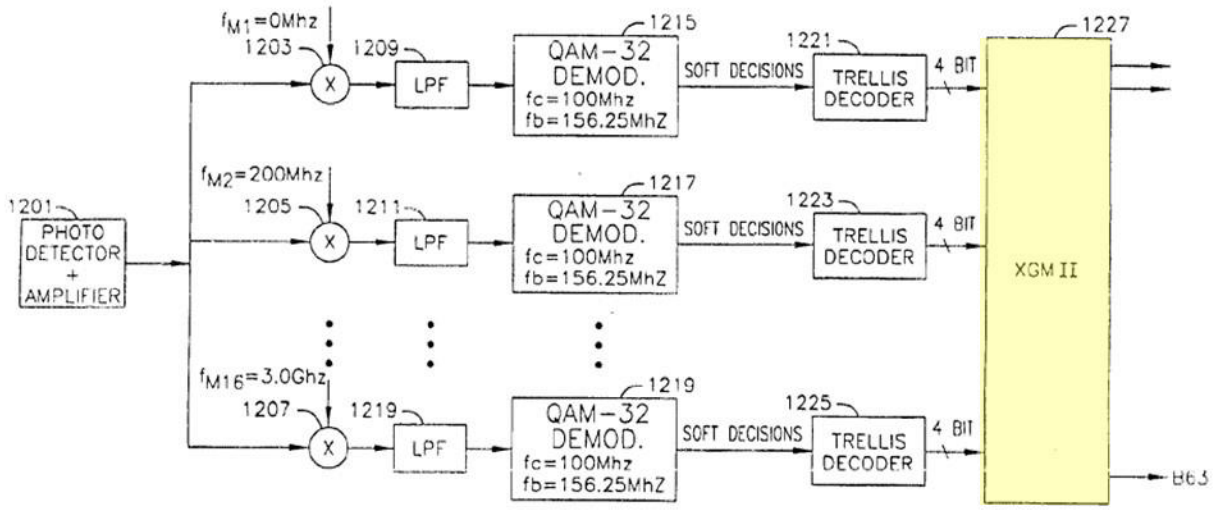


FIG. 12

135. A POSITA would have understood the XGMII interface (in yellow above) to be a system interface for the transmission of electrical data signals because the '795 Patent explicitly notes that the XGMII interface is a conventional system interface. Ex. 1001 at 9:13-17. A POSITA would also have understood that the electrical system interface transmits many electrical data signals, each of which is an example of the claimed "second electrical binary data signal." The "second" electrical binary data signal is an arbitrary name for a signal that passes through the electrical system interface. A POSITA would further have understood the electrical data signals are digital which are understood to be binary. Ex. 1005 at 1:52-65; 11:36-42. For example, Leon-Garcia teaches that digital signals "transfer a sequence of 0s and 1s," which is a binary sequence. Ex. 1015, 107.

136. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '640 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei discloses a male electrical connector coupled to an external electrical connector that "allow[s] electrical signals … to be coupled into or out of the fiber optic module." Ex. 1006 at 4:56-62. A POSITA would have understood this coupled area (see red rectangles below) to be an interface for the receipt and transmission of binary electrical data signals. Ex. 1006 at Figs. 3, 6C, 2:5-11.

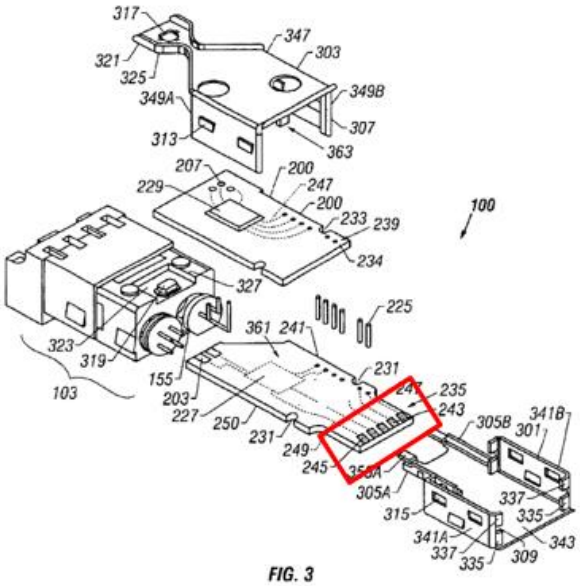


FIG. 3

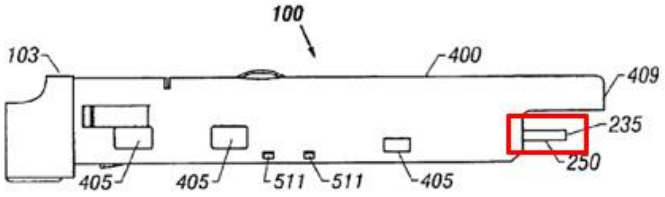


FIG. 6C

xi. Claim 2: The method of claim 1, whereby the form factor of the pluggable optical transceiver module is a pluggable form factor standard.

137. A POSITA would have understood Wei discloses this limitation. Wei discloses a "fiber optic transceiver module" with "vertically stacked printed circuit boards allows packaging the [transceiver] within an LC or other ***small form factor package***." Ex. 1006 at 2:17-35 (emphasis added). Specifically, Wei discloses a "***small form pluggable*** (SFP)" transceiver. Ex. 1006 at 2:1-4. As I explain in the technical background section, multisource agreements define the physical requirements for standardized pluggable form factors, which include the SFP. *See supra*, Section V(b). A POSITA would have understood that the SFP was a pluggable form factor standard for optical transceiver modules.

xii. Claim 3: The method of claim 2, whereby the pluggable form factor standard of the pluggable optical transceiver module is an SFP form factor or SFP+ form factor standard;

138. A POSITA would have understood Wei discloses this limitation. Wei discloses a "fiber optic transceiver module" with "vertically stacked printed circuit boards allows packaging the [transceiver] within an LC or other ***small form factor package***." Ex. 1006 at 2:17-35 (emphasis added). Specifically, Wei discloses a "***small form pluggable (SFP)***" transceiver. Ex. 1006 at 2:1-4. As I explain in the technical background section, multisource agreements define the physical requirements for standardized pluggable form factors, which include the SFP. *See*

supra, Section V(b). A POSITA would have understood that the SFP was a pluggable form factor standard for optical transceiver modules.

xiii. Claim 5: The method of claim 1, whereby the m-ary modulation is a m-ary pulse amplitude modulation communication method that uses two or more bits per symbol for communication.

139. A POSITA would have understood Agazzi '640 discloses this limitation. Agazzi '640 discloses performing multilevel modulation within the transmitter portion of the optical transceiver, including "***Pulse Amplitude Modulation*** (PAM) … to ***encode several bits per*** transmitted ***symbol***." Ex. 1005 at 3:15-20 (emphasis added), Figs. 2A, 10.

140. The '795 Patent identifies PAM as an example of m-ary modulation. Ex. 1001 at 10:11-19. A POSITA would have understood the PAM modulation disclosed in Agazzi '640 to cover m-ary PAM modulation because the '795 Patent disclosed PAM modulation as a type of m-ary modulation.

xiv. Claim 10: The method of claim 1, whereby the first electrical binary data signal and second electrical binary data signal are parallel electrical binary data signals.

141. A POSITA would have understood Agazzi '640 discloses this limitation. Agazzi '640 discloses an optical transceiver module that employs "parallel processing architectures" in order to "process the higher data rates available in optical fibers." Ex. 1005 at 4:15-21, Figs. 2A, 3. Agazzi '640 further discloses transmitters and receivers that operate "in a parallel type format." Ex. 1005 at 7:1-

9, 7:51-58, 11:17-44. A POSITA would have understood that the electrical interface was configured to receive/transmit parallel signals and that there would be multiple such signals. This is depicted in Figures 10 and 12 below. For example, the system interface (shown in yellow in Figs. 10 and 12 below) where the electrical binary data signals are received into and transmitted out of the transceiver show that the signals (depicted by the arrows entering or leaving the system interface) are parallel. Ex. 1005 at Figs. 10, 12.

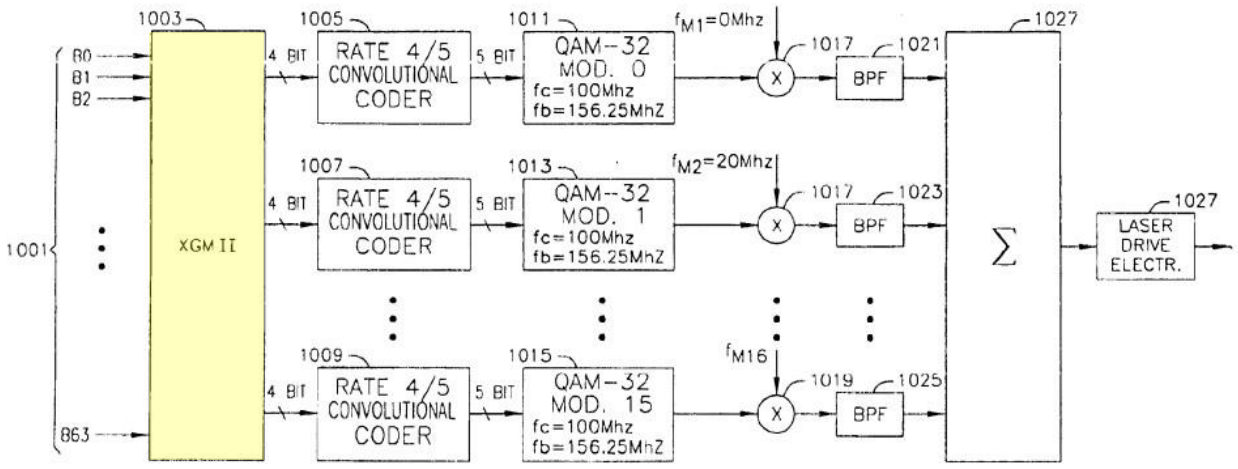


FIG. 10

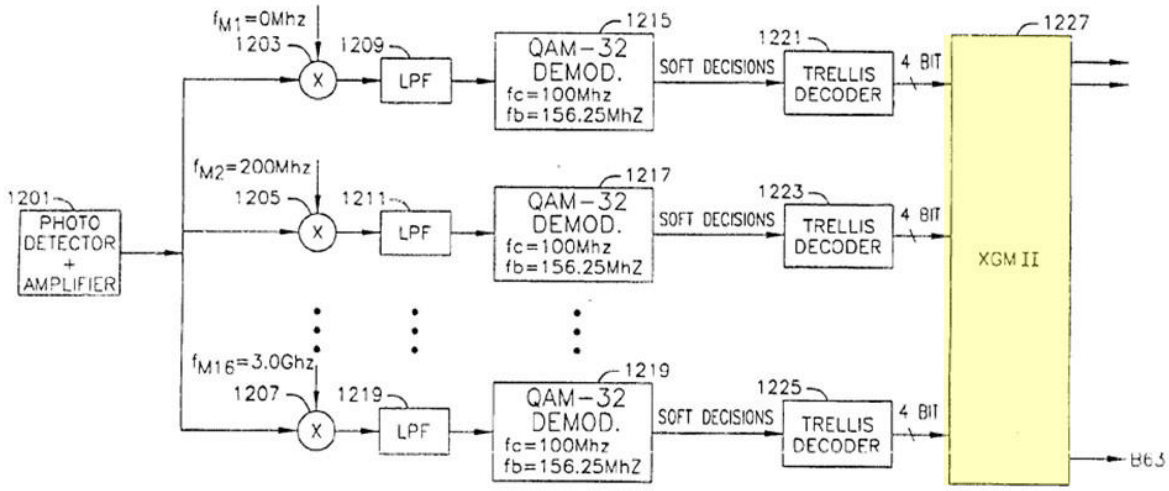


FIG. 12

xv. Claim 13: The method of claim 1, whereby the m-ary modulation is a m-ary quadrature amplitude modulation communication method that uses two or more bits per symbol for communication.

142. A POSITA would have understood Agazzi '640 discloses this limitation. Agazzi '640 discloses performing multilevel modulation within the transmitter portion of the optical transceiver, including "***Quadrature Amplitude Modulation*** (QAM) to ***encode several bits per*** transmitted ***symbol***." Ex. 1005 at 3:15-20 (emphasis added), Figs. 2A, 10.

143. The '795 Patent identifies QAM as an example of m-ary modulation. Ex. 1001 at 10:11-19. A POSITA would have understood the QAM modulation disclosed in Agazzi '640 to cover m-ary QAM modulation because the '795 Patent disclosed QAM modulation as a type of m-ary modulation.

xvi. Claim 14: The method of claim 1, whereby the m-ary modulation is a m-ary quadrature phase shift keying modulation communication method that uses two or more bits per symbol for communication.

144. A POSITA would have understood Agazzi '640 discloses this limitation. Agazzi '640 discloses performing multilevel modulation within the transmitter portion of the optical transceiver, including "***quadrature phase shift keying*** (QPSK)." Ex. 1005 at 17:5-8 (emphasis added). Agazzi '640 further teaches that multilevel modulation is used "to ***encode several bits per*** transmitted ***symbol***." Ex. 1005 at 3:15-20 (emphasis added), Figs. 2A, 10.

145. The '795 Patent identifies QPSK as an example of m-ary modulation. Ex. 1001 at 10:11-19. A POSITA would have understood the QPSK modulation disclosed in Agazzi '640 to cover m-ary QPSK modulation because the '795 Patent disclosed QPSK modulation as a type of m-ary modulation.

xvii. Claim 16: The method of claim 1, further comprising coding the first electrical binary data signal and decoding the second electrical binary signal according to an error correcting code in the pluggable optical transceiver module.

146. A POSITA would have understood the combination of Agazzi '640 and Wei discloses this limitation. Agazzi '640 discloses signal processing techniques including coding algorithms that reduce signal to noise ratios, which results in higher bandwidth efficiency. Ex. 1005 at 3:29-39. For example, Agazzi '640 discloses an optical transceiver module with "trellis encod[ers]" and "trellis decoders." Ex. 1005

at 15:45-48, 12:13-18. Encoding and decoding "results in increased robustness and decreased error rate in the presence of noise and other channel impairments." Ex. 1005 at 12:16-20. Agazzi '640 further discloses a convolutional code. Ex. 1005 at 12:5-23, 15:29-39. As shown in Figures 10 and 12 below, the electrical data signals received by the transmitter system, including the first electrical binary data signal, and the electrical data signals transmitted by the receiver system, including the second electrical binary data signal, are coded and decoded using an error correction code.

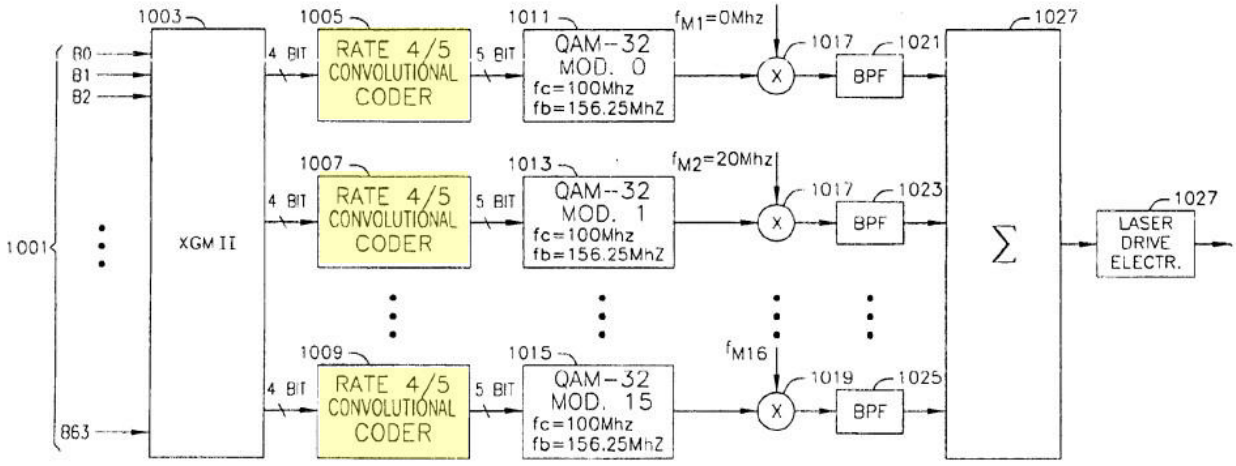


FIG. 10

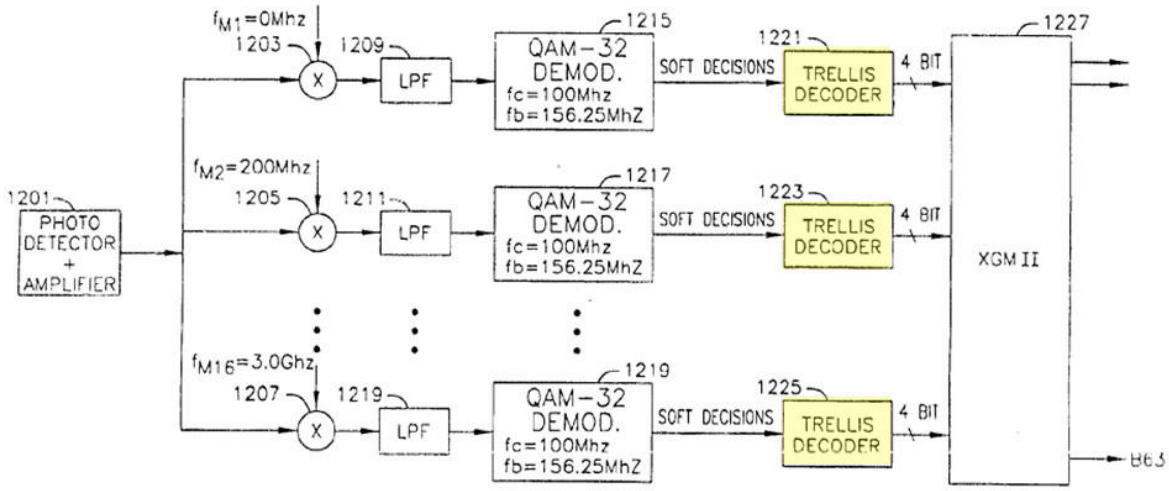


FIG. 12

147. As I explain in the technical background section, a trellis code and a convolutional code are error correcting codes, and this would have been well-known by a POSITA. *See supra*, Section V(e). A POSITA would also have known that error correcting codes require encoding and decoding processing to implement.

148. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '640 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

xviii. Claim 17: The method of claim 16, whereby the error correcting code is a convolutional code.

149. A POSITA would have understood Agazzi '640 discloses this limitation. Agazzi '640 discloses signal processing techniques including coding algorithms that reduce signal to noise ratios, which results in higher bandwidth

efficiency. Ex. 1005 at 3:29-39. For example, Agazzi '640 discloses an optical transceiver module with "encoders" and "decoders." Ex. 1005 at 12:13-18, 16:15-17. Encoding and decoding "results in increased robustness and decreased error rate in the presence of noise and other channel impairments." Ex. 1005 at 12:16-20. Specifically, Agazzi discloses a "***convolutional coder.***" Ex. 1005 at 12:7-9. As I explain in the technical background section, a convolutional code is a type of error correcting code, and this would have been well-known by a POSITA. *See supra,* Section V(e).

xix. Claim 18: The method of claim 16, whereby the error correcting code is a forward error correcting (FEC) code.

150. A POSITA would have understood Agazzi '640 discloses this limitation. Agazzi '640 discloses signal processing techniques including coding algorithms that reduce signal to noise ratios, which results in higher bandwidth efficiency. Ex. 1005 at 3:29-39. For example, Agazzi '640 discloses an optical transceiver module with "trellis encod[ers]" and "trellis decoders." Ex. 1005 at 15:45-48, 12:13-18. Encoding and decoding "results in increased robustness and decreased error rate in the presence of noise and other channel impairments." Ex. 1005 at 12:16-20. Agazzi '640 further discloses a convolutional coder. Ex. 1005 at 12:5-23, 15:29-39. As I explain in the technical background section, a trellis code and a convolutional code are forward error correcting codes, and this would have been well-known by a POSITA. *See supra*, Section V(e).

xx. Claim 19: The method of claim 16, whereby the error correcting code is a trellis code.

151. A POSITA would have understood Agazzi '640 discloses this limitation. Agazzi '640 discloses signal processing techniques including coding algorithms that reduce signal to noise ratios, which results in higher bandwidth efficiency. Ex. 1005 at 3:29-39. For example, Agazzi '640 discloses an optical transceiver module with "***trellis encod[ers]***" and "***trellis decoders***." Ex. 1005 at 15:45-48, 12:13-18 (emphasis added). Encoding and decoding "results in increased robustness and decreased error rate in the presence of noise and other channel impairments." Ex. 1005 at 12:16-20. As I explain in the technical background section, a trellis code is a type of error correcting code, and this would have been well-known by a POSITA. *See supra,* Section V(e).

b. Ground 2: The combination of Agazzi '640, Wei, and Gans render claims 11-12 obvious.

152. As previously described, both Agazzi '640 and Wei relate to fiber-optic communications. And both Agazzi '640 and Wei attempt to increase the data throughput rates in a cost effective manner. Ex. 1005 at 1:23-49; Ex. 1006 at 1:66-2:4. However, Agazzi '640 and Wei do not expressly disclose transmitting/receiving dual polarized optical signals.

153. Gans, like Agazzi '640 and Wei, relates to fiber-optic communications. Ex. 1007 at Abstract. Specifically, Gans discloses transmitting and receiving dual

polarized optical signals. Ex. 1007 at 2:13-34. There were several reasons a POSITA would have been motivated to combine Gans with Agazzi '640 and Wei.

154. First, Gans discloses a technique for increasing the data throughput—a problem addressed in both Agazzi '640 and Wei. Ex. 1005 at 2:66-3:55; Ex. 1006 at 1:66-2:4. In particular, Gans discloses transmitting/receiving dual polarized optical signals because "it permits more information to pass through the fiber without increasing the bit rate in any particular polarization." Ex. 1007 at 1:20-27. A POSITA would have been motivated to add the dual polarization technique disclosed in Gans to the m-ary pluggable transceiver taught by the combination of Agazzi '640 and Wei in order to further increase the data throughput rate.

155. Second, dual polarization was cost effective. Gans discloses a dual polarization technique that increases the data throughput rate of the optical fiber without the need to replace pre-existing fiber systems. Ex. 1007 at 1:14-19. A POSITA would have understood that this was a cost effective technique because it was expensive to replace optical fibers. Moreover, decreasing costs was a stated goal in both Agazzi '640 and Wei. Ex. 1005 at 1:45-49; Ex. 1006 at 1:50-69. Thus, a POSITA would have been motivated to combine Gans with Agazzi '640 and Wei because higher order modulation, coupled with dual polarization, allowed for the transmission of higher data rates over the same optical fibers. This allowed for more data to be transferred in the same channel over the same amount of time and was a

simple way to increase data speeds in a communication system without going through the costly and resource intensive activity of replacing older fiber channels.

156. Moreover, a POSITA would have had a reasonable expectation of success in adding dual polarization functionality to a higher order modulation pluggable transceiver to produce expected results. In fact, many of the expected results of the combination were stated goals in the references.

i. Claim 11: The method of claim 1, whereby the first optical signal emitted by the pluggable optical transceiver module is dual polarized.

157. A POSITA would have understood the combination of Agazzi '640, Wei, and Gans discloses this limitation. Wei discloses a pluggable optical transceiver module and Agazzi '640 discloses the other limitations in claim 1 for the reasons previously stated. Gans discloses the use of dual polarization, which was a known modulation/demodulation scheme for optical networks. Ex. 1007 at 8:11-24. In particular, Gans discloses a "method for increasing transmission capacity using … ***dual polarization***." Ex. 1007 at 8:11-13 (emphasis added). Gans further discloses that "two optical signals of different polarizations are transmitted through a single optical fiber." Ex. 1007 at 1:20-23.

158. A POSITA would have been motivated to combine the dual polarization technique disclosed in Gans with the pluggable transceiver module

taught by the combination of Agazzi ’640 and Wei for the reasons previously stated above.

ii. Claim 12: The method of claim 1, whereby the second optical signal received by the pluggable optical transceiver module is dual polarized.

159. A POSITA would have understood the combination of Agazzi ’640, Wei, and Gans discloses this limitation. Wei discloses a pluggable optical transceiver module and Agazzi ’640 discloses the other limitations in claim 1 for the reasons previously stated. Gans discloses the use of dual polarization, which was a known modulation/demodulation scheme for optical networks. Ex. 1007 at 8:11-24. In particular, Gans discloses a “method for increasing transmission capacity using … ***dual polarization***.” Ex. 1007 at 8:11-13 (emphasis added). Gans further discloses that “[o]ptical signals of different polarizations that are received from a single optical fiber are distinguished from one another by separating the output of the optical fiber into different optical polarization components.” Ex. 1007 at 2:16-22.

160. A POSITA would have been motivated to combine the dual polarization technique disclosed in Gans with the pluggable transceiver module taught by the combination of Agazzi ’640 and Wei for the reasons previously stated above.

c. Ground 3: The combination of Agazzi ’640, Wei, and Eroz render claims 20-21 obvious.

161. As previously described, both Agazzi ’640 and Wei relate to fiber-optic communications. And both Agazzi ’640 and Wei attempt to increase the data throughput rates. Ex. 1005 at 1:23-49; Ex. 1006 at 1:66-2:4. In particular, Agazzi ’640 discloses implementing error correcting codes to “increase[] robustness and decrease[] error rate in the presence of noise and other channel impairments.” Ex. 1005 at 12:16-18.

162. To that end, Agazzi ’640 discloses “trellis encoding” and “trellis decoders that encode/decode signals according to a trellis code. Ex. 1005 at 12:13-16, 15: 45-48. Agazzi ’640 further discloses signal processing using a convolutional code. Ex. 1005 at 12:5-23. A POSITA would have understood that a trellis code and a convolutional code are both types of forward error correcting codes that require encoding and decoding processing to implement. However, Agazzi ’640 and Wei do not expressly disclose implementing Reed-Solomon or LDPC error correcting codes—both of which are types of forward error correcting codes.

163. Eroz, like Agazzi ’640 and Wei, relates to fiber-optic communications. Ex. 1008 at 1:38-39, 14:42-47. Specifically, Eroz discloses coding optical signals using an error correcting code “to ensure reliable communication across noisy communication channels.” Ex. 1008 at 1:42-45, 13:65-14:2. Eroz further discloses utilizing “LDPC codes efficiently to support high data rates, without introducing

greater complexity." *Id.* at 2:3-5. Eroz also discloses utilizing a "Reed-Solomon (RS) code." *Id.* at 7:12-16. A POSITA would have understood that LDPC and Reed-Solomon codes are both types of forward error correcting codes. There were several reasons a POSITA would have been motivated to combine Eroz with Agazzi '640 and Wei.

164. First, both Agazzi '640 and Eroz disclose forward error correcting codes that were used to minimize the impact of noise on the signals. Ex. 1005 at 12:16-18; Ex. 1008 at 1:42-45, 13:65-14:2. By implementing this error correction signal processing, it increased the efficiency of the data through the fiber system by minimizing errors. And, when determining what error correcting code to use, a POSITA would have naturally looked from Agazzi '640 to Eroz to find additional error correcting codes as both references teach different types of forward error correction codes that can be used in high data throughput fiber systems. For example, a POSITA would have understood that, compared to other coding techniques, like trellis coding, LDPC codes as taught by Eroz offer the advantage of highly efficient information transfer over bandwidth-constrained channels in the presence of noise, especially at high code rates. Ex. 1022 at 1. A POSITA would also have understood that BCH codes, such as Reed Solomon codes, have the advantage of substantially reducing the bit error rate in the presence of noise, and have been successfully used in numerous consumer applications where there are

burst errors, such as compact discs, DVDs, QR codes, and satellite communications. Ex. 1021, 1-15.

165. Second, Eroz discloses a technique for efficiently increasing the data throughput—a problem addressed in both Agazzi '640 and Wei. Ex. 1005 at 2:66-3:55; Ex. 1006 at 1:66-2:4. In particular, Eroz discloses LDPC codes and Reed-Solomon codes that can be used "efficiently to support high data rates." Ex. 1008 at 2:3-5. A POSITA would have been motivated to add the error correcting codes disclosed in Eroz to the m-ary pluggable transceiver taught by the combination of Agazzi '640 and Wei to further increase the data throughput rate by minimizing errors.

166. Third, LDPC and Reed-Solomon codes were cost effective. Eroz discloses error correcting techniques that allow for high data throughput with reduced errors without the need to replace pre-existing fiber systems. A POSITA would have understood that this was a cost effective technique because it did not require replacement of existing optical infrastructure to increase data rates and data reliability. Moreover, decreasing costs was a stated goal in both Agazzi '640 and Wei. Ex. 1005 at 1:45-49; Ex. 1006 at 1:50-69. Thus, a POSITA would have been motivated to combine Eroz with Agazzi '640 and Wei because higher order modulation in a pluggable transceiver, coupled with LDPC or Reed-Solomon error correcting codes, allows for the transmission of higher data rates with increased

reliability over the same optical fibers. This allowed for more data to be transferred in the same channel over the same amount of time and was a simple way to increase data speeds while maintaining reliability without replacing older fiber channels.

167. Moreover, a POSITA would have had a reasonable expectation of success in adding the LDPC and/or Reed-Solomon error correcting functionality to the higher order modulation transceiver to produce expected results. In fact, many of the expected results of the combination were stated goals in the references.

i. Claim 20: The method of claim 16, whereby the error correcting code is a Reed-Solomon code.

168. A POSITA would have understood the combination of Agazzi '640, Wei, and Eroz discloses this limitation. Agazzi '640 and Wei disclose the limitations in claim 16 and claim 1 from which claim 16 depends for the reasons previously stated. Eroz discloses encoding/decoding "optical signals that carry digital data streams representing various types of information." Ex. 1008 at 13:65-14:2. Eroz further discloses encoding/decoding using a "***Reed-Solomon (RS) code***." Ex. 1008 at 7:12-16 (emphasis added). As I explain in the technical background section, a Reed-Solomon code is a type of error correcting code, and this would have been well-known by a POSITA. *See supra,* Section V(e).

ii. Claim 21: The method of claim 16, whereby the error correcting code is a low-density parity-check (LDPC) code.

169. A POSITA would have understood the combination of Agazzi '640, Wei, and Eroz discloses this limitation. Agazzi '640 and Wei disclose the limitations in claim 16 and claim 1 from which claim 16 depends for the reasons previously stated. Eroz discloses encoding/decoding "optical signals that carry digital data streams representing various types of information." Ex. 1008 at 13:57-65. Eroz further discloses encoding/decoding using "***low density parity check (LDPC) codes***." Ex. 1008 at Abstract (emphasis added). As I explain in the technical background section, a LDPC code is a type of error correcting code, and this would have been well-known by a POSITA. *See supra,* Section V(e).

XI. Grounds 4-7 render the challenged claims obvious.

a. Ground 4: The combination of Agazzi '341 and Wei render claims 1-3, 5, 10, and 16-19 obvious.

170. Both Agazzi '341 and Wei are directed to optical transceiver modules with integrated optoelectronics that interface optical fibers to electronic circuitry by converting between optical signals and electrical signals. Ex. 1006 at 1:24-30; Ex. 1009 at Fig. 23. Indeed, Agazzi '341 and Wei both teach transceiver modules that include an electrical system interface, an optical transmitter, an optical receiver, and an amplifier. Ex. 1009 at Figs. 5, 23, 1:66-2:7; Ex. 1006 at 1:24-45, 4:40-55.

171. As explained, *supra*, Wei specifically discloses vertically stacked transmitter and receiver printed circuit boards that allow for the functionality of

larger GBIC modules to be included inside a SFP package. This accomplishes the stated goal in Wei—creating a smaller, more compact transceiver module that is hot pluggable with "reduce[d] manufacturing costs" in order to allow service technicians to quickly replace damaged transceiver modules with limited down time. Ex. 1006 at 1:53-2:11.

172. Agazzi '341 specifically teaches a transceiver module that performs signal processing, including m-ary modulation/demodulation, equalization, and error correction. Ex. 1009 at 1:55-2:7, 4:33-35. This allows the transceiver module in Agazzi '341 to transmit data at higher rates through existing fiber infrastructure, which is a specific goal of Agazzi '341. Ex. 1009 at 1:44-49, 3:20-26. Agazzi '341 also teaches implementing the transmitter and receiver sections of the transceiver together as an "integrated circuit constructed as a single chip" and discloses an "ever present economic motivation to achieve such results in a cost effective manner." Ex. 1009 at 4:62-65, 1:46-51.

173. Agazzi '341 does not, however, expressly disclose a pluggable transceiver module in a small form factor package as taught in Wei. Nor does Wei expressly disclose the signal processing techniques taught in Agazzi '341. A POSITA would have understood that the transceiver as contemplated in Agazzi '341, which was taught as constructed as a single chip, would have been implemented in a SFP transceiver as taught in Wei. And a POSITA would have been motivated to

combine the transceiver module of Agazzi '341 with the SFP package of Wei to create a smaller transceiver with greater data throughput that is easily removable and cost-effective.

174. There were several reasons a POSITA would have been motivated to make such a combination. First, market pressures were increasing the demand for compact pluggable transceivers with high data throughput rates in a standardized form factor as users desired a high throughput pluggable transceiver which led the industry to standardize the SFP form factor to ensure compatibility across fiber-optic systems. Ex. 1008, 1:66-2:4; Ex. 1014. Accordingly, as a result of consumer preferences and industry standards, a POSITA would have understood that higher throughput pluggable transceivers in an SFP form factor were needed. Second, an m-ary pluggable transceiver module would be easier to install, repair, and replace than a mounted transceiver. Ex. 1006 at 2:5-11. This would decrease the chances for improper installation. It also decreases the likelihood that other components near the transceiver would be damaged during servicing. An m-ary pluggable transceiver would also take less time to install, repair, and/or replace. This, in turn, means less down time for the fiber-optic system during maintenance or servicing of the transceiver. Ex. 1011 at 1:45-52.

175. Third, an m-ary pluggable transceiver in an SFP package was more compact and takes less room than other transceivers. Decreasing the transceiver size

was a stated goal in both Agazzi '341 and Wei. Ex. 1009 at 4:62-65; Ex. 1006 at 1:67-2:4. Thus, a POSITA would have been motivated to combine Agazzi '341 with Wei to create a smaller transceiver. This is because Wei discloses how to efficiently package transceiver components to fit within a pluggable form factor: "separate vertically stacked printed circuit boards allows packaging the functions of [larger modules] within an LC or other small form factor package" like the SFP. Ex. 1006, 2:1-2, 2:28-32. A POSITA would have understood how to package the components of a module like Agazzi '341 into an SFP based on the disclosure in Wei. This was important because OLTs and ONTs often have many components, like switches and routers, located in large racks. Therefore, space was a limiting factor in many cases and smaller optical components were desired.

176. Fourth, an m-ary pluggable transceiver was more cost effective. Decreasing costs was a stated goal in both Agazzi '341 and Wei. Ex. 1009 at 1:50-51; Ex. 1006 at 1:50-69. Thus, a POSITA would have been motivated to combine Agazzi '341 with Wei to create an m-ary pluggable transceiver because pluggable transceivers were easier to install, repair, and replace, which allows less skilled technicians to be able to service the communication system. Ex. 1006 at 2:5-11. Moreover, technicians did not have to repair and replace larger equipment, like a switch or router, when an optoelectrical component in a mounted transceiver failed. Instead, the technician simply replaced the hot pluggable transceiver with a new

transceiver. And manufacturing costs were decreased when transceivers were produced separate from other optoelectrical equipment on printed circuit boards. Ex. 1006 at 1:45-60. Further, the smaller size of the transceiver allowed the optical equipment to take up less space, thus saving on rent and utilities. And, importantly, the increased data throughput rates of m-ary pluggable transceivers allowed for higher data speeds without the need to replace older fiber channels.

177. Fifth, an m-ary pluggable transceiver would have higher data throughput rates in a small form factor. Increasing the data throughput rate in the transceiver was a stated goal in both Agazzi '341 and Wei. Ex. 1009 at 1:46-51; Ex. 1006 at 1:66-2:4. Accordingly, a POSITA who wanted to maintain high data throughput rates, as taught by Agazzi '341's use of m-ary modulation, would have looked to Wei when evaluating how to package a high throughput transceiver in a SFP form factor as Wei also taught high data throughput. This allowed for more data to be transferred in the same channel over the same amount of time as traditional binary modulation and was a simple way to increase data speeds in a communication system because it did not require replacement of older fiber channels.

178. Moreover, a POSITA would have had a reasonable expectation of success in combing the transceivers in Agazzi '341 and Wei to produce expected results. In fact, many of the expected results of the combination were stated goals in the references.

179. A POSITA also would have been motivated to combine transceivers that perform advanced signal processing, like in Agazzi '341, with a pluggable transceiver, like in Wei, after reviewing the prior art. For example, U.S. Patent No. 6,665,498 to Jiang discloses a high-speed transceiver module that has a transmitter, receiver, amplifier, and clock data recovery unit. Ex. 1010 at 3:34-4:3. In addition to signal processing techniques, Jiang teaches that is it important to provide a smaller transceiver that is capable of conveying information at similar rates to larger transceivers, wherein the transceiver is "inexpensive to manufacture." Ex. 1010 at 1:54-61. Jiang also recommends making the transceiver pluggable, stating: "It is also easier to make the transceiver pluggable." Ex. 1010 at 5:34-41. A POSITA would thus have been motivated to combine signal processing capabilities inside a small pluggable transceiver.

180. As another example, U.S. Patent No. 6,295,272 to Feldman discloses a pluggable transceiver module in the form of a GBIC (the larger predecessor of the SFP) that conveys m-ary modulated signals from a subcarrier channel to a high-speed channel. Ex. 1019 at Abstract, 6:21-29, Fig. 13. Although the m-ary modulation disclosed in Feldman occurs before the signal is conveyed by the GBIC, a POSITA would have understood that the m-ary functionality can be added into the pluggable to reduce the number of components. Moreover, Wei teaches

"package[ing] the functions of a GBIC into the compact size of an SFP." Ex. 1006 at 2:1-4.

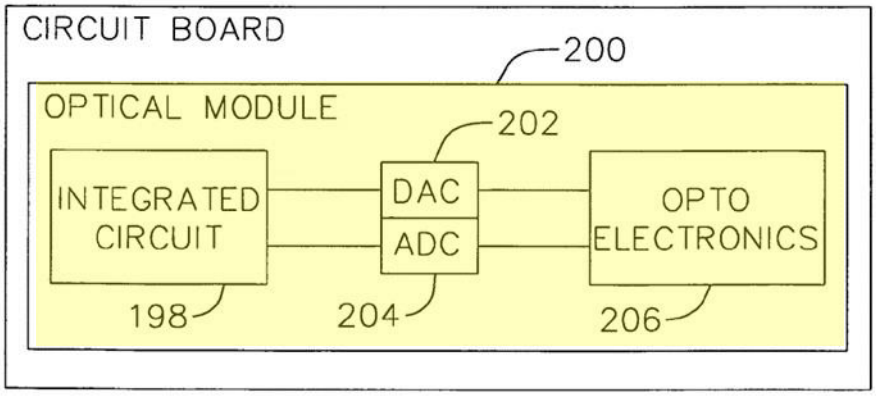
181. For at least these reasons, in reading Agazzi '341, a POSITA would have been motivated to look to the pluggable transceiver module in Wei and would have had a reasonable expectation of success in combining the two optical transceiver modules.

i. Claim 1: [1.pre] A method for m-ary modulation communication by a pluggable optical transceiver module comprising of:

182. To the extent the preamble is limiting, a POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation.

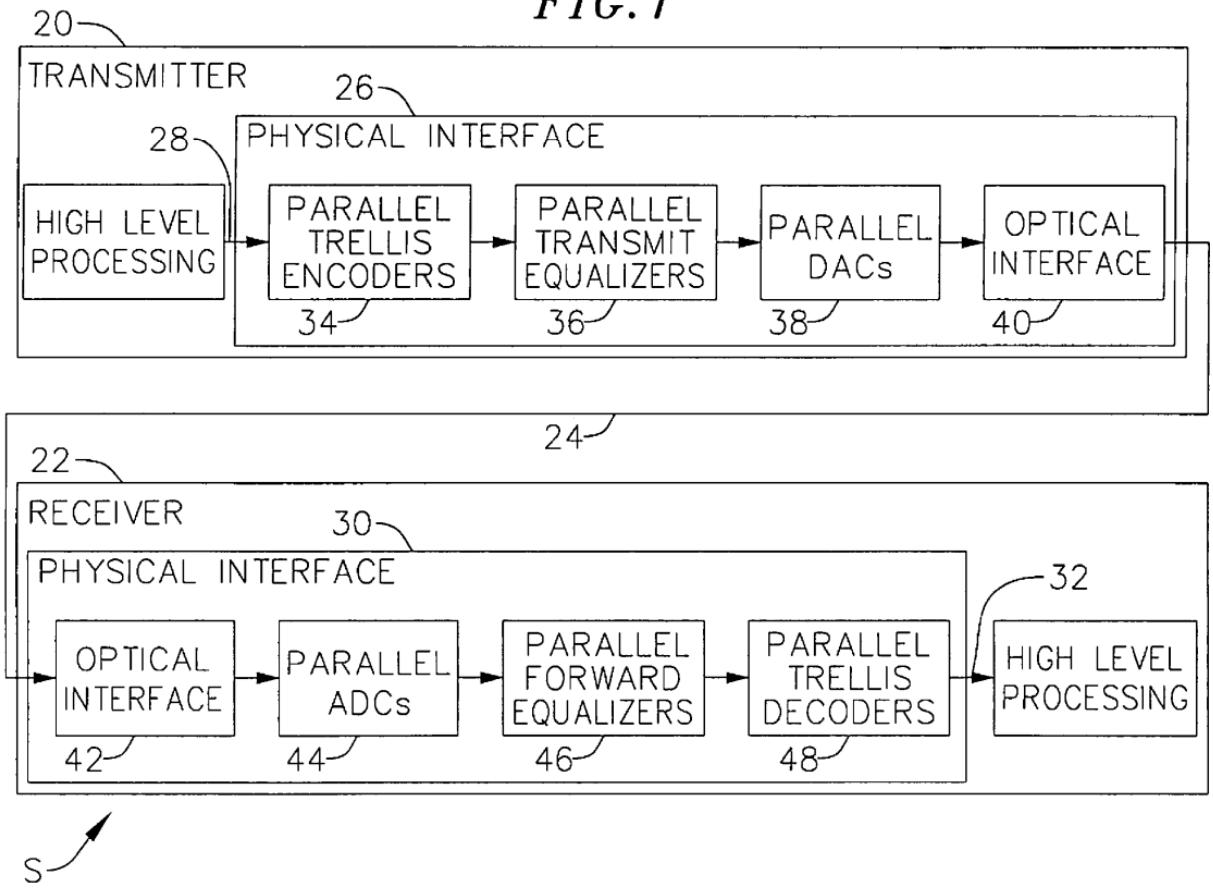
183. Agazzi '341 discloses an "optical transceiver module" in Figure 22 (shown in yellow below). Ex. 1009 at 3:34-36, Fig. 22.

FIG. 22



184. Agazzi ’341 further discloses an optical transceiver module that includes a transmit section (*i.e.*, optical transmitter) and a receive section (*i.e.*, optical receiver) as shown in Figure 1 below. Ex. 1009 at 2:1-7, Fig. 1.

FIG. 1



185. Agazzi ’341 also discloses a method for m-ary modulation in an optical transceiver module, including, for example, “utiliz[ing] five-level pulse amplitude modulation (PAM-5) signaling.” Ex. 1009 at 4:33-39, 15:47-49. The ’795 Patent identifies PAM as an example of m-ary modulation. Ex. 1001 at 10:13-19. A POSITA would have understood the PAM modulation disclosed in Agazzi ’341 to cover m-ary modulation.

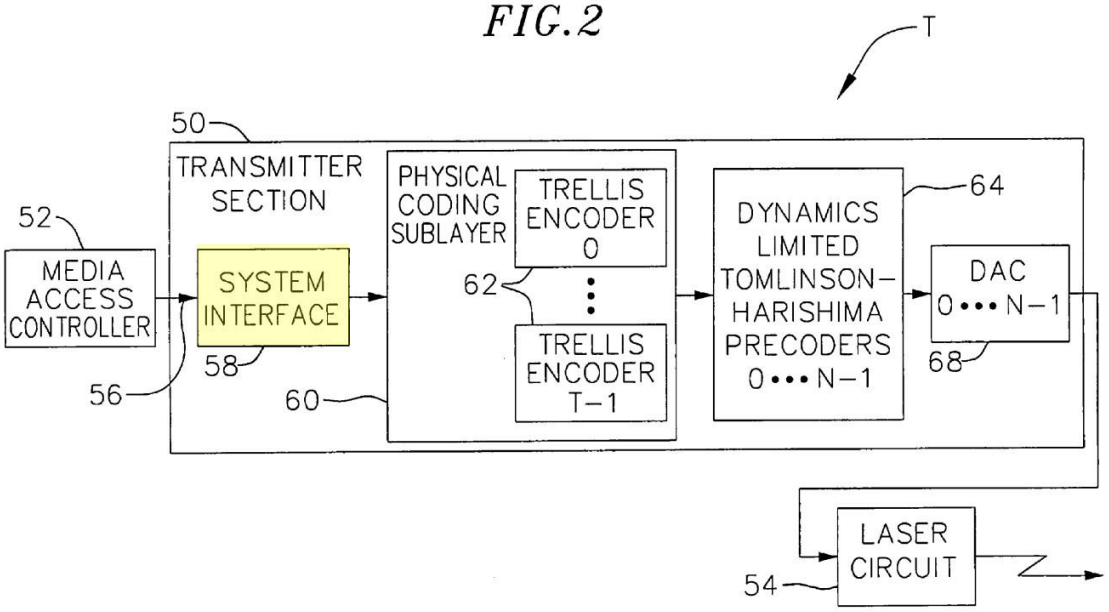
186. Wei discloses a "fiber optic transceiver module" where the module is a "pluggable optical transceiver in a small form pluggable." Ex. 1006 at 2:17-20, 3:29-32. Specifically, Wei discloses an optical transceiver module "in a small form pluggable (SFP), LC package." Ex. 1006 at 2:1-4, 2:28-35.

187. A POSITA would have been motivated to implement the transceiver in Agazzi '341 in Wei's SFP package for at least the reasons explained in Section XI(a) above. Therefore, it is my opinion that a POSITA would have understood that the combination of Agazzi '341 and Wei disclose "[a] method for m-ary modulation communication by a pluggable optical transceiver module." To the extent the "pluggable" limitation is included in subsequent claim limitations, my above analysis applies.

ii. Claim 1: [1.A] receiving a first electrical binary data signal through a system interface of the pluggable optical transceiver module;

188. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses an optical transceiver module that includes a transmitter that receives an electrical data signal through the system interface, performs signal processing, converts it to an optical signal, and then transmits the optical signal onto the optical fiber. *See, e.g.*, Ex. 1009 at Fig. 23. For example, Agazzi '341 discloses a system interface (shown in yellow below) that receives electrical data signals. Ex. 1009 at Fig. 2.

FIG. 2



189. Agazzi '341 teaches that the system interface "may comprise X-GMII interfaces." Ex. 1009 at 15:1-7. The '795 Patent teaches that the XGMII interface is a conventional system interface for receiving and transmitting signals. Ex. 1001 at 9:13-17. A POSITA would have understood that the system interface in Agazzi '341 (*i.e.*, electrical system interface), which can be an X-GMII interface, receives many electrical data signals, any one of which can be the claimed "first electrical binary data signal." The "first" electrical binary data signal is an arbitrary name for a signal that passes through the electrical system interface. A POSITA would further have understood the electrical data signals are digital which are understood to be binary. Ex. 1005 at 1:52-65. For example, Leon-Garcia teaches that digital signals "transfer a sequence of 0s and 1s," which is a binary sequence. Ex. 1015, 107.

190. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei discloses a male electrical connector coupled to an external electrical connector that "allow[s] electrical signals … to be coupled into or out of the fiber optic module." Ex. 1006 at 4:56-62. A POSITA would have understood this coupled area (see red rectangles below) to be an interface for the receipt and transmission of binary electrical data signals. Ex. 1006 at Figs. 3, 6C, 2:5-11.

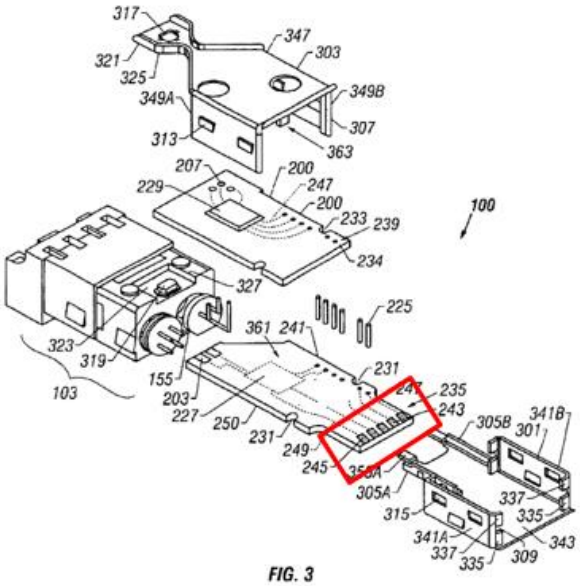


FIG. 3

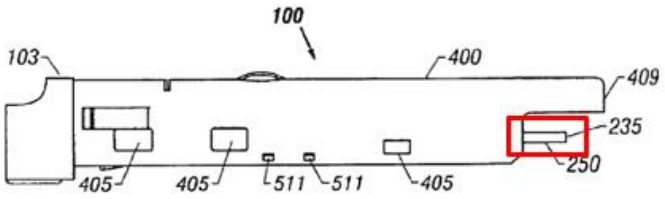
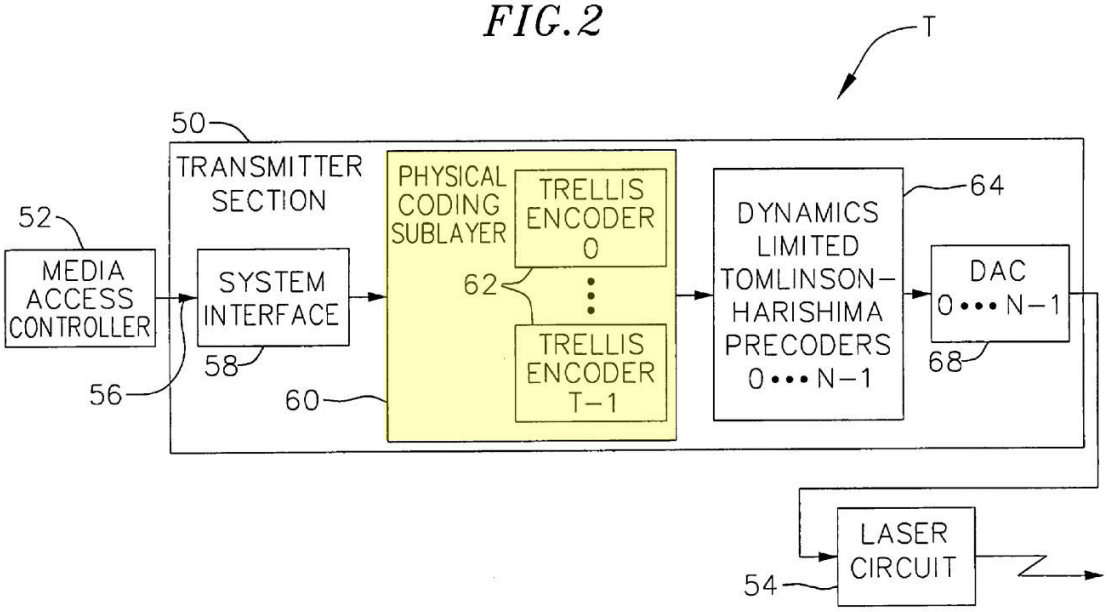


FIG. 6C

iii. Claim 1: [1.B] converting the first electrical binary data signal in the pluggable optical transceiver module to a first electrical m-ary modulation signal;

191. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses an optical transceiver module that "utilizes five-level pulse amplitude modulation (PAM-5)." Ex. 1009 at 4:33-39. Agazzi '341 further discloses that "[t]he invention may be practiced with different data modulation schemes. Including, for example, any level of PAM coding (e.g., PAM-3, PAM-7)." Ex. 1009 at 15:47-49. A POSITA would have understood that Agazzi '341 includes modulators as modulators are necessary to perform PAM modulation. While not specifically disclosed in Figure 2 below, Agazzi '341 teaches that trellis coding (in yellow below) is conducted in combination with a PAM-5 system. Ex. 1009, 4:54-57. This is consistent with the prior art as Leon-Garcia teaches that trellis encoding systems "combine error-correction coding with the modulation." Ex. 1015, 131.

FIG. 2



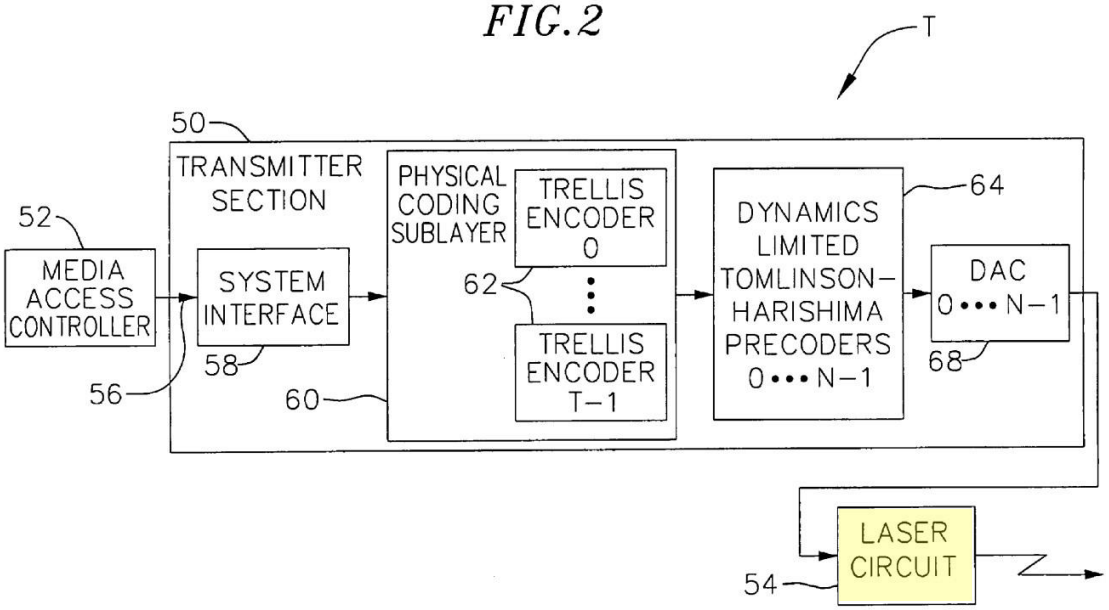
192. Moreover, Agazzi '341 also discloses that the transmitter portion of the optical receiver module performs PAM-5 modulation. Ex. 1009 at 4:28-35, Figs. 2-6. The PAM modulation disclosed in Agazzi '341 covers m-ary modulation because the '795 Patent identifies PAM as an example of m-ary modulation. Ex. 1001 at 10:11-19. A POSITA would have understood that the m-ary modulator in the trellis encoder in Agazzi '341 converts an input signal (*i.e.*, first electrical binary data signal) to a modulated output signal (*i.e.*, first electrical m-ary modulation signal) using m-ary modulation.

193. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

iv. Claim 1: [1.C] amplifying the first electrical m-ary modulation signal to drive an optical transmitter in the pluggable optical transceiver module;

194. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses a transmitter that provides an encoded data stream to drive a laser circuit (in yellow below). Ex. 1009 at 4:66-5:3, Fig. 2 (annotated). The laser circuit includes a laser driver. Ex. 1009 at 13:14.

FIG. 2



195. Agazzi '341 further discloses that encoded PAM-5 symbols drive a laser circuit, where the laser circuit "generates optical signals that are sent over an optical channel." Ex. 1009 at 4:35-39, 4:66-5:3, 11:38-42. A POSITA would have understood that the modulated signals are amplified by the optical driver to ensure the signals are sufficiently strong to drive the optical transmitter, which emits optical signals that must be able to travel long distances through optical fibers. For example,

a prior art textbook teaches a "laser drive circuit … consists of two differential amplifiers … The two differential amplifiers provide sufficient modulation current amplitude for the laser." Ex. 1017, 400. A POSITA would also have understood that the laser driver in Agazzi '341 amplifies a received signal (*i.e.*, first electrical m-ary modulation signal) to drive the optical transmitter.

196. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei also discloses a laser driver and amplifier. Ex. 1006 at 4:40-55. A POSITA would have understood that the electrical signals are amplified to ensure the driver receives electrical data signals that are sufficiently strong to drive the optical transmitter.

v. Claim 1: [1.D] emitting a first optical signal on a first wavelength responsive to and representative of the amplified first electrical m-ary modulation signal from the optical transmitter in the pluggable optical transceiver module;

197. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses an "optical transmitter." Ex. 1009 at 15:50-54. Specifically, Agazzi '341 discloses that the "transmitter 20 sends data to a receiver 22 over an optical channel." Ex. 1009 at 3:52-53. Agazzi '341 further discloses that "digital input signals" are received by the transmitter (Ex. 1009 at 14:7-9), "are processed by one or more processing elements" (*id.*), and then

"optical signals [] are sent over an optical channel" (Ex. 1009 at 6:66-5:3). As I explain in the technical background section, the optical transmitter receives electrical signals and converts them to optical signals where the optical signal is representative of the electrical signal. *See supra,* Section V(b). A POSITA would have understood that the optical transmitter is driven by (*i.e.*, is responsive to) an electrical signal (*i.e.*, amplified first electrical m-ary modulation signal) from the laser driver that it converts to a corresponding (*i.e.*, representative) optical signal (*i.e.*, first optical signal on a first wavelength) and then emits onto an optical fiber.

198. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei also discloses an optical transmitter that emits an optical signal onto an optical fiber that is responsive to and representative of the signal it receives. Ex. 1006 at 1:24-45.

vi. Claim 1: [1.E] receiving a second optical signal on a second wavelength and producing an electrical signal from an optical detector in the pluggable optical transceiver module;

199. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses an optical receiver that includes a photodetector (*i.e.*, optical detector, which is shown in yellow below) that receives

optical signals (*i.e.*, second optical signal on a second wavelength) and converts the optical signals to electrical signals (*i.e.*, electrical signal). Ex. 1009 at Fig. 5.

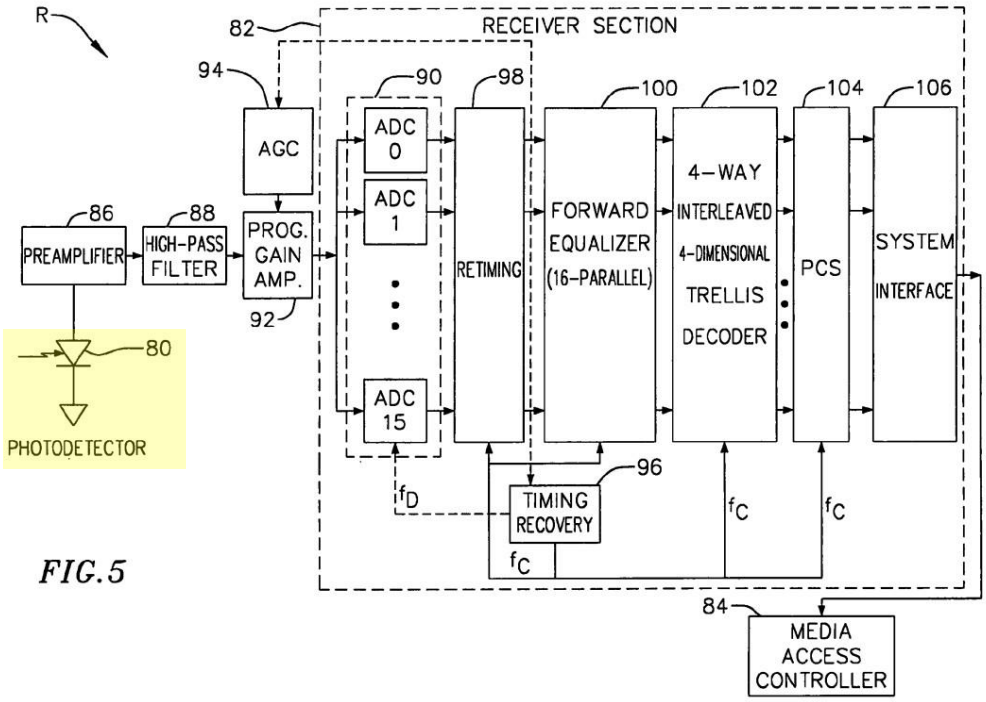


FIG.5

200. For example, Agazzi '341 discloses that "a photodetector 80 receives optical signals form an optical channel … to provide an encoded data stream to the receiver section." Ex. 1009 at 6:40-49. A POSITA would have understood that the photodetector (*i.e.*, optical detector) receives the signal when it is an optical signal, then produces an electrical signal that corresponds to the received optical signal. A POSITA would further have understood that the photodetector receives many optical signals, any one of which can be the claimed "second optical signal on a second wavelength."

201. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei discloses a receiver that "includes a photodetector (such as a photodiode) mounted in a package and an optical coupling element for coupling light or photons from the optical fiber into the photodetector." Ex. 1006 at 1:37-41.

vii. Claim 1: [1.F] amplifying the electrical signal to facilitate clock and data recovery in the pluggable optical transceiver module;

202. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses a preamplifier (shown in yellow below) that amplifies the electrical signals received from the photodetector, where the amplitude of the signals is controlled by a programmable gain amplifier (shown in blue below). Ex. 1009 at 6:46-60, Fig. 5.

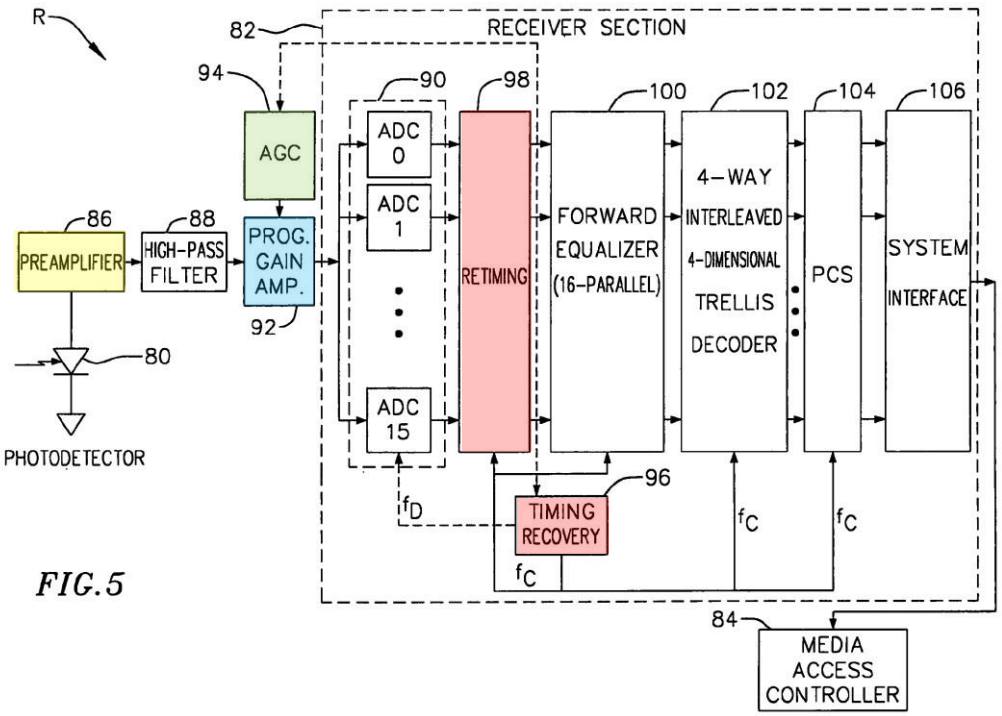


FIG. 5

203. The gain of the amplifier is, in turn, controlled by an automatic gain control ("AGC") (shown in green above). Ex. 1009 at 6:46-60. The amplified electrical signal is then sent to retiming and a timing recovery circuit (shown in red above) to facilitate clock recovery (Ex. 1009 at 7:14-17, 6:61-7:17) and to the forward equalizers, 4-way interleaved 4-dimensional trellis decoders, and physical coding sublayer (PCS) to facilitate data recovery (Ex. 1009 at 7:18-52). A POSITA would have understood that amplification of the electrical output of the photodetector is necessary to ensure that the received signal overcomes the subsequent noise in the electrical circuitry that follows, so that the data can be recovered. To perform data recovery a clock must first be recovered to help synchronize the demodulation process. This clock is typically recovered by isolating

a spectral component in the received signal that corresponds to the data rate and is in phase with the data. Ex. 1029, 152-153.

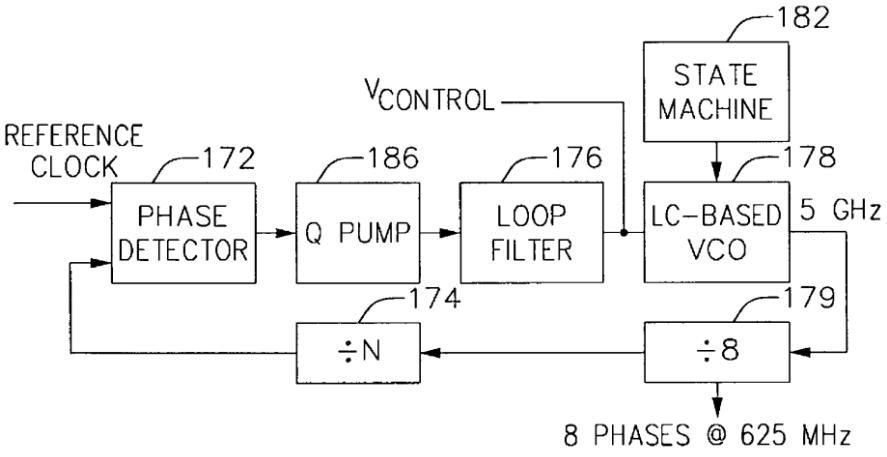
204. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

viii. Claim 1: [1.G] recovering a clock data information from the amplified electrical signal to produce a second m-ary modulation signal in the pluggable optical transceiver module;

205. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses a receiver system that amplifies the electrical signals received from the photodetector, where the amplitude of the signals is controlled by a programmable gain amplifier. Ex. 1009 at 6:46-60, Fig. 5. The gain of the amplifier is, in turn, controlled by an automatic gain control AGC. Ex. 1009 at 6:46-60. The amplified electrical signal is then sent to a timing recovery circuit to recover clock data information. Ex. 1009 at 6:61-7:17.

206. Agazzi '341 further discloses a receiver system that uses a phase locked loop architecture with a reference clock signal for timing recovery between the transmitter clock signal and the receiver clock signal. Ex. 1009 at 11:21-29, Fig. 17.

FIG. 17



207. A POSITA would have understood that timing recovery circuit receives an input signal (*i.e.*, amplified electrical signal), recovers clock data information, and produces an output signal (*i.e.*, second m-ary modulation signal).

208. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

ix. Claim 1: [1.H] demodulating the second m-ary modulation signal to a second electrical binary data signal in the pluggable optical transceiver module; and

209. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses that the invention may be practiced with different levels of modulation including any level of PAM coding, such as PAM-3 or PAM-5. Ex. 1009 at 15:47-49. Agazzi '341 also discloses a receiver system with a "symbol-by-symbol decoder … that compares the input

signal with threshold levels to determine, for example, the PAM level of the received signal." Agazzi at 14:25-48. While not disclosed in Figure 5, a POSITA would have known that the decoder (shown in yellow below) includes a demodulator to process the m-ary modulated signal. For example, a prior art textbook teaches that trellis encoding systems "are more complex in that they combine error-correction with the modulation." Ex. 1015, 121.

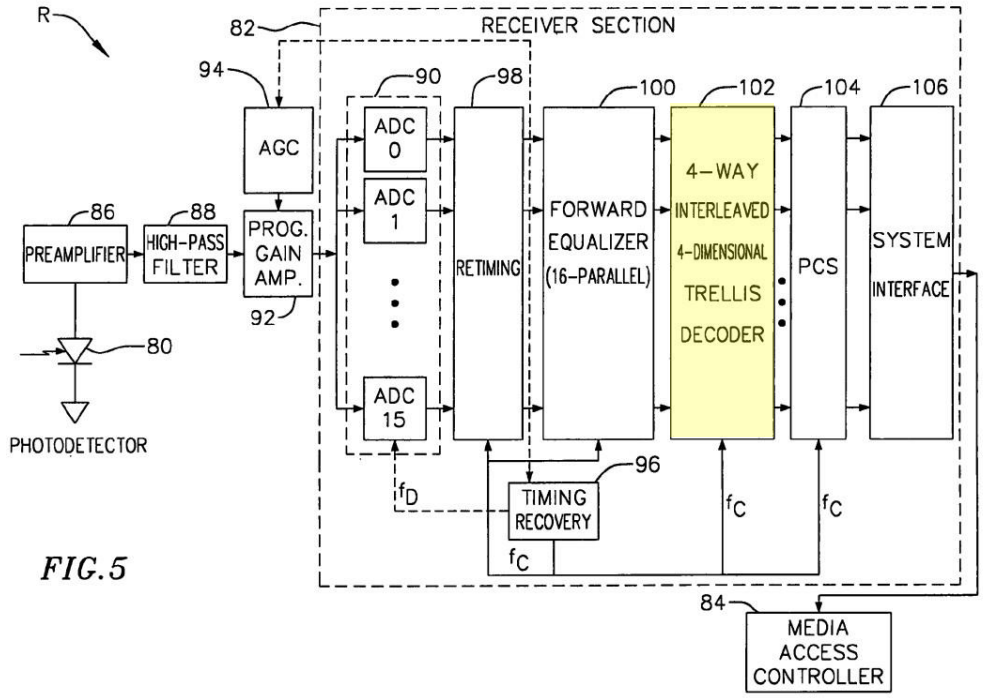


FIG.5

210. Moreover, the PAM-demodulators disclosed in Agazzi '341 are m-ary demodulators because the '795 Patent identifies PAM as an example of a m-ary modulation technique. Ex. 1001 at 10:11-19. A POSITA would have understood that the PAM-demodulator (*i.e.*, m-ary demodulator) in the trellis decoder

demodulates the input signal (*i.e.*, second m-ary modulation signal) to produce a demodulated output signal (*i.e.*, second electrical binary data signal).

211. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

x. Claim 1: [1.I] transmitting the second electrical binary data signal through the system interface of the pluggable optical transceiver module.

212. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses a receiver system that receives an optical signal, converts it to an electrical signal, performs signal processing, and then transmits the electrical signal through the system interface (shown in yellow below). *See, e.g.*, Ex. 1009 at Fig. 23.

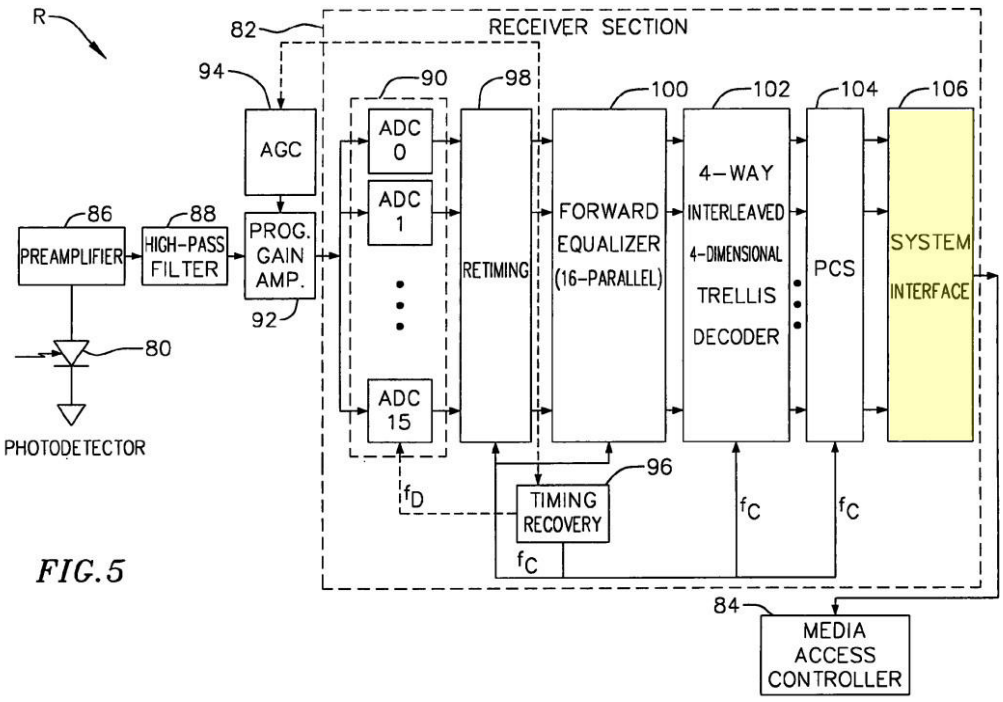


FIG. 5

213. Agazzi '341 teaches that the system interface "may comprise X-GMII interfaces." Ex. 1009 at 15:1-7. The '795 Patent teaches that the XGMII interface is a conventional system interface for receiving and transmitting signals. Ex. 1001 at 9:13-17. A POSITA would also have understood that the system interface, which can be an X-GMII interface, transmits many electrical data signals, any one of which can be the claimed "second electrical binary data signal." The "second" electrical binary data signal is an arbitrary name for a signal that passes through the electrical system interface. A POSITA would further have understood the electrical data signals are digital which are understood to be binary. Ex. 1005 at 1:52-65; 11:36-42. For example, Leon-Garcia teaches that digital signals "transfer a sequence of 0s and 1s," which is a binary sequence. Ex. 1015, 107.

214. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above. Moreover, Wei discloses a male electrical connector coupled to an external electrical connector that "allow[s] electrical signals … to be coupled into or out of the fiber optic module." Ex. 1006 at 4:56-62. A POSITA would have understood this coupled area (see red rectangles below) to be an interface for the receipt and transmission of binary electrical data signals. Ex. 1006 at Figs. 3, 6C.

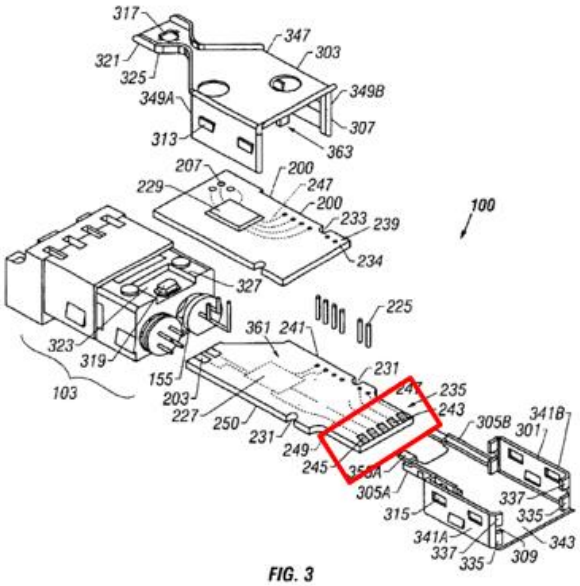


FIG. 3

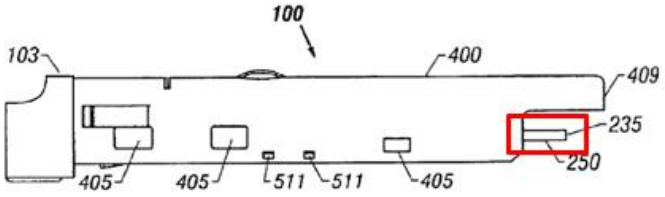


FIG. 6C

xi. Claim 2: The method of claim 1, whereby the form factor of the pluggable optical transceiver module is a pluggable form factor standard.

215. A POSITA would have understood Wei discloses this limitation. Wei discloses a "fiber optic transceiver module" with "vertically stacked printed circuit boards allows packaging the [transceiver] within an LC or other ***small form factor package***." Ex. 1006 at 2:17-35 (emphasis added). Specifically, Wei discloses a "***small form pluggable*** (SFP)" transceiver. Ex. 1006 at 2:1-4. As I explain in the technical background section, multisource agreements define the physical requirements for standardized pluggable form factors, which include the SFP. *See supra*, Section V(b). A POSITA would have understood that the SFP was a pluggable form factor standard for optical transceiver modules.

xii. Claim 3: The method of claim 2, whereby the pluggable form factor standard of the pluggable optical transceiver module is an SFP form factor or SFP+ form factor standard;

216. A POSITA would have understood Wei discloses this limitation. Wei discloses a "fiber optic transceiver module" with "vertically stacked printed circuit boards allows packaging the [transceiver] within an LC or other ***small form factor package***." Ex. 1006 at 2:17-35 (emphasis added). Specifically, Wei discloses a "***small form pluggable (SFP)***" transceiver. Ex. 1006 at 2:1-4. As I explain in the technical background section, multisource agreements define the physical requirements for standardized pluggable form factors, which include the SFP. *See*

supra, Section V(b). A POSITA would have understood that the SFP was a pluggable form factor standard for optical transceiver modules.

xiii. Claim 5: The method of claim 1, whereby the m-ary modulation is a m-ary pulse amplitude modulation communication method that uses two or more bits per symbol for communication.

217. A POSITA would have understood Agazzi '341 discloses this limitation. Agazzi '341 discloses an optical transceiver module that "utilizes five-level ***pulse amplitude modulation*** (PAM-5)." Ex. 1009 at 4:33-39 (emphasis added). Agazzi '341 further discloses that "[t]he invention may be practiced with different data modulation schemes. Including, for example, any level of PAM coding (e.g., PAM-3, PAM-7)." Ex. 1009 at 15:47-49.

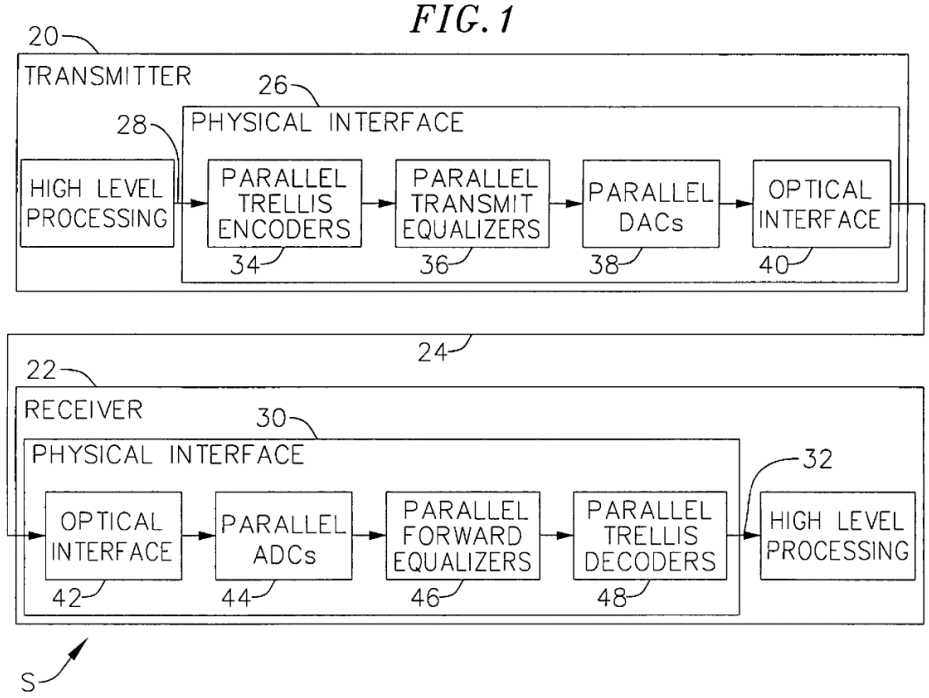
218. The '795 Patent identifies PAM as an example of m-ary modulation. Ex. 1001 at 10:13-19. A POSITA would have understood the PAM modulation disclosed in Agazzi '341 to cover m-ary PAM modulation because the '795 Patent disclosed PAM modulation as a type of m-ary modulation.

xiv. Claim 10: The method of claim 1, whereby the first electrical binary data signal and second electrical binary data signal are parallel electrical binary data signals.

219. A POSITA would have understood Agazzi '341 discloses this limitation. Agazzi '341 discloses an optical transceiver module that employs "***parallel processing*** to achieve reliable data transmission at relatively high data transfer rates." Ex. 1009 at 1:55-2:7 (emphasis added). Specifically, Agazzi '341

discloses "***parallel processing*** in the transmitter, receiver and data converters." Ex. 1009 at 4:50-57. For example, Agazzi '341 discloses that "[o]ne embodiment of the transceiver incorporates parallel encoding and decoding." Ex. 1009 at 2:21-23. Figure 1, reproduced below, shows the parallel processing capabilities disclosed in Agazzi '341.

FIG. 1



220. Figure 1 also shows electrical binary data signals that are received into and transmitted out of the transceiver and which are parallel signals. Ex. 1009 at Fig. 1. Because the transceiver has parallel processing capabilities, the transceiver must have an electrical interface configured to receive and transmit parallel signals. Accordingly, a POSITA would have understood the electrical system interface includes parallel signals as the transceiver receives and transmits parallel signals,

and there are multiple such signals (*i.e.*, first electrical binary data signal and second electrical binary data signal).

xv. Claim 16: The method of claim 1, further comprising coding the first electrical binary data signal and decoding the second electrical binary signal according to an error correcting code in the pluggable optical transceiver module.

221. A POSITA would have understood the combination of Agazzi '341 and Wei discloses this limitation. Agazzi '341 discloses an optical transceiver module with a "set of parallel trellis encoders" and a "set of parallel trellis decoders" that encode/decode signals according to a trellis code. Ex. 1009 at 4:12-27. Agazzi '341 further discloses that "the invention may be practiced with a wide variety of encoding and decoding schemes [i]ncluding different trellis encoding schemes and convolutional encoding and block encoding." Ex. 1009 at 15:55-58. As I explain in the technical background section, a trellis code and a convolutional code are both types of error correcting codes, and this would have been well-known by a POSITA. *See supra*, Section V(e). A POSITA would also have known that error correcting codes require encoding and decoding processing to implement.

222. Wei discloses a pluggable optical transceiver module, and a POSITA would have been motivated to combine the optical transceiver module disclosed in Agazzi '341 with the pluggable form factor disclosed in Wei for the reasons previously stated above.

xvi. Claim 17: The method of claim 16, whereby the error correcting code is a convolutional code.

223. A POSITA would have understood Agazzi '341 discloses this limitation. Agazzi '341 discloses an optical transceiver module with a "***convolutional coder***" and a "***convolutional code decoder***" that encode/decode signals according to a convolutional code. Ex. 1009 at 13:62-14:5 (emphasis added). As I explain in the technical background section, a convolutional code is a type of error correcting code, and this would have been well-known by a POSITA. *See supra*, Section V(e).

xvii. Claim 18: The method of claim 16, whereby the error correcting code is a forward error correcting (FEC) code.

224. A POSITA would have understood Agazzi '341 discloses this limitation. Agazzi '341 discloses an optical transceiver module with a "set of parallel trellis encoders" and a "set of parallel trellis decoders" that encode/decode signals according to a trellis code. Ex. 1009 at 4:12-27. Agazzi '341 further discloses signal processing using a convolutional code or a block code. Ex. 1009 at 14:2-6. As I explain in the technical background section, a trellis code, convolutional code, and block code are all types of forward error correcting codes, and this would have been well-known by a POSITA. *See supra*, Section V(e).

xviii. Claim 19: The method of claim 16, whereby the error correcting code is a trellis code.

225. A POSITA would have understood Agazzi '341 discloses this limitation. Agazzi '341 discloses an optical transceiver module with a "set of parallel ***trellis encoders***" and a "set of parallel ***trellis decoders***" that encode/decode signals according to a trellis code. Ex. 1009 at 4:12-27 (emphasis added). As I explain in the technical background section, a trellis code is a type of error correcting code, and this would have been well-known by a POSITA. *See supra*, Section V(e).

b. Ground 5: The combination of Agazzi '341, Wei, and Gans render claims 11-12 obvious.

226. As previously described, both Agazzi '341 and Wei relate to fiber-optic communications. And both Agazzi '341 and Wei attempt to increase the data throughput rates in a cost effective manner. Ex. 1009 at 1:46-51; Ex. 1006 at 1:66-2:4. However, Agazzi '341 and Wei do not expressly disclose transmitting/receiving dual polarized optical signals.

227. Gans, like Agazzi '341 and Wei, relates to fiber-optic communications. Ex. 1007 at Abstract. Specifically, Gans discloses transmitting and receiving dual polarized optical signals. Ex. 1007 at 2:13-34. There were several reasons a POSITA would have been motivated to combine Gans with Agazzi '341 and Wei.

228. First, Gans discloses a technique for increasing the data throughput—a problem addressed in both Agazzi '341 and Wei. Ex. 1009 at 1:46-51; Ex. 1006 at

1:66-2:4. In particular, Gans discloses transmitting/receiving dual polarized optical signals because "it permits more information to pass through the fiber without increasing the bit rate in any particular polarization." Ex. 1007 at 1:20-27. A POSITA would have been motivated to add the dual polarization technique disclosed in Gans to the m-ary pluggable transceiver taught by the combination of Agazzi '641 and Wei in order to further increase the data throughput rate.

229. Second, dual polarization was cost effective. Gans discloses a dual polarization technique that increases the data throughput rate of the optical fiber without the need to replace pre-existing fiber systems. Ex. 1007 at 1:14-19. A POSITA would have understood that this was a cost effective technique because it was expensive to replace optical fibers. Moreover, decreasing costs was a stated goal in both Agazzi '341 and Wei. Ex. 1009 at 1:50-51; Ex. 1006 at 1:50-69. Thus, a POSITA would have been motivated to combine Gans with Agazzi '341 and Wei because higher order modulation, coupled with dual polarization, allowed for the transmission of higher data rates over the same optical fibers. This allowed for more data to be transferred in the same channel over the same amount of time and was a simple way to increase data speeds in a communication system without going through the costly and resource intensive activity of replacing older fiber channels.

230. Moreover, a POSITA would have had a reasonable expectation of success in adding dual polarization functionality to a higher order modulation

pluggable transceiver to produce expected results. In fact, many of the expected results of the combination were stated goals in the references.

i. Claim 11: The method of claim 1, whereby the first optical signal emitted by the pluggable optical transceiver module is dual polarized.

231. A POSITA would have understood the combination of Agazzi '341, Wei, and Gans discloses this limitation. Wei discloses a pluggable optical transceiver module and Agazzi '341 discloses the other limitations in claim 1 for the reasons previously stated. Gans discloses the use of dual polarization, which was a known modulation/demodulation scheme for optical networks. Ex. 1007 at 8:11-24. In particular, Gans discloses a "method for increasing transmission capacity using … ***dual polarization***." Ex. 1007 at 8:11-13 (emphasis added). Gans further discloses that "two optical signals of different polarizations are transmitted through a single optical fiber." Ex. 1007 at 1:20-23.

232. A POSITA would have been motivated to combine the dual polarization technique disclosed in Gans with the pluggable transceiver module taught by the combination of Agazzi '341 and Wei for the reasons previously stated above.

ii. Claim 12: The method of claim 1, whereby the second optical signal received by the pluggable optical transceiver module is dual polarized.

233. A POSITA would have understood the combination of Agazzi '341, Wei, and Gans discloses this limitation. Wei discloses a pluggable optical transceiver module and Agazzi '341 discloses the other limitations in claim 1 for the reasons previously stated. Gans discloses the use of dual polarization, which was a known modulation/demodulation scheme for optical networks. Ex. 1007 at 8:11-24. In particular, Gans discloses a "method for increasing transmission capacity using … ***dual polarization***." Ex. 1007 at 8:11-13 (emphasis added). Gans further discloses that "[o]ptical signals of different polarizations that are received from a single optical fiber are distinguished from one another by separating the output of the optical fiber into different optical polarization components." Ex. 1007 at 2:16-22.

234. A POSITA would have been motivated to combine the dual polarization technique disclosed in Gans with the pluggable transceiver module taught by the combination of Agazzi '341 and Wei for the reasons previously stated above.

c. Ground 6: The combination of Agazzi '341, Wei, and Agazzi '640 render claims 13-14 obvious.

235. As previously described, both Agazzi '341 and Wei relate to fiber-optic communications. And both Agazzi '341 and Wei attempt to increase the data

throughput rates. Ex. 1009 at 1:46-51; Ex. 1006 at 1:66-2:4. In particular, Agazzi '341 teaches a transceiver module that performs m-ary modulation, including "five-level pulse amplitude modulation (PAM-5)." Ex. 1009 at 4:33-35. Agazzi '341 further teaches that "any level of PAM coding (e.g., PAM-3, PAM-7)" can be used. Ex. 1009 at 15:47-49. This allows the transceiver module in Agazzi '341 to transmit data at higher rates through existing fiber infrastructure, which is a specific goal of Agazzi '341. However, Agazzi '341 and Wei do not expressly disclose QAM or QPSK.

236. Agazzi '640, like Agazzi '341 and Wei, relates to fiber-optic communications. Ex. 1005 at 4:15-32, 12:18-23, 15:7-10, 16:7-14, at Figs. 1D, 2A, 3. Specifically, Agazzi '640 discloses performing multilevel modulation within the transmitter/receiver portions of the optical transceiver, including "Pulse Amplitude Modulation (PAM) or Quadrature Amplitude Modulation (QAM) to encode several bits per transmitted symbol." Ex. 1005 at 3:15-20, Figs. 2A, 3. Agazzi '640 further discloses performing "quadrature phase shift keying (QPSK)" modulation. Ex. 1005 at 17:7. There were several reasons a POSITA would have been motivated to combine Agazzi '640 with Agazzi '341 and Wei.

237. First, both Agazzi '341 and Agazzi '640 disclose multilevel modulation techniques that can be used to increase the data throughput. And Agazzi '640 discloses additional multilevel modulation techniques (e.g., QAM and QPSK) that

allow for increased data transmission compared to the PAM modulation disclosed in Agazzi ’341. Ex. 1006 at 1:66-2:4. As increasing the data throughput rate was a stated goal in both Agazzi ’341 and Agazzi ’640, a POSITA would naturally have look to Agazzi ’640 to find higher order modulation techniques to further increase the data transmission rate.

238. Moreover, increasing the data transmission rate was also a stated goal in Wei. Thus, a POSITA would have been motivated to add one of the higher order modulation techniques described in Agazzi ’640 to the m-ary pluggable transceiver taught by the combination of Agazzi ’341 and Wei to create an m-ary pluggable transceiver with increased data rates. This allowed for more data to be transferred in the same channel over the same amount of time and was a simple way to increase data speeds in a communication system without going through the costly and resource intensive activity of replacing older fiber channels.

239. Second, the higher order modulation techniques disclosed in Agazzi ’640 were cost effective ways to increase data throughput. Decreasing costs was a stated goal in both Agazzi ’341 and Wei as well as Agazzi ’640. Ex. 1009 at 1:50-51; Ex. 1006 at 1:50-69; Ex. 1005 at 1:45-49. Agazzi ’640 was cost effective because it allowed for increased data speeds without the need to replace older fiber channels, which can be costly endeavor. Thus, a POSITA would have been motivated to combine Agazzi ’640 with Agazzi ’341 and Wei because an m-ary

pluggable transceiver with the advanced modulation techniques taught by Agazzi '640 allows for greater data transmission rates. This allowed for more data to be transferred in the same channel over the same amount of time and was a simple way to increase data speeds without replacing older fiber channels.

240. Moreover, a POSITA would have had a reasonable expectation of success in adding the QAM and/or QPSK modulation capabilities to the m-ary pluggable transceiver to produce expected results. In fact, many of the expected results of the combination were stated goals in the references.

i. Claim 13: The method of claim 1, whereby the m-ary modulation is a m-ary quadrature amplitude modulation. communication method that uses two or more bits per symbol for communication.

241. A POSITA would have understood the combination of Agazzi '341, Wei, and Agazzi '640 discloses this limitation. Wei discloses a pluggable optical transceiver module and Agazzi '341 discloses the other limitations in claim 1 for the reasons previously stated. Agazzi '640 discloses performing multilevel modulation within the transmitter portion of the optical transceiver, including "***Quadrature Amplitude Modulation*** (QAM) to ***encode several bits per*** transmitted ***symbol***." Ex. 1005 at 3:15-20 (emphasis added), Figs. 2A, 10.

242. The '795 Patent identifies QAM as an example of m-ary modulation. Ex. 1001 at 10:11-19. A POSITA would have understood the QAM modulation

disclosed in Agazzi ’640 to cover m-ary QAM modulation because the ’795 Patent disclosed QAM modulation as a type of m-ary modulation.

ii. Claim 14: The method of claim 1, whereby the m-ary modulation is a m-ary quadrature phase shift keying modulation communication method that uses two or more bits per symbol for communication.

243. A POSITA would have understood the combination of Agazzi ’341, Wei, and Agazzi ’640 discloses this limitation. Wei discloses a pluggable optical transceiver module and Agazzi ’341 discloses the other limitations in claim 1 for the reasons previously stated. Agazzi ’640 discloses performing multilevel modulation within the transmitter portion of the optical transceiver, including “***quadrature phase shift keying*** (QPSK).” Ex. 1005 at 17:5-8 (emphasis added). Agazzi ’640 further teaches that multilevel modulation is used “to ***encode several bits per*** transmitted ***symbol***.” Ex. 1005 at 3:15-20 (emphasis added), Figs. 2A, 10.

244. The ’795 Patent identifies QPSK as an example of m-ary modulation. Ex. 1001 at 10:11-19. A POSITA would have understood the QPSK modulation disclosed in Agazzi ’640 to cover m-ary QPSK modulation because the ’795 Patent disclosed QPSK modulation as a type of m-ary modulation.

d. Ground 7: The combination of Agazzi ’341, Wei, and Eroz render claims 20-21 obvious.

245. As previously described, both Agazzi ’341 and Wei relate to fiber-optic communications. And both Agazzi ’341 and Wei attempt to increase the data

throughput rates. Ex. 1009 at 1:46-51; Ex. 1006 at 1:66-2:4. In particular, Agazzi '341 discloses implementing error correcting codes "to achieve reliable data transmission at relatively high data transfer rates." Ex. 1009 at 1:55-59.

246. To that end, Agazzi '341 discloses an optical transceiver module with a "set of parallel trellis encoders" and a "set of parallel trellis decoders" that encode/decode signals according to a trellis code. Ex. 1009 at 4:12-27. Agazzi '341 further discloses signal processing using a convolutional code or a block code. Ex. 1009 at 14:2-6. A POSITA would have understood that a trellis code, convolutional code, and block code are all types of forward error correcting codes that require encoding and decoding processing to implement. However, Agazzi '341 and Wei do not expressly disclose implementing Reed-Solomon or LDPC error correcting codes—both of which are types of forward error correcting codes.

247. Eroz, like Agazzi '341 and Wei, relates to fiber-optic communications. Ex. 1008 at 1:38-39, 14:42-47. Specifically, Eroz discloses coding optical signals using an error correcting code "to ensure reliable communication across noisy communication channels." Ex. 1008 at 1:42-45, 13:65-14:2. Eroz further discloses utilizing "LDPC codes efficiently to support high data rates, without introducing greater complexity." *Id.* at 2:3-5. Eroz also discloses utilizing a "Reed-Solomon (RS) code." *Id.* at 7:12-16. A POSITA would have understood that LDPC and Reed-Solomon codes are both types of forward error correcting codes. There were several

reasons a POSITA would have been motivated to combine Eroz with Agazzi '341 and Wei.

248. First, both Agazzi '341 and Eroz disclose forward error correcting codes that were used to minimize the impact of noise on the signals. By implementing this error correction signal processing, it increases the efficiency of the data through the fiber system by minimizing errors. And, when determining what error correcting code to use, a POSITA would have naturally looked from Agazzi '341 to Eroz to find additional error correcting codes as both references teach different types of forward error correction codes that can be used in fiber systems. For example, a POSITA would have understood that, compared to other coding techniques, like trellis coding, LDPC codes as taught by Eroz offer the advantage of highly efficient information transfer over bandwidth-constrained channels in the presence of noise, especially at high code rates. Ex. 1022 at 1. A POSITA would also have understood that BCH codes, such as Reed Solomon codes, have the advantage of substantially reducing the bit error rate in the presence of noise, and have been successfully used in numerous consumer applications where there are burst errors, such as compact discs, DVDs, QR codes, and satellite communications. Ex. 1021, 1-15.

249. Second, Eroz discloses a technique for efficiently increasing the data throughput—a problem addressed in both Agazzi '341 and Wei. Ex. 1009 at 1:46-

51; Ex. 1006 at 1:66-2:4. In particular, Eroz discloses LDPC codes and Reed-Solomon codes that can be used "efficiently to support high data rates." Ex. 1008 at 2:3-5. A POSITA would have been motivated to add the error correcting codes disclosed in Eroz to the m-ary pluggable transceiver taught by the combination of Agazzi '341 and Wei to further increase the data throughput rate by minimizing errors.

250. Third, LDPC and Reed-Solomon codes were cost effective. Eroz discloses error correcting techniques that allow for high data throughput with reduced errors without the need to replace pre-existing fiber systems. A POSITA would have understood that this was a cost effective technique because it did not require replacement of existing optical infrastructure to increase data rates and data reliability. Moreover, decreasing costs was a stated goal in both Agazzi '341 and Wei. Ex. 1009 at 1:50-51; Ex. 1006 at 1:50-69. Thus, a POSITA would have been motivated to combine Eroz with Agazzi '341 and Wei because higher order modulation in a pluggable transceiver, coupled with LDPC or Reed-Solomon error correcting codes, allowed for the transmission of higher data rates with increased reliability over the same optical fibers. This allowed for more data to be transferred in the same channel over the same amount of time and was a simple way to increase data speeds while maintaining reliability without replacing older fiber channels.

251. Moreover, a POSITA would have had a reasonable expectation of success in adding the LDPC and/or Reed-Solomon error correcting functionality to the higher order modulation transceiver to produce expected results. In fact, many of the expected results of the combination were stated goals in the references.

i. Claim 20: The method of claim 16, whereby the error correcting code is a Reed-Solomon code.

252. A POSITA would have understood the combination of Agazzi '341, Wei, and Eroz discloses this limitation. Wei discloses a pluggable optical transceiver module and Agazzi '341 discloses the other limitations in claim 1 from which claim 16 depends for the reasons previously stated. Eroz discloses encoding/decoding "optical signals that carry digital data streams representing various types of information." Ex. 1008 at 13:65-14:2. Eroz further discloses encoding/decoding using a "***Reed-Solomon (RS) code***." Ex. 1008 at 7:12-16 (emphasis added). As I explain in the technical background section, a Reed-Solomon code is a type of error correcting code, and this would have been well-known by a POSITA. *See supra*, Section V(e).

ii. Claim 21: The method of claim 16, whereby the error correcting code is a low-density parity-check (LDPC) code.

253. A POSITA would have understood the combination of Agazzi '341, Wei, and Eroz discloses this limitation. Wei discloses a pluggable optical transceiver module and Agazzi '341 discloses the other limitations in claim 1 from

which claim 16 depends for the reasons previously stated. Eroz discloses encoding/decoding "optical signals that carry digital data streams representing various types of information." Ex. 1008 at 13:65-14:2. Eroz further discloses encoding/decoding using "***low density party check (LDPC) codes***." Ex. 1008 at Abstract (emphasis added). As I explain in the technical background section, a LDPC code is a type of error correcting code, and this would have been well-known by a POSITA. *See supra*, Section V(e).

XII. Revision or Supplementation

254. In this report, I have presented my opinions regarding the invalidity of the challenged claims of the '795 Patent based on the information available to me. My opinions are subject to change in view of opinions provided by the Patent Owner or its expert, or any additional information that I may receive. I reserve the right to supplement my opinions accordingly.

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.

Executed March 13, 2023

Dr. Paul R. Prucnal