IW 7416943

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

May 16, 2013

THIS IS TO CERTIFY THAT ANNEXED IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF THE FILE WRAPPER AND CONTENTS OF:

APPLICATION NUMBER: ***11/514,725***
FILING DATE: ***September 01, 2006***
PATENT NUMBER: ***7,664,395***
ISSUE DATE: ***February 16, 2010***

By Authority of the
Under Secretary of Commerce for Intellectual Property and Director of the United States Patent and Trademark Office

R. PONDEXTER
Certifying Officer

FINISAR 1002
TS0001167

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

UTILITY PATENT APPLICATION TRANSMITTAL (Only for new nonprovisional applications under 37 CFR 1.53(b))	Attorney Docket No.	3274.1003-002
	First Named Inventor	Melanie Holmes
	Express Mail Label No.	EV 214902601 US
Title of Invention	OPTICAL PROCESSING	

APPLICATION ELEMENTS See MPEP chapter 600 concerning utility patent application contents.	ADDRESS TO: **Commissioner for Patents P.O. Box 1450 Alexandria, VA 22313-1450**

1. [ ] Fee Transmittal Form *(Submit an original and a duplicate for fee processing)*
2. [X] Specification **Total Pages [100]** Both the claims and the abstract must start on a new page *(For information on the preferred arrangement, see MPEP 608.01(a))*
3. [X] Drawing(s) (35 U.S.C. 113) **Total Sheets [36]**
   [X] Fig. of the Drawings for Publication [13b]
   [ ] No Figure to be Published
4. [ ] Oath or Declaration **Total Pages [ ]**
   a. [ ] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. 1.63(d)) *(for continuation/divisional with Box 18 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. [ ] CD-ROM or CD-R in duplicate, large table or Computer Program *(Appendix)*
6. [ ] Nucleotide and/or Amino Acid Sequence Submission (if applicable, items a.-c. are required)
   a. [ ] Computer Readable Form (CRF)
      i. [ ] Computer Readable Form (CRF)
      ii. [ ] Transfer Request (37 CFR 1.821(e))
   b. [ ] Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] Paper [ ] **Pages**
   c. [ ] Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & documents)
   Name of Assignee Thomas Swan & Co. Ltd.
   City & State: Durham, United Kingdom
8. [ ] 37 CFR 3.73(b) Statement (when there is an assignee) [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [X] Information Disclosure Statement *(PTO-1449)*
    [ ] Copies of foreign patent documents, publications, and other information
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard
13a. [ ] Foreign Priority Claim under 35 U.S.C. § 119 or 365
13b. [ ] Certified Copy of Priority Document(s)
14. [ ] Nonpublication Request under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
15. [X] Remarks
16. [ ] Small Entity Statement(s)
17. [ ] Other

18. **If a CONTINUING APPLICATION,** check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title:

[ ] Continuation [X] Divisional [ ] Continuation-in-part (CIP) of prior application No.: 10/487,810

Prior application information: Examiner: Loha Ben Group Art Unit: 2873

The entire disclosure of the prior application is considered a part of the disclosure of the accompanying application and is hereby incorporated by reference.
(Add standard Related Applications section with incorporation by reference to specification or update same)

19. CORRESPONDENCE ADDRESS

NAME	Customer No. 021005				
	HAMILTON, BROOK, SMITH & REYNOLDS, P.C.				
ADDRESS	530 Virginia Road, P.O. Box 9133				
CITY	Concord	STATE	MA	ZIP CODE	01742-9133
COUNTRY	USA	TELEPHONE	(978) 341-0036	FAX	(978) 341-0136

Signature	[signature]	Date	9/1/6
Submitted by Typed or Printed Name	Timothy J. Meagher	Reg. Number	39,302

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;647412;1

TS0001168

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;644031;1
TJM/jk
08/22/06

PATENT APPLICATION
Attorney's Docket No.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Melanie Holmes

Divisional Application of

Application No.: 10/487,810

371C File Date: September 10, 2004

For: OPTICAL PROCESSING

Date: 9/1/06

EXPRESS MAIL LABEL NO. EV214902601US

REMARKS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

The above-captioned application is a divisional of application number 10/487,810 to which priority is claimed under 35 U.S.C. §120.

The specification of the present application is substantially the same as that of the parent application. The related applications paragraph has been revised to include a specific reference to the parent application.

Claims 19-21 and 23-27 as presented in the parent application have been renumbered sequentially beginning with Claim 1. A newly executed declaration under 37 C.F.R. 1.63 is not believed to be necessary under 37 C.F.R. 1.63(d) or 1.67(b).

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 9/1/6

TS0001169

Date: 9/1/06 Express Mail Label No. EV 214902601 US

Inventor: Melanie Holmes

Attorney's Docket No.: 3274.1003-002

OPTICAL PROCESSING

RELATED APPLICATIONS

This application is a divisional of U.S. Appl. No. 10/487,810, which is the U.S. National Stage of International Appl. No. PCT/GB02/04011, filed September 2, 2002, and published in English. This application claims priority under 35 U.S.C. § 119 or 365 to Great Britain Appl. No. 0121308.1, filed September 3, 2001. The entire teachings of the above application(s) are incorporated herein by reference.

FIELD OF THE INVENTION

[0001] The present invention relates to an optical device and to a method of controlling an optical device.

[0002] More particularly but not exclusively the invention relates to the general field of controlling one or more light beams by the use of electronically controlled devices. The field of application is mainly envisaged as being to fields in which reconfiguration between inputs and outputs is likely, and stability of performance is a significant requirement.

BACKGROUND OF THE INVENTION

[0003] It has previously been proposed to use so-called spatial light modulators to control the routing of light beams within an optical system, for instance from selected ones of a number of input optical fibres to selected ones of output fibres.

[0004] Optical systems are subject to performance impairments resulting from aberrations, phase distortions and component misalignment. An example is a multiway fibre connector, which although conceptually simple can often be a critical source of system failure or insertion loss due to the very tight alignment tolerances for optical fibres, especially for single-mode optical fibres. Every time a fibre connector is connected, it may provide a different alignment error. Another example is an optical switch in which aberrations, phase distortions and component misalignments result in poor optical coupling efficiency into the intended output optical fibres. This in turn may lead to high insertion loss. The aberrated propagating waves may diffract into intensity fluctuations creating significant unwanted coupling of light into other output optical fibres, leading to levels of crosstalk that impede operation. In some cases, particularly where long path lengths are involved, the component misalignment may occur due to ageing or temperature effects.

[0005] Some prior systems seek to meet such problems by use of expensive components. For example in a communications context, known free-space wavelength multiplexers and demultiplexers use expensive thermally stable opto-mechanics to cope with the problems associated with long path lengths.

[0006] Certain optical systems have a requirement for reconfigurability. Such reconfigurable systems include optical switches, add/drop multiplexers and other optical routing systems where the mapping of signals from input ports to output ports is dynamic. In such systems the path-dependent losses, aberrations and phase distortions encountered by optical beams may vary from beam to beam according to the route taken by the beam through the system. Therefore the path-dependent loss, aberrations and phase distortions may vary for each input beam or as a function of the required output port.

[0007] The prior art does not adequately address this situation.

[0008] Other optical systems are static in terms of input/output configuration. In such systems, effects such as assembly errors, manufacturing tolerances in the optics and also changes in the system behaviour due to temperature and ageing, create the desirability for dynamic direction control, aberration correction, phase distortion compensation or misalignment compensation.

[0009] It should be noted that the features of dynamic direction control, phase distortion compensation and misalignment control are not restricted to systems using input beams coming from optical fibres. Such features may also be advantageous in a reconfigurable optical system. Another static system in which dynamic control of phase distortion, direction and (relative) misalignment would be advantageous is one in which the quality and/or position of the input beams is time-varying.

[0010] Often the input and output beams for optical systems contain a multiplex of many optical signals at different wavelengths, and these signals may need to be separated and adaptively and individually processed inside the system. Sometimes, although the net aim of a system is not to separate optical signals according to their wavelength and then treat them separately, to do so increases the wavelength range of the system as a whole. Where this separation is effected, it is often advantageous for the device used to route each channel to have a low insertion loss and to operate quickly.

[0011] It is an aim of some aspects of the present invention at least partly to mitigate difficulties of the prior art.

[0012] It is desirable for certain applications that a method or device for addressing these issues should be polarisation-independent, or have low polarisation-dependence.

[0013] SLMs have been proposed for use as adaptive optical components in the field of astronomical devices, for example as wavefront correctors. In this field of activity, the constraints are different to the present field-for example in communication and like devices, the need for consistent performance is paramount if data is to be passed without errors. Communication and like devices are desirably inexpensive, and desirably inhabit and successfully operate in environments that are not closely controlled. By contrast, astronomical devices may be used in conditions more akin to laboratory conditions, and cost constraints are less pressing. Astronomical devices are unlikely to need to select successive routings of light within a system, and variations in performance may be acceptable.

SUMMARY OF THE INVENTION

[0014] According to a first aspect of the invention, there is provided a method of operating an optical device comprising an SLM having a two-dimensional array of controllable phase-modulating elements, the method comprising

[0015] delineating groups of individual phase-modulating elements;

[0016] selecting, from stored control data, control data for each group of phase-modulating elements;

[0017] generating from the respective selected control data a respective hologram at each group of phase-modulating elements; and

[0018] varying the delineation of the groups and/or the selection of control data whereby upon illumination of said groups by respective light beams, respective emergent light beams from the groups are controllable independently of each other.

[0019] In some embodiments, the variation of the delineation and/or control data selection is in response to a signal or signals indicating a non-optimal performance of the device. In other embodiments, the variation is performed during a set up or training phase of the device. In yet other embodiments, the variation is in response to an operating signal, for example a signal giving the result of sensing non-performance system parameters such as temperature.

[0020] An advantage of the method of this aspect of the invention is that stable operation can be achieved in the presence of effects such as ageing, temperature, component, change of path through the system and assembly tolerances.

[0021] Preferably, control of said light beams is selected from the group comprising: control of direction, control of power, focussing, aberration compensation, sampling and beam shaping.

[0022] Clearly in most situations more than one of these control types will be needed- for example in a routing device (such as a switch, filter or add/drop multiplexer) primary changes of direction are likely to be needed to cope with changes of routing as part of the main system but secondary correction will be needed to cope with effects such as temperature and ageing. Additionally such systems may also need to control power, and to allow sampling (both of which may in some cases be achieved by direction changes).

[0023] Advantageously, each phase modulating element is responsive to a respective applied voltage to provide a corresponding phase shift to emergent light, and the method further comprises;

[0024] controlling said phase-modulating elements of the spatial light modulator to provide respective actual holograms derived from the respective generated holograms, wherein the controlling step comprises;

[0025] resolving the respective generated holograms modulo 2pi.

[0026] The preferred SLM uses a liquid crystal material to provide phase shift and the liquid crystal material is not capable of large phase shifts beyond plus or minus 2π. Some liquid crystal materials can only provide a smaller range of phase shifts, and if such materials are used, the resolution of the generated hologram is correspondingly smaller.

[0027] Preferably the method comprises:

[0028] providing a discrete number of voltages available for application to each phase modulating element;

[00294] on the basis of the respective generated holograms, determining the desired level of phase modulation at a predetermined point on each phase modulating element and choosing for each phase modulating element the available voltage which corresponds most closely to the desired level.

[0030] Where a digital control device is used, the resolution of the digital signal does not provide a continuous spectrum of available voltages. One way of coping with this is to determine the desired modulation for each pixel and to choose the individual voltage which will provide the closest modulation to the desired level.

[0031] In another embodiment, the method comprises:

[0032] providing a discrete number of voltages available for application to each phase modulating element;

[0033] determining a subset of the available voltages which provides the best fit to the generated hologram.

[0034] Another technique is to look at the pixels of the group as a whole and to select from the available voltages those that give rise to the nearest phase modulation across the whole group.

[0035] Advantageously, the method further comprises the step of storing said control data wherein the step of storing said control data comprises calculating an initial hologram using a desired direction change of a beam of light, applying said initial hologram to a group of phase modulating elements, and correcting the initial hologram to obtain an improved result.

[0036] The method may further comprise the step of providing sensors for detecting temperature change, and performing said varying step in response to the outputs of those sensors.

[0037] The SLM may be integrated on a substrate and have an integral quarter-wave plate whereby it is substantially polarisation insensitive.

[0038] Preferably the phase-modulating elements are substantially reflective, whereby emergent beams are deflected from the specular reflection direction.

[0039] In some aspects, for at least one said group of pixels, the method comprises providing control data indicative of two holograms to be displayed by said group and generating a combined hologram before said resolving step.

[0040] According to a second aspect of the invention there is provided an optical device comprising an SLM and a control circuit, the SLM having a two-dimensional array of controllable phase-modulating elements and the control circuit having a store constructed and arranged to hold plural items of control data, the control circuit being constructed and arranged to delineate groups of individual phase-modulating elements, to select, from stored control data, control data for each group of phase-modulating elements, and to generate from the respective selected control data a respective hologram at each group of phase-modulating elements,

[0041] wherein the control circuit is further constructed and arranged, to vary the delineation of the groups and/or the selection of control data

[0042] whereby upon illumination of said groups by respective light beams, respective emergent light beams from the groups are controllable independently of each other.

[0043] An advantage of the device of this aspect of the invention is that stable operation can be achieved in the presence of effects such as ageing, temperature, component and assembly tolerances. Embodiments of the device can handle many light beams simultaneously. Embodiments can be wholly reconfigurable, for example compensating differently for a number of routing configurations.

[0044] Preferably, the optical device has sensor devices arranged to detect light emergent from the SLM, the control circuit being responsive to signals from the sensors to vary said delineation and/or said selection.

[0045] In some embodiments, the optical device has temperature responsive devices constructed and arranged to feed signals indicative of device temperature to said control circuit, whereby said delineation and/or selection is varied.

[0046] In another aspect, the invention provides an optical routing device having at least first and second SLMs and a control circuit, the first SLM being disposed to receive respective light beams from an input fibre array, and the second SLM being disposed to receive emergent light from the first SLM and to provide light to an output fibre array, the first and second SLMs each having a respective two-dimensional array of controllable phase-modulating elements and the control circuit having a store constructed and arranged to hold plural items of control data, the control circuit being constructed and arranged to delineate groups of individual phase-modulating elements, to select, from stored control data, control data for each group of phase-modulating elements, and to generate from the respective selected control data a respective hologram at each group of phase-modulating elements,

[0047] wherein the control circuit is further constructed and arranged, to vary the delineation of the groups and/or the selection of control data

[0048] whereby upon illumination of said groups by respective light beams, respective emergent light beams from the groups are controllable independently of each other.

[0049] In a further aspect, the invention provides a device for shaping one or more light beams in which the or each light beam is incident upon a respective group of pixels of a two-dimensional SLM, and the pixels of the or each respective group are controlled so that the corresponding beams emerging from the SLM are shaped as required.

[0050] According to a further aspect of the invention there is provided an optical device comprising one or more optical inputs at respective locations, a diffraction grating constructed and arranged to receive light from the or each optical input, a focussing device and a continuous array of phase modulating elements, the diffraction grating and the array of phase modulating elements being disposed in the focal plane of the focussing device whereby diverging light from a single point on the diffraction grating passes via the focussing device to form beams at the array of phase modulating elements, the device further comprising one or more optical output at respective locations spatially separate from the or each optical input, whereby the diffraction grating is constructed and arranged to output light to the or each optical output.

[0051] This device allows multiwavelength input light to be distributed in wavelength terms across different groups of phase-modulating elements. This allows different processing effects to be applied to any desired part or parts of the spectrum.

[0052] According to a still further aspect of the invention there is provided a method of filtering light comprising applying a beam of said light to a diffraction grating whereby emerging light from the grating is angularly dispersed by wavelength, forming respective beams from said emerging light by passing the emerging light to a focussing device having the grating at its focal plane, passing the respective beams to an SLM at the focal plane of the focussing device, the SLM having a two-dimensional array of controllable phase-modulating elements, selectively reflecting light from different locations of said SLM and passing said reflected light to said focussing element and then to said grating.

[0053] Preferably the method comprises delineating groups of individual phase-modulating elements to receive beams of light of differing wavelength;

[0054] selecting, from stored control data, control data for each group of phase-modulating elements;

[0055] generating from the respective selected control data a respective hologram at each group of phase-modulating elements; and

[0056] varying the delineation of the groups and/or the selection of control data.

[0057] According to a still further aspect of the invention there is provided an optical add/drop multiplexer having a reflective SLM having a two-dimensional array of controllable phase-modulating elements, a diffraction device and a focussing device wherein light beams from a common point on the diffraction device are mutually parallel when incident upon the SLM, and wherein the SLM displays respective holograms at locations of incidence of light to provide emergent beams whose direction deviates from the direction of specular reflection.

[0058] In a yet further aspect, the invention provides a test or monitoring device comprising an SLM having a two-dimensional array of pixels, and operable to cause incident light to emerge in a direction deviating from the specular direction, the device having light sensors at predetermined locations arranged to provide signals indicative of said emerging light.

[0059] The test or monitoring device may further comprise further sensors arranged to provide signals indicative of light emerging in the specular directions.

[0060] Yet a further aspect of the invention relates to a power control device for one or more beams of lights in which the said beams are incident on respective groups of pixels of a two-dimensional SLM, and holograms are applied to the respective group so that the emergent beams have power reduced by comparison to the respective incident beams.

[0061] The invention further relates to an optical routing module having at least one input and at least two outputs and operable to select between the outputs, the module comprising a two dimensional SLM having an array of pixels, with circuitry constructed and arranged to display holograms on the pixels to route beams of different frequency to respective outputs.

[0062] According to a later aspect of the invention there is provided an optoelectronic device comprising an integrated multiple phase spatial light modulator (SLM) having a plurality of pixels, wherein each pixel can phase modulate light by a phase shift having an upper and a lower limit, and wherein each pixel has an input and is responsive to a value at said input to provide a phase modulation determined by said value, and a controller for the SLM, wherein the controller has a control input receiving data indicative of a desired phase modulation characteristic across an array of said pixels for achieving a desired control of light incident on said array, the controller has outputs to each pixel, each output being capable of assuming only a discrete number of possible values, and the controller comprises a processor constructed and arranged to derive, from said desired phase modulation characteristic, a non-monotonic phase modulation not extending outside said upper and lower limits, and a switch constructed and arranged to select between the possible values to provide a respective one value at each output whereby the SLM provides said non-monotonic phase modulation.

[0063] Some or all of the circuitry may be on-chip leading to built-in intelligence. This leads to more compact and ultimately low-cost devices. In some embodiments, some or all on-chip circuitry may operate in parallel for each pixel which may provide huge time advantages; in any event the avoidance of the need to transfer data off chip and thereafter to read in to a computer allows configuration and reconfiguration to be faster.

[0064] According to another aspect of the invention there is provided a method of controlling a light beam using a spatial light modulator (SLM) having an array of pixels, the method comprising:

[0065] determining a desired phase modulation characteristic across a sub-array of said pixels for achieving the desired control of said beam;

[0066] controlling said pixels to provide a phase modulation derived from the desired phase modulation, wherein the controlling step comprises

[0067] providing a population of available phase modulation levels for each pixel, said population comprising a discrete number of said phase modulation levels;

[0068] on the basis of the desired phase modulation, a level selecting step of selecting for each pixel a respective one of said phase modulation levels; and

[0069] causing each said pixel to provide the respective one of said phase modulation levels.

[0070] The SLM may be a multiple phase liquid crystal over silicon spatial light modulator having plural pixels, of a type having an integrated wave plate and a reflective element, such that successive passes of a beam through the liquid crystal subject each orthogonally polarised component to a substantially similar electrically-set phase change.

[0071] If a non-integrated wave plate is used instead, a beam after reflection and passage through the external wave plate will not pass through the same zone of the SLM, unless it is following the input path, in which case the zero order component of said beam will re-enter the input fibre.

[0072] The use of the wave plate and the successive pass architecture allows the SLM to be substantially polarisation independent.

[0073] In one embodiment the desired phase modulation at least includes a linear component.

[0074] Linear phase modulation, or an approximation to linear phase modulation may be used to route a beam of light, i.e. to select a new direction of propagation for the beam. In many routing applications, two SLMs are used in series, and the displayed information on the one has the inverse effect to the information displayed on the other. Since the information represents phase change data, it may be regarded as a hologram. Hence an output SLM may display a hologram that is the inverse of that displayed on the input SLM. Routing may also be "one-to-many" (i.e. multicasting) or "one-to-all" (i.e. broadcasting) rather than the more usual one-to-one in many routing devices. This may be achieved by correct selection of the relevant holograms.

[0075] Preferably the linear modulation is resolved modulo 2pi to provide a periodic ramp.

[0076] In another embodiment the desired phase modulation includes a non-linear component.

[0077] Preferably the method further comprises selecting, from said array of pixels, a sub-array of pixels for incidence by said light beam.

[0078] The size of a selected sub-array may vary from switch to switch according to the physical size of the switch and of the pixels. However, a typical routing device may have pixel arrays of between 100*100 and 200*200, and other devices such as add/drop multiplexers may have arrays of between 10*10 and 50*50. Square arrays are not essential.

[0079] In one embodiment the level-selecting step comprises determining the desired level of phase modulation at a predetermined point on each pixel and choosing for each pixel, the available level which corresponds most closely to the desired level.

[0080] In another embodiment, the level-selecting step comprises determining a subset of the available levels, which provides the best fit to the desired characteristic.

[0081] The subset may comprise a subset of possible levels for each pixel.

[0082] Alternatively the subset may comprise a set of level distributions, each having a particular level for each pixel.

[0083] In one embodiment, the causing step includes providing a respective voltage to an electrode of each pixel, wherein said electrode extends across substantially the whole of the pixel.

[0084] Preferably again the level selecting step comprises selecting the level by a modulo 2pi comparison with the desired phase modulation. The actual phase excursion may be from A to A+2π where A is an arbitrary angle.

[0085] Preferably the step of determining the desired phase modulation comprises calculating a direction change of a beam of light.

[0086] Conveniently, after the step of calculating a direction change, the step of determining the desired phase modulation further comprises correcting the phase modulation obtained from the calculating step to obtain an improved result.

[0087] Advantageously, the correction step is retroactive.

[0088] In another embodiment the step of determining the desired phase modulation is retroactive, whereby parameters of the phase modulation are varied in response to a sensed error to reduce the error.

[0089] A first class of embodiments relates to the simulation/synthesis of generally corrective elements. In some members of the first class, the method of the invention is performed to provide a device, referred to hereinafter as an accommodation element for altering the focus of the light beam.

[0090] An example of an accommodation element is a lens. An accommodation element may also be an anti-astigmatic device, for instance comprising the superposition of two cylindrical lenses at arbitrary orientations.

[0091] In other members of the first class, the method of the invention is performed to provide an aberration correction device for correcting greater than quadratic aberrations.

[0092] The sub-array selecting step may assign a sub-array of pixels to a beam based on the predicted path of the beam as it approaches the SLM just prior to incidence.

[0093] Advantageously, after the sub-array is assigned using the predicted path, it is determined whether the assignment is correct, and if not a different sub-array is assigned.

[0094] The assignment may need to be varied in the event of temperature, ageing or other physical changes. The sub-array selection is limited in resolution only by the pixel size. By contrast other array devices such as MEMS have fixed physical edges to their beam steering elements.

[0095] An element of this type may be used in a routing device to compensate for aberrations, phase distortions and component misalignment in the system. By providing sensing devices a controller may be used to retroactively control the element and the element may maintain an optimum performance of the system.

[0096] In one embodiment of this first class, the method includes both causing the SLM to route a beam and causing the SLM to emulate a corrective element to correct for errors, whereby the SLM receives a discrete approximation of the combination of both a linear phase modulation applied to it to route the beam and a non-linear phase modulation for said corrections.

[0097] Synthesising a lens using an SLM can be used to change the position of the beam focused spot and therefore correct for a position error or manufacturing tolerance in one or more other lenses or reflective (as opposed to transmissive) optical elements such as a curved mirror.

[0098] The method of the invention may be used to correct for aberrations such as field curvature in which the output 'plane' of the image(s) from an optical system is curved, rather than flat.

[0099] In another embodiment of the first class, intelligence may be integrated with sensors that detect the temperature changes and apply data from a look-up table to apply corrections.

[0100] In yet another embodiment of this class, misalignment and focus errors are detected by measuring the power coupled into strategically placed sensing devices, such as photodiode arrays, monitor fibres or a wavefront sensor. Compensating holograms are formed as a result of the discrete approximations of the non-linear modulation. Changes or adjustments may then be made to these holograms, for example by applying a stimulus and then correcting the holograms according to the sensed response until the system alignment is measured to be optimised.

[0101] In embodiments where the method provides routing functions by approximated linear modulation, adaptation of non-linear modulation due to changes in the path taken through the system desirably takes place on a timescale equivalent to that required to change the hologram routing, i.e. of the order of milliseconds.

[0102] A control algorithm may use one or more of several types of compensation.

[0103] In one embodiment a look-up table is used with pre-calculated 'expected' values of the compensation taking account of the different routes through the system.

[0104] In another embodiment the system is trained before first being operated, by repeated changes of, or adjustments to, the compensating holograms to learn how the system is misaligned.

[0105] A further embodiment employs intelligence attached to the monitor fibres for monitoring and calculation of how these compensating holograms should adapt with time to accommodate changes in the system alignment. This is achieved in some embodiments by integrating circuitry components into the silicon backplane of the SLM.

[0106] In many optical systems there is a need to control and adapt the power or shape of an optical beam as well as its direction or route through the optical system. In communications applications, power control is required for network management reasons. In general, optical systems require the levelling out or compensation for path and wavelength-dependent losses inside the optical system. It is usually desirable that power control should not introduce or accentuate other performance impairments.

[0107] Thus in a second class of embodiments, the modulation applied is modified for controlling the attenuation of an optical channel subjected to the SLM.

[0108] In one particular embodiment, the ideal value of phase modulation is calculated for every pixel, and then multiplied by a coefficient having a value between 0 and 1, selected according to the desired attenuation and the result is compared to the closest available phase level to provide the value applied to the pixels.

[0109] In another embodiment, the method further comprises selecting by a discrete approximation to a linear phase modulation, a routing hologram for display by the SLM whereby the beams may be correctly routed; selecting by a discrete approximation to a non-linear phase modulation, a further hologram for separating each beam into main and subsidiary beams, wherein the main beam is routed through the system and the or each subsidiary beam is diffracted out of the system; combining the routing and further holograms together to provide a resultant hologram; and causing the SLM to provide the resultant hologram.

[0110] The non-linear phase modulation may be oscillatory.

[0111] In yet another embodiment, the method further comprises selecting by a discrete approximation to a linear phase modulation, a routing hologram for display by the SLM whereby the beams may be correctly routed; selecting by a discrete approximation to a non-linear phase modulation, a further hologram for separating each beam into main and subsidiary beams, wherein the main beam is routed through the system and at least one subsidiary beam is incident on an output at an angle such that its contribution is insignificant; combining the routing and further holograms together to provide resultant hologram; and causing the SLM to display the resultant hologram.

[0112] The non-linear phase modulation may be oscillatory.

[0113] In a closely allied class of embodiments, light may be selectively routed to a sensor device for monitoring the light in the system. The technique used may be a power control technique in which light diverted from the beam transmitted through the system to reduce its magnitude is made incident on the sensor device.

[0114] In another class of embodiments, a non-linear phase modulation profile is selected to provide beam shaping, for example so as to reduce cross-talk effects due to width clipping. This may use a pseudo amplitude modulation technique.

[0115] In a further class of embodiments, the method uses a non-linear modulation profile chosen to provide wavelength dependent effects.

[0116] The light may be at a telecommunications wavelength, for example 850 nm, 1300 nm or in the range 1530 nm to 1620 nm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0117] Exemplary embodiments of the invention will now be described with reference to the accompanying drawings in which:

[0118] FIG. 1 shows a cross-sectional view through an exemplary SLM suitable for use in the invention;

[0119] FIG. 2 shows a sketch of a routing device in which a routing SLM is used additionally to provide correction for performance impairment due to misalignment;

[0120] FIG. 3 shows a sketch of a routing device in which a routing SLM is used to route light beams and an additional SLM provides correction for performance impairment due to misalignment;

[0121] FIG. 4 shows a block diagram of an adaptive corrective SLM;

[0122] FIG. 5 shows an adaptive optical system using three SLMs;

[0123] FIG. 6 shows a partial block diagram of a routing device with a dual function SLM and control arrangements;

[0124] FIG. 7 shows a block diagram of an SLM for controlling the power transferred in an optical system;

[0125] FIG. 8a shows a diagram of phase change distribution applied by a hologram for minimum attenuation;

[0126] FIG. 8b shows a diagram of phase change distribution applied by a hologram enabling attenuation of the signal;

[0127] FIG. 9 shows a power control system;

[0128] FIG. 10 shows a phasor diagram showing the effect of non-linear oscillatory phase modulation applied to adjacent pixels;

[0129] FIG. 11 shows a schematic diagram of a part of an optical routing system illustrating the effects of clipping and cross talk;

[0130] FIG. 12 shows a partial block diagram of a system enabling beams of different wavelength from a composite input beam to be separately controlled before recombination; and

[0131] FIG. 13 shows a schematic diagram of an add/drop multiplexer using an SLM.

[0132] FIG. 14 is a diagram similar to FIG. 12 but showing a magnification stage for increasing the effective beam deflection angle;

[0133] FIG. 15 shows a vector diagram of the operation of an add/drop multiplexer;

[0134] FIG. 16 shows a block diagram showing how loop back may be effected;

[0135] FIG. 17 is a vector diagram illustrating the operation of part of FIG. 16;

[0136] FIG. 18 is a vector diagram of a multi-input/multi-output architecture;

[0137] FIG. 19 is a graph showing the relative transmission Tlo for in-band wavelengths as a function of the ratio of the wavelength offset u to centre of the wavelength channel separation;

[0138] FIG. 20 is a graph showing the relative transmission Thi inside adjacent channels;

[0139] FIG. 21 shows a logical diagram of the sorting function;

[0140] FIG. 22 shows a block diagram of an add/drop node using two routing modules;

[0141] FIG. 23 shows a block diagram of modules used to cross-connect two rings;

[0142] FIG. 24 shows a block diagram of routing modules connected to provide expansion;

[0143] FIG. 25 shows a block diagram of an optical cross-connect;

[0144] FIG. 26 shows a block diagram of an upgrades node having a cascaded module at an expansion output port;

[0145] FIG. 27 is a graph showing the effect of finite hologram size of the field of a beam incident on a hologram;

[0146] FIG. 28 shows a schematic layout of a wavelength filter device; and,

[0147] FIG. 29 shows a schematic layout of an add/drop device;

[0148] FIG. 30 shows a block diagram of an optical test set;

[0149] FIG. 31 is a diagram showing the effect of finite hologram size on a beam at a wavelength different to the centre wavelength associated with the hologram;

[0150] FIG. 32 shows the truncated beam shapes for wavelengths at various wavelength differences from the centre of the wavelength channel dropped in isolation;

[0151] FIG. 33 shows the overlap integrands of the beams of FIG. 32 with the fundamental mode of the fibre;

[0152] FIG. 34 shows beam output positions for different wavelengths with respect to two optical fibres; and

[0153] FIG. 35 shows the overlap integrand between the beams of FIG. 34 and the fundamental mode of one of the optical fibres.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0154] Many of the embodiments of the invention centre upon the realisation that the problems of the prior art can be solved by using a reflective SLM having a two-dimensional array of phase-modulating elements that is large in number, and applying a number of light beams to groups of those phase-modulating elements. A significant feature of these embodiments is the fact that the size, shape and position of those groups need not be fixed and can, if need be, be varied. The groups may display holograms which can be set up as required to deflect the light so as to provide a non-specular reflection at a controllable angle to the specular reflection direction. The holograms may additionally or alternatively provide shaping of the beam.

[0155] The SLM may thus simulate a set of highly flexible mirrors, one for each beam of light. The size, shape and position of each mirror can be changed, as can the deflection and the simulated degree of curvature.

[0156] Devices embodying the invention act on light beams incident on the device to provide emerging light beams which are controlled independently of one another. Possible types of control include control of direction, control of power, focussing, aberration compensation, sampling and beam shaping.

[0157] The structure and arrangement of polarisation-independent multiple phase liquid crystal over silicon spatial light modulators (SLMs) for routing light beams using holograms are discussed in our co-pending patent application PCT/GB00/03796. Such devices have an insertion loss penalty due to the dead-space between the pixels. As discussed in our co-pending patent application GB0107742.9, the insertion loss may be reduced significantly by using a reflecting layer inside the substrate positioned so as to reflect the light passing between the pixels back out again.

[0158] Referring to FIG. 1, an integrated SLM 200 for modulating light 201 of a selected wavelength, e.g. 1.5 μm, consists of a pixel electrode array 230 formed of reflective aluminium. The pixel electrode array 230, as will later be described acts as a mirror, and disposed on it is a quarter-wave plate 221. A liquid crystal layer 222 is disposed on the quarter-wave plate 221 via an alignment layer (not shown) as is known to those skilled in the art of liquid crystal structures. Over (as shown) the liquid crystal layer 222 are disposed in order a second alignment layer 223, a common ITO electrode layer 224 and an upper glass layer 225. The common electrode layer 224 defines an electrode plane. The pixel electrode array 230 is disposed parallel to the common electrode plane 224. It will be understood that alignment layers and other intermediate layers will be provided as usual. They are omitted in FIG. 1 for clarity.

[0159] The liquid crystal layer 222 has its material aligned such that under the action of a varying voltage between a pixel electrode 230 and the common electrode 224, the uniaxial axis changes its tilt direction in a plane normal to the electrode plane 224.

[0160] The quarter wave plate 221 is disposed such that light polarised in the plane of tilt of the director is reflected back by the mirror 230 through the SLM with its plane of polarisation perpendicular to the plane of tilt, and vice-versa.

[0161] Circuitry, not shown, connects to the pixel electrodes 230 so that different selected voltages are applied between respective pixel electrodes 230 and the common electrode layer 224.

[0162] Considering an arbitrary light beam 201 passing through a given pixel, to which a determined potential difference is applied, thus resulting in a selected phase modulation due to the liquid crystal layer over the pixel electrode 230. Consider first and second orthogonal polarisation components, of arbitrary amplitudes, having directions in the plane of tilt of the director and perpendicular to this plane, respectively. These directions bisect the angles between the fast and slow axes of the quarter-wave plate 221.

[0163] The first component experiences the selected phase change on the inward pass of the beam towards the aluminium layer 230, which acts as a mirror. The second component experiences a fixed, non-voltage dependent phase change.

[0164] However, the quarter-wave plate 221 in the path causes polarisation rotation of the first and second components by 90 degrees so that the second polarisation component of the light beam is presented to the liquid crystal for being subjected to the selected phase change on the outward pass of the beam away from the mirror layer 230. The first polarisation component experiences the fixed, non-voltage dependent phase change on the outward pass of the beam. Thus, both of the components experience the same overall phase change contribution after one complete pass through the device, the total contribution being the sum of the fixed, non-voltage dependent phase and the selected voltage dependent phase change.

[0165] It is not intended that any particular SLM structure is essential to the invention, the above being only exemplary and illustrative. The invention may be applied to other devices, provided they are capable of multiphase operation and are at least somewhat polarisation independent at the wavelengths of concern. Other SLMs are to be found in our co-pending applications WO01/25840, EP1050775 and EP1053501 as well as elsewhere in the art.

[0166] Where liquid crystal materials other than ferroelectric are used, current practice indicates that the use of an integral quarter wave plate contributes to the usability of multiphase, polarisation-independent SLMs.

[0167] A particularly advantageous SLM uses a liquid crystal layer configured as a pi cell.

[0168] Referring to FIG. 2, an integrated SLM 10 has processing circuitry 11 having a first control input 12 for routing first and second beams 1,2 from input fibres 3,4 to output fibres 5,6 in a routing device 15. The processing circuitry 11 includes a store holding control data which is processed to generate holograms which are applied to the SLM 10 for control of light incident upon the SLM 10. The control data are selected in dependence upon the data at the control input 12, and may be stored in a number of ways, including compressed formats. The processing circuitry 11, which may be at least in part on-chip, is also shown as having an additional input 16 for modifying the holograms. This input 16 may be a physical input, or may be a "soft" input-for example data in a particular time slot.

[0169] The first beam 1 is incident on, and processed by a first array, or block 13 of pixels, and the second beam 2 is incident on and processed by a second array, or block 14 of pixels. The two blocks of pixels 13,14 are shown as contiguous. In some embodiments they might however be separated from one another by pixels that allow for misalignment.

[0170] Where the SLM is used for routing the beams 1,2 of light, this is achieved by displaying a linearly changing phase ramp in at least one direction across the blocks or arrays 13,14. The processing circuitry 11 determines the parameters of the ramp depending on the required angle of deflection of the beam 1,2. Typically the processing circuitry 11 stores data in a look-up table, or has access to a store of such data, to enable the required ramp to be created in response to the input data or command at the first control input 12. The angle of deflection is probably a two dimensional angle where the plane common to the direction of the incident light and that of the reflected light is not orthogonal to the SLM.

[0171] Assigning x and y co-ordinates to the elements of the SLM, the required amount of angular shift from the specular reflection direction may be resolved into the x and y directions. Then, the required phase ramp for the components is calculated using standard diffraction theory, as a "desired phase characteristic".

[0172] This process is typically carried out in a training stage, to provide the stored data in the look-up table.

[0173] Having established a desired phase modulation characteristic across the array so as to achieve the desired control of said beam the processing circuitry 11 transforms this characteristic into one that can be displayed by the pixels 13,14 of the SLM 10. Firstly it should be borne in mind that the processing circuitry 11 controlling the pixels of an SLM 10 is normally digital. Thus there is only a discrete population of values of phase modulation for each pixel, depending on the number of bits used to represent those states.

[0174] To allow the pixels 13,14 of the SLM 11 to display a suitable phase profile, the processing circuitry 11 carries out a level selecting operation for each pixel. As will be appreciated, the ability of the SLM to phase modulate has limits due to the liquid crystal material, and hence a phase ramp that extends beyond these limits is not possible. To allow for the physical device to provide the effects of the ideal device (having a continuously variable limitless phase modulation ability), the desired phase ramp may be transformed into a non-monotonic variation having maxima and minima within the capability limits of the SLM 10. In one example of this operation, the desired phase modulation is expressed modulo 2pi across the array extent, and the value of the desired modulo-2pi modulation is established at the centre of each pixel. Then for each pixel, the available level nearest the desired modulation is ascertained and used to provide the actual pixel voltage. This voltage is applied to the pixel electrode for the pixel of concern.

[0175] For small pixels there may be edge effects due to fringing fields between the pixels and the correlations between the director directions in adjacent pixels. In such systems the available phase level nearest to the value of the desired modulo-2pi modulation at the centre of each pixel (as described above) should be used as a first approximation. A recursive algorithm is used to calculate the relevant system performance characteristic taking into account these 'edge' effects and to change the applied level in order to improve the system performance to the required level.

[0176] "Linear" means that the value of phase across an array of pixels varies linearly with distance from an arbitrary origin, and includes limited linear changes, where upon reaching a maximum phase change at the end of a linear portion, the phase change reverts to a minimum value before again rising linearly.

[0177] The additional input 16 causes the processing circuitry 11 to modify the holograms displayed by applying a discrete approximation of a non-linear phase modulation so that the SLM 10 synthesises a corrective optical element such as a lens or an aberration corrector. As will be later described, embodiments may also provide power control (attenuation), sampling and beam shaping by use of the non-linear phase modulation profile. "Non-linear" is intended to signify that the desired phase profile across an array of pixels varies with distance from an arbitrary origin in a curved and/or oscillatory or like manner that is not a linear function of distance. It is not intended that "non-linear" refer to sawtooth or like profiles formed by a succession of linear segments of the same slope mutually separated by "flyback" segments.

[0178] The hologram pattern associated with any general non-linear phase modulation $\exp j\phi(u) = \exp j(\phi_0(u) + \phi_1(u) + \phi_3(u) \ldots.)$ where j is the complex operator, can be considered as a product. In this product, the first hologram term in the product $\exp j \phi_0(u)$implements the routing while the second hologram term $\exp j \phi_1(u)$ implements a corrective function providing for example lens simulation and/or aberration correction. The third hologram term $\exp j \phi_2(u)$ implements a signal processing function such as sampling and/or attenuation and/or beam shaping. The routing function is implemented as a linear phase modulation while the corrective function includes non-linear terms and the signal processing function includes non-linear oscillatory terms.

[0179] Different methods of implementing the combination of these three terms are possible. In one embodiment the total required phase modulation $\phi_0(u) + \phi_1(u) + \phi_2(u)$ including linear routing and corrective function and the signal processing function is resolved modulo 2 pi and approximated to the nearest available phase level before application by the pixels. In another embodiment the summation of the phase modulation required for the linear and corrective function $\phi_0(u) + \phi_1(u)$ is resolved modulo 2 pi and approximated to the nearest phase level in order to calculate a first phase distribution. A second phase distribution $\phi_2(u)$ is calculated to provide sampling and/or attenuation and/or beam shaping. The two phase distributions are then added, re-resolved modulo 2 pi and approximated to the nearest available phase level before application by the pixels. Other methods are also possible.

[0180] Mathematically the routing phase modulation is periodic due to the resolution modulo 2pi and by nature of its linearity.

[0181] Therefore the routing phase modulation results in a set of equally spaced diffraction orders. The greater the number of available phase levels the closer the actual phase modulation to the ideal value and the stronger the selected diffraction order used for routing.

[0182] By contrast, the corrective effects are realised by non-linear phase changes $\phi_1(u)$ that are therefore non-periodic when resolved modulo 2pi. This non-periodic phase modulation changes the distribution of the reflected beam about its centre, but not its direction. The combined effect of both linear (routing) and non-periodic phase modulation is to change both the direction and distribution of the beam, as may be shown using the convolution theorem.

[0183] The signal processing effects are usually realised by a method equivalent to 'multiplying' the initial routing and/or hologram exp $j(\phi_0(u)+\phi_1(u))$ by a further hologram exp j $\phi_2(u)$ in which $\phi_2(u)$ is non-linear and oscillatory. Therefore the set of diffraction orders associated with the further hologram creates a richer structure of subsidiary beams about the original routed beam, as may be shown using the convolution theorem.

[0184] While this explanation is for a one-dimensional phase modulator array the same principle may be applied in 2-D.

[0185] Hence in a reconfigurable optical system this non-linear phase modulation may be applied by the same spatial light modulator(s) that route the beam. It will be understood by those skilled in the art that the SLM may have only a single control input and the device may have processing circuitry for combining control data for routing and control data for corrective effects and signal processing effects to provide an output to control the SLM.

[0186] The data may be entered into the SLM bit-wise per pixel so that for each pixel a binary representation of the desired state is applied. Alternatively, the data may be entered in the form of coefficients of a polynomial selected to represent the phase modulation distribution of the pixel array of concern in the SLM. This requires calculating ability of circuitry of the SLM, but reduces the data transfer rates into the SLM. In an intermediate design the polynomial coefficients are received by a control board that itself sends bit-wise per pixel data to the SLM. On-chip circuitry may interpret data being entered so as to decompress that data.

[0187] The pixel array of concern could be all of the pixels associated with a particular beam or a subset of these pixels. The phase modulation distribution could be a combined phase modulation distribution for both routing and corrective effects or separate phase modulation distributions for each. Beam shaping, sampling and attenuation phase modulation distributions, as will be described later, can also be included. In some cases it may not be possible to represent the phase modulation distribution as a simple polynomial. This difficulty may be overcome by finding a simple polynomial giving a first approximation to the desired phase modulation distribution. The coefficients of this polynomial are sent to the SLM. A bit-wise correction is sent for each pixel requiring a correction, together with an address identifying the location of the pixel. When the applied distribution is periodic only the corrections for one period need be sent.

[0188] The processing circuitry 11 may be discrete from or integral with the SLM, or partly discrete and partly integral.

[0189] Referring to FIG. 3, a routing device 25 includes two SLMs 20,21 which display holograms for routing light 1,2 from an input fibre array 3,4 to an output fibre array 5,6. The two SLMs are reflective and define a zigzag path. The first SLM 20 hereinafter referred to as a "corrective SLM" not only carries out routing but also synthesises a corrective optical element. The second SLM 21 carries out only a routing function in this embodiment, although it could also carry out corrections or apply other effects if required. The second SLM 21 is hereinafter referred to as a "routing SLM". Although the corrective SLM 20 is shown disposed upstream of the routing SLM 21, it may alternatively be disposed downstream of the routing SLM 21, between two routing SLMs, or with systems using routing devices other than the routing SLM 21.

[0190] The routing SLM 21 has operating circuitry 23 receiving routing control data at a routing control input 24, and generating at the SLM 21 sets of holograms for routing the beams 1,2. The corrective SLM 20 has operating circuitry 26 receiving compensation or adaptation data at a control input 27 to cause the SLM 20 to display selected holograms. In this embodiment, the SLM 20 forms a reflective lens.

[0191] Synthesising a lens at the SLM 20 can be used to change the position of the beam focused spot and therefore correct for a position error or manufacturing tolerance in one or more other lenses or reflective (as opposed to transmissive) optical elements, such as a curved mirror. The synthesised lens can be spherical or aspheric or cylindrical or a superposition of such lenses. Synthesised cylindrical lenses may have arbitrary orientation between their two long axes and the lens focal lengths can both be positive, or both be negative, or one can be positive and the other negative.

[0192] To provide a desired phase modulation profile for a lens or curved mirror to compensate for an unwanted deviation from a required system characteristic, the system is modelled without the lens/mirror. Then a lens/mirror having the correction to cancel out the deviation is simulated, and the parameters of the lens/mirror are transformed so that when applied to an SLM the same effect is achieved.

[0193] In one application what is required is to adjust the position and width of the beam waist, of a Gaussian-type beam at some particular point in the optical system, in order to compensate for temperature changes or changes in routing configuration. Hence two properties of the beam must be adjusted and so it is necessary to change two properties of the optical system. In a conventional static optical system both a lens focal length and the position of the lens are selected to achieve the required beam transformation. In the dynamic systems under consideration it is rarely possible deliberately to adjust the position of the optical components. A single variable focus action at a fixed position changes both the position and the width of the beam waist and only in special circumstances will both properties be adjusted to the required value.

[0194] One method to overcome this problem is to apply both corrective phase and corrective 'pseudo-amplitude' modulation (to be described later) with a single SLM. However the amplitude modulation reduces the beam power which may be undesirable in some applications. A further and preferred method is to apply corrective phase modulation with two separate SLMs.

[0195] For example consider coupling from one input fibre (or input beam) through a routing system into the selected output fibre (or output beam). Inside the routing system there are at least two SLMs carrying out a corrective function. They may also be routing and carrying out other functions (to be described in this application). In between a given pair of SLMs carrying out focus correction there is an intermediate optical system.

[0196] At the first SLM carrying out a corrective function there may be calculated and/or measured the incident amplitude and phase distribution of the input beam that had propagated from the input fibre or beam. At the second SLM carrying out a corrective function there may be calculated and/or measured the ideal amplitude and phase distribution that the output beam would adopt if coupling perfectly into the output fibre or beam. This can be achieved by backlaunching from the output fibre or beam or by a simulation of a backlaunch. The required focus correction functions of these two SLMs is to transform the incident amplitude and phase distribution arriving at the first SLM to the ideal amplitude and phase distribution at the second SLM to achieve perfect (or the desired) coupling efficiency into the output fibre or output beam.

[0197] The corrective phase modulation to be applied at the first SLM should be calculated, so as to achieve the ideal amplitude distribution at the second SLM as the beam arrives at the second SLM after passing from the first SLM and through the intermediate system. This calculation should take into account propagation through the intermediate system between the first and second SLMs. Hence the function of the first SLM is to correct the beam so as to achieve the ideal amplitude distribution for the output beam. The beam phase distribution should also be calculated as it arrives at the second SLM. The corrective phase distribution to be applied at the second SLM should be calculated so as to transform the phase distribution of the beam incident upon it from the intermediate system to the ideal phase distribution required for the output beam at the second SLM.

[0198] Two variables available at the SLM to effect corrections from an optimal or other desired level of performance are firstly the blocks of pixels that are delineated for the incident light beam, and secondly the hologram that is displayed on the block(s) of concern.

[0199] Starting with the delineation of blocks, it should be borne in mind that the point of arrival of light on the SLM can only be predicted to a certain accuracy and that the point may vary according to physical changes in the system, for example due to temperature effects or ageing. Thus, the device allows for assessment of the results achieved by the current assignment, and comparison of those results with a specified performance. In response to the comparison results, the delineation may be varied so as to improve the results.

[0200] In one embodiment a training phase, uses for example a hill climbing approach to control and optimise the position of the centre of the block. Then if the "in-use" results deviate by more than a specified amount from the best value, the delineation of the block is varied. This process reassignment may step the assigned block one pixel at a time in different directions to establish whether an improved result is achieved, and if so continuing to step to endeavour to reach an optimum performance. The variation may be needed where temperature effects cause positional drift between components of the device. It is important to realise that unlike MEMS systems and the like, all the pixels are potentially available for all the beams. Also the size, shape and location of a delineated block is not fixed.

[0201] Equally the size and shape of a block may be varied if required. Such changes may be necessary under a variety of situations, especially where a hologram change is needed. If for example a hologram requiring a larger number of pixels becomes necessary for one beam, the size of the block to display that hologram can be altered. Such changes must of course usually be a compromise due to the presence of other blocks (possibly contiguous with the present block) for displaying holograms for other beams of light.

[0202] Monitoring techniques for determining whether the currently assigned block is appropriate include the techniques described later herein as "taking moments".

[0203] Turning to variation of the hologram that is displayed on the block of concern, one option to take into account for example physical changes in the system, such as movement out of alignment, is to change one normal linear-type routing hologram for another, or to adjust the present hologram in direct response to the sensed change. Thus if, due for example to temperature effects, a target location for a beam moves, it may be necessary to change the deflection currently being produced at a pixel block. This change or adjustment may be made in response to sensed information at the target location, and may again be carried out "on-line" by varying the hologram step by step. However, it may be possible to obtain an actual measure of the amount and direction of change needed, and in this case either a new hologram can be read in to the SLM or a suitable variation of the existing hologram carried out.

[0204] As well as, or instead of, linear changes to linear routing holograms, corrective changes may be needed, for example to refocus a beam or to correct for phase distortion and non-focus aberrations.

[0205] Having corrected the beam focus other aberrations may remain in the system. Such aberrations distort the phase distributions of the beams. These aberrations will also change with routing configuration as the beams are passing through different lenses and/or different positions on the same lenses. Similarly the aberrations will change with temperature. To obtain stable and acceptable performance of a reconfigurable optical system, the aberrations can be corrected dynamically.

[0206] To provide a desired phase modulation profile for these aberrations the system may be modelled or measured to calculate the phase distortion across the SLM, compared to the ideal phase distribution. The ideal phase distribution may again be found by modelling the system 'backwards' from the desired output beam, or by backlaunching and measurement, while the actual phase distribution may be found by modelling the system forwards from the input beam or measurement. The calculations will include the effects of reflection from the SLM itself. The corrective function of the SLM is to transform between the actual and ideal phase distortion. The phase distortion is defined as the phase difference between the actual phase distribution and the ideal phase distribution. The desired corrective profile is the conjugate phase of the phase distortion.

[0207] Alternatively, these corrective functions can be shared by two SLMS, which allows an extra degree of freedom in how the beam propagates inside the intermediate system between the two SLMs.

[0208] Further, given a real system a sampling method (as will be described later) may be used to direct a fraction of the beam towards a wavefront sensor that may assess the beam. So far the process is deterministic. Then the changes are applied to the real system, and perturbations on the parameters are applied while monitoring the sensor and/or the input/output state, so as to determine whether an optimum configuration is achieved. If not, the parameters are changed until a best case is achieved. Any known optimising technique may be used. It is preferred to provide a reasonable starting point by deterministic means, as otherwise local non-optimum performance maxima may be used instead of the true optimum.

[0209] The method or device of the invention may be used to correct for aberrations such as field curvature in which the output 'plane' of the image(s) from an optical system is curved, rather than flat.

[0210] Equally, even if in use the SLM forms a corrective element by having non-linear phase modulation applied across it, if it is operated in separate training and use phases, it may be desirable while training for the SLM to route as well. In this case the SLM scans the processed beam over a detector or routes the beam, for example using one or more dummy holograms, into a monitor fibre.

[0211] Referring now to FIG. 4, the corrective SLM 20, used purely for synthesising a corrective element, has operating circuitry 125, and further comprises processing circuitry 122 and temperature sensors 123. In this embodiment the operating circuitry, temperature sensors and processing circuitry are integrated on the same structure as the rest of the SLM, but this is not critical to the invention. Associated with the processing circuitry is a store 124 into which is programmed a lookup table. The sensors detect temperature changes in the system as a whole and in the SLM, and in response to changes access the look up table via the processing circuitry 122 to apply corrections to the operating circuitry. These corrections affect the holograms displayed on the blocks 13, 14 of pixels. The sensors may also be capable of correction for temperature gradients.

[0212] This technique may also be applied to an SLM used for routing.

[0213] Referring now to FIG. 5, an optical system 35 has a corrective SLM 30 with operating circuitry 31, and processing circuitry 32. The system includes further devices, here second and third SLMs 33 and 34, disposed downstream of the corrective SLM 30. The second SLM 33 is intended to route light to particular pixel groups 15, 16 of the third SLM 34. The third SLM 34 has monitor sensors 37 for sensing light at predetermined locations. In one embodiment these sensors 37 are formed by making the reflective layer partially transmissive, and creating a sensing structure underneath. In another, the pixel electrode of selected pixels is replaced by a silicon photodetector or germanium sensor structure.

[0214] In either case, circuitry may be integrated into the silicon backplane to process the output of the sensors 37, for example to compare the outputs of adjacent sensors 37, or to threshold one sensor against neighbouring sensor outputs. Where possible, processing circuitry is on chip, as it is possible to reduce the time taken after light has been received to respond to it in this way. This is because there is no need to read information off-chip for processing, and also because calculations may be able to be performed in parallel.

[0215] Provided the routing-together with any compensation effects from the corrective SLM 30-is true, the sensors 37 will receive only a minimal amount of light. However where misalignment or focus errors are present, the extent of such errors is detected by measuring the power coupled into the monitor sensors. To that end, the sensors 37 provide data, possibly after some on-chip processing, to the processing circuitry 32. The processing circuitry 32 contains a control algorithm to enable it to control the operating circuitry 31 to make changes of, or adjustments to, the compensating holograms displayed on the corrective SLM 30 until the system alignment is measured to be optimised. In some embodiments, changes to the sub-arrays to which beam affecting holograms are applied may be made in response to the sensor output data.

[0216] In another embodiment a determined number of dummy ports are provided. For example for a connector two or more such ports are provided and for routing devices three or more dummy ports are provided. These are used for continuous misalignment monitoring and compensation, and also for system training at the start.

[0217] Although some embodiments can operate on a trial and error basis, or can be adapted "on the fly", a preferred optical system uses a training stage during which it causes to be stored in the look-up table data enabling operation under each of the conditions to be encountered in use.

[0218] In one embodiment, in the training stage, a set of initial starting values is read in for application to the SLM 30 as hologram data, then light is applied at a fibre and the result of varying the hologram is noted. The variations may include both a change of pixels to which the hologram is applied, and a change of the hologram. Where more than one fibre is provided, light is applied to each other fibre in turn, and similar results obtained. Then other environmental changes are applied and their effects noted, e.g. at the sensors 37, and the correction for input data either calculated or sought by varying the presently-applied data using optimisation techniques to seek best or acceptable performance.

[0219] Then, in use, the system may be operated on a deterministic basis-i.e. after ascertaining what effect is sought, for example responding to a temperature change or providing a change in routing, the change to the applied data for operating the device can be accessed without the need for experiment.

[0220] A preferred embodiment operates in the deterministic way, but uses one or more reference beams of light passed through the device using the SLM 30. In that way the effect of deviations due to the device itself can be isolated. Also it can be confirmed that changes are being correctly made to take into account environmental and other variations.

[0221] The device may also have further monitor sensors placed to receive the zero-order reflections from the SLM(s) to enable an assessment to be made of the input conditions. For example, where an input channel fails, this can be determined by observing the content of the specular reflection from the light beam representing that channel. Where there are two SLMs as in some routing systems, the specular reflections from each SLM may be sensed and compared.

[0222] Referring now to FIG. 6, a dual-function SLM 40 provides both routing and correction. The SLM 40 has operating circuitry 41 and processing circuitry 42. The operating circuitry 41 receives routing data at a first control input 44 for causing the processing circuitry 42 to generate the holograms on the SLM 40 to achieve the desired routing. The processing circuitry 42 also receives routing data on an input 45, and controls the operating circuitry 41 using an algorithm enabling adaptation due to changes in the path taken through the system to take place on a timescale equivalent to that required to change the hologram display, i.e. of the order of milliseconds.

[0223] The control algorithms for this embodiment may use one or more of several types of compensation.

[0224] In one embodiment a look-up table is stored in a memory 43, the look-up table storing pre-calculated and stored values of the compensation for each different route through the system.

[0225] In another embodiment the system is trained before first being operated, using changes of, or to the compensating holograms to learn how changing the compensating holograms affects the system performance, the resulting data being held in the memory 43.

[0226] In a further embodiment, the processing circuitry 42 employs intelligence responsive to signals from monitor sensors 47,48 for monitoring and calculation of how these compensating holograms should adapt with time to accommodate changes in the system alignment. This is achieved in some embodiments by integrating circuitry components into the silicon backplane of the SLM, or by discrete components such as germanium detectors where the wavelengths are beyond those attainable by silicon devices. In some embodiments sensors 47 are provided for sensing light at areas of the SLM, and in others the sensors 48 may instead or also be remote from the SLM 40 to sense the effects of changes on the holograms at the SLM 40.

[0227] Referring now to FIG. 7, an optical system 80 includes an SLM 81 for routing beams 1,2 of light from input fibres 3,4 to output fibres 5,6 by means of holograms displayed on pixel groups 13,14 of the SLM. The holograms are generated by processing circuitry 82 which responds to a control input 83 to apply voltages to an array of pixellated elements of the SLM, each of which is applied substantially uniformly across the pixel of concern. This result is a discrete approximation of a linear phase modulation to route the beams.

[0228] The processing circuitry 82 calculates the ideal linear phase ramp to route the beams, on the basis of the routing control input 83 and resolves this phase modulo 2Pi. The processing circuitry at each of the pixels then selects the closest available phase level to the ideal value. For example if it is desired to route into the m'th diffraction order with a grating period Ω the ideal phase at position u on the SLM 81 is 2pi.mu/Ω.

Therefore, approximately, the phase goes linearly from zero up to 2pi over a distance Ω/m after which it falls back to zero, see FIG. 8a.

[0229] Control of the power in individual wavelength channels is a common requirement in communication systems. Typical situations are the need to avoid receiver saturation, to maintain stable performance of the optical amplifiers or to suppress non-linear effects in the transmission systems that might otherwise change the information content of the signals. Power control may be combined with sampling or monitoring channels to allow adjustment of the power levels to a common power level (channel equalisation) or to some desired wavelength characteristic.

[0230] Deliberate changes to the value of 'Ω' can be used to reduce the coupling efficiency into the output in order to provide a desired attenuation. This is suitable for applying a low attenuation. However, it is not suitable for a high attenuation as, in that event, the beam may then be deflected towards another output fibre, increasing the crosstalk. If there is only one output fibre this method may be used regardless of the level of attenuation.

[0231] To provide a selected desired attenuation of the optical channel in the system, processing circuitry 85 responds to an attenuation control input 84 to modify the operation of the operating circuitry 83 whereby the operating circuitry selects a linear phase modulation such that by the end of each periodic phase ramp the phase has reached less than 2pi, see FIG. 8b.

[0232] This may be achieved by calculating the ideal value of phase for every pixel, and then multiplying this ideal value by a coefficient r between 0 and 1, determined on the basis of the desired attenuation. The coefficient is applied to every pixel of the array in order to get a reduced level per pixel, and then the available phase level nearest to the reduced level is selected.

[0233] The method of this embodiment reduces the power in this diffraction order by making the linear phase modulation incomplete, such that by the end of each periodic phase ramp the phase has only reached 2pi.r. It has however been found that the method of this embodiment may not provide sufficient resolution of attenuation. It also increases the strength of the unwanted diffraction orders likely to cause crosstalk. When combined with deliberate changes in the length of the ideal phase ramp the resolution of attenuation may be improved. Again if there is only a single output fibre the crosstalk is less important.

[0234] Resolution may also be improved by having a more complex incomplete linear phase modulation. However, the unwanted diffraction orders may still remain too strong for use in a wavelength-routed network. Hence to control the power by adapting the routing hologram may have undesirable performance implications in many applications, as crosstalk worsens with increase of attenuation. The problem can be overcome by use of a complex iterative design. This could be used to suppress the higher orders but makes the routing control more expensive.

[0235] Referring now to FIG. 9, a system 99 includes an SLM 90 controlled by applying a discrete approximation of a linear phase modulation to route beams 1,2 from input fibres 3,4 to output fibres 5,6 as previously described with respect to FIG. 7. Thus operating circuitry 91 selects a routing hologram for display by the SLM, in accordance with a routing input 92, whereby the beams may be correctly routed, using a look up table or as otherwise known. A memory holds sets of data each allowing the creation of a respective power controlling hologram. Processing circuitry 93 runs an algorithm which chooses a desired power controlling hologram corresponding to a value set at a power control input 94. The power controlling hologram is selected to separate each beam into respective main 1a, 2a and subsidiary 1b, 2b beams, such that the main beams 1a, 2a are routed through the system and the or each subsidiary beam(s) 1b, 2b is/are diffracted out of the system, for example to a non-reflective absorber 97.

[0236] The processing circuitry 93 applies the power controlling hologram data to a second input 95 of the operating circuitry 91 which acts on the routing hologram data so as to combine the routing and power controlling holograms together to provide a resultant hologram. The operating circuitry then selects voltages to apply to the SLM 90 so that the SLM displays the resultant hologram.

[0237] Thus power in a routing context is controlled by combining the routing hologram with another hologram that has the effect of separating the beam into a main beam and a set of one or more subsidiary beams of these the main beam is allowed to propagate through the system as required while the other(s) are diffracted out of the system.

[0238] For example consider a hologram that applies phases of $+\phi$ and $-\phi$ on adjacent pixels. In terms of real and imaginary parts this hologram has the same real part, cos ϕ, on every pixel, see FIG. 10, while the imaginary part oscillates between +- sin ϕ. It can be shown using Fourier theory that the net effect is to multiply the amplitude of the original routed beam by a factor cos ϕ, and to divert the unwanted power into a set of weak beams at angles that are integer multiples of $\pm\lambda/2p$ with respect to the original routed beam, where λ is the operating wavelength and p is the pixel pitch.

[0239] The system is designed from a spatial viewpoint such that light propagating at such angles falls outside the region of the output fibres 5,6 of FIG. 9. An alternative design directs the unwanted light into output fibres 5,6 at such a large angle of incidence that the coupling into the fundamental mode is very weak, and has no substantial effect. In this case the unwanted power is coupling into the higher-order modes of the fibre and so will be attenuated rapidly. A fibre spool or some other technique providing mode stripping is then used on the output fibre before the first splice to any other fibre.

[0240] In either case, the effective attenuation of the beam is $10 \log_{10} \cos^2\phi$. Hence, in this way, polarisation-independent phase modulation may be used to create an effect equivalent to polarisation-independent amplitude modulation. This is termed herein "pseudo amplitude modulation". In this particular case the pseudo-amplitude modulation applied at every pixel is cos ϕ.

[0241] It will be clear to those skilled in the art that use of alternate pixels as the period of alternation is not essential, and may in some cases be undesirable. This is because of edge effects in the pixels.

[0242] The period and pattern of alternation can be varied so as to adjust the deflection angle of the 'unwanted power'. This light directed away from the output fibres can be collected and used as a monitor signal. Hence the pseudo-amplitude modulation can be used to sample the beam incident on an SLM as previously discussed. This sampling hologram can be combined with a routing and/or power control and/or corrective SLM. In the latter case the sampled beam can be directed towards a wavefront sensor and then used to assess the quality of the beam correction. While the pseudo-amplitude modulation as described above is applied to the whole beam, it could be applied selectively to one or more parts of the beam.

[0243] A further modification to this pseudo-amplitude modulation is to multiply it by a further phase modulating hologram such as to achieve a net effect equivalent to a complex modulation.

[0244] It is often important that the sampling hologram takes a true sample of the output beam. Therefore in some cases the sampling hologram should be applied after the combination of all other desired effects including resolution modulo 2pi and approximation to the nearest available phase level. In this case the overall actual phase modulation distribution is achieved by a method equivalent to forming the product of the sampling hologram and the overall hologram calculated before sampling.

[0245] Similar pseudo-amplitude modulation techniques may be extended to suppress the crosstalk created by clipping of the beam tails at the edges of each hologram and to tailor the coupling efficiency vs. transverse offset characteristic of the output fibres. Since the transverse position at the output fibre is wavelength dependent, this tailoring of the coupling efficiency vs. offset can be used to tailor the wavelength response of the system. This is important in the context of wavelength division multiplexing (WDM) systems where the system wavelength can be expected to lie anywhere in the range of the available optical amplifiers. The output angle for beam steering using an SLM and periodic linear phase modulation is proportional to the wavelength while the focal length of corrective lenses is also wavelength-dependent. Therefore a hologram configured to give the optimum coupling efficiency at one wavelength will produce an output beam with transverse and/or longitudinal offset at another wavelength. These effects result in wavelength-dependent losses in systems required to route many wavelength channels as an ensemble. Hence a method designed to flatten or compensate for such wavelength-dependent losses is useful and important.

[0246] Among the envisaged applications are the flattening of the overall wavelength response and the compensation for gain ripple in optical amplifiers, especially Erbium-doped fibre optic amplifiers (EDFA).

[0247] An SLM device may also be used to adapt the shape, e.g. the mode field shape, of a beam in order to suppress crosstalk.

[0248] Beam shaping is a type of apodisation. It is advantageously used to reduce crosstalk created at a device by clipping of the energy tails of the light beams. Such clipping leads to ripples in the far field. These ripples cause the beam to spread over a wider region than is desired. In telecommunications routing this can lead to crosstalk. Other applications may also benefit from apodisation of a clipped laser beam, such as laser machining, for example, where it is desired to process a particular area of a material without other areas being affected and laser scalpels for use in surgery.

[0249] Clipping occurs because the energy of the beam spreads over an infinite extent (although the amplitude of the beam tails tends to zero), while any device upon which the beam is incident has a finite width. Clipping manifests itself as a discontinuity in the beam amplitude at the edges of the device.

[0250] Referring to FIG. 11, two SLMs 100,101 are used for beam steering or routing of beams 1,2 from input fibres 3,4 to output fibres 5,6, as described in PCT GB00/03796. Each SLM 100,101 is divided into a number of blocks of pixels 103a, 104a; 103b, 104b. Each block 103a, 104a is associated with a particular input fibre 3,4- i.e. the fibre of concern points to the subject block. Each block displays a hologram that applies routing. As previously discussed herein the holograms may also or alternatively provide focus compensation, aberration correction and/or power control and/or sampling, as required.

[0251] The blocks 103a, 104a at the input SLM 100 each receive a beam from an associated input fibre 3,4 while the blocks 103b, 104b at the output SLM 101 each direct a beam towards an associated output fibre 5,6. Each block 103a, 103b has a finite width and height. As known to those skilled in the art and as previously noted, the beam width is infinite, therefore the block clips the beam from or to the associated fibre and this creates undesired ripples in the far field.

[0252] The ripples due to clipping of the beam 1 are figuratively shown as including a beam 106 which, it will be seen, is incident on the wrong output hologram, displayed on block 104b at the output SLM 101. "Wrong" signifies holograms other than that to which the beam of concern is being routed, for example holograms displayed by blocks around the block to which the beam should be routed. Some of these ripples will then be coupled into "wrong" output fibres 5,6-i.e. those to which the beam is not deliberately being routed-leading to crosstalk. It will be clear to those skilled in the art that these effects will be present on blocks other than those adjacent to the "correct" blocks, as the field of beam 1 is infinite in extent.

[0253] In any physical system the effect of the ripples created by clipping at the output SLM 101 depends on the optical architecture.

[0254] In practice the non-ideal transfer function of the optics (due to finite lens apertures and aberrations) means that a sharp change in the amplitude spreads out and causes crosstalk in adjacent output fibres. In effect the optics applies a limit to the range of spatial frequencies that can be transmitted. This frequency limit causes crosstalk.

[0255] The wider the device, compared to the beam spot size at the device, the weaker the ripples in the far field and the lower the crosstalk. In general a parameter C is defined such that the required width of SLM per beam is given by $H=C.\omega$, where ω is the beam spot size at the SLM. The value of C depends on the beam shape, the optical architecture and the allowable crosstalk. Typically for a Gaussian beam, with no beam shaping and aiming for crosstalk levels around -40 dB, C would be selected to have a value greater than or equal to three. Looking at this system from the spatial frequency viewpoint, the field incident on the SLM contains (for perfect optics) all the spatial frequencies in the input beam. The finite device width cuts off the higher spatial frequencies, so, again, the optics applies a limit to the range of spatial frequencies that can be transmitted and this frequency limit causes crosstalk.

[0256] Beam shaping can be used to decrease the crosstalk for a given value of C, and also allow the use of a lower value of C. Calculations for N*N switches have shown that decreasing the value of C leads to more compact optical switches and increases the wavelength range per port. Hence beam shaping can be employed to provide more compact optical switches and/or an increased wavelength range per port.

[0257] The idea behind using beam shaping or 'apodisation' to reduce crosstalk is based on an analogy with digital transmission systems. In these systems a sequence of pulses is transmitted through a channel possessing a limited bandwidth. The frequency response of the channel distorts the edges of pulses being transmitted so that the edges may interfere with one another at the digital receiver leading to crosstalk. The channel frequency response can, however, be shaped so as to minimise such crosstalk effects. Filters with responses that have odd-symmetry can be used to make the edges go through a zero at the time instants when pulses are detected.

[0258] Therefore beam-shaping with odd symmetry can be used to make the crosstalk go through a zero at the positions of the output fibres. Such a method is likely to be very sensitive to position tolerances.

[0259] Another method used in digital systems is to shape the frequency cut-off so that it goes smoothly to zero. In the present context the ideal case of 'smoothly' is that the channel frequency response and all derivatives of the frequency response become zero. In practice it is not possible to make all derivatives go to zero but a system may be designed in which the amplitude and all derivatives up to and including the k'th derivative become zero at the ends of the frequency range. The higher the value of k, the quicker the tails of the pulse decay. Therefore the beam shaping should go as smoothly as possible to zero.

[0260] To investigate the effects of beam shaping the amplitude modulation was treated as continuous. The system studied was a single lens 2f system where 2f is the length of the system between fibres and SLM, assuming f is the focal length with fibres in one focal plane, and an SLM in the other focal plane. The input fibre beam was treated as a Gaussian. Various amplitude modulation shapes were applied at the SLM and the coupling efficiency into the output fibre was calculated. In this architecture and from Abbe theory, the incident field at the SLM is proportional to the Fourier Transform of the field leaving the input fibre. In particular, different spatial frequencies in the fibre mode land on different parts of the SLM. Clipping removes the spatial frequencies outside the area of the hologram. Beam shaping at the SLM has the effect of modifying the relative amplitude of the remaining spatial frequencies.

[0261] Residual ripples may still remain due to the discontinuity in the beam derivative but the ripples will be reduced in amplitude and decay more quickly. Further reduction in the ripple amplitude and increase in the rate of decay may be achieved by shaping the beam such that both the amplitude and the first k derivatives go to zero at the edges.

[0262] Mathematical analysis of the effect has also been carried out. The results are as follows:

[0263] The n^{th} time derivative of a function can be expressed in terms of its Fourier Transform as shown in equation (1):

$$\frac{d^n g(t)}{dt^n} = \int_{-\infty}^{\infty} (i2\pi f)^n G(f) \exp i2\pi ft \, df \qquad (1)$$

[0264] Hence, by inversion, the frequency dependence of the Fourier Transform (FT) may be expressed as an FT of any one of the function's derivatives as shown in equation (2):

$$G(f) = \frac{1}{(i2\pi f)^n} \int_{-\infty}^{\infty} \frac{d^n g(t)}{dt^n} \exp - i2\pi ft \, dt \qquad (2)$$

[0265] Choosing the zeroth derivative provides the expression in equation (3):

$$G(f) = \int_{-\infty}^{\infty} g(t) \exp - i2\pi ft \, dt \qquad (3)$$

[0266] To apply the analysis to free-space beam-steering:

[0267] let x and y be the position co-ordinates at the fibre output from a switch, and u and v be the position co-ordinates at the SLM. Assume the SLM to be in one focal plane of a lens of focal length f, and the fibre array to be in the other focal plane:

$$E_{FIB}(x,y) = \frac{i}{f\lambda} \exp(-i\frac{2\pi}{\lambda}(2f + nt)) \iint E_{SLM}(u,v) \exp i\frac{2\pi f}{\lambda}(xu + yv) du dv \qquad (4)$$

[0268] such that the output field (see equation (4)) is a 2-D Fourier Transform of the field at the SLM, E_{SLM}. In this result t is the lens thickness and N its refractive index, while λ is the optical wavelength.

[0269] For the present purposes the 1-D equivalent is considered (relation 5):

$$E_{FIB}(x) = \frac{i}{f\lambda}\exp(-i\frac{2\pi}{\lambda}(2f+nt))\int E_{SLM}(u)\exp i\frac{2\pi f}{\lambda}(xu)du \qquad (5)$$

[0270] Comparing with (3) it is clear that the position co-ordinate at the SLM (u) is equivalent to the time domain and the position co-ordinate at the output (x) is equivalent to the frequency domain. Hence from (2) the output field may be expressed in terms of a derivative of the field at the SLM, as shown in equation (6):

$$E_{FIB}(x) = \frac{i}{f\lambda}\exp(-i\frac{2\pi}{\lambda}(2f+nt))\left(\frac{i}{2\pi x}\right)^n \int \frac{d^n E_{SLM}(u)}{du^n}\exp i\frac{2\pi f}{\lambda}(xu)du \qquad (6)$$

[0271] Let the k^{th} derivative of $E_{SLM}(u)$ be non-zero and smoothly varying over the range [-H/2, H/2], but zero outside this range, such that the derivative changes discontinuously at u = ±H/2:

$$\begin{aligned}\frac{d^k E_{SLM}(u)}{du^k} &= 0 && \forall u : u < -\tfrac{H}{2}\\ &= g^H && u = -\tfrac{H}{2}\\ &= s(u) + g^H && -\tfrac{H}{2} < u < \tfrac{H}{2}\\ &= g^H && u = +\tfrac{H}{2}\\ &= 0 && u > \tfrac{H}{2}\end{aligned} \qquad (7)$$

[0272] This representation assumes E_{SLM} to be even in u. Physically this situation represents a beam that is perfectly aligned with respect to the centre of a hologram of width H.

[0273] This derivative may be expressed as the sum of a rect function and a smoothly varying function, s(u), that is zero at and outside |u|=H/2:

$$\frac{d^k E_{SLM}(u)}{du^k} \equiv g_H rect\left(\frac{u}{H/2}\right) + s(u) \qquad (8)$$

TS0001211

[0274] For example consider a clipped (and unapodised) Gaussian beam; the zeroth derivative (k=0) may be expressed as:

$$s(u) = \exp-\left(\frac{u}{\omega_{HOL}}\right)^2 - \exp-\left(\frac{H}{2\omega_{HOL}}\right)^2 \quad \forall|u| < \frac{H}{2}$$
$$= 0 \quad \forall|u| \geq \frac{H}{2} \tag{9}$$

$$g_H = \exp-\left(\frac{H}{2\omega_{HOL}}\right)^2 \tag{10}$$

[0275] Now returning to the general case (equation(8)) the k+1th derivative is calculated:

$$\frac{d^{k+1}E_{SLM}(u)}{du^{k+1}} \equiv g_H\left\{\delta\left(u+\frac{H}{2}\right) - \delta\left(u-\frac{H}{2}\right)\right\} + \frac{ds(u)}{du} \tag{11}$$

[0276] It is now convenient to calculate the output field.. Set $n=k+1$ in (6) to obtain:

$$E_{FIB}(x) \propto \frac{1}{(i2\pi x)^{k+1}}\left\{\begin{matrix} g_H \int_{-\infty}^{\infty}(\delta(t+H/2)+\delta(t-H/2))\exp-i2\pi xu\,du \\ +\int_{-\infty}^{\infty}\frac{ds(u)}{du}\exp-i2\pi xu\,du \end{matrix}\right\} \tag{12}$$

[0277] which becomes equation (13):

$$E_{FIB}(x) \propto \frac{1}{(i2\pi x)^{k+1}}\left\{2ig_H\sin(\pi xH) + \int_{-\frac{H}{2}}^{\frac{H}{2}}\frac{ds(u)}{du}\exp-i2\pi xu\,du\right\} \tag{13}$$

[0278] As the position is increased, the exponential term in the 2nd integral of (13) oscillates more and more rapidly. Eventually the spatial frequency is so high that the derivative of s(u) can be considered to be constant, or nearly constant, over the spatial period. In which case the integral is zero, or nearly zero, when evaluated over each period of the oscillation. Therefore at high frequencies the whole of the second integral must approach zero.

[0279] It is assumed that the behaviour is dominated by the first integral. The first integral shows that if the amplitude changes discontinuously (k=0, i.e. an unapodised hologram), the spectrum (E_{FIB}) decays as 1/x. Now, if the amplitude and the first derivative are continuous, it is the second derivative that changes discontinuously, and so k=2 and the spectrum (E_{FIB}) decays as $1/x^3$. Numerical simulations have been carried out to confirm this behaviour.

[0280] A particularly advantageous shape is one in which the shaped beam has odd symmetry about points midway between the centre and the edges such that the beam amplitude and all of its derivatives go to zero at the beam edges.

[0281] The beam shaping may be effected to remove only a small amount of power from the central portion of the beam, to maintain acceptable system efficiency. A method for shaping a beam to achieve suppression of the ripples is now described.

[0282] Defining the middle of the beam as f(u), then f(u) can describe the original beam in its central portion, or what is left in the original beam after it has already been partially shaped, using, for example, pseudo-amplitude. To avoid ripples in the far field the edges of the beam go to zero at u = ±H/2, where H is the width of the hologram.

[0283] Hence, at the right-hand edge, describe the beam as in equation (14):

$$f_R(u) = f(0) - f(u-H/2) \qquad (14)$$

[0284] (The left-hand edge is considered later).

[0285] To get matching of the amplitude half-way between the middle and the edge it is required that

$$f(H/4) = f_R(H/4) \qquad (15)$$

[0286] From which there is obtained

$$f(H/4)+f(-H/4)= f(0) \qquad (16)$$

[0287] Now consider the derivatives at the joining point. The n[th] derivative of the right-hand edge function is given by equation (17):

$$\left.\frac{d^n f_{RH}}{du^n}\right|_{u=U} = \left.\frac{d^n f}{du^n}\right|_{u=U-H/2} \qquad (17)$$

[0288] Hence at the joining point condition (18) is valid:

$$\left.\frac{d^n f_{RHEDGE}}{du^n}\right|_{u=H/4} = \left.\frac{d^n f}{du^n}\right|_{u=-H/4} \qquad (18)$$

[0289] In order to avoid the creation of high frequency effects (crosstalk tails) by the joining point all derivatives are desirably continuous here. Hence it is required that condition (19) should be true:

$$\left.\frac{d^n f}{du^n}\right|_{u=H/4} = -\left.\frac{d^n f}{du^n}\right|_{u=-H/4} \qquad (19)$$

[0290] To find out whether this is possible, expand the function f in a Taylor series about x=0 to obtain equation (20)

$$f = f(0)+a_1u+a_2u^2+a_3u^3+a_4u^4+a_5u^5+a_6u^6+\dots\dots\dots\dots \qquad (20)$$

[0291] The first derivative is given by equation (21):

$$\frac{df}{du} = a_1+2a_2u+3a_3u^2+4a_4u^3+\dots\dots \qquad (21)$$

[0292] The required condition (19) for the first derivative (n=1) can be obtained provided f is even in x, so that all the odd coefficients {a1, a3. . . } in (20) and (21) are zero. This makes the first derivative continuous at the joining point. Furthermore if *f* is an even function then *f(H/4)=f(–H/4)* in which case (16) becomes:

$$f(H/4) = \tfrac{1}{2}f(0) \qquad (22)$$

[0293] Given that f is now an even function, the second derivative of f is given by equation (23):

TS0001214

$$\frac{d^2 f}{du^2} = 2a_2 + 12a_4 u^2 + ... \qquad (23)$$

[0294] Returning to the required condition in (19) it is clear that it cannot be satisfied for n=2. Hence the second derivative is discontinuous at the joining point u=H/4.

[0295] The left-hand edge is given by equation (24)

$$f_{LH}(u) = f(0) - f(u+H/2) \qquad (24)$$

[0296] Given that f is even, the overall function has odd symmetry in each half plane x = ± H/4.

[0297] To work out what happens at x = ± H/2, expand f_{RH} and f_{LH} in Taylor series, as shown in equations 25 and 26:

$$f_{RH} = a_2\left(u - \tfrac{H}{2}\right)^2 + a_4\left(u - \tfrac{H}{2}\right)^4 + a_6\left(u - \tfrac{H}{2}\right)^6 + ... \qquad (25)$$

$$f_{LH} = a_2\left(u + \tfrac{H}{2}\right)^2 + a_4\left(u + \tfrac{H}{2}\right)^4 + a_6\left(u + \tfrac{H}{2}\right)^6 + ... \qquad (26)$$

[0298] The function and its first derivative are both zero at u= ½H, but the second derivative has the value $2a_2$. Outside of the range [−½H, ½H] the beam drops to zero. Hence the second derivative is discontinuous at both u=±½H and u=±H/4, and the far field must therefore decay as the cube of the distance measured in the far field.

[0299] From the analysis, the required properties of f(u) for a hologram of width H are that firstly it should be even in u, and that secondly its amplitude at the position u=H/4 should be half the amplitude at u=0. After apodisation has been applied the shape of the beam in the region between u=H/4 and u=H/2 should be given by $f_{RH}(u) = f(0) - f(u-H/2)$ while in the region between u=-H/2 and u=-H/4 the shape of the beam should be given by fLH(u)=f(0)-f(u+H/2). In practice the shaping may not increase the local beam amplitude. Hence the hologram width and/or the shape of the central portion may have to be adjusted to avoid the requirement for 'amplifying' shaping.

[0300] As an example these conditions are satisfied by a Gaussian distribution given by equation (27):

$$f(u) = \exp-\left(\frac{u\sqrt{\ln(2)}}{H/4}\right)^2 \quad - \quad (27)$$

[0301] If the original beam satisfies the first two conditions it can be apodised without removing power from the central region. Otherwise shaping can be applied to the central region so that these two conditions are satisfied.

[0302] In some systems there may be a requirement to adapt the width of the beam in the far field: either to narrow the beam or to broaden the beam. This may be useful for laser processing of materials as well as for routing. It is advantageous that the method to change the width does not introduce side lobes. A particular application that would benefit is laser drilling of holes. The SLM could be used to narrow the drilling beam as well as to change its focus so that the drilled hole remains of uniform diameter (or has reduced diameter variation) as the hole is progressively bored.

[0303] In order to broaden the far field, the near field (at the SLM) needs to be made narrower. This may be implemented by applying shaping to the central portion of the beam so that its full width half maximum (FWHM) points become closer together and so that the beam shape has even symmetry about its centre. Preferably the amplitude at the very peak is not reduced so as not to lose too much power. The distance between the two FWHM points defines the effective half-width of the hologram. Further shaping should be applied to the left-hand and right-hand edges of this effective hologram, so that the beam shape has the required properties as described previously. Outside of the width of the effective hologram the beam shape should have zero amplitude.

[0304] To narrow the far field, the near field (at the SLM) needs to be made broader. This may be implemented by applying shaping to the central portion of the beam, so that the FWHM points become further apart, and so that the beam shape has even symmetry about its centre. Typically this will require reduction of the amplitude around its peak. The extent of this reduction is governed by the need to be able to apply shaping to the right and left hand edges of the hologram with the constraint that the shaping may only decrease the amplitude (and not increase it).

[0305] Amplitude-modulating SLMs can be used to implement the shaping but they are polarisation-dependent.

[0306] Another pseudo-amplitude modulation can be created to implement the beam shaping by using a phase-modulating SLM, which may be made polarisation-independent. This may be achieved by recognising that a phase modulation exp j ϕ (u), where j is the complex operator, is equivalent to a phase modulation cos ϕ (u)+j sin ϕ (u). Now choose ϕ (u) such that the modulus of ϕ (u) is varying slowly but the sign is oscillating.

[0307] Hence the real part of the modulation, cos ϕ (u), will be slowly varying and can act as the amplitude modulator to create the beam shape, while the imaginary part of the modulation, ± sin ϕ(u), will be oscillating rapidly with an equivalent period of two or more pixels. Hence the energy stripped off by the effective amplitude modulator will be diffracted into a set of beams that are beam-steered out of the system at large angles.

[0308] In a preferred embodiment, the system is designed such that light travelling at such angles will either not reach the output plane or will land outside the region defined by the output ports. Therefore the beam component shaped by sin ϕ (u) is rejected by the optical system, while the beam component shaped by cos ϕ (u) is accepted by the system and couples into one or more output ports, as required. While this explanation is for a one-dimensional phase modulator array the same principle is applicable in 2-D. If ϕ (u) varies from 0 at the centre of the beam to $\pi/2$ at the edges then the amplitude of the beam shaped by cos ϕ (u) varies from 1 at the centre of the beam to 0 at the edges, thus removing the amplitude discontinuity that creates rippling tails in the far field. This can be achieved with minimal change to the insertion loss of the beam as it passes through the system. Indeed, often the insertion loss due to clipping is due to interference from the amplitude discontinuity, rather than the loss of energy from the beam tails.

[0309] The beam-shaping hologram is non-periodic but oscillatory and may be applied as a combination with other routing and/or lens synthesis and/or aberration correcting and/or power control and/or sampling holograms.

[0310] Further advantages of the beam shaping are that it reduces the required value of C for a given required crosstalk, allowing more compact optical switches. Another advantage is that the crosstalk decays much more rapidly with distance away from the target output fibre. Hence, essentially, the output fibres receive crosstalk only from their nearest neighbour fibres.

[0311] Therefore in a large optical switch used as a shared N*N switch for a range of wavelengths, it should be possible to arrange the wavelength channel allocation such that no output fibre collects crosstalk from a channel at the same system wavelength as the channel it is supposed to be collecting. This would reduce significantly the homodyne beat noise accumulation in networks using such switches, and, conversely, allow an increase in the allowed crosstalk in each switch as heterodyne crosstalk has much less of an impact at the receiver, and can also be filtered out if necessary.

[0312] The crosstalk suppression method uses beam shaping to suppress ripples in the beam tails. The same method can be adapted to change the beam shape around the beam centre. For the case when the output beam is an image of the beam at the SLM the beam shaping is working directly on an image of the output beam. The fraction of the initial beam that is shaped by the slowly varying function cos ϕ (u) can have the correct symmetry to couple efficiently into the fundamental mode of the output fibre. The fraction of the initial beam that is shaped by the rapidly varying function $\pm$ sin ϕ(u) has the wrong symmetry to couple into the fundamental mode and can be adjusted to be at least partially orthogonal to the fundamental mode.

[0313] Effectively, it is the fraction of the beam shaped by cos ϕ (u) that dominates the coupling efficiency into the fundamental mode. Therefore the dependence of the coupling efficiency vs. transverse offset is dominated by the overlap integral between the cos ϕ (u) shaped beam and the fibre fundamental mode.

[0314] When the incident beam is the same shape as the fundamental mode and for small transverse offsets the coupling efficiency decreases approximately parabolically with transverse offset. In many beam-steering systems using phase-modulating SLMs the transverse offset at the output fibre increases linearly with the wavelength difference from the design wavelength. Consequently the system coupling efficiency decreases approximately parabolically with wavelength difference from the design wavelength. Beam shaping can be used to adjust the shape of the incident beam and optimised to flatten the dependence on transverse offset and hence to flatten the wavelength response. Alternatively a more complex wavelength dependence could be synthesised to compensate for other wavelength-dependent effects.

[0315] Beam shaping may also be used during system assembly, training or operation in order to measure mathematical moments of a light beam. A description of the method and theory will be followed by a description of some example applications.

[0316] The method requires a first stage during which corrective phase modulation is applied by the SLM such that the phase profile of the beam leaving the SLM has no non-linear component. This may be confirmed with a collimeter or wavefront sensor or some other suitable device. In a first embodiment the phase profile has no linear component applied to deflect the beam such that the beam is reflected in a specular direction. An optical receiver is placed to receive the reflected beam. The power reflected exactly into the specular direction is proportional to the square of an integral A(n) given in equation (28) where f(n,u,v) is the complex amplitude of the beam leaving the SLM at co-ordinates u,v during the n^{th} stage of the method.

$$A(n) = \iint f(n,u,v)\,du\,dv \qquad (28)$$

[0317] The optical power received by the photodiode during the n^{th} stage of the method is given by equation (29)

$$P(n) = K(A(n))^2 \qquad (29)$$

[0318] where K is a constant of proportionality.

[0319] If received by an optical fibre the received power will be modified according to the fibre misalignment and mode field distribution, leading to possible ambiguities in the method. Hence it is preferred instead to receive the beam by a photodiode. During the first stage of the method the net phase modulation applied by the SLM is such that the beam is of uniform phase. Let b(u, v) be the beam amplitude distribution. Therefore during this first stage the integral A is equal to the zeroth moment, a0, of the beam amplitude distribution, as shown in equation (30), and f(n,u,v) is equal to

$$A(1) = a0 = \iint b(u,v)\,du\,dv \qquad (30)$$

[0320] Therefore the power, P(1), measured by the photodiode during this first stage is given by equation (31).

$$P(1) = Ka_0^{\ 2} \qquad (31)$$

[0321] In order to characterise a two-dimensional beam, moments of the beam distribution may be taken in two orthogonal directions, in this case the u and v directions. Consider the pixel block of concern to be broken up into a set of columns. To each column in the block a particular effective amplitude modulation may be applied using the pseudo-amplitude method or some other method. For example consider the pixel column with a centre at co-ordinate u*. By applying an alternating phase modulation of +ϕ (u*) and -ϕ (u*) to adjacent pixels in the same column the effective amplitude modulation applied to the particular column is cos(ϕ (u*)).

[0322] In order to calculate the first moment in the u direction, during the second stage of the method the values of cos(ϕ (u*)) are chosen such as to approximate to a linear distribution, as described in equation (32)

$$\cos(\phi(u^*)) \approx mu^* + c \qquad (32)$$

[0323] Therefore the power P(2) measured during the second stage of the process is given by (33).

$$P(2) \approx K\left(m^2 a_{1U}^{\ 2} + 2mca_{1U}a_0 + c^2 a_0^{\ 2}\right) \qquad (33)$$

[0324] where a_{1U} is the first moment of the beam distribution in the u direction, as given by (34).

[0325] $a1u = \iint ub(u,v)\,du\,dv$ (34)

[0326] The ratio of the powers measured during the two stages is then given by equation (35)

$$\frac{P(2)}{P(0)} \approx m^2 \left(\frac{a_{1U}}{a_0} \right)^2 + 2mc \frac{a_{1U}}{a_0} + c^2 \qquad (35)$$

[0327] Given the measured power ratio and the values of m and c as chosen to satisfy the constraints of the method, the quadratic equation given in (35) may be solved to calculate the ratio of the first order moment in the u direction to the zeroth order moment.

[0328] The constraints on m and c are such that the actual values of the alternating phase of each column need to be chosen from the available set and such that the total phase excursion across the expected area of the beam remains within the range $[0,\pi]$ or $[-\pi,0]$ so that the cos(ϕ (u*)) term may decrease (or increase) monotonically. In practise a photodiode of finite size will receive power diffracted from the SLM within an angular distribution about the specular direction. A further constraint on the gradient 'm' in equation (32) is such that the side lobes created by the linear amplitude modulation fall outside the area of the photodiode.

[0329] Similar methods may be used to take approximate higher-order moments in the u direction, and also first and higher-order moments in the v direction. In the latter case to each row in the block a particular effective amplitude modulation is applied, e.g. by setting adjacent pixels in the row to alternating phases of +ϕ (v*) and -ϕ (v*), where v* is the position co-ordinate of the row. The second-order moments may also be calculated and used to estimate the beam spot size at the hologram. This estimate can be used as part of the control algorithm for focus adjustment.

[0330] In a second embodiment a further linear phase modulation is applied to the hologram during each stage so as to deflect the beam to be measured while taking the moments towards a particular photodiode.

[0331] Consider a Gaussian type beam b(u,v) centred at position co-ordinates (u0,v0).

The even symmetry of the beam about axes parallel to the u and v directions and through the centre lead to the identities given by equations (36) and (37).

$$\iint (u-u0)b(u,v)\,du\,dv = 0 \quad (36)$$

$$\iint (v-v0)b(u,v)\,du\,dv = 0 \quad (37)$$

[0332] Hence approximate values of the first order moments measured as described previously, or by some other method, may be used to deduce approximate positions for the beam centres, as shown by equations (38) and (39).

$$u_0 \approx \frac{a_{1U}}{a_0} \quad (38)$$

$$v_0 \approx \frac{a_{1V}}{a_0} \quad (39)$$

[0333] In the next stage of the measurement the pixel block initially assigned to the beam is re-assigned such that it is centred within half a pixel in each of the u and v directions from the approximate centre of the beam, as just calculated.

[0334] Let the new centre of the pixel block be at (u1,v1). A new hologram should be calculated such that the beam leaving the SLM acts as the product of a beam of uniform phase distribution and an effective amplitude distribution given by equation (40)

$$\cos(\phi(u^*)) \approx m(u^* - u1) \quad (40)$$

[0335] The principle is that if the beam centre lies exactly at u1 the measured power exactly in the specular direction will be zero. Taking into account the finite area of the photodiode the measured power cannot be zero but will be minimised when u1 is within half a pixel pitch of the beam centre.

[0336] This new hologram should be applied to the pixel block and the power measured. At this point the method can proceed in two ways.

[0337] In one embodiment a further estimate of the beam centre can be calculated, as described previously, a new centre position u1 calculated, the hologram recalculated according to equation (40) and the power measured again. This process can be repeated until the value of u1 appears to have converged.

[0338] In a second embodiment the centre of the pixel block, u1 can be re-assigned, the hologram recalculated according to (40) and the power measured again. At the current pixel block centre, u1, for which the beam centre is within half a pixel of u1, the measured power should be at a minimum value.

[0339] A further embodiment is to use a suitable combination of these two alternative methods.

[0340] The centre of the pixel block in the v direction can be measured using similar methods.

[0341] The size of the pixel block used should be chosen so as to cover the expected area of the beam. Outside of this area the phase can be modulated on a checkerboard of, for example, +-pi/2, so that the effective amplitude modulation is zero and the light from these regions is diffracted far away from the photodiode.

[0342] It can be shown that equations (36) and (37) are also satisfied if the beam waist is not coincident with the SLM, that is the beam is defocused. Although the method as described above will not be calculating the proper moments of the beam, it can be shown that the position of the beam centre may still be identified using the methods described.

[0343] The beam shaping method may be extended to control and adapt the amplitude of the beam steered through the system. If $\phi(u)$ varies from ψ at the centre of the beam to $\pi/2$ at the edges then the real part of the pseudo-amplitude modulation can be considered as cos ψ multiplied by an ideal beam-shaping function that causes insignificant insertion loss. In which case there is an associated additional insertion loss given by approximately $10\log_{10}(\cos^2\psi)$. By varying the value of ψ the beam power can be varied. Therefore the same device can be used to achieve power control, otherwise known as channel equalisation, as well as changing the routing or direction of a beam. Deliberate changes in the beam shaping function can be used to increase the number of 'grey levels' possible for the beam attenuation, i.e. to provide an increased resolution. As for the beam shaping, the rejected power is diffracted out of the system. Therefore this attenuation method does not increase crosstalk.

[0344] Another technique for controlling beam power without increasing crosstalk is to deflect the unwanted energy in a direction orthogonal to the fibres susceptible to crosstalk.

[0345] This may be combined with yet another technique, namely distorting the beam phase in such a way that much of the energy couples in to the higher-order modes of the fibre, rather than the fundamental mode that carries the signal. The beam phase distortion may alternatively be used alone.

[0346] In an embodiment, these methods are achieved by dividing the area of the SLM on which the beam is incident into a set of 'power controlling' stripes. The long side of the stripes are at least substantially in the plane in which the input and output-beam are travelling. By varying the relative phase in the stripes the coupling efficiency into the fundamental mode of the output fibre is changed, and hence the throughput efficiency of the optical system is set. This method can be applied to a pixellated device that is also routing or otherwise adapting a beam. In this case each 'stripe' would contain between one and many of the pixels already in use.

[0347] Alternatively the long side of the power controlling stripes could be in one plane in one electrode, with the long side of the routing pixels in an orthogonal direction in the other electrode, of which either the stripe electrodes, or the pixellated electrodes, or both, are transparent.

[0348] Alternatively the device acts solely as a beam power controller, or channel equaliser. In this case each stripe could be a single pixel. The set of stripes for each beam defines a block. Many blocks could be placed side by side to form a row of blocks, with each block in the row providing channel equalisation for a different beam. Many rows could also be provided so as to provide channel equalisation for signals coming in on different input fibres.

[0349] If a pair of confocal focusing elements is disposed between the output fibre and SLM then the output fibre receives an image of the field at the SLM. In this case the attenuation at the output fibre is governed by the orthogonality between the image and the fundamental mode of the fibre. Assuming, and without loss of generality, that a perfect image is formed such that sharp phase discontinuities are preserved, it may be shown that the coupling efficiency into the fundamental mode is proportional to the square of a sum of weighted integrals. The weight is the modulation exp jϕ applied by a stripe, and the associated integral is over the area onto which that stripe is imaged. The integrand is positive and depends on the square of the local electric field associated with the fundamental mode. Each integral is represented as a phasor, with a length depending on how much of the fundamental mode power passes through the region onto which the stripe is imaged, and a phasor angle depending on the phase modulation. The net coupling efficiency is given by the magnitude of the vector summation of the individual phasors associated with each stripe. For simple devices it may be advantageous to use as few stripes as possible as this reduces any losses due to dead space between the stripes and reduces the control complexity. With only two stripes of approximately equal area (and hence two phasors of approximately equal length) the possible vector sums lie on a semicircle and hence the number of possible grey levels is equal to the number of phase levels between 0 and π, which may not be sufficient. Transverse offset of the output fibre with respect to the centre of the image has the effect of making the two phasors unequal and hence complete extinction is not possible. These problems may be overcome by using three or more stripes per hologram. For example with three stripes the loci of vector sums lie on circles centred about the semicircle taking just two of the stripes into consideration. Hence many more values are possible. Increasing the number of stripes increases the number of grey levels and the depth of attenuation.

[0350] A fibre spool is used on the output fibre before any splices are encountered. It will clear to those skilled in the art that other mode stripping devices or techniques could be used instead.

[0351] This system can also be adaptive: given knowledge of the applied phase by each stripe and enough measurements of the coupling efficiency, the lengths of the different phasors associated with each stripe can be calculated. Given these lengths the performance can be predicted for any other applied phases. Hence suitable algorithms can be included in the SLM or interface to train and adapt the device performance to cater for transverse offset of the output fibre and other misalignments.

[0352] Sharp edges or phase discontinuities in this image will be eroded by the optical modulation transfer function (MTF) but, nevertheless, where a sufficient number of stripes is provided it is possible to vary the phase modulation of each and achieve a wide range of attenuation.

[0353] Ultimately what limits the depth of attenuation is the residual zero-order due to, for example, an imperfect quarter-wave plate or Fresnel reflections from different surfaces inside the SLM such that the reflected light has not yet been phase-modulated. An example reflection is from the interface between the cover glass and transparent electrode. Such residual zero orders will couple into the output fibre independently of the phase modulation. In many cases the residual zero order will have a different polarisation state to the beam that has been properly processed by the phase modulation, so even adapting the phase modulation will not recover the depth of attenuation.

[0354] In such cases it is advantageous to apply some routing to the output fibre, such that the zero order is offset from the output fibre and the intended output beam is steered into a diffraction order of the routing hologram. For a many-pixellated SLM this may be achieved using the standard routing algorithm described earlier. For a simple SLM with few pixels, e.g. the one with the stripes in the plane of the input and output fibres, these stripes can be subdivided in an orthogonal direction, that is to create a 2-D array of pixels. This however increases the device complexity.

[0355] An alternative simple device is to combine it with a tip-tilt beam-steering element, as described in Optics Letters, Vol. 19, No 15, Aug. 1, 1994 "Liquid Crystal Prisms For Tip-Tilt Adaptive Optics" G D Love et al. In this case the top 'common electrode' is divided into a set of top electrodes, one for each device, where each device is assumed to receive a separate beam or set of beams. Each top electrode has different voltages applied on two opposite sides. The shape of the top electrode is such that the voltage between the electrodes varies nonlinearly in such a way as to compensate for the non-linearity of the phase vs. applied volts characteristic of the liquid crystal. Hence with all the stripe electrodes at the same voltage the device provides a linear phase ramp acting like a prism and deflecting the phase-modulated beam in a pre-defined direction, such that the residual zero order falls elsewhere, as required. Changing the stripe electrode voltage causes phase changes in the imaged beam but does not prevent the deflection. Small adjustments in the phase ramp can be used to compensate for component misalignments and/or curvature of the SLM substrate and/or wavelength difference from the design wavelength for the tip-tilt device. Such small adjustments in the phase ramp can also be used to achieve fine control over the attenuation. Hence such a device would be useful whether or not the required attenuation is sufficiently strong for the residual zero order to become a problem. Alternatively the top electrode can be divided into two or more areas, with the shape of each so as to compensate for the phase vs. volts non-linearity. Varying the voltage on the ends of each electrode can be used to offset the phase modulation of each stripe in order to create the desired attenuation. In this case the aluminium electrode would be common to the device, removing dead-space effects.

[0356] In another embodiment of the tip-tilt device, the top electrode is common to all devices and a shaped transparent electrode is provided, e.g. by deposition, on top of the quarter-wave plate, with connections to the SLM circuitry to either side of the device. In this case the aluminium may act only as a mirror and not as an electrode. Again the shaped transparent electrode may be subdivided into two or more areas to provide the attenuation. This embodiment avoids dead-space effects and also a voltage drop across the quarter-wave plate.

[0357] In a further embodiment, such a tip-tilt device has a shaped transparent electrode on both cover glass and quarter-wave plate. The planes of tip-tilt for the two devices may be orthogonal or parallel. With two parallel tip-tilt electrodes the device may act as a power-controlling two-way switch, and also, as will be described later, can be used in a multi-channel add/drop multiplexer. With two orthogonal tip-tilt electrodes the device can beam steer in 2-dimensions such as to correct for positional errors. Either of the two tip-tilt electrodes can be subdivided so as to provide attenuation.

[0358] One advantageous SLM is that described in our co-pending patent application EP1053501.

[0359] If there is a single focusing element between the output fibre and SLM then the field at the output fibre is the Fourier Transform of the field leaving the SLM. In this case three classes of phase modulation can be used to change the coupling efficiency into the output fibre. The first two classes assume a many-pixellated SLM while the third class assumes a few-pixel SLM with or without tip-tilt features as described earlier. In the third class the tip-tilt feature may be used to compensate for transverse positional errors in the input and output fibre.

[0360] The different classes of phase modulation result in a variable coupling efficiency at the output fibres using the following methods:

[0361] As noted above, the first class uses a many-pixellated SLM. A periodic phase modulation is applied that creates a set of closely spaced diffraction orders at the output fibre. The spacing is comparable to the fibre mode spot size such that there is significant interference between the tails of adjacent diffraction orders. The phases of these diffraction orders are chosen such that the resulting superposition is rapidly alternating in phase and therefore couples into the higher-order fibre modes. Varying the strength, phase and position of each diffraction order changes the attenuation. If the long sides of the stripes used to create this alternating output field are in the plane of the input and output fibres, then diffraction orders landing outside the target optical fibre fall along a line orthogonal to the output fibre array, and therefore do not cause crosstalk.

[0362] In the second class, again using a many-pixellated SLM, a non-periodic smoothly varying non-linear phase modulation is applied at the SLM, in this case the SLM acts as a diffractive lens such that the beam is defocused and couples into higher-order modes.

[0363] In the third class, which uses a simple SLM with few pixels, the pixels are used to apply phase distortion across the beam incident on the SLM. Such phase modulation can be considered to be equivalent to the first class but with a long period. The phase distortion at the SLM results in amplitude and phase distortion in the reflected beam and hence reduces the coupling efficiency into the output fibre.

[0364] Again, all three methods require use of a mode stripper on the output fibre. Again suitable algorithms can be included in the SLM or interface to train the system.

[0365] Another embodiment, not illustrated, uses a graded-index (GRIN) lens secured to one face of an SLM, and having input and output fibres directed on or attached to the opposite face. The SLM may provide selective attenuation, and/or may selectively route between respective input fibres and selected output fibres. A requirement for stable performance is fundamental for optical devices used in communications and like fields. One of the dominant manufacturing costs for such optical devices is device packaging. The GRIN lens architecture results in a compact packaged device resilient to vibrations. However, the architecture can have problems with spherical aberration and problems in achieving the required alignment accuracy. In particular there is often a requirement for precise transverse positioning of the fibres. Also due to manufacturing tolerances in the GRIN lens the focused spot in the reflected beam can be offset significantly in the longitudinal direction from the end face of the output fibre, resulting in an insertion loss penalty. This problem gets worse the longer the GRIN lens. Applying selected non-linear phase modulation to the SLM may compensate for problems such as focus errors, length errors, longitudinal positional errors and spherical aberration. Applying selected linear phase modulation to the SLM and/or using tip-tilt electrodes may compensate for problems such as transverse positional errors.

[0366] Optical systems using SLMs may individually process the channels from an ensemble of channels on different wavelengths, entering the system as a multiplex of signals in a common beam. Given a continuous array of pixels the SLM may also process noise between the channels. Hence the optical system acts as a multiwavelength optical processor. The processing may include measurement of the characteristics of the signals and accompanying noise as well as routing, filtering and attenuation.

[0367] In a first application, the SLMs carry out attenuation, known in this context as channel equalisation. A second application is a channel controller. A third application is an optical monitor. A fourth application is an optical test set. A fifth application is add/drop multiplexing. Further applications are reconfigurable wavelength demultiplexers and finally modular routing nodes. In all of these applications the SLMs may carry out routing and/or power control and/or beam shaping and/or sampling and/or corrective functions as described earlier. The system to be described is not restricted to this set of seven applications but is a general multi-wavelength system architecture for distributing the wavelength spectrum from one or more inputs across an array of devices and recombining the processed spectrum onto one or more selected outputs.

[0368] The inputs and outputs may be to and from optical networking equipment such as transmission systems, transmitter line cards and receiver line cards. Alternatively the inputs may be from one or more local optical sources used as part of a test set: either via an intermediate optical fibre or emitting directly into the optical system. The outputs may be to one or more local photo detectors for use in testing and monitoring. Applications outside the field of communications are also possible such as spectroscopy.

[0369] Such multi-wavelength architectures can be adaptations of optical architectures used for wavelength de-multiplexing. Wavelength demultiplexers typically have a single input port and many output ports. These can use one or more blazed diffraction gratings: either in free-space or in integrated form such as an AWG (Arrayed Waveguide Grating). These devices are reciprocal and hence work in reverse. Hence if a signal of the appropriate wavelength is injected into the output port it will emerge from the input port. The output port usually consists of an optical waveguide or fibre with an accepting end that receives a focused beam from the optical system and a delivery end providing an external connection. Now consider replacing the acceptance end of the output waveguide/fibre with a reflective SLM: all of the processed signals reflected straight back will couple into the input fibre and emerge from the input port. These signals can be separated from the input signal with a circulator. Alternatively the system is adapted so that the reflected signals emerge and are collected together into a different fibre.

[0370] Free-space optical systems performing wavelength de-multiplexing can use diffraction gratings made by ruling, or from a master, or made holographically, or by etching. Usually these work in reflection but some can work in transmission. One or two gratings can be used in the system. The optics used to focus the beams can be based on refractive elements such as lenses or reflective elements such as mirrors or a combination of the two.

[0371] Referring to FIG. 12, a channel equaliser 350 has a single grating 300 used with a refractive focusing element 310 and an SLM 320. To make the diagram clearer, the grating 300 is drawn as working in transmission. Other embodiments use two gratings and/or reflective focusing elements and/or gratings that work in reflection, such as blazed gratings.

[0372] A first input beam 301 from an input port 304 contains an ensemble of channels at different wavelengths entering the equaliser on the same input port 304. As a result of the grating 300 the beam 301 is split into separate beams 301a, 301b, 301c for each wavelength channel, each travelling in a different direction governed by the grating equation. The grating 300 is positioned in the input focal plane of a main routing lens 310 with a reflective SLM 320 at the output focal plane of the routing lens 310. If desired, there may also be a field-flattening lens just in front of the SLM 320.

[0373] If lens 310 were an ideal lens, rays passing through the same point on the focal plane of the lens, regardless of direction provided they are incident on the lens, emerge mutually parallel from the lens. As lens 310 is not a real lens, this is no longer strictly true: however well-known lens design techniques can be applied to make it true over the required spatial window.

[0374] Hence, the beams 301a, 301b, 301c that were incident upon the lens 310 from the same point on the focal plane, but at different angular orientations, emerge mutually parallel from the routing lens 310, but spatially separate. Thus, the lens refracts each beam to a different transverse position 320a, 320b, 320c on the SLM 320. At each position the SLM 320 displays a pixellated hologram and/or has a tip-tilt device for processing the relevant wavelength component of the beam. In the preferred embodiment, the SIM 320 is a continuous pixel array of phase-modulating elements and is polarisation independent. The width of each hologram or tip/tilt device compared to the spot size of the incident beam incident is sufficient to avoid clipping effects. Instead, or additionally, beam shaping may be used. The device may be controlled to deflect or attenuate the beam as described earlier, and provides output processed beams 302a, 302b, 302c. Beams 302a and 302b have moderate channel equalisation applied by a power control hologram and routing towards the output port 305 applied by a routing hologram. As explained previously it is advantageous to use a routing hologram as it deflects the beams from their specular output direction and hence increases the available depth of attenuation. Beam 302c has strong attenuation applied in order to "block" the channel: this is achieved by selecting holograms that direct the light well away from the output port 305 towards, for example, an optical absorber 306. The processed beams are reflected back from the SLM 320 towards the main lens 310 and then refracted back by the main lens towards the diffraction grating 300. Assuming the SLM 320 is flat, all beams subjected to the same deflection at the SLM 320 and entering the system in the same common input beam emerge mutually parallel from the diffraction grating. Curvature of the SLM 320 is compensated by small changes in the deflection angle achieved due to the holograms displayed on the SLM 320. As the light beams 302a, 302b emerge parallel from the SLM 320 they are refracted by the lens 310 to beams 303a, 303b propagating towards a common point in the grating 300, which (having the same grating equation across the whole area of concern) diffracts the beams to provide a single output beam 302. Note that due to the action of the lens, beam 303a is parallel (but in the opposite direction) to beam 301a and beam 303b is parallel (but in the opposite direction) to beam 301b. Therefore all beams subjected to the same eventual output angle from the SLM 320 are collected into the same output port 305. Hence a system may be constructed with a single input port 304 and a single output port 305 that produces independent attenuation or level equalisation for each wavelength channel. Note that to obtain the same deflection angle for all wavelength channels, as required, the effective length of the hologram phase ramp, Ω/m, where m is the mode number of the excited diffraction order and Ω is the hologram period, should be adjusted in proportion to the channel wavelength. That is the wavelength dependence of the beam deflection should be suppressed.

[0375] As described later the channel equalisation can be uniform across each channel so as to provide the required compensation as measured at the centre of each channel. Alternatively the channel equalisation can vary across each channel, so as to compensate for effects such as amplifier gain tilt that become important at higher bit rates such as 40 Gb/s. Channels may be blocked as described earlier so as to apply policing to remote transmitters that renege on their access agreements or whose lasing wavelength has drifted too far. Furthermore the noise between selected channels may be partially or completely filtered out, as described later. Hence in a second application the multiwavelength optical processor acts as a channel controller.

[0376] Although such processing can be applied using conventional optics the multiwavelength optical processor has a number of advantages. Compared to a series of reconfigurable optical filters the multiwavelength processor has the advantage that the channels are processed by independent blocks of pixels. Hence reconfiguration of the processing applied to one or more selected channels does not cause transient effects on the other channels. Compared to a parallel optical architecture that separates the channels onto individual waveguides/fibres before delivery to a processing device (and hence avoids the transient effects) the multiwavelength optical processor has a number of advantages. Firstly it can process the whole spectrum entering the processor (subject to the grating spectral response). Secondly the filter passband width is reconfigurable and can be as much as the entire spectrum, reducing concatenation effects that occur when filtering apart sets of channels routed in the same direction. Thirdly the filter centre frequencies are reconfigurable. Further advantages are discussed later in this application.

[0377] By having a choice of two or more deflection angles at the SLM every input channel may be routed independently to one of two or more output ports. There may also be two or more input ports. It may be shown that for one or more parallel input beams, the action of the grating and main routing lens is such that all channels at the same wavelength but from different input ports are incident at the same transverse position at the SLM. Again this is because "parallel rays converge to the same point". Hence these channels at the same wavelength are incident on the same channel processing hologram and/or tip-tilt device. As every wavelength channel is incident on a different device, the device response may be optimised for that particular wavelength. For example if a pixellated SLM is used the deflection angle is proportional to the wavelength. Hence small adjustments in the phase ramp can be used to adjust the deflection angle to suit the wavelength to be routed. All channels incident on a particular transverse position on the SLM must be reflected from that same position. As this position is in the focal plane of the lens beams from said position will emerge parallel from the lens and travelling towards the grating. After the grating the beams will be diffracted (according to their wavelength). It may be shown that all beams entering the system in a parallel direction will emerge from the system in exactly the opposite direction. It may also be shown that all beams subject to the same output angle from the SLM will emerge coincident from the system and may therefore be collected into the same port.

[0378] Analysis of the beams at the diffraction grating in this architecture shows that the spot size required for a given wavelength channel separation and beam clipping factor C at the hologram depends on the grating dispersion but does not depend on the routing lens focal length nor the number of output ports. The beam centres must be far enough apart to provide adequate crosstalk suppression. Hence the greater the number of output beams the further the beam must be steered by the SLM and lens. As an example consider just routing in 1-D, into the m'th diffraction order with a hologram period , Ω and a routing lens of focal length f. The output beam at the diffraction grating will be offset from its zero order reflection by a distance given approximately by $f.m.\lambda/\Omega$, where λ is the optical wavelength and Ω/m is the effective length of the phase ramp on the hologram (as explained previously). To increase this offset distance the length of the phase ramp can be reduced, which tends to require smaller pixels, or the lens focal length can be increased. In practice there is a lower limit to the pixel size set by the dead space losses and the size of the pixel drive circuits, while increasing the lens focal length makes the overall system longer. This can be a particular problem when there are many output ports, even when close-packing 2-D geometries are used for the output beams.

[0379] Referring to FIG. 14, another method is to put a demagnification stage between the SLM 400 and a routing lens 404. This is positioned so that the SLM 400 is in the object plane of the demagnification stage while the image plane of the demagnification stage 402 is where the SLM would otherwise be, that is in the focal plane of the routing lens 404. What appears in this image plane is a demagnified image of the SLM 400, which therefore acts like a virtual SLM 402 with pixels smaller than those of the real

SLM 400 and hence a shorter effective phase ramp length. As an example consider the two lens confocal magnification stage shown in FIG. 14. In FIG. 14 f1 is the focal length of the first lens 401 and f2 is the focal length of the second lens 403 (closer to the virtual SLM). The demagnification is f2/f1 while the beam-steering deflection angle is magnified by f1/f2.

[0380] While this method for increasing the effective beam deflection angle has been described and illustrated in the context of one particular routing architecture it could also be applied to other optical architectures using SLMs to process an optical beam, for routing and other applications. The operating principle is that the virtual SLM 402 has an effective pixel size and hence an effective phase distribution that is smaller in spatial extent than that of the real SLM 400, by an amount equal to the demagnification ratio of the optics. The off-axis aberrations that occur in demagnification stages can be compensated using any of the methods described in this application or known to those skilled in the art.

[0381] In an alternative embodiment the input beam or input beams contain bands of channels, each incident on their own device. In this and the previous embodiment for the channel equaliser the beam deflection or channel equalisation may vary discontinuously with wavelength.

[0382] In a third embodiment the input beam could contain one or more signals spread almost continuously across the wavelength range. The light at a particular wavelength will be incident over a small transverse region of the SLM, with, typically a Gaussian type spatial distribution of energy against position. The position of the peak in the spatial distribution is wavelength dependent and may be calculated from the grating and lens properties. For such a system the beam deflection or channel equalisation varies continuously with wavelength. The pixellated SLM is divided into blocks, each characterised by a 'central wavelength', defined by the wavelength whose spatial peak lands in the middle of the block. A particular channel equalisation or beam deflection is applied uniformly across this block. Light of a wavelength with a spatial peak landing in between the centres of two blocks will see a system response averaged across the two blocks. As the spatial peak moves towards the centre of one block the system response will become closer to that of the central wavelength for the block. Hence a continuous wavelength response is obtained. The block size is selected with respect to the spatial width of each beam in order to optimise the system response. This method is particularly attractive for increasing the wavelength range of a 1 to N switch.

[0383] To achieve this aim the multi-wavelength architecture described earlier, should be configured so as to allow reconfigurable routing from a single input port to one of a set of multiple output ports. The length of the phase ramp used to route the beam to each output port should vary slowly across the SLM such that the wavelength variation in the deflection angle is minimised, or certainly reduced considerably compared to the case for which the phase ramp length is uniform across the SLM. Hence the transverse position of each output beam will vary considerably less with wavelength, with a consequent reduction in the wavelength dependence of the coupling efficiency at the system output. Alternatively, the length of the phase ramp can be varied spatially so as to obtain some desired wavelength dependence in the coupling efficiency.

[0384] The efficiency of a blazed diffraction grating is usually different for light polarised parallel or perpendicular to the grating fringes. In the multi-wavelength systems described above the effect of the quarter-wave plate inside the SLM is such that light initially polarised parallel to the grating fringes before the first reflection from the blazed grating is polarised perpendicular to the grating fringes on the second reflection from the blazed grating. Similarly the light initially polarised perpendicular to the grating fringes before the first reflection from the blazed grating is polarised parallel to the grating fringes on the second reflection from the blazed grating. Hence, in this architecture, the quarter-wave plate substantially removes the polarisation dependence of the double pass from the blazed grating, as well as that of the phase modulation. As is clear to those skilled in the art, this polarisation independence requires the fast and slow axes of the integrated quarter-wave plate to have a particular orientation with respect to the grating fringes. This required orientation is such that the integrated quarter-wave plate exchanges the polarisation components originally parallel and perpendicular to the grating fringes.

[0385] Referring to FIG. 28 a wavelength routing and selection device 600is shown.

This device has a multiwavelength input 601 from an input port 611, and provides three outputs 602, 603, 604 at output ports 612-614.

[0386] The device 600, similar to the device of FIG. 12, has a grating 620, a lens 621 and an SLM 622, with the disposition of the devices being such that the grating 620 and SLM 622 are in respective focal planes of the lens 621. Again the grating is shown as transmissive, although a reflective grating 620, such as a blazed grating, would be possible. Equally, the SLM 622 is shown as reflective and instead a transmissive SLM 622 could be used where appropriate.

[0387] The grating 620 splits the incoming beam 601 to provide three single wavelength emergent beams 605, 606, 607 each angularly offset by a different amount, and incident on the lens 621. The lens refracts the beams so that they emerge from the lens mutually parallel as beams 615,616, 617. Each of the beams 615,616,617 is incident upon a respective group of pixels 623,624,625 on the SLM 622. The groups of pixels display respective holograms which each provide a different deviation from the specular direction to provide reflected beams 635, 636 and 637. The beams 635, 636, 637 are incident upon the lens 621 and routed back to the grating 620.

[0388] In the embodiment shown, the beams 605 and 606 are finally routed together to output port 614 and the beam 607 is routed to output port 612. No light is routed to port 613.

[0389] However it will be understood that by careful selection of the holograms, the light can be routed and combined as required. It would be possible to route light of a selected frequency right out of the system if needed so as to extinguish or "block" that wavelength channel. It is also envisaged that holograms be provided which provide only a reduced amount of light to a given output port, the remaining light being "grounded", and that holograms may be provided to multicast particular frequencies into two or more output ports.

[0390] Although the number of output ports shown is three, additional output ports can be included: with appropriate lens design the insertion loss varies weakly with the number of output ports. Although the output ports are shown in the same plane as the input it will be clear to those skilled in the art that a 2-D distribution of output ports is possible.

[0391] Hence the device 600 provides the functions of wavelength demultiplexing, routing, multiplexing, channel equalisation and channel blocking in a single subsystem or module. These operations are carried out independently and in parallel on all channels. Reconfiguration of one channel may be performed without significant long-term or transient effects on other channels, as occurs in serial filter architectures. With most conventional optics (including parallel architectures) separate modules would be required for demultiplexing, routing, multiplexing and the power control functions. This adds the overheads of fibre interconnection between each module, separate power supplies, and a yield that decreases with the number of modules. The device 600 has no internal fibre connections, and a single active element requiring power-the SLM. Each active processing operation (routing, power control, monitoring etc) requires an associated hologram pattern to be applied by the controller but may be carried out by the same SLM, hence the yield does not decrease with increased functionality. Although integrated optical circuits can be made that combine different functions, in general they require a separate device inside the optical chip to perform each function. Again the power (dissipation) and the yield worsen with increased functionality.

[0392] Further applications of the multiwavelength optical processor are as an optical performance monitor, and as a programmable multifunction optical test set. In both applications the SLM may perform two or more different but concurrent monitoring or testing functions on two or more portions of the wavelength spectrum. This may be achieved by applying routing holograms to the pixel block associated with said portions of the wavelength spectrum that connect optically a selected input fibre or input optical source to a selected output fibre or output detector. The routing hologram applied to each portion of the spectrum may be reconfigured as required in order to perform different testing or monitoring functions on said portion of the spectrum. To each output photo detector or to each input optical source is applied control circuitry for carrying out the required tests.

[0393] Considering firstly the performance monitor, the method described later to measure the centre wavelength of a channel may be applied to a selected channel in order to monitor the lasing wavelength. Earlier in this application there is a description of how to measure the second order moments of a beam. Consider orthogonal axes u and v at the SLM. Choose the orientation of these axes such that all wavelength channels entering the system and incident on the grating in the defined parallel direction have the centres of their associated beams along a line of constant v. Hence the position along the u axis increases with wavelength. The second order moment in the v direction is related to the spot size of a monochromatic beam. The second order moment in the u direction is related to this spot size and also the wavelength distribution of the energy in each channel. Hence by measuring second order moments, as described previously, an estimate of the channel bandwidth may be obtained. The noise power between a selected pair of channels may be measured by routing that part of the spectrum between the channels towards a photo detector. Similarly the power of a selected channel may be measured by routing towards a photo detector. One or more photo detectors may be assigned to each type of measurement is allowing many parallel tests to proceed independently on different portions of the spectrum. Alternatively the control circuitry associated with each photo detector output may be designed to be able to perform two or more of the required monitor functions.

[0394] Hence the multiwavelength optical processor acts as an optical spectrum analyser with integrated parallel data processing. Conventional methods for achieving this use either a grating that is rotated mechanically to measure different portions of the spectrum with a photo detector in a fixed position, or a fixed grating with a linear photodiode array. In both cases data acquisition hardware and software and data processing are used to extract the required information from the measured spectrum. Both systems are expensive and require stabilisation against the effects of thermal expansion. The multiwavelength optical processor has no moving parts, can use as few as a single photodiode, and can adapt the holograms to compensate for temperature changes, ageing, aberrations as described previously in this application. The multiwavelength processor also carries out the data processing to measure centre wavelength and channel bandwidth in the optical domain. When used in a communications network the optical performance monitor would pass the processed data from the measurements to a channel controller, such as the one described previously, and also to a network management system. The signal for monitoring would be tapped out from a monitor port at the channel controller or from a routing system or from elsewhere in the network. The monitor processing could be implemented with the same or a different SLM to the channel controller. Monitor processing can also be implemented with the same or different SLMs used to route beams in the add drop routers and routing modules described later in this application. The control electronics for the monitor processing can be integrated with the control electronics for the pixel array.

[0395] With reference to FIG. 30, the programmable multifunction optical test set 900 has a multiwavelength optical processor 928 with one or more inputs 901, 902 from optical sources, 903, 904 each with control circuitry 905, 906 for performing one or more tests of optical performance. The channel equalisation and blocking functions described earlier may be used to adapt the spectrum of the selected source to suit a particular test. The channel filtering functions described later may be used to synthesise a comb or some other complex wavelength spectrum from a selected broadband optical source. A further input 907 from an optical source 910 may be used to exchange data and control information from control and communications software 929 with the same 900 or one or more other optical test sets, allowing remote operation over the fibre under test, or some other fibre. One or more outputs ports 911, 912 from the multiwavelength optical processor are connected to a set of optical fibre transmission systems (or other devices) 913, 914 to be tested. Routing holograms are applied to the pixels associated with the selected parts of the spectrum to direct said parts of the spectrum or said data and control information to the selected output port. A further or the same multiwavelength optical processor has input ports 917, 918 connected to the set of optical fibre transmission systems (or other devices) 915, 916 under test and output ports 919, 920 connected to a set of one or more photo detectors, 921, 922 each with associated control circuitry 925, 926 for carrying out testing functions. A further photo detector 924 connected to a further output port 923 is used to receive data and control information from one or more other test sets. Routing holograms are applied to direct the signals from the selected input port to the required photo detector. The optical monitor functions described above can be applied to the signals. The frequency shaping of the source or spectrum can take place at the transmitting test set or the receiving test set. The control electronics for the test set 927 and control and communications software 929 can be integrated with the control electronics for the pixel array.

[0396] Conventionally, different optical sources would be used to perform different types of test on the wavelength and transmission properties of fibres or devices under test; a separate optical switch would be used to poll the devices under test, and an external communications link would be used for communication of data and control information with a remote test set. However, the multiwavelength optical processor may be used to provide a multifunction programmable optical test set that is capable of remote operation. The test set may include as few as a single source and a single photo detector and performs a wide range of tests on fibres or devices selected from a group of fibres or devices attached to the test ports of the multiwavelength processor.

[0397] A multiwavelength system with two inputs and two outputs can work as an add/drop multiplexer. Add-drop multiplexers are usually used in ring topologies, with the 'main' traffic travelling between the ring nodes, and 'local' traffic being added and dropped at each node. Considering each node, one input (main in) is for the ensemble of channels that has travelled from the 'previous' routing node. The second input (add) is for the ensemble of channels to be added into the ring network at the add/drop node. One output (main out) is for the ensemble of channels travelling to the 'next' routing node while the second output (drop) is for the ensemble of channels to be dropped out of the ring network at the node. If a particular incoming wavelength channel is not to be 'dropped' at the node, then the channel-dedicated device at the SLM should be configured to route the incoming wavelength from the main input to the main output. However, if a particular incoming wavelength channel is to be dropped, then the channel-dedicated device at the SLM should be configured to route the incoming wavelength from the main input to the drop output. In this case the main output now has available capacity for an added channel at that same wavelength. Therefore the channel-dedicated device at the SLM should also be configured to route the incoming wavelength from the add input to the main output.

[0398] The multiwavelength optical processor described in this application distributes wavelength channels across and collects the wavelength channels from a single SLM, allowing the SLM to provide a set of one or more processing operations to each of the channels. However, in most conventional reconfigurable add drop multiplexers, the routing has to be carried out in two successive stages. Usually a first 1*2 switching stage either drops the channel or routes the channel through, while a second 2*1 switching stage either receives the through channel from the first stage or receives an added channel. Fortunately, careful choice of the deflection angles applied by the SLM, and the sharing of the same hologram by input signals at the same wavelength, allows add drop routing to be carried out in a single stage. Hence add drop routing may be conveniently applied in an independent and reconfigurable manner to every wavelength channel in the multiwavelength optical processor.

[0399] An explanatory diagram is shown in FIG. 13a.

[0400] Referring now to FIG. 13a, an SLM 141, used in the context of the multi-wavelength architecture, has a pixel block 140 and/or tip-tilt device upon which a main input beam 130 is incident, at an angle m1 to the normal 142. The main beam has a zero order or specular reflection 130a. Holograms are made available that will cause deflections at $+\theta_1$ to the specular direction and $-\theta_2$ to the specular direction. Due to the display of a first hologram on the pixel block 140, the main output is deflected by $+\theta_1$ from the specular direction to a main output beam 132. An add input 131 is incident at an angle a1 on the block 140, and produces a zero order reflection 131a. The device also has a drop output beam direction 133.

[0401] When the hologram applying the deflection of $+\theta_1$is displayed, light at the relevant wavelength entering in the add direction 131 is not steered into either of the main output beam direction 132 or the drop output beam direction 133. Effectively it is 'grounded'. This feature may be used to help to stop crosstalk passing between and around rings.

[0402] When the hologram applying the alternative deflection of $+\theta_2$ is applied, the add input is routed to the main output beam direction 132 while the main input is routed to the drop output beam direction 133.

[0403] In the interests of clarity, a simplified diagram may be used to explain an add-drop using 1-D routing. This is shown in FIG. 13b in which the point 134 represents the output position of the specular reflection from the add input while the point 135 represents the output position of the specular reflection from the main input. When a first routing hologram is applied the main output beam is deflected by an angle of $+\theta_1$ and therefore the output position of the main beam is deflected by an offset of $f.\theta_1$, compared to the output position 135 of its specular reflection. Here f is the focal length of the routing lens. In FIG. 13b this deflection is represented as a vector 136a and the output beam is routed to the main output 137. The beam from the add input is subject to the same angular deflection with respect to its specular reflection and is thus deflected by a vector of equal length and the same direction 136b with no output port to receive it this beam is "grounded". When a second routing hologram is applied the main output beam is deflected in the opposite direction by a vector 138a to arrive at a drop output 139. The beam from the add input is deflected by an identical vector 138b to arrive at the main output 137.

[0404] The example in FIG. 13a assumes 1-D routing due to the hologram. Given an ability to route in 2-D, either with two orthogonal tip-tilt electrodes or a 2-D pixel array (as described previously) the arrangement of the four ports can be generalised, as shown in FIG. 15. The use of 2-D routing allows closer packing of the input and output beams reducing off-axis aberrations. In FIG. 15 the output positions are shown in 2-D. The point 151 represents the output position of the zero order (specular) reflection from the add input while the point 152 represents the output position of the zero-order reflection from the main input. The hologram deflections are represented as vectors 155a, 155b, 156a and 156b. Vector 155b has the same length and direction as vector 155a and vector 156b has the same length and direction as vector 156a. When a first routing hologram is applied the add input beam is deflected from its specular output position 151 by the vector 155b to the main output 154 while the main input is deflected from its specular output position 152 by the identical vector 155a to the drop output 153. When the alternate routing hologram is applied the main input is deflected from its specular output position 152 by the vector 156a to the main output 154 while the add input is again 'grounded' due to deflection by the identical vector 156b.

[0405] In this general configuration there are six variables. These are the output positions of the main output and drop output, the positions of the zero order reflections from the main input and add input, and the two hologram deflections. Of these six variables only three are mutually independent.

[0406] For example, selection of the input position for the main input with respect to the routing lens axis defines the output position of the zero order reflection, 152. If this is followed by selection of the output positions for the main and drop outputs with respect to the routing lens axis then all three independent variables have been defined. Hence the required hologram deflections are determined as is the input position for the add input with respect to the routing lens axis (which then defines 151).

[0407] FIGS. 13a, 13b and 15 show the hologram deflections required to provide add-drop routing: FIGS. 13a and 13b assume 1-D routing while FIG. 15 assumes 2-D routing. A multiwavelength add-drop architecture using such hologram deflections is shown in FIG. 29. Compared to other methods for achieving add-drop functionality, the advantages are as described previously for FIG. 28.

[0408] Turning now to FIG. 29, an add/drop multiplexer device 700 has two input ports 701, 702 and two output ports 703,704. The first input port 701 is for an input beam 711 termed "add" and the second input port 702 is for a second input beam 712 termed "main in" having two frequencies in this embodiment. The first output port 703 is for a first output beam 713 termed "drop" and the second output port 704 is for a second output beam 714 termed "main out"

[0409] The input beams 711, 712 are incident upon a grating 720 that deflects the beams according to wavelength to provide emergent beams 731, 732 and 733. The emergent beams 731, 732 and 733 are incident upon a lens 722 having its focal plane at the grating 720, and the beams emerge from the lens respectively as beams 741, 742, and 743 to be incident upon an SLM 722 in the other focal plane of the lens 721. As the beams 741, 742 do not originate on the grating 720 from the same location, they are not mutually parallel when emerging from the lens 721. The beam 743 is from a point on the grating 720 common to the origin on the grating 720 of beam742, and hence these beams are mutually parallel. Although the grating is drawn as transmissive and the SLM as reflective, these types are arbitrary.

[0410] The first beam 731 and the third beam 733 are at the same wavelength, hence they emerge parallel from the grating 720 and are refracted by the lens 721 propagating as beams 741 and 743 respectively to a first group or block of pixels 723 on the SLM 722. This pixel block 723 applies the required hologram pattern that routes a channel entering the add port 701 to the main output 704, and also routes a channel entering the main input 702 to the drop port 703. Hence the first group of pixels 723 deflects the first beam 741 to provide first reflected beam 751, and deflects the third beam 743 to provide third reflected beam 753.

[0411] The second beam 732 is at a different wavelength to the first and third beams 731 and 733 and therefore emerges at a different angle from the grating 720. This third beam is refracted by the lens 721 and propagates as beam 742 to a second group of pixels or pixel block 724 on the SLM 722. This second group of pixels applies the hologram pattern that routes a channel entering the main input port 702 to the main output port 704 and "grounds" a channel entering the add port 701. The second group of pixels 724 deflects the second beam 742 to provide the second reflected beam 752. The holograms on the first and second groups of pixels are selected, (examples were described for FIGS. 13a, 13b and 15), so that the first and second reflected beams 751,752 are mutually parallel; the third beam 753 is routed in a different direction. The consequence of this is that the first and second beams 751,752, after passing again through the lens 721 become incident at a common point 726 on the grating 720, and emerge as main out beam 714. The third beam 753 is incident upon a different point on the grating 720 and emerges into as the drop beam 713.

[0412] In most cases ring networks are bi-directional, with separate add/drop nodes for each direction of travel. In some networks a loopback function is required. This allows isolation of one segment of the ring in case of link failure, for example. It also allows the transmission systems for both directions of a link between two nodes to be tested from a single node. This latter function is useful to confirm that a failed link has been repaired. Loop back requires the main input on each add/drop node to be routed to the main output on the other add/drop node, as shown in FIG. 16.

[0413] The figure shows a first module 161a and a second module 161b. The first module 161a has a main input 162a, an add input 166a, a loop back input 165a, a main output 163a, a drop output 167a and a loop back output 164a. The second module 161b has a main input 162b, an add input 166b, a loop back input 165b, a main output 163b, a drop output 167b and a loop back output 164b.

[0414] The node is divided into two sides: a west side 168 and an east side 169. Loop back may be required for one or for both sides of the node. Channels coming from the ring enter the first module 161a on a main input 162a and enter the second module 161b on a main input 162b. In normal operation through channels will be routed from the main input 162a to the main output 163a and from the main input 162b to the main output 163b.

[0415] In loop back operation for the west side 168 the through channels entering the input 162a on the first module 161a are routed to the loop back output 164a. This output 164a is connected to the loop back input 165b of the second module 161b. In loop back operation for the west side all channels entering the input 165b are routed to the main output 163b of the second module 161b.

[0416] In loop back operation for the east side 169 the through channels entering the second module 161b on the main input 162b are routed to the loop back output 164b. This output 164b is connected to the loop back input 165a of the first module 161a. In loop back operation for the east side 169 all channels entering the input 165a are routed to the main output 163a of the first module 161a.

[0417] The function can be implemented in the four port add drop node (explained in FIGS. 13, 13a, 15 and 29) by selecting a further hologram deflection 179a and 179b, as shown in FIG. 17. In the four port architecture both sides of the node loop back at the same time. This is due to the sharing of the same hologram by input signals at the same wavelength. In FIG. 17 the vector 179a deflects the main input from its specular output position 172 to the loop back output 176. The identical vector 179b is applied by the shared hologram to the loop back input such that it is deflected from its specular output position 173 by the identical vector 179b to the main output 175. The other vectors 177a, 177b, 178a and 178b are used for normal add-drop operation: 174 is the drop output and 171 is the specular output position for the add input.

[0418] When such a hologram is applied the main input is routed to the loopback output and the loop back input is routed to the main output. The two add/drop nodes are then connected as in FIG. 16.

[0419] The loop back function can be implemented in other add drop architectures (described later) by reserving drop ports for loop back out and add ports for loop back in. In these other architectures the loop back may be applied to just one side of the node, as well as to both sides.

[0420] The method used to provide loop back ports may also be applied to the multiport add drop (FIG. 18). This method may be used to provide cross connection ports to exchange channels between adjacent add drop nodes.

[0421] It is also possible to devise holograms for multicast, i.e. forwarding an incident light beam to each of several outputs. Such a hologram can be applied to route the main input to two outputs, with vectors 177a and 178a (in FIG. 17). In this case the device is performing a drop and continue function. This is required to provide a duplicated path at nodes connecting two touching ring networks.

[0422] Alternatively, or additionally, additional inputs and outputs can be provided so as to have a separate input for each added channel and a separate output for each dropped channel. This saves the expense and space taken up by additional filtering and/or wavelength multiplexing components that would otherwise be used to combine all added channels onto a common add port, and to separate all dropped channels to individual receivers. An example layout is shown in FIG. 18. In such an implementation care must be taken that sufficient distance is provided between the zero order reflections from each input, and the output positions for each output, so as to control the crosstalk. In FIG. 18 deflection v2 is used to deflect channels entering the main input from the specular output position m0 to the main output position m2. Deflections v4 to v7 are used to route from the four add inputs (with specular output positions a1, a2, a3 and a4) to the main output m2. Identical deflections v4 to v7 are applied by the shared holograms to deflect the main input from its specular output position m0 to the four drop outputs d1 to d4. For example if wavelength channels$\lambda 5$ and $\lambda 7$ enter on add input 2 which has its zero order (specular) reflection at a2, the holograms associated with these wavelength channels are configured to produce deflection v5. Hence these two channels will exit from the main output m2. Any channels entering the main input on these two wavelengths will experience the same hologram deflection, and will then exit from output d2.

[0423] In one implementation of the multiwavelength architecture the optics between any input fibre and the corresponding input beam that arrives at the diffraction grating, is such that the beam spot that arrives at the SLM is an image of the beam spot that leaves the input fibre. Similarly the optics between any output beam and the corresponding output fibre is such that the beam spot that arrives at the output fibre is an image of the beam spot that leaves the SLM. An example embodiment that would achieve this behaviour is to have an individual collimating lens associated with and aligned to every optical fibre.

[0424] Referring to FIG. 27, it is assumed that two adjacent channels are being routed in a different direction to the channel under consideration. Thus the beam under consideration has a first hologram 500, and the two adjacent beams have contiguous holograms 501 and 502 respectively. The beam under consideration has an intensity distribution shown as 510. Hence the energy incident from the beam under consideration on the two adjacent holograms, shown as 511 and 512, is lost. Given a perfect optical system what arrives at the selected output fibre is a demagnified image of the truncated beam. Due to the way that the optical system works, the centre line of the beam incident at the output fibre will be lined up with the centre of the output fibre (indeed the beam deflection angle at the SLM should be adjusted so this is the case).

[0425] To each wavelength channel there is assigned a block of pixels applying the same routing hologram. Preferably this block of pixels should be chosen such that an input light beam exactly at the centre wavelength for the channel arrives at the SLM such that the centre of the beam is within a half pixel's width of the centre of the assigned pixel block. In the presence of thermal expansion of the optomechanical assembly the centre of said beam may arrive at a different point on the pixel block resulting in partial loss of signal as more of the beam tails are lost. This problem can be avoided either by expensive thermally stable optomechanics or by dynamic reassignment of pixels to the blocks associated with each channel. For this to be achievable the pixel array should be continuous. This continuity of the pixel array is advantageous for thermal stability whether or not the imaging criterion used to calculate the filter response is satisfied.

[0426] The way that the architecture behaves is that for all parallel beams incident on the grating, the position at which the beam at a particular wavelength reaches the SLM is independent of the input port. Hence a reference signal of known wavelength will be incident at the same particular point on the SLM, whether it comes in with any of the signals to be routed, or on a separate input. The method to measure the position of the beam centre can be used on one or a pair of such reference signals. Given this information, an interpolation method can be used to measure the wavelength of some other signal entering the system on one of its input ports, given the measurement of the position of the centre of the beam associated with said other signal. This information can be used to monitor the behaviour of the original transmitter lasers, and also to inform the controller for the routing system.

[0427] Furthermore, given the position of said reference beams as they reach the SLM, and also the centre wavelength(s) of (an)other signal(s) entering the system, the position of the beam(s) at said centre wavelength(s) upon the SLM may also be calculated. This information can be used to control the adjustment of the pixel blocks and/or holograms used to route and control said other signal(s). Conversely the position of said reference beams may be used to select a pixel block that provides a given required centre wavelength for a filter. Hence reconfigurable assignment of pixel blocks may be used to tune the centre wavelength of one or more filter pass bands.

[0428] For the purpose of calculating the wavelength filtering response it is assumed that the centre of the beam at the centre wavelength of the channel (shown as 500 in FIG. 27) arrives exactly at the centre of the associated pixel block. With reference to

FIG. 31, as the wavelength is increased above the centre wavelength of the channel the centre line 946 of the beam 940 lands at a distance 941 away from the centre 945 of the pixel block or hologram 942. As a result of the offset 941 due to wavelength difference, the beam loses more energy 943 to the adjacent hologram 944. Assuming perfect imaging, what arrives at the output fibre is a demagnified image of this truncated beam.

[0429] An important difference for the multi-wavelength architecture, compared to conventional wavelength demultiplexers, is that a wavelength difference from the centre of a wavelength channel does not (to first order) result in an offset error of the beam at the output. This is because of the way the second pass from the grating 'undoes' the dispersion of the (fixed) diffraction grating, as was shown, for example, in FIG. 12. Hence the original centre line of the truncated beam should be aligned with the peak of the fundamental mode in the output fibre, or, equivalently, aligned with the optical axis of the output fibre. Standard methods for the calculation of coupling efficiency into single-mode fibres have been used to calculate the filter characteristics. Example results are in FIGS. 19 and 20.

[0430] FIG. 19 shows the relative transmission Tlo for in-band wavelengths as a function of the ratio of the wavelength offset u to centre of the wavelength channel separation. Each curve in the Figure is for a different value of the hologram clipping factor (CR) in the range 2 to 4: this factor is defined as the ratio of the hologram width to the beam spot size at the hologram.

[0431] FIG. 20 shows the relative transmission Thi inside the adjacent channel, with u=1 at the centre of the adjacent channel while u-0.5 is at the boundary with the adjacent channel. Again, each curve in the Figure is for a different value of the hologram clipping factor (CR) in the range 2 to 4. FIGS. 19 and 20 also show that a change in the width of the pixel block assigned to the filter passband (that is a change in CR) will change the passband width and extinction rate at the edges of the passband. Hence reconfigurable assignment of pixel blocks may be used to tune the shape and width of the filter pass bands.

[0432] Independently of the clipping factor, the suppression at the edges of the wavelength channel is 6 dB and the full width half maximum (FWHM) filter bandwidth is approximately 80% of the channel separation. Comparison of the different curves in FIG. 19 shows that the flatter the filter passband the steeper the skirts at the edges, leading to greater extinction of the adjacent channel, as shown in FIG. 20.

[0433] This behaviour is advantageous as it avoids the usual tradeoff between adjacent channel extinction and centre flatness. Good centre flatness means that the filters concatenate better, so more routing nodes using such filters can be traversed by a signal before the signal spectrum and hence fidelity starts to deteriorate. Good adjacent channel extinction is also important as it prevents excessive accumulation of crosstalk corrupting the signal.

[0434] For example, in a known conventional wavelength demultiplexer the filter pass bands are Gaussian and the 1 dB and 3 dB filter bandwidths are inversely proportional to the square root of the adjacent channel extinction (in dB), such that the greater the extinction, the narrower the filter passband. For the same FWHM filter bandwidth of 80% a Gaussian filter would have an adjacent channel extinction weaker than 20 dB, leading to crosstalk problems. However for the SLM multi-wavelength architecture the adjacent channel extinction is better than 30 dB, avoiding such problems in most known networks.

[0435] As is well-known to those skilled in the art, an arbitrary beam incident on an optical fibre couples partially into the fundamental mode of the fibre with the rest of the beam energy coupling into a superposition of the higher order modes of the fibre. The higher order modes may be stripped out with a fibre mode stripper. The coupling efficiency into the fundamental mode is given by the modulus squared of the ratio of an overlap integral divided by a normalisation integral. The overlap integrand is the product of the incident field and the fundamental mode. The normalisation integrand is the product of the fundamental mode with itself.

[0436] FIGS. 33 and 34 are included with the aim of explaining the behaviour of the 'imaging filter' as described above. FIG. 32 shows the truncated incident beam profiles 960-964 as the wavelength is increased from the centre of the channel under consideration, 960, to the centre of the adjacent channel, 964. Truncated beams 961, 962 and 963 are for wavelength differences of a quarter, a half and three-quarters, respectively, of the channel separation. In the diagram the truncated beam profiles are offset vertically for clarity. The beam profiles are aligned horizontally as they would be physically at the output fibre; the original centre of each truncated beam is aligned with the centre of the fibre fundamental mode. This is because, as explained above, a wavelength difference from the centre of a wavelength channel does not (to first order) result in an offset error at the output. Beam 965 is the fundamental mode of the fibre. FIG. 33 shows the overlap integrands 970-974 of the truncated incident beams with the fundamental mode of the fibre, as the wavelength is increased from the centre of the channel under consideration, 970, to the centre of the adjacent channel, 974. The normalisation integrand, 975, is also shown. The results in the figures show that the overlap integrand 974 has almost vanished explaining why the adjacent channel extinction is very strong. Overlap integrands 971 and 972 are for wavelength differences of a quarter and a half, respectively, of the channel separation.

* These results explain why the overlap integrand decreases slowly with wavelength difference in this range leading to a flat passband centre. In particular for the halfway case, 972, the overlap integral is exactly half of the normalisation integral (from integrating 975). Hence the amplitude transmission coefficient at this wavelength difference is a half with a power extinction of 6 dB, as was shown in FIG. 19. Therefore two factors are responsible for the excellent filter characteristics. The first factor is that the field incident on the fibre is an image of the field reflected from the SLM. The second factor is that the second pass from the grating undoes the dispersion applied by the first pass from the grating, such that whatever the wavelength offset inside the collected channel, (to first order), the peak of the reflected truncated beam is aligned with the peak of the fundamental mode of the fibre.

[0437] By way of comparison, FIGS. 34 and 35 illustrate the filtering process for a conventional wavelength demultiplexer. In FIG. 34 the centre of a first beam 984 is aligned with the optical axis 980 of the centre of a first optical fibre or optical waveguide 981. Hence the first beam 984 is at the centre wavelength of the channel collected by the first optical fibre 981. A second optical fibre 9B3, adjacent to the first fibre 981, has an optical axis 982. A second beam 988 is aligned with the optical axis

982 of this second optical fibre. Hence the second beam is at the centre wavelength of the channel collected by the second optical fibre, that is at the centre of the adjacent optical channel to that collected by the first fibre. Beams 985 to 987 are at wavelength differences from the first beam 984 of a quarter, a half, and three-quarters, respectively, of the wavelength separation between the two adjacent channels. The coupling efficiency of each of the beams 985 to 988 into the first optical fibre 981 again depends on the overlap integral of the respective beam with the fundamental mode of the fibre 981. This is mathematically identical to the overlap integral of the respective beam with the first beam 984.

[0438] FIG. 35 shows the overlap integrands 994 to 998 plotted against a vertical axis 990. The spatial width and shape of each curve is identical, as may be shown analytically. Hence the overlap integrand is proportional to the amplitude of the curve, as may be read from the axis 990. Curve 994 is the overlap integrand at the centre of the channel, and is the product of the distribution 984 of FIG. 34 with itself. This curve has an amplitude of 1.0 and hence maximal coupling efficiency. Curves 995 to 997 are the overlap integrands at wavelength differences from the channel centre of a quarter, a half, and three-quarters, respectively, of the wavelength separation between the two adjacent channels. Curve 998 is the overlap integrand at the centre of the adjacent wavelength channel. The coupling efficiency is given by the square of the amplitude of the overlap integrand. The results in FIG. 35 show that the coupling efficiency for the conventional wavelength demultiplexer decreases more quickly around the centre of the filter passband than for the 'imaging' filter discussed in this application. The results also show that the adjacent channel extinction is weaker for the conventional demultiplexer.

[0439] FIGS. 34 and 35 also explain why there is a performance tradeoff for the conventional multiplexer between filter passband flatness and adjacent channel extinction: to increase the width of the filter passband the beams 9B5-986 must be incident closer to the first optical fibre 981. Necessarily the beams 987-988 will also be closer to the first optical fibre, reducing the extinction of the adjacent channel, and requiring the second optical fibre 983 to be moved closer to the first fibre 981.

[0440] FIGS. 32 and 33 explain why the imaging filter behaves in a different way, such that a broader filter passband is associated with a greater extinction of the adjacent channel. Beam 960 in FIG. 32 shows the truncated reflected beam at the centre of the filter passband. The first and second amplitude discontinuities 966a, 966b are due to the two edges of the hologram. An increase in the hologram width relative to the spot size moves these two discontinuities outwards. The significant amplitude discontinuity in the middle beam 962 is exactly at the centre of said beam, whatever the hologram width. This is because said middle beam is associated with a wavelength halfway between the centres of adjacent channels. Hence the coupling efficiency for this halfway point is 6 dB, independently of the hologram width. The significant amplitude discontinuity in the quarterway beam, 961, is exactly halfway between the first amplitude discontinuity, 966a of the centre beam 960 and the significant amplitude discontinuity in the halfway beam, 962. As the first discontinuity 966a moves outwards due to an increased hologram width (in the direction of arrow 967) the significant discontinuity in the quarterway beam must move in the same direction, increasing the overlap integral and improving the filter passband centre flatness. Similarly as the second discontinuity 966b moves outwards (in the direction of arrow 968) the significant discontinuities in the three-quarter way beam 963 and adjacent beam 964 must move in the direction of arrow 968, decreasing the overlap integral and improving the adjacent channel extinction. This explanation reinforces the argument that the two factors described above (imaging and the second 'undoing' pass from the grating) are responsible for the excellent filter characteristics. This explanation also explains how the selection of the width of the block of pixels assigned to a channel may control the filter passband characteristics.

[0441] Analytically it can be shown that the filter response for dropping or adding an isolated channel is purely real. Hence there are no phase distortions with this type of dropping filter. This is advantageous because in many 'flat-top' filters the phase distortions associated with the steep skirts may distort the pulses, particularly in higher bit-rate transmission systems for which the signal bandwidth is broader.

[0442] In these calculations it was assumed that the blocks of pixels assigned to each wavelength channel are contiguous. That is there are no 'guard bands' of pixels between each block. Further analysis showed that introducing such guard bands has the effect of decreasing the channel bandwidth for a given channel separation. Hence, preferably the pixel blocks assigned to each wavelength channel should be contiguous. Alternatively guard bands can be used to route in a third direction to deliberately narrow a channel bandwidth, if required.

[0443] While the above discussion is for the case of an isolated channel, in which both adjacent channels are routed in a different direction to the channel under consideration, there are also filtering effects that can occur when one or both adjacent channels are routed in the same direction. These effects are caused by 'stitching errors' at the adjacent edges of a pair of holograms routing in the same direction. For example a stitching error of pi causes (in theory) complete extinction of a light beam at a wavelength exactly halfway between the centres of two adjacent channels, while for an absence of stitching error at either side of a hologram, the transmission is uniform right across the entire channel. Intermediate stitching errors cause intermediate extinction. This acts as an additional programmable filtering mechanism and can be used to advantage to partially or completely filter out amplifier noise between selected channels, if required. Alternatively when maximally flat passbands are required the stitching error should be minimised.

[0444] As described previously, all channels entering the architecture at the same wavelength are incident on the same hologram. This is because the input beams are arranged to be parallel as they arrive at the diffraction grating, such that all channels at the same wavelength emerge parallel from the diffraction grating. As the diffraction grating is at the focal plane of the lens the beams therefore converge towards the same point in the other focal plane of the routing lens (or equivalent mirror) at which point the SLM is placed.

[0445] Hence for the four port and multiport add/drop devices the channels entering on the main beam (from the main input fibre) share a hologram with those channels at the same wavelength entering on an add port. When configured with one particular routing hologram the channel entering the main input is routed to the (selected) drop port while the channel entering the add port is routed to the main output. Therefore any channel equalisation applied to an added channel will also be unavoidably applied to the dropped channel. Hence it is not possible to carry out independent channel equalisation on added and dropped channels.

[0446] This problem does not occur, however, for the devices with a single input and/or with a single output. This is because in these devices there is no sharing of individual holograms between channels entering or leaving on different ports. Nor does the problem occur for the devices with multiple inputs and multiple outputs, for channels routed from the main input to the main output.

[0447] Another configuration of the multi-wavelength architecture is to have a single input port and a separate output port for every wavelength channel and SLM devices for each channel capable of providing a set of many deflections. When configured so that a single channel leaves on each output port, the device acts as a reconfigurable demultiplexer such that the assignment of a particular wavelength to each output port can be changed dynamically.

[0448] Conventional wavelength demultiplexers are not reconfigurable and are therefore less flexible as a routing component. They also have a Gaussian filtering characteristic, which is inferior to the filter characteristic of the SLM multiwavelength optical processor, as described earlier. A further advantage of the invention, compared to a conventional free-space wavelength demultiplexer, is that the channel filter bandwidth is independent of the physical separation between the output fibres and also independent of the spot size of the output fibre. In contrast, for the conventional demultiplexer, the channel bandwidth is proportional to the ratio of the output waveguide spot size to the physical separation of the output waveguides. Consequently, and in order to obtain sufficient channel bandwidth, microlens arrays are required to increase the effective spot size or waveguide concentrators are used to decrease the waveguide separation.

[0449] When used in reverse the device acts as a reconfigurable multiplexer, allowing the use of, for example, tuneable lasers at each input. In contrast, for a conventional wavelength multiplexer, fixed-tuned lasers must be used at each input.

[0450] A system with a single input port and many output ports can act as a module to

TS0001256

form part of a modular routing node. If the system has M output ports and a single input port, then each routing device produces M different deflections, with small adjustments to compensate for wavelength differences and alignment tolerances. All devices (i.e. holograms) producing the same eventual deflection will cause the associated wavelength channel to be routed out of the same output port. Hence such a system can send none, one or many (up to the number of channels entering the input port) channels out from the same output port. The logical function of the module is to sort the incoming channels on the input port according to their required output port, as also illustrated in FIG. 21. Considering firstly the case of the routing architecture shown in FIG. 12. As there is a single input port, every wavelength channel has its own hologram. Hence independent channel equalisation may be applied for all the signals flowing through the module.

[0451] One application of these modules is to use two of them to make an add/drop node, as shown in FIG. 22. FIG. 22 shows a first routing module 660 having one input 661 from a previous node, a through output 662 and three drop outputs 663-5, as well as two spare outputs 666,667. A second routing module 670 has a first input 671 connected to the through output 662 of the first module, three add inputs 672-4 and two spare inputs 675,676. The second module 670 has an output 677 to the next node. The second (output) module can be physically identical to the first (input) module but it is used 'in reverse'.

[0452] The first module routes all the through traffic out on a common through port 662 while providing multiple drop ports: one for each dropped channel. Any single wavelength or any set of wavelengths can be sent to any drop port. Hence each of the drop ports may connect to a local optoelectronic receiver in a local electronic switch, or to a remote customer requiring one or more channels for remote demultiplexing. The reconfigurability of the wavelength assignment means that the module acts like a wavelength demultiplexer combined with a matrix switching function, so may reduce the switching demands placed on the electronics servicing the drop ports. The ability to send a selectable set of wavelengths to the same port reduces the need for additional fibre/multiplexing components and increases flexibility. Furthermore the routing applied to each wavelength channel may be multicast, as well as unicast. Hence drop and continue operation may be provided in which the signal is routed to a drop port and also to the through port. If a transparent optical connection is required through to access and distribution networks this multicasting may also be applied to broadcast signals to a number of drop fibres. In this multicasting operation one or more of the previously described power control methods may be applied to equalise the channels on the through and drop fibres, as required for the transmission systems and receivers to function correctly.

[0453] The first module provides any channel equalisation and monitoring required for the drop ports. Channel equalisation and monitoring for the through channels may take place in the first module, or the second module, or both.

[0454] The second module provides multiple add ports: one for each added channel. Any single wavelength or any set of wavelengths can be received at any of the input ports. This allows each of the add inputs to be a tuneable laser, which would not be possible with a conventional non-reconfigurable wavelength multiplexer. In the conventional case there are two options for providing the added channels. A first option is to use conventional non-reconfigurable wavelength multiplexing to combine the added channels, because this is much more efficient in terms of insertion loss than a non-wavelength-specific multiplexer (such as a 1:N fibre splitter used in reverse, that is a N:1 combiner). However this requires each input port of the wavelength multiplexer to have a transmitter laser at a fixed wavelength. When a particular wavelength channel is added at the node the associated transmitter is in use. However when the network reconfigures its wavelength assignment that laser may no longer be in use. To allow complete reconfigurability a complete set of transmitter lasers must be provided, one for each system wavelength. This makes reconfigurable add drop nodes uneconomic when adding small numbers of channels, due to the large overhead of idle transmitter lasers. A second option is to use tuneable lasers, one for each added channel. With conventional optics this requires a non-wavelength-specific multiplexer, which imposes insertion loss penalties. The multi-wavelength architecture described provides a reconfigurable wavelength multiplexer with lower insertion loss than a N:1 combiner.

Furthermore the routing applied to each wavelength channel can be reconfigured without transient effects on other wavelength channels, as occurs in 'serial' multiplexing architectures that have a reconfiguration capability.

[0455] Any add port can receive a reconfigurable set of wavelength channels from a remote customer. The second module also provides any channel equalisation required for the added signals. Finally the second module routes the through channels entering on the port 671 to the output 677.

[0456] The spare ports 666,667,675,676 can be used for routing selected channels to optical regenerators if the signal quality demands it; to wavelength converters to avoid wavelength blocking; to another add/drop node to allow cross-connection between rings, as shown in FIG. 23, or to further modules to allow expansion, as shown in FIG. 24.

[0457] FIG. 23 shows a first to fourth routing modules 720, 730, 740 and 750. The first and fourth modules each have one input 721, 751, a through output 722, 752, a cross-connect output 723,753 and a number of drop outputs721, 754. The second and third modules 730,740 each have respective single output 731,741, a number of add inputs 732,742 a cross-connect input 733,743 and a through input 734, 744. The through output 722 of the first module 720 is connected to the through input 734 of the second module 730, and the through output 752 of the fourth module 750 is connected to the through input 744 of the third module 740. The cross-connect output 723 of the first module 720 is connected to the cross-connect input 743 of the third module 740, and the cross-connect output 753 of the fourth module 750 is connected to the cross-connect input 733 of the second module 730.

[0458] The first and second modules 720, 730 are on one ring and the third and fourth 740, 750 on a second ring. This cross connection capability allows a new ring network to be overlaid on an original ring network when the original ring capacity is becoming exhausted. Channels may be exchanged between the two rings at each node as required. Hence the ring network acts like a ring with two fibres per link (in each direction around the ring). The concept may be extended to three or more overlaid rings, and hence three or more fibres per link (in each direction around the ring). As is well known from many traffic studies, increasing the number of fibres per link reduces significantly a phenomenon known as wavelength blocking, such that more efficient use is made of the capacity of each fibre. Hence cross connection between rings makes better use of the available capacity, allowing more traffic to be carried for the same investment in infrastructure. Cross connection may also be used to exchange signals between diverging rings.

[0459] FIG. 24 shows expansion of a first (input) module 760 having a single input 761, and five outputs 762-6,via an optical amplifier 768 and an intermediate module 770 having four outputs 771-4. The first output 762 of the first module 760 is a through path, the third output 764 is an expansion port and provides an input to the optical amplifier 768, and the output 769 of the optical amplifier is to the intermediate module 770. The intermediate module 770 has an expansion port 771 and three new ports 772-4. Fourth and fifth outputs 765, 766 of the input module 760 form drop outputs. The same principle can also be applied to expansion of a second (output) module. The use of such modules allows extra add and drop ports to be provided without service interruption to the channels flowing through the add drop node. It also allows network operators to apply just in time provisioning, delaying investment in infrastructure until the demand is there to use it. Furthermore it is only the channels dropped or added through the expansion module(s) that are subject to an additional amplification stage. If every node in the ring were upgraded in this manner, the channels should only pass through an additional two amplification stages. This could be reduced to one additional stage by suitable assignment of the added and dropped channels to the original and expansion module.

[0460] Returning to the basic routing module shown in FIG. 21. This type of connectivity would be useful in mesh networks where each node is connected by a multi-fibre link to, typically, each of between two and five nearest neighbour nodes. Each link carries traffic to and from one of the nearest neighbour nodes. Usually individual fibres in the link carry traffic in just one direction but some are bi-directional. For an example where a link has an average of six pairs of external fibres and a node has five links, then there would be thirty external incoming fibres and thirty external outgoing fibres. The function of the node is to route any wavelength channel from any incoming fibre to any outgoing fibre. Each fibre may carry many wavelength channels. Currently up to 160 channel systems are being installed although 40 or 80 channel systems are more usual.

[0461] An ideal node architecture allows the network operator to start with one or more add/drop nodes connected to one or more rings and then allow the individual add/drop nodes to be connected so that the network topology can evolve towards a mesh. The node architecture should also allow extra fibres to be added to each link as required to meet the demand, with the extra parts or modules of the node being installed as and when required. Fibre management and installation between sub-components inside the routing node is also expensive.

[0462] A known architecture for such a routing node uses a separate wavelength demultiplexer for every input fibre. The separated wavelength channels are then carried over optical fibres to N*N optical switches. To avoid internal wavelength blocking then all channels at a particular wavelength must be connected to the same N*N switch. Hence the switch will receive channels at the same wavelength from every single input fibre. The channels leaving the switch are carried over optical fibres to a separate wavelength multiplexer for every output fibre. Hence the switch will route channels at the same wavelength towards every single output fibre.

[0463] These switches have a sufficient number of ports for added and dropped channels, and channels passing to and from wavelength conversion and optical regeneration. This sufficient number is estimated based on traffic analysis as it depends on the instantaneous mapping of channels between nodes and the wavelength and fibre allocation. Each switch may service one or more wavelength channels. In one device, the number of fibres is around b 3000 resulting in significant fibre management and installation costs. Even grouping together different fibres to or from the same link and grouping together the add fibres and regenerator fibres only reduces the number of separate entities to be managed to 560.

[0464] With such a large number of fibres it is not economic to provide optical amplifiers inside the routing node to compensate for insertion losses. Another problem with this architecture is how to add in extra external fibres once the switch capacity has been exhausted with the current number of external fibres. This cannot be done without replacing every single switch. In advance it is difficult to know how large to provision the switch to avoid or delay this problem.

[0465] An alternative node architecture uses one of the multi-wavelength architectures described to provide a separate module for every input fibre and a separate module for every output fibre. Consider first an input module. This should be designed so that none, one, many or all of the input channels may leave any of the output ports (as shown in FIG. 21). These output ports are used to carry channels towards output modules and towards other parts of the node providing wavelength conversion, regeneration and ports to electronic switches, for example. A connection between an input module and an output module carries every wavelength channel mapped between the corresponding input and output fibre. Hence the logical function of an input module is to sort the incoming channels according to their destination output fibre. This logical functionality was illustrated in FIG. 21.

[0466] A particular input module does not have connections to every output module. It does not have connections to output modules going back to the same neighbouring node from which the input channels have travelled, except perhaps for network monitoring and management functions. It might not need to have separate connections to every output module for the output fibres to the other neighbouring nodes. It is however provided with sufficient connectivity to the output channels on every output link to avoid unacceptable levels of wavelength blocking. For example each input module could be connected to a subset of the output modules, with an overflow system used to provide a connection to the other output modules, when required. An output module is designed like an input module but works in the opposite direction. Hence the logical function of the output module is to collect the channels coming from each input module and direct them to a common output port.

[0467] In this architecture, the dropped channels and channels needing wavelength conversion may exit from each module on a common port or a pair of ports. As a result of using the modules it can be shown that satisfactory performance is achieved using fewer than 1000 fibres and fewer than 50 fibre groups.

[0468] Hence the total number of fibres inside the node is reduced by a factor of over 3 while the total number of fibre entities to be installed and managed is reduced by a factor of 10 or more. This represents a significant reduction in cost and complexity.

[0469] An example wavelength-routing crossconnect using the modules is shown in FIG. 25. FIG. 25 shows four input routing modules 790-3, each with a respective input 790i-793i and four outputs 79001-79003 etc. and four output routing modules 794-7 each with four inputs and a respective single output 794o-797o to a respective output fibre. One output of each input module 790-3 forms a drop output. The input and output modules are associated together with input module 790 associated with output module 794, input module 791 associated with output module 795, input module 792 associated with output module 796 and input module 793 associated with output module 797. The remaining three outputs of each input module are cross-connected to the non associated output modules, so that for example the three non-drop outputs of input module 790 are coupled to respective inputs of output modules 795, 796 and 797. Specifically, output 79001 is connected to output module 795. Of the inputs to the four output modules, one per module is an add input and the remainder are connected to outputs of the input modules 790-3.

[0470] In the example the routing function carried out by each input module 790-3 is to sort the incoming channels with respect to the selected output fibre 794o-797o for example, and with reference to the figure, all wavelength channels entering the cross-connect on input 790i that need to leave the cross-connect on 795o are routed by the input module 790 to the output 79001. This output carries these channels to the output module 795 which is collecting frequency channels for output 795o. The output module combines all incoming channels onto a respective single. output.

[0471] In this architecture channel equalisation may be carried out independently for all channels routed through the cross connect.

[0472] The cross connect architecture of FIG. 25 is modular in that it can be used to build a range of nodes of different connectivity and dimension. The modules can be used to assemble a node like that described above, starting with only 1 or 2 fibre pairs per link and adding in extra modules to allow more fibres per link. Extra modules can be added in and connected up as and when required, allowing the network operator to delay investment in infrastructure for as long as possible. When the node has reached, for example, 6 fibre pairs per link and the capacity begins to be exhausted there are three ways to upgrade the node. The first way is to upgrade the numbers of wavelength channels on particular fibres in each link. This requires replacing the associated modules with modules processing more channels. However the other modules (and the fibre interconnections) can remain in service. In contrast for the conventional architecture as well as upgrading the demultiplexers and multiplexers associated with the particular fibres to be upgraded, a whole set of N*N switches must be installed, one for every new system wavelength. These switches will remain under-utilised until all the fibre systems have been upgraded.

[0473] A second way to upgrade the node is to replace selected modules with models providing an increased number of fibre choices per output link allowing more fibres per link. This requires the installation of more fibre groups inside the node. In contrast for the conventional architecture every N*N switch must be replaced meaning the associated system wavelengths would be out of service on every fibre entering or leaving the node.

[0474] A third way to upgrade the node is to upgrade selected modules by cascading another module from a spare, or expansion output port, as shown in FIG. 26.

[0475] FIG. 26 shows a somewhat similar arrangement to FIG. 24, and has an input module 860, with an input 861, five outputs 862-6, an optical amplifier 870 and an intermediate module 880 receiving the output of the optical amplifier 870 and providing four outputs 881-4. The input module has three outputs 862-4 to existing output modules, fourth output 865 to the optical amplifier 870 and fifth output as a drop output. The first to third outputs 881-3 of the intermediate module 880 connect to new or later output modules.

[0476] The advantage of this third way is that service interruption is not required during installation.

[0477] The smallest node can have as few as two modules, which would act as an add/drop node. Several pairs of such modules can service a stacked set of rings, allowing interconnection between different rings. Adjacent rings can also be interconnected. A hybrid ring/mesh network can be created. Hence the same modular system can be used for ring networks, mesh networks and mixes of the two. It can also allow re-use of existing plant and allow an add/drop node to grow and evolve into a wavelength-routing cross-connect.

[0478] It will be clear to those skilled in the art that the use of reflective SLMs may allow optical folding to be accomplished and provide a compact system. Thus folding mirrors which may be found in some systems are replaced by SLMs that serve the dual function of folding and performance management for the system. The performance management may include managing direction change, focus correction, correction of non-focus aberration, power control and sampling. When taken together with the controller and sensors, the SLM can then act as an intelligent mirror.

[0479] As an example, this application of SLMs would be attractive in the context of free-space wavelength demultiplexers as it would help to suppress the problems associated with long path lengths.

[0480] Another example is to provide correction for alignment tolerances and manufacturing tolerances in systems requiring alignment between fibre arrays and lens arrays. In particular focal length errors in the lenses (due to chromatic aberration or manufacturing tolerance) can be compensated by focus correction at the SLM or SLMs, while transverse misalignment between a fibre and lens which leads to an error in the beam direction after the lens, can be compensated by beam deflection at the SLM or SLMs.

[0481] It will also be clear to those skilled in the art that although the described embodiments refer to routing in the context of one-to-one, it would also be possible to devise holograms for multicast and broadcast, i.e. one-to-many and one-to-all, if desired.

[0482] Although the invention has been described with reference to a number of embodiments, it will be understood that the invention is not limited to the described details. The skilled artisan will be aware that many alternatives may be employed within the general concepts of the invention as defined in the appended claims.

CLAIMS

What is claimed is:

1. An optical add/drop multiplexer having a reflective SLM having a two-dimensional array of controllable phase-modulating elements, a diffraction device and a focussing device wherein light beams from a common point on the diffraction device are mutually parallel when incident upon the SLM, and wherein the SLM displays respective holograms at locations of incidence of light to provide emergent beams whose direction deviates from the direction of specular reflection.

2. A test or monitoring device comprising an SLM having a two-dimensional array of pixels, and operable to cause incident light to emerge in a direction deviating from the specular direction, the device having light sensors at predetermined locations arranged to provide signals indicative of said emerging light.

3. A test or monitoring device according to claim 2, further comprising further sensors arranged to provide signals indicative of light emerging in the specular directions.

4. An optical routing module having at least one input and at least two outputs and operable to select between the outputs, the module comprising a two dimensional SLM having an array of pixels, with circuitry constructed and arranged to display holograms on the pixels to route beams of different frequency to respective outputs.

5. A routing device having an input and plural outputs, the input constructed and arranged to receive a light beam having plural wavelengths, the device comprising an optical device for selecting the wavelengths of the input beam to appear in the outputs, wherein each output may contain any desired set of the plural wavelengths.

6. A routing device according to claim 5, wherein the members of the desired set may be varied in use.

7. A routing device according to claim 5, wherein at least two of the outputs contain at least one common wavelength.

8. A routing device having plural input signals and an output, the output constructed and arranged to deliver a signal having plural wavelengths, the device comprising a device for combining the wavelengths from the input signals to appear in the output, wherein each input signal may contain any desired set of the plural wavelengths of the output.

ABSTRACT OF THE DISCLOSURE

To operate an optical device comprising an SLM with a two-dimensional array of controllable phase-modulating elements groups of individual phase-modulating elements are delineated, and control data selected from a store for each delineated group of phase-modulating elements. The selected control data are used to generate holograms at each group and one or both of the delineation of the groups and the selection of control data is/are varied. In this way upon illumination of the groups by light beams, light beams emergent from the groups are controllable independently of each other.

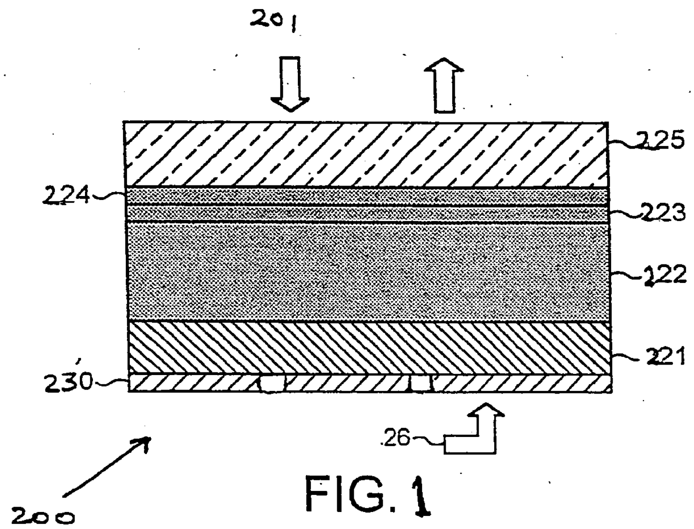

FIG. 1

BEST AVAILABLE COPY

TS0001270

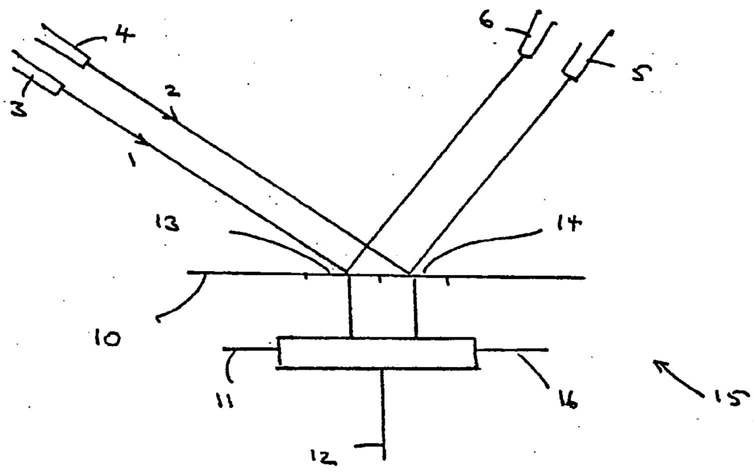

FIG 2

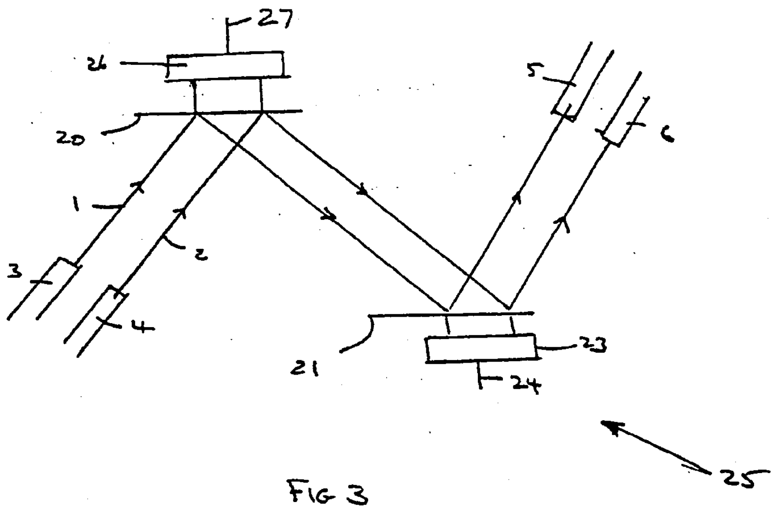

FIG 3

TS0001272

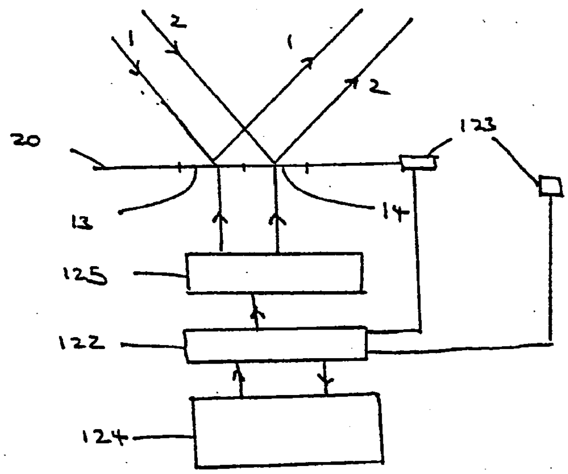

FIG 4

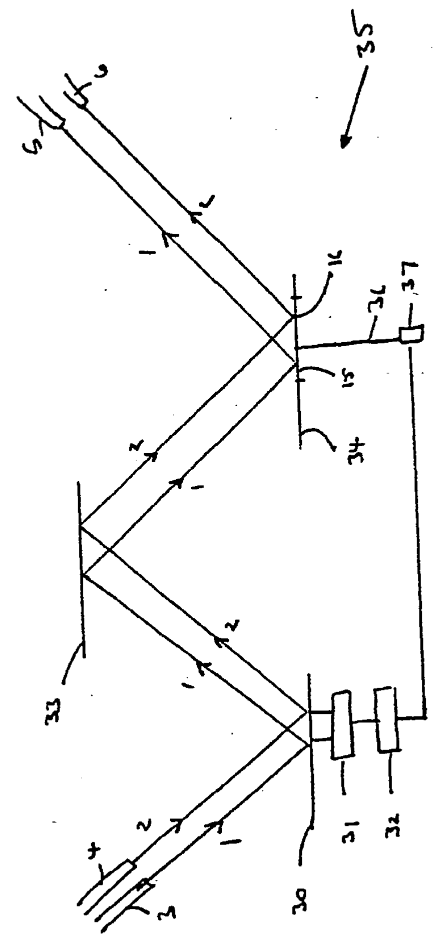

FIG. 5

TS0001274

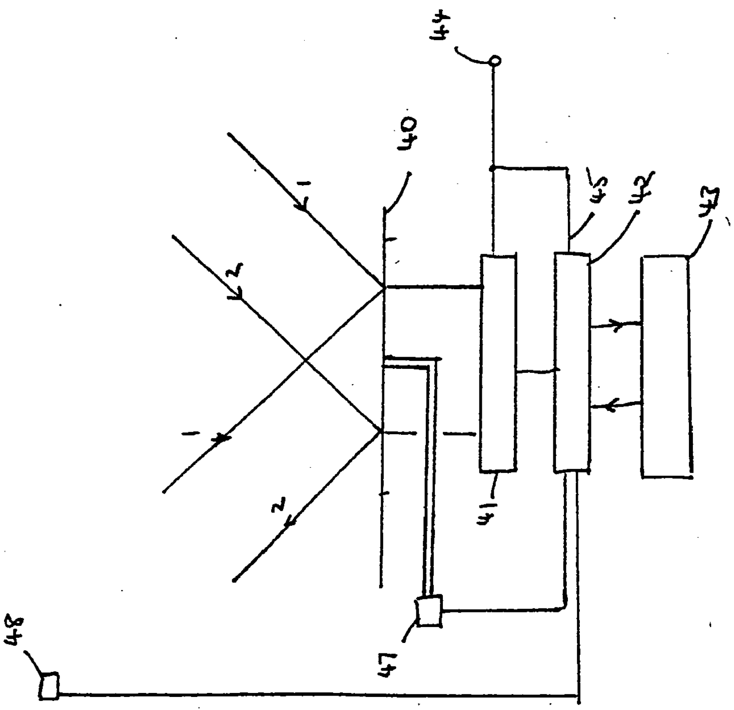

FIG. 6

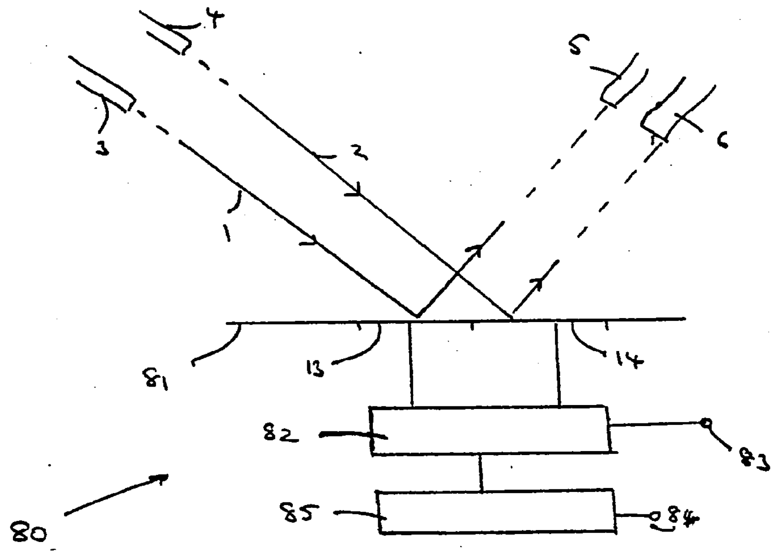

FIG 7

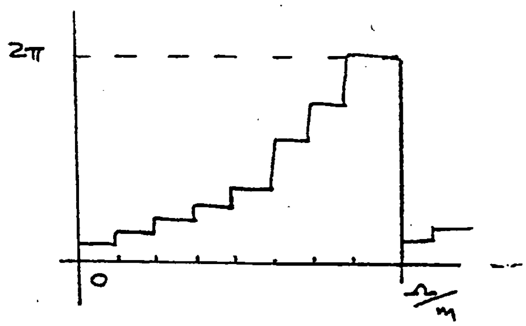

FIG 8a

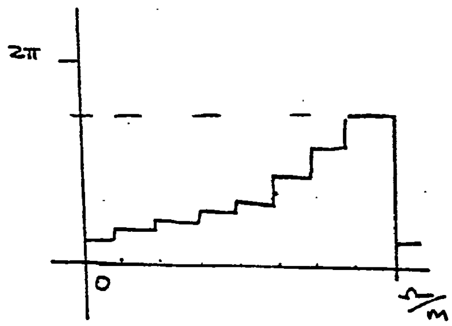

FIG 8b

TS0001277

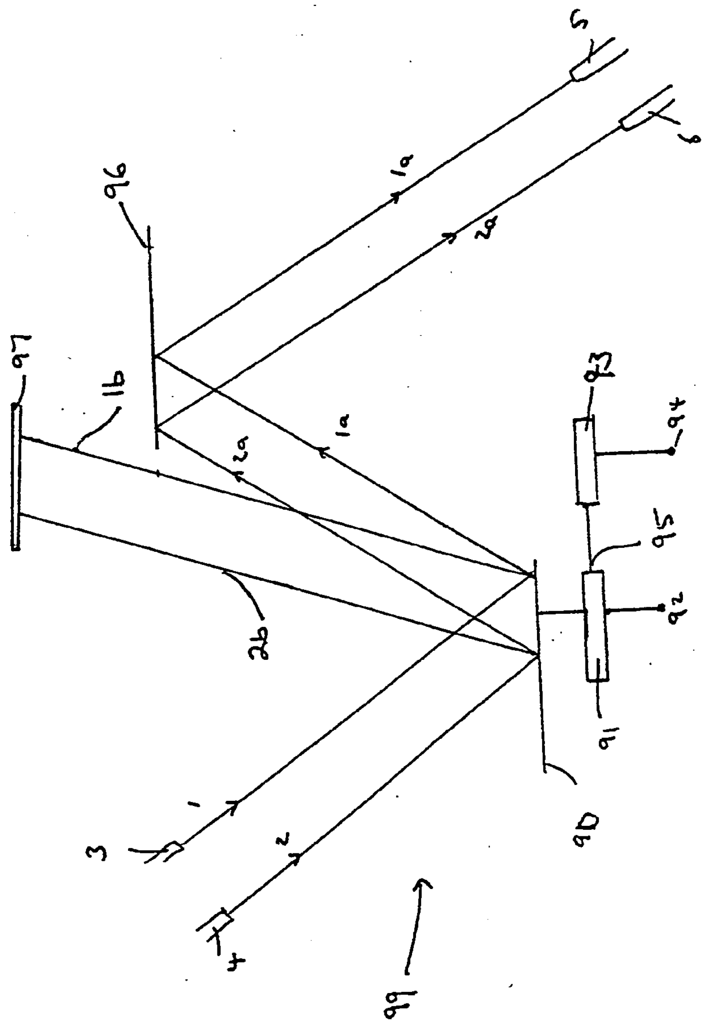

FIG 9

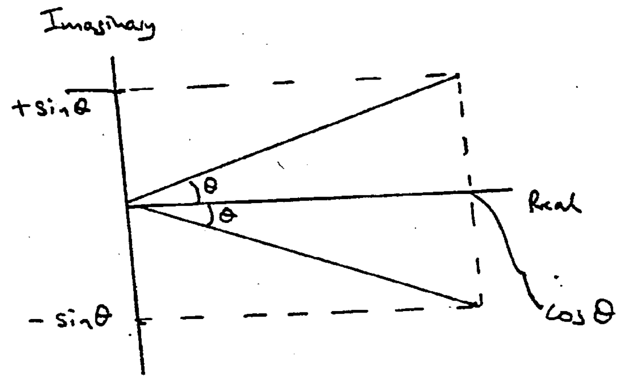

Fig 10

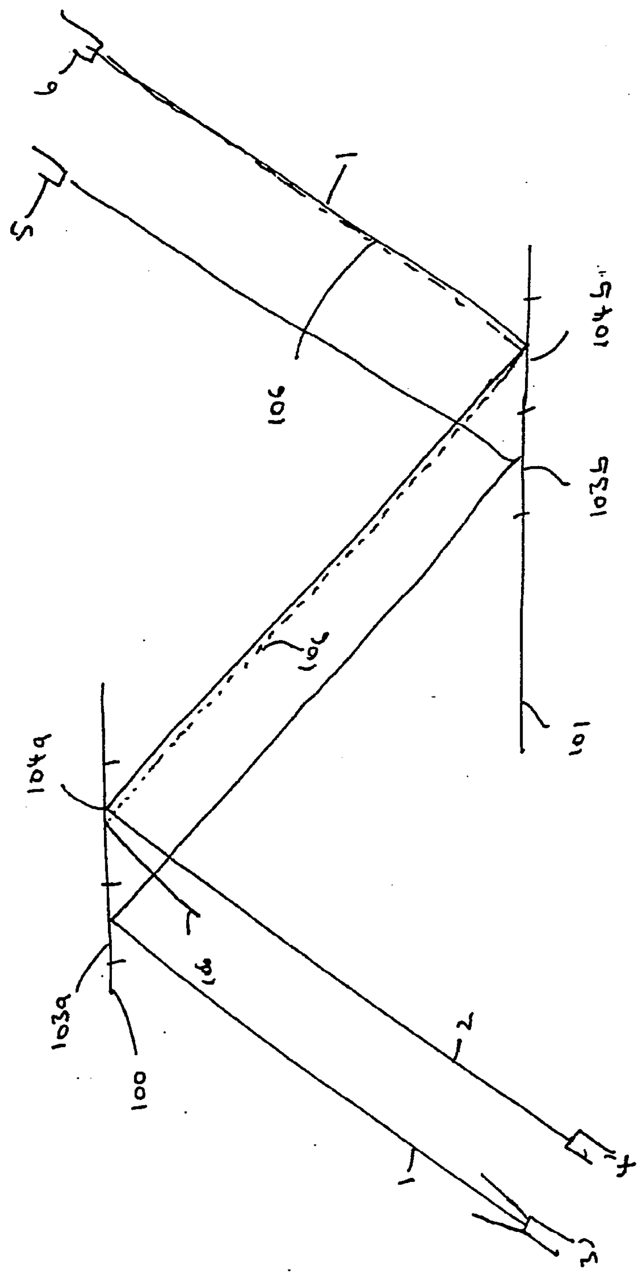

FIG 11

TS0001280

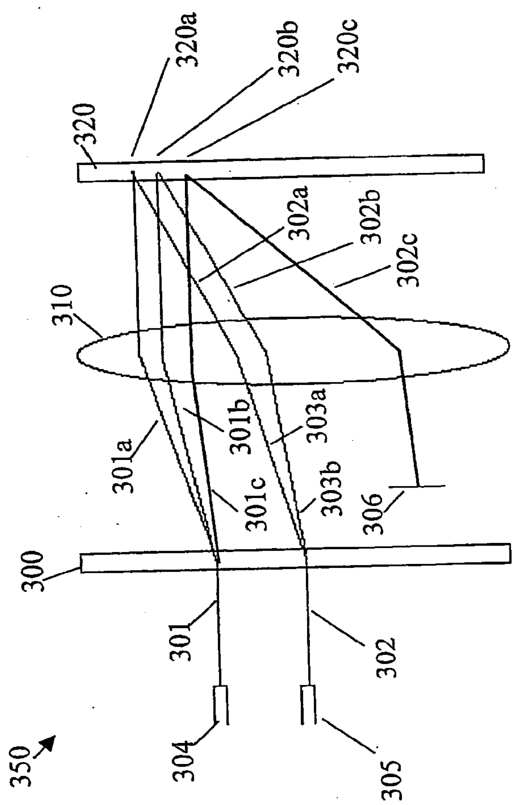
320a
320b
320c
320
302a
302b
302c
310
301a
301b
303a
301c
303b
306
300
301
302
304
305
350

Figure 12

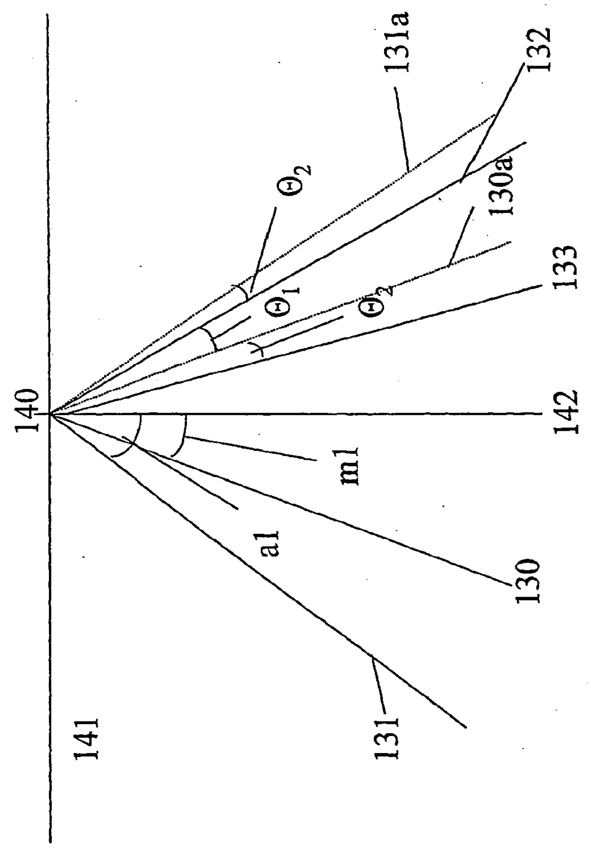
140
141
142
131a
132
Θ_2
130a
Θ_1
Θ_2
133
m1
a1
130
131

Figure 13a

Figure 13b

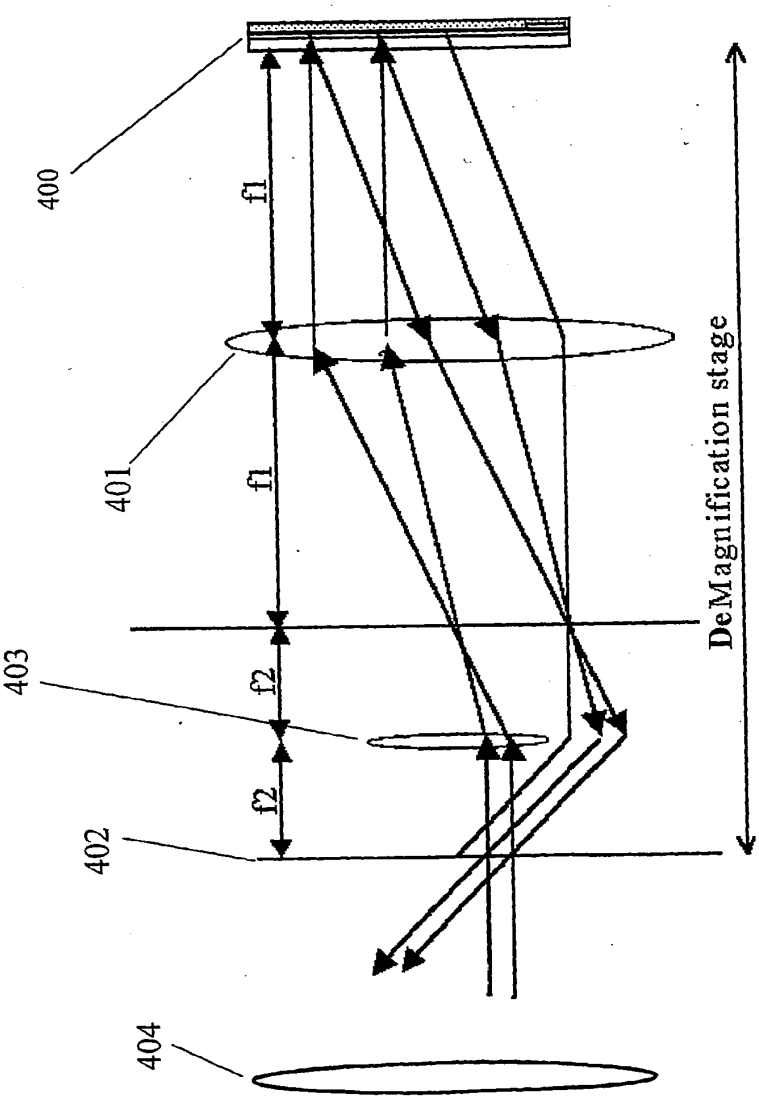

Figure 14

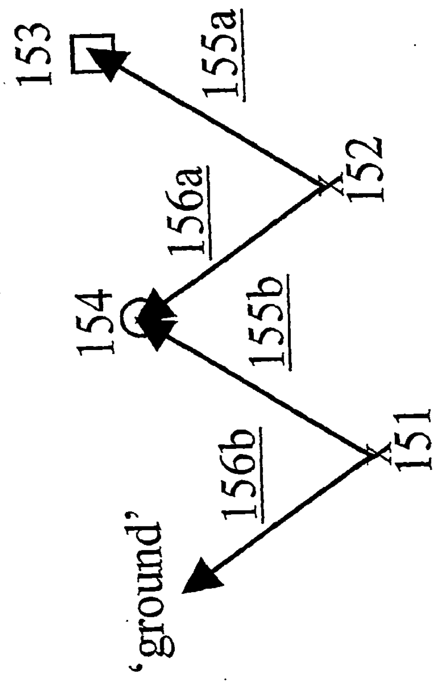

Figure 15

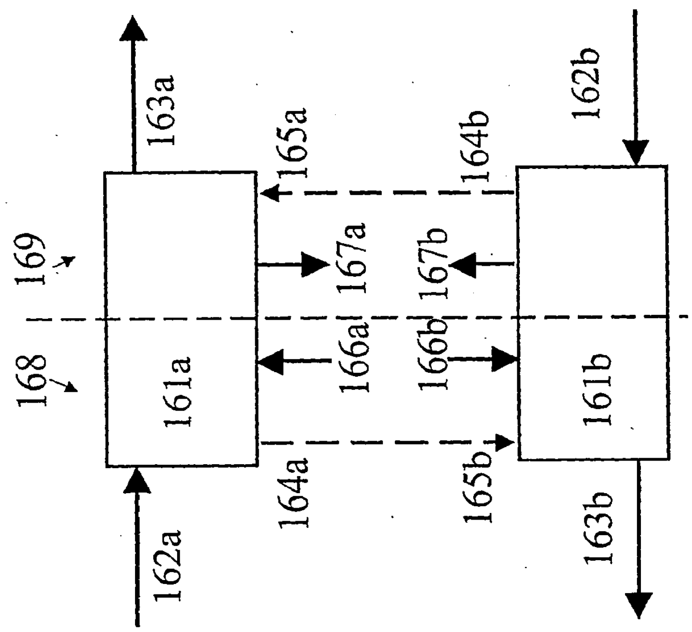

Figure 16

TS0001286

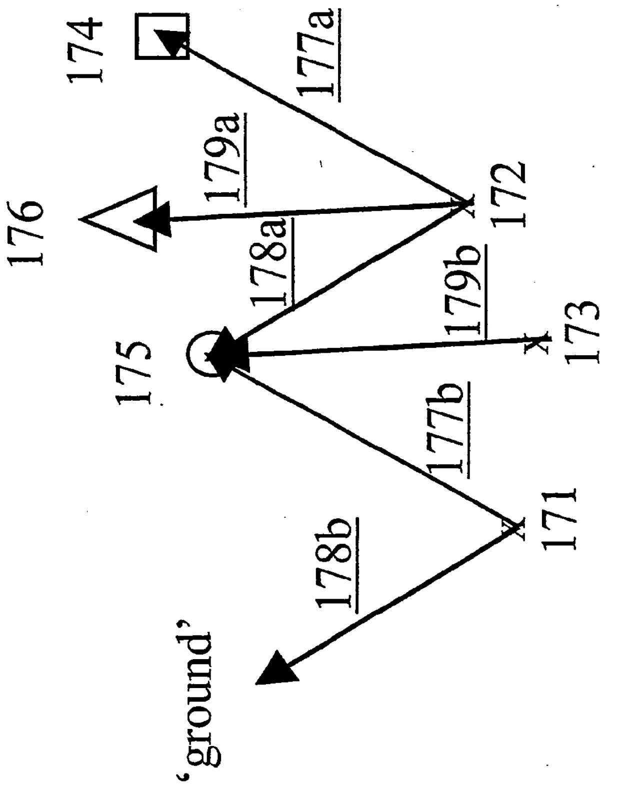

Figure 17

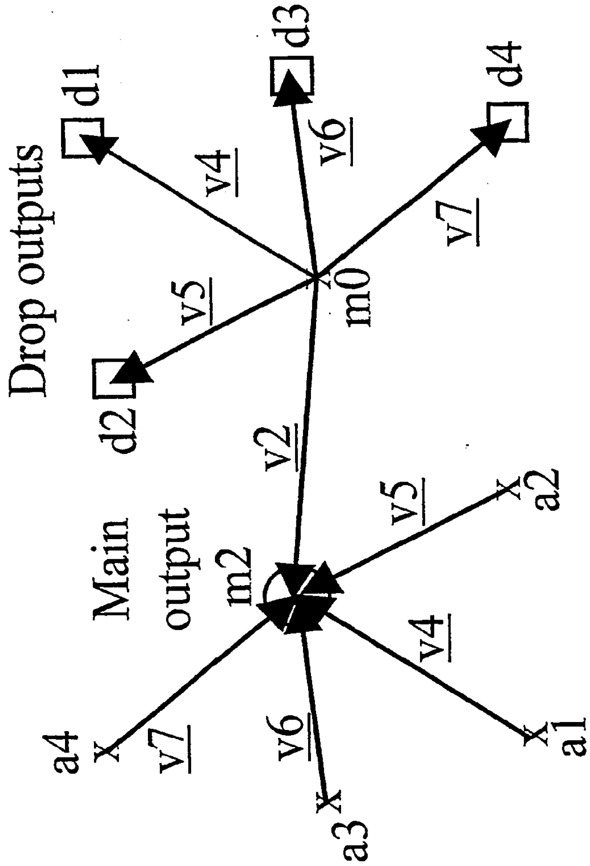
Drop outputs
d1
d2
d3
d4
v4
v5
v6
v7
m0
v2
Main
output
m2
v5
v4
v6
v7
a1
a2
a3
a4

Figure 18

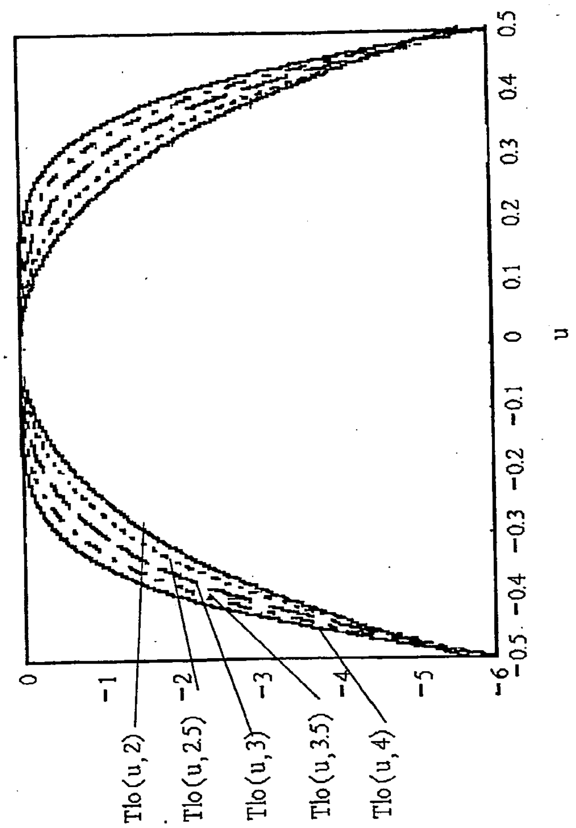
0
−1
−2
−3
−4
−5
−6
−0.5
−0.4
−0.3
−0.2
−0.1
0
0.1
0.2
0.3
0.4
0.5
u
Tlo(u,2)
Tlo(u,2.5)
Tlo(u,3)
Tlo(u,3.5)
Tlo(u,4)

Figure 19

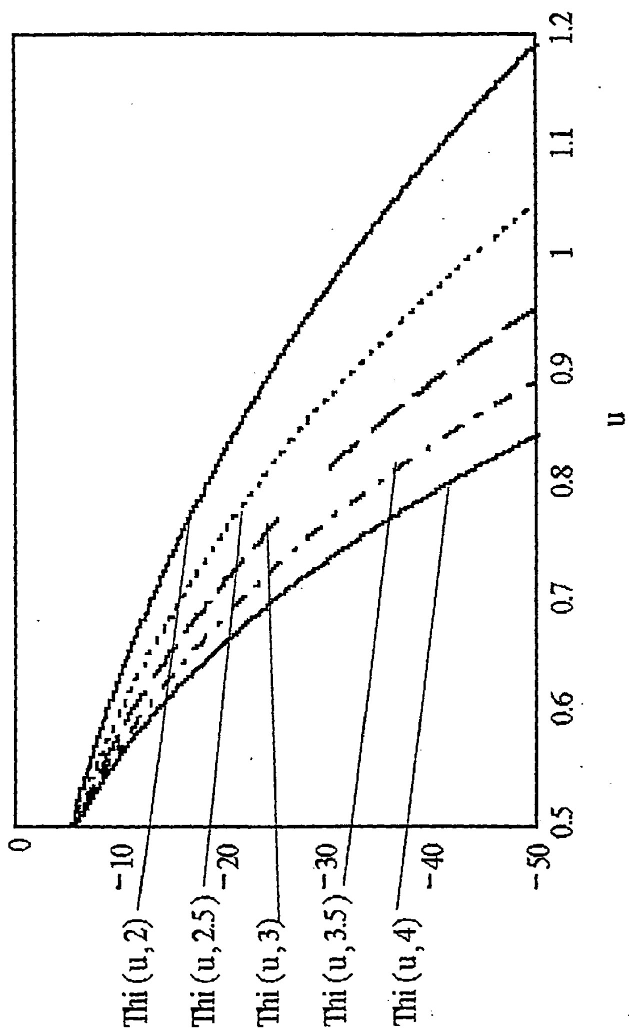
0
−10
−20
−30
−40
−50
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
u
Thi (u, 2)
Thi (u, 2.5)
Thi (u, 3)
Thi (u, 3.5)
Thi (u, 4)

Figure 20

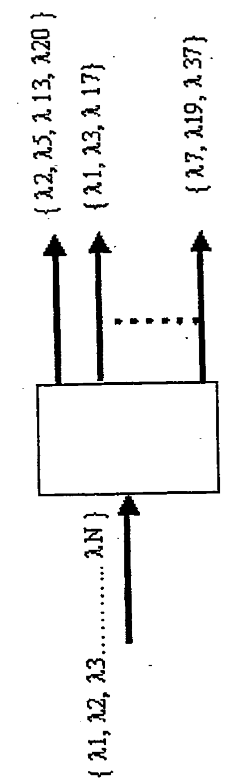

Figure 21

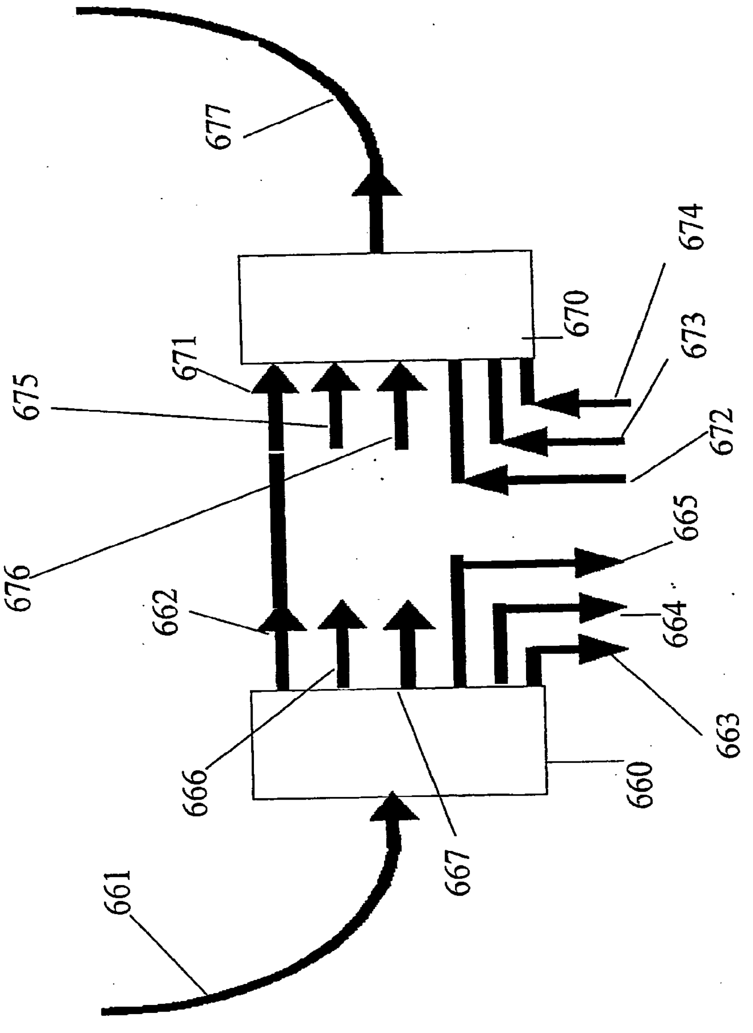

Figure 22

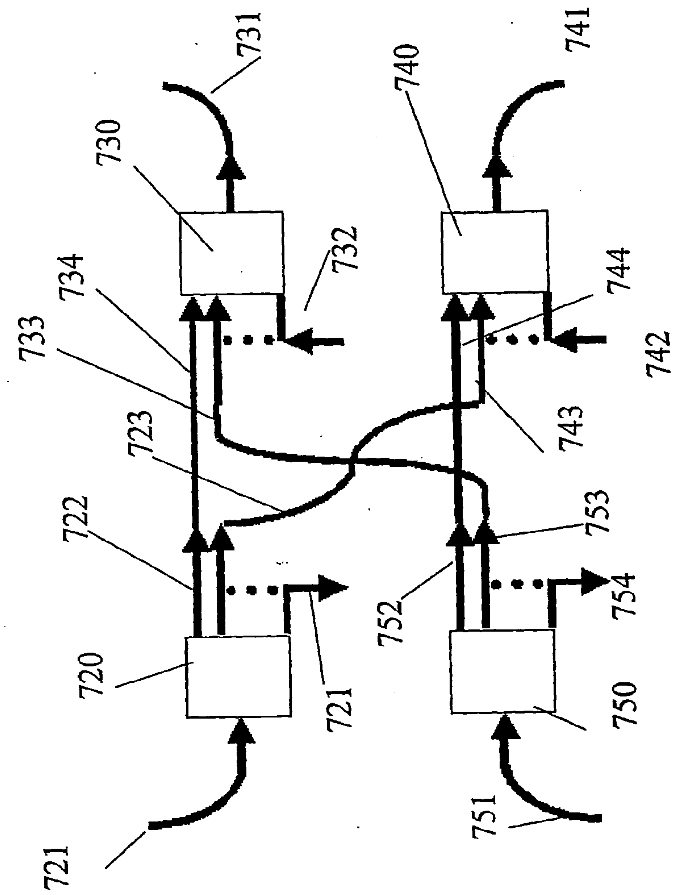
731
730
740
741
734
732
733
744
723
742
743
722
753
752
754
720
721
750
721
751

Figure 23

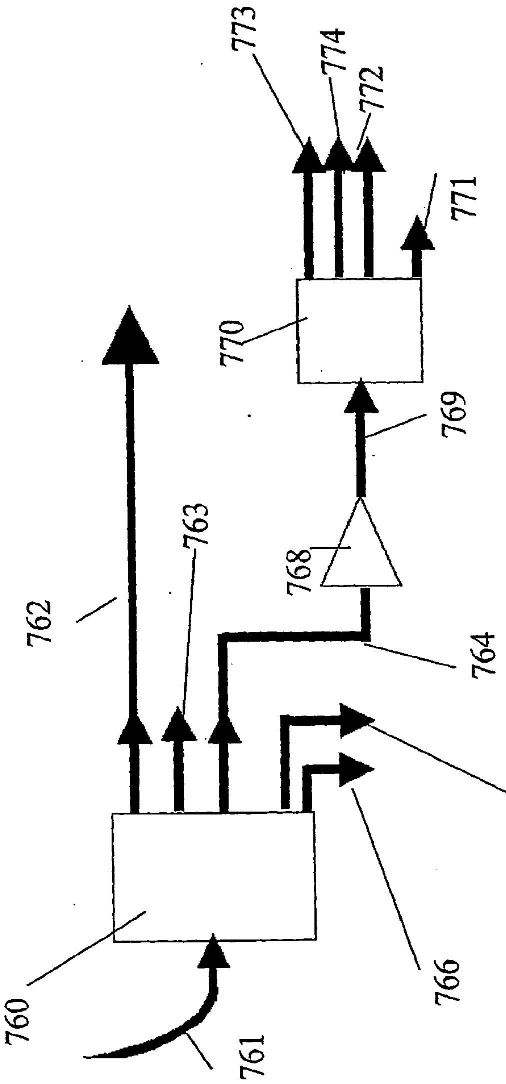

Figure 24

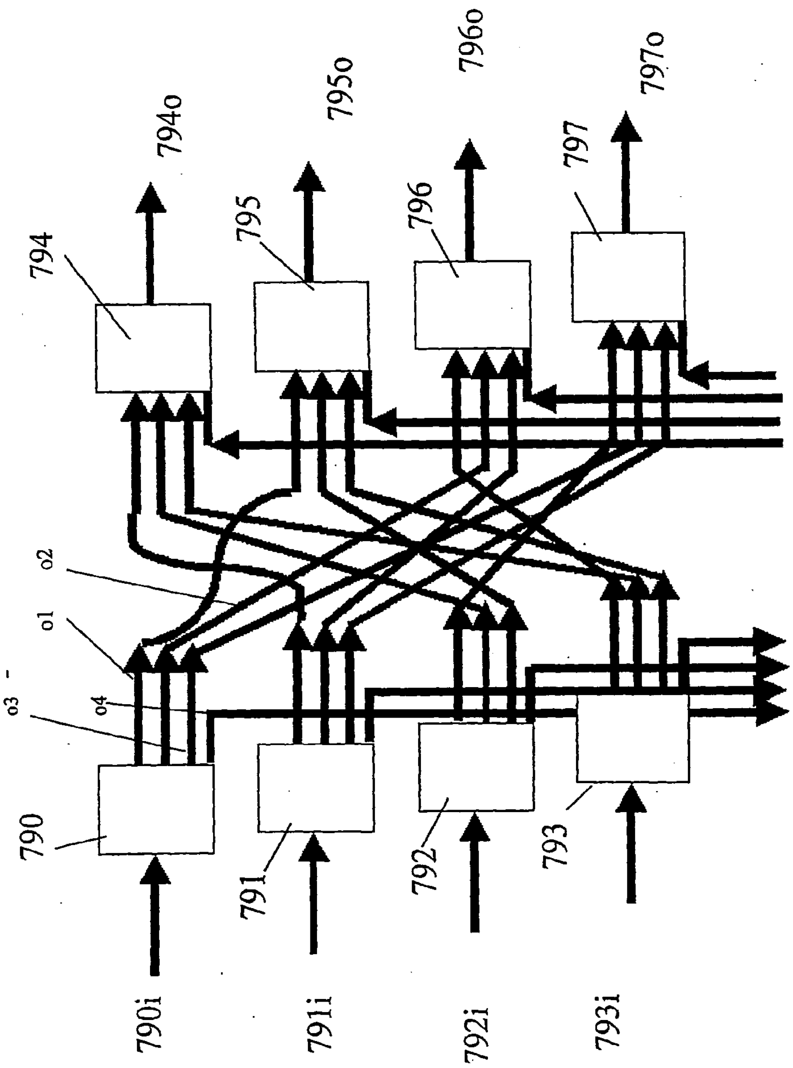
790i
791i
792i
793i
790
791
792
793
794
795
796
797
794o
795o
796o
797o
o1
o2
o3
o4

Figure 25

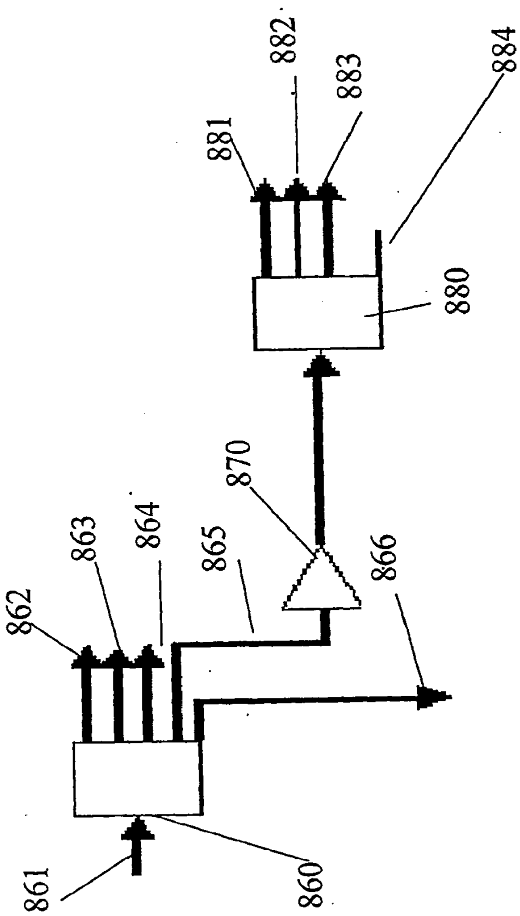

Figure 26

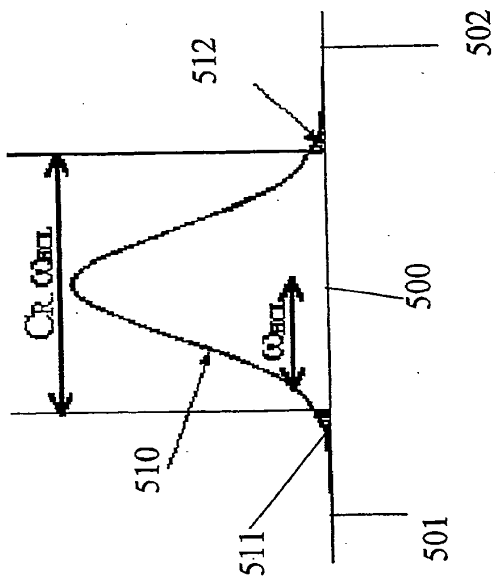

Figure 27

TS0001297

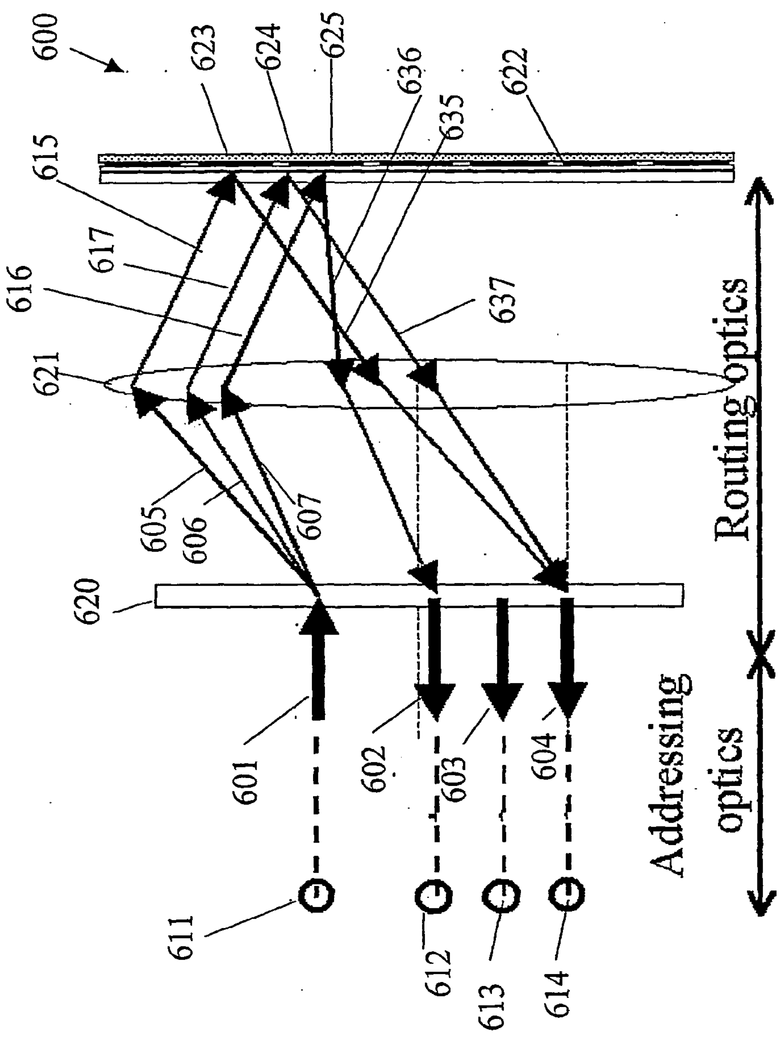
600
623
624
625
636
635
622
615
617
616
621
637
605
606
607
620
601
602
603
604
611
612
613
614
Routing optics
Addressing optics

Figure 28

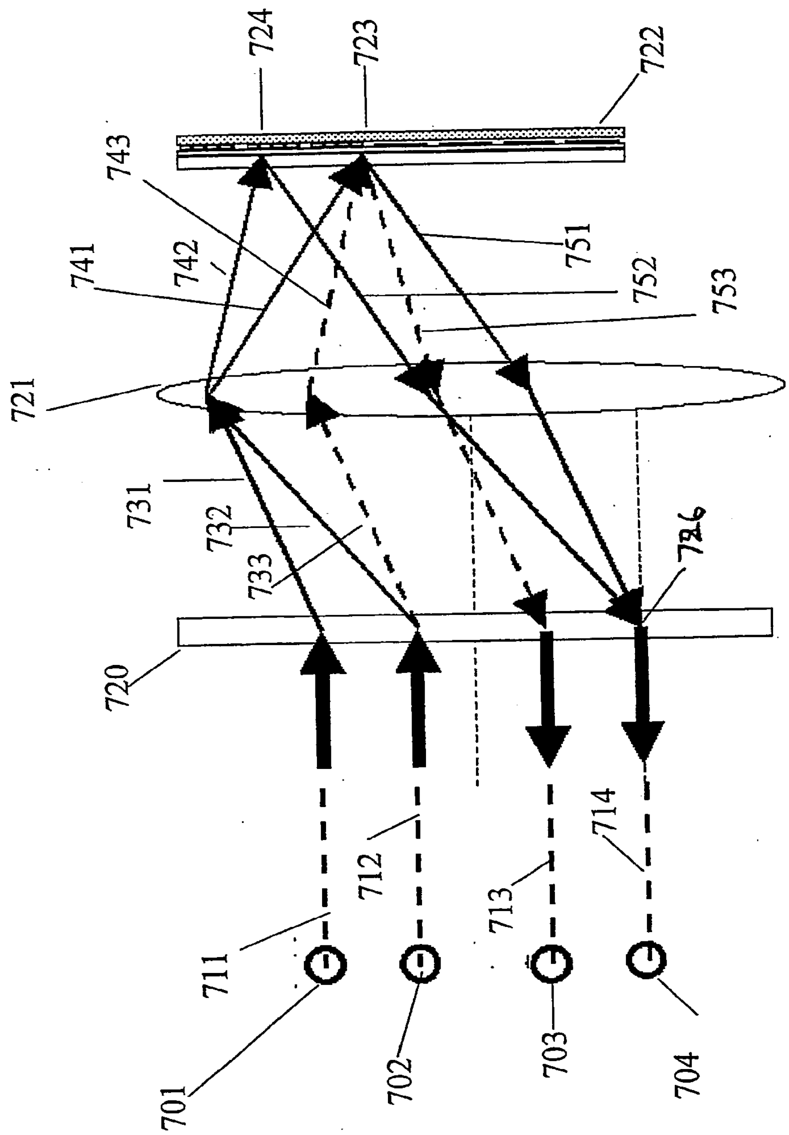
724
723
722
743
741
742
751
752
753
721
731
732
733
726
720
711
712
713
714
701
702
703
704

Figure 29

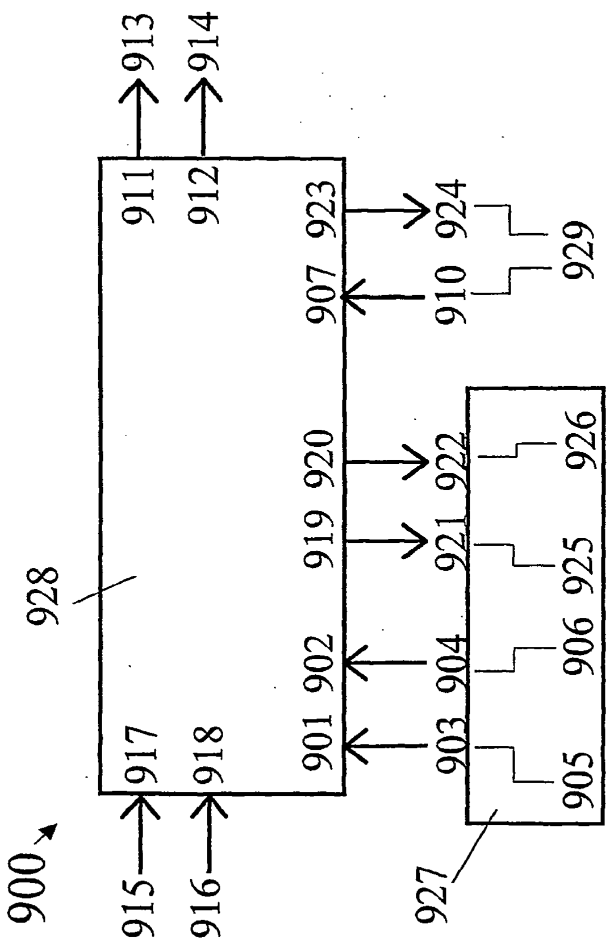
900
928
911
912
913
914
915
916
917
918
901
902
907
919
920
923
903
904
921
922
910
924
929
905
906
925
926
927

Figure 30

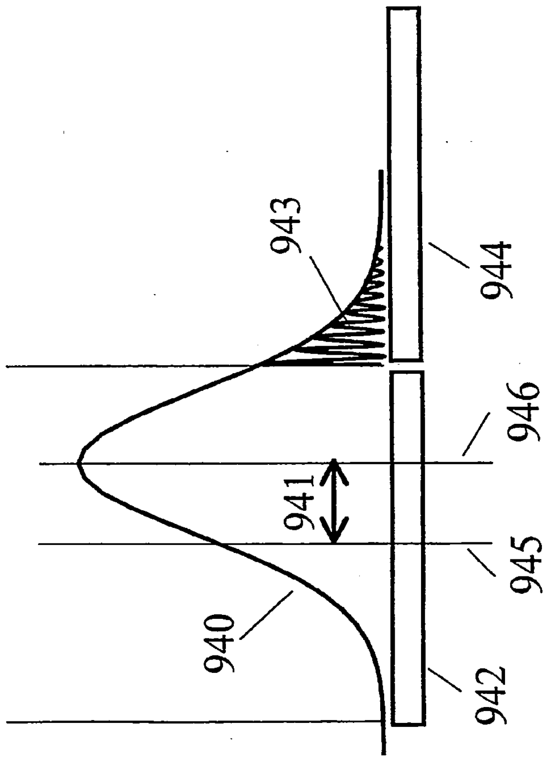

Figure 31

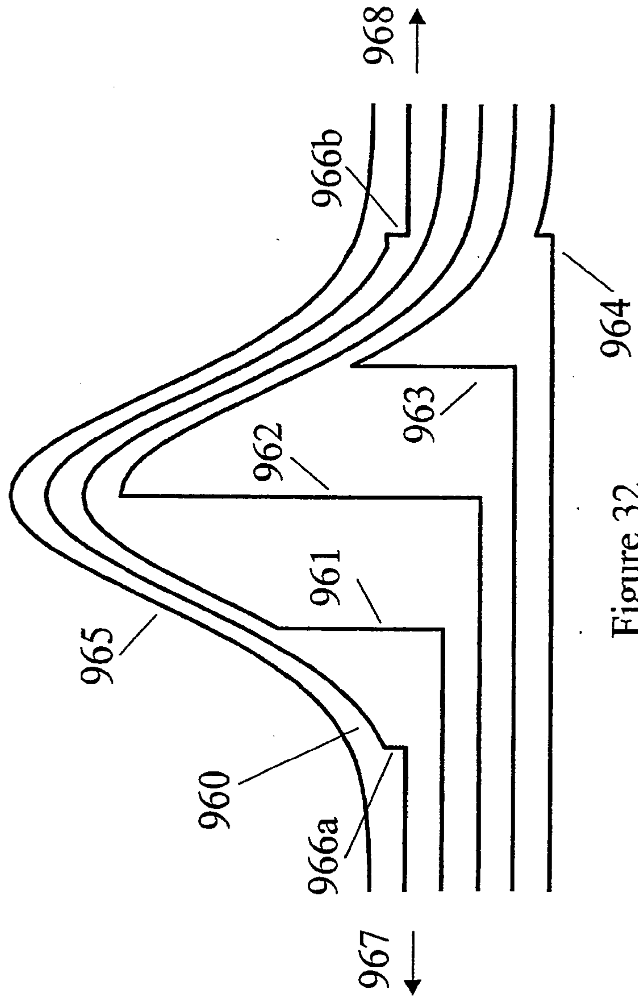

Figure 32

TS0001302

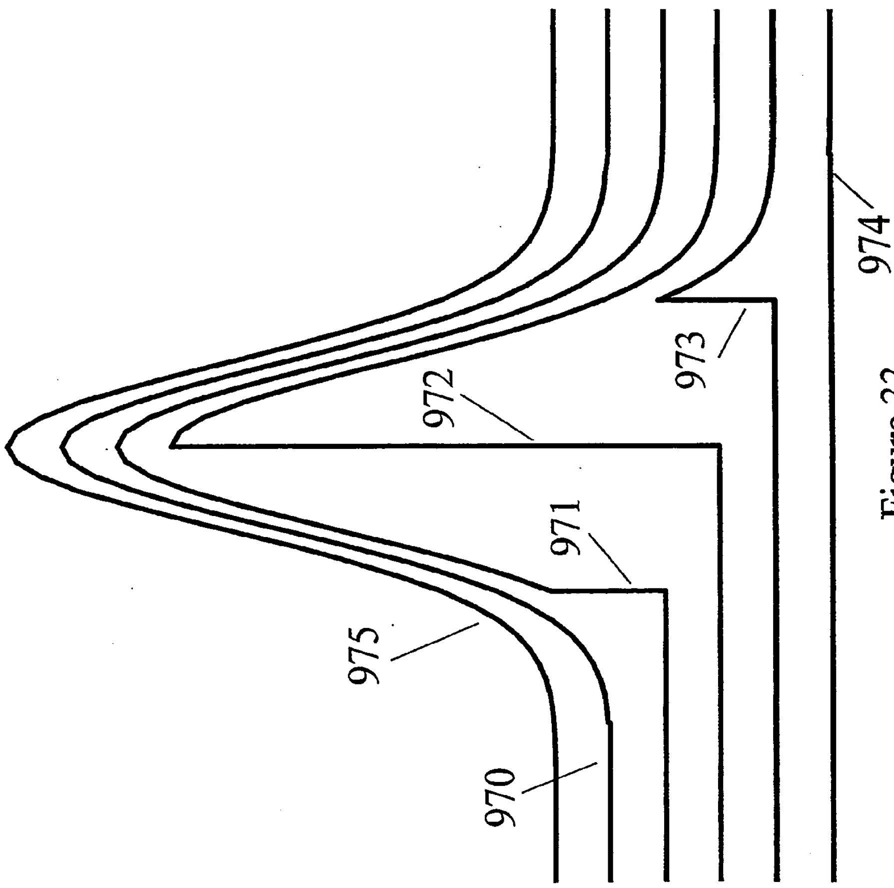

Figure 33

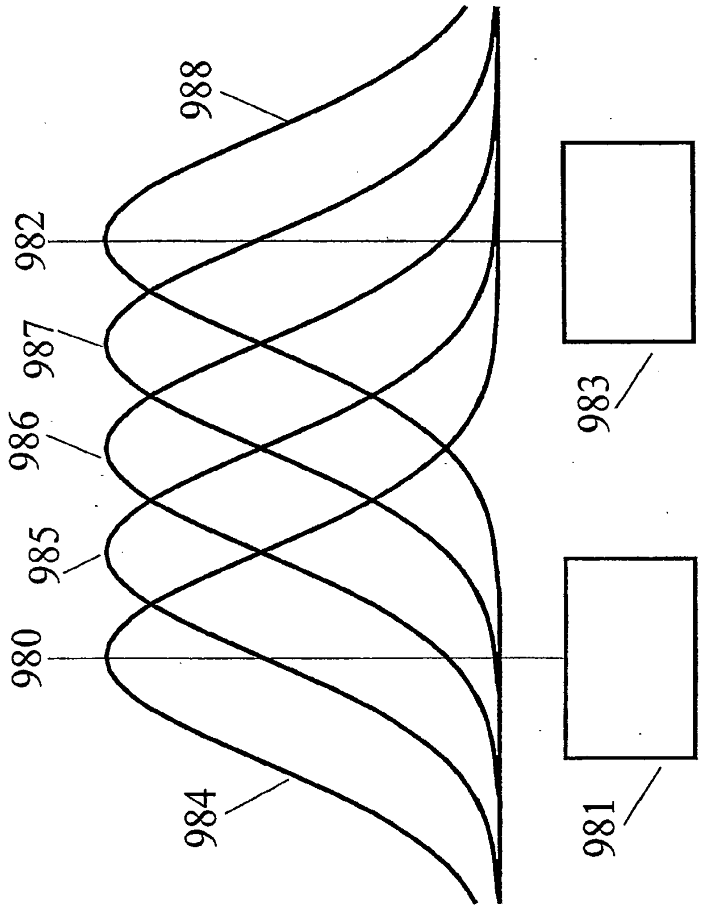

Figure 34

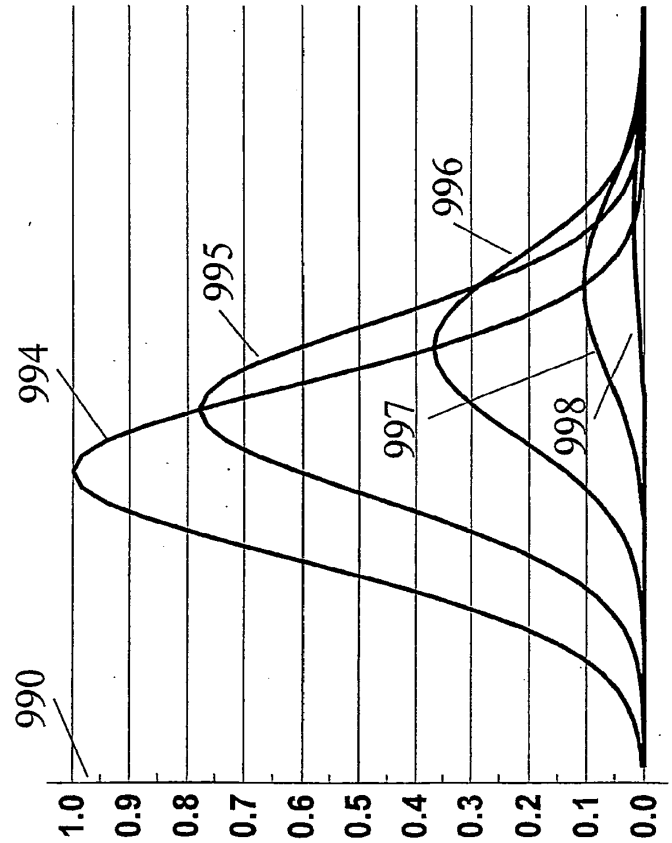

Figure 35

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☑ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

TS0001306

PATENT APPLICATION
DOCKET NO.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Melanie Holmes

Divisional Application of

Application No.: 10/487,810

371C File Date: September 10, 2004

For: OPTICAL PROCESSING

Date: 9/1/06

EXPRESS MAIL LABEL NO. EV214902601 US

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Information Disclosure Statement is submitted:

[ ] under 37 CFR 1.129(a), or
(First/Second submission after Final Rejection)

[X] under 37 CFR 1.97(b), or
(Within any one of the following time periods: three months of filing national application (other than a CPA) or date of entry of the national stage in an international application; or before the mailing date of a first office action on the merits in a non-provisional application, including a CPA, or a Request for Continued Examination).

[ ] under 37 CFR 1.97(c) together with either:

[ ] a Statement under 37 CFR 1.97(e), as checked below, or

[ ] a $180.00 fee under 37 CFR 1.17(p), or
(After the 37 CFR 1.97(b) time period, but before final action or notice of allowance, whichever occurs first)

[ ] under 37 CFR 1.97(d) together with:

[ ] a Statement under 37 CFR 1.97(e), as checked below, and

[ ] a $180.00 fee under 37 CFR 1.17(p), or
(Filed after final action or notice of allowance, whichever occurs first, but on or before payment of the issue fee)

[ ] under 37 CFR 1.97(i):
Applicant requests that the IDS and cited reference(s) be placed in the application file.
(Filed after payment of issue fee)

Statement Under 37 CFR 1.97(e)

[ ] Each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement; or

[ ] No item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned, after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

Statement Under 37 CFR 1.704(d) (Patent Term Adjustment)
Applies to original applications (other than design) filed on or after May 29, 2000

[ ] Each item of information contained in the Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the Information Disclosure Statement.

[X] Enclosed herewith is form PTO-1449:

[ ] Copies of the cited references are enclosed.

[X] Copies of issued U.S. patents and published U.S. applications are not required and are not being provided.

[X] Copies of the cited references are enclosed except those entered in prior application, U.S. Application No. 10/487,810, to which priority under 35 U.S.C. 120 is claimed.

[ ] The listed references were cited in the enclosed International Search Report in a counterpart foreign application.

[ ] The "concise explanation" requirement (non-English references) for reference(s) [ ] under 37 CFR 1.98(a)(3) is satisfied by:

[ ] the explanation provided on the attached sheet.

[ ] the explanation provided in the Specification.

[ ] submission of the enclosed International Search Report.

[ ] submission of the enclosed English-language version of a foreign Search Report and/or foreign Office Action.

[ ] the enclosed English language abstract.

[ ] Applicant requests that the following non-published pending applications be considered:
(Affix a label or apply the stamp "Non-Published IDS Reference - Do Not Scan" to the front of each unpublished pending appl'n.)

Examiner's Initials

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

Examiner _____ Date _____

[ ] A copy of each above-cited application, including the current claims, is enclosed, except any application filed on or after June 30, 2003, which has been scanned into the PTO's Image File Wrapper (IFW) system and is available to the examiner.

[ ] A copy of each above-cited application, including the current claims, is enclosed, except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. 120 is claimed.

The Examiner is requested to return a copy of the above list of pending applications indicating which references were considered with the next office communication.

It is requested that the information disclosed herein be made of record in this application.

Method of payment:

[ ] A check for the fee noted above is enclosed, or the fee has been included in the check with the accompanying Reply. A copy of this Statement is enclosed.

[ ] Please charge Deposit Account 08-0380 in the amount of $[ ]. A copy of this Statement is enclosed.

[X] Please charge any deficiency in fees and credit any overpayment to Deposit Account 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]
Timothy J. Meagher
Registration No.: 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 9/1/6

PTO-1449 REPRODUCED **INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **September 1, 2006** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO.	
	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE	
	EXAMINER	CONFIRMATION NO.	GROUP

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
	A1	5,107,359	04-21-92	Ohuchida
	A2	5,539,543	07-23-96	Liu, et al.
	A3	5,589,955	12-1996	Amako, et al.
	A4	5,428,466	06-1995	Rejman-Greene, et al.
	A5	4,952,010	08-1990	Healey, et al.
	A6	6,710,292 B2	03-2004	Fukuchi, et al.
	A7	6,975,786 B1	12-2005	Warr, et al.
	A8	6,115,123	09-2000	Stappaerts, et al.
	A9	5,995,251	11-19999	Hesselink, et al.
	A10	5,959,747	09-1999	Psaltis, et al.
	A11	6,072,608	06-2000	Psaltis, et al.
	A12			
	A13			
	A14			
	A15			
	A16			
	A17			
	A18			
	A19			
	A20			
	A21			
	A22			
	A23			
	A24			
	A25			

EXAMINER	DATE CONSIDERED

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

TS0001310

PTO-1449 REPRODUCED **INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **September 1, 2006** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO.	
	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE	
	EXAMINER	CONFIRMATION NO.	GROUP

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER Country Code-Number-Kind Code (if known)	DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT	TRANSLATION YES	NO
	B1	WO 01 90823 A1	11-29-01	Intelligent Pixels, Inc.		
	B2	WO 01 25848 A2	04-12-01	Thomas Swan & Co., Ltd.		
	B3	WO 01 25840 A1	04-12-01	Thomas Swan & Co., Ltd.		
	B4	WO 02 101451 A1	12-19-02	Honeywell International, Inc.		
	B5	WO 02 079870 A2	10-10-02	Thomas Swan & Co., Ltd.		
	B6	EP 1 050 775 A1	11-08-00	Thomas Swan & Co., Ltd.		
	B7	EP 1 053 501 B1	07-23-03	Thomas Swan & Co., Ltd.		
	B8					
	B9					
	B10					
	B11					
	B12					
	B13					
	B14					
	B15					
	B16					
	B17					
	B18					
	B19					
	B20					
	B21					
	B22					
	B23					
	B24					

EXAMINER	DATE CONSIDERED

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

PTO-1449 REPRODUCED **INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **September 1, 2006** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO.	
	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE	
	EXAMINER	CONFIRMATION NO.	GROUP

		OTHER DOCUMENTS ***(Including Author, Title, Date, Pertinent Pages, Etc.)***
	C1	Mears, R. J., et al., "Telecommunications Applications of Ferroelectric Liquid-Crystal Smart Pixels," IEEE Journal of Selected Topics in Quantum Electronics, Vol. 2, No. 1, April 1996, pp. 35-46.
	C2	Mears, R. J., et al., "WDM Channel Management Using Programmable Holographic Elements," IEE Colloquim on Multiwavelength Optical Networks: Devices, Systems and Network Implementations," IEE, London, GB, 18 June 1998, pp. 11-1 - 11-6.
	C3	Pan, Ci-Ling, et al., "Tunable Semiconductor Laser with Liquid Crystal Pixel Mirror in Grating-Loaded External Cavity," Electronics Letters, IEE Stevenage, GB, Vol. 35, No. 17, 19 August 1999, pp. 1472-1473.
	C4	Marom, D.M., *et al.,* "Wavelength-Selective 1x4 Switch for 128 WDM Channels at 50 Ghz Spacing," *OFC Postdeadline Paper*, pp. FB7-1-FB7-3 (2002).
	C5	
	C6	
	C7	
	C8	
	C9	
	C10	
	C11	
	C12	
	C13	
	C14	
	C15	

EXAMINER	DATE CONSIDERED

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Melanie Holmes

Divisional Application of

Application No.: 10/487,810

371C File Date: September 10, 2004

For: OPTICAL PROCESSING

Date: 9/1/06
EXPRESS MAIL LABEL NO. EV214902601 US

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Information Disclosure Statement is submitted:

[ ] under 37 CFR 1.129(a), or
(First/Second submission after Final Rejection)

[X] under 37 CFR 1.97(b), or
(Within any one of the following time periods: three months of filing national application (other than a CPA) or date of entry of the national stage in an international application; or before the mailing date of a first office action on the merits in a non-provisional application, including a CPA, or a Request for Continued Examination).

[ ] under 37 CFR 1.97(c) together with either:

[ ] a Statement under 37 CFR 1.97(e), as checked below, or

[ ] a $180.00 fee under 37 CFR 1.17(p), or
(After the 37 CFR 1.97(b) time period, but before final action or notice of allowance, whichever occurs first)

[ ] under 37 CFR 1.97(d) together with:

[ ] a Statement under 37 CFR 1.97(e), as checked below, and

[ ] a $180.00 fee under 37 CFR 1.17(p), or
(Filed after final action or notice of allowance, whichever occurs first, but on or before payment of the issue fee)

[ ] under 37 CFR 1.97(i):
Applicant requests that the IDS and cited reference(s) be placed in the application file.
(Filed after payment of issue fee)

Statement Under 37 CFR 1.97(e)

[ ] Each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement; or

[ ] No item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned, after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

Statement Under 37 CFR 1.704(d) (Patent Term Adjustment)
Applies to original applications (other than design) filed on or after May 29, 2000

[ ] Each item of information contained in the Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the Information Disclosure Statement.

[X] Enclosed herewith is form PTO-1449:

- [ ] Copies of the cited references are enclosed.
  - [X] Copies of issued U.S. patents and published U.S. applications are not required and are not being provided.
- [X] Copies of the cited references are enclosed except those entered in prior application, U.S. Application No. 10/487,810, to which priority under 35 U.S.C. 120 is claimed.
- [ ] The listed references were cited in the enclosed International Search Report in a counterpart foreign application.
- [ ] The "concise explanation" requirement (non-English references) for reference(s) [ ] under 37 CFR 1.98(a)(3) is satisfied by:
  - [ ] the explanation provided on the attached sheet.
  - [ ] the explanation provided in the Specification.
  - [ ] submission of the enclosed International Search Report.
  - [ ] submission of the enclosed English-language version of a foreign Search Report and/or foreign Office Action.
  - [ ] the enclosed English language abstract.

[ ] Applicant requests that the following non-published pending applications be considered:
(Affix a label or apply the stamp "Non-Published IDS Reference - Do Not Scan" to the front of each unpublished pending appl'n.)

Examiner's Initials

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

Examiner Date

[ ] A copy of each above-cited application, including the current claims, is enclosed, except any application filed on or after June 30, 2003, which has been scanned into the PTO's Image File Wrapper (IFW) system and is available to the examiner.

[ ] A copy of each above-cited application, including the current claims, is enclosed, except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. 120 is claimed.

The Examiner is requested to return a copy of the above list of pending applications indicating which references were considered with the next office communication.

It is requested that the information disclosed herein be made of record in this application.

Method of payment:

[ ] A check for the fee noted above is enclosed, or the fee has been included in the check with the accompanying Reply. A copy of this Statement is enclosed.

[ ] Please charge Deposit Account 08-0380 in the amount of $[ ]. A copy of this Statement is enclosed.

[X] Please charge any deficiency in fees and credit any overpayment to Deposit Account 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]

Timothy J. Meagher
Registration No.: 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 9/1/6

TS0001315

PTO-1449 REPRODUCED **INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **September 1, 2006** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO.	
	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE	
	EXAMINER	CONFIRMATION NO.	GROUP

U.S. PATENT DOCUMENTS				
EXAM-INER INI-TIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
	A1	5,107,359	04-21-92	Ohuchida
	A2	5,539,543	07-23-96	Liu, et al.
	A3	5,589,955	12-1996	Amako, et al.
	A4	5,428,466	06-1995	Rejman-Greene, et al.
	A5	4,952,010	08-1990	Healey, et al.
	A6	6,710,292 B2	03-2004	Fukuchi, et al.
	A7	6,975,786 B1	12-2005	Warr, et al.
	A8	6,115,123	09-2000	Stappaerts, et al.
	A9	5,995,251	11-19999	Hesselink, et al.
	A10	5,959,747	09-1999	Psaltis, et al.
	A11	6,072,608	06-2000	Psaltis, et al.
	A12			
	A13			
	A14			
	A15			
	A16			
	A17			
	A18			
	A19			
	A20			
	A21			
	A22			
	A23			
	A24			
	A25			

EXAMINER	DATE CONSIDERED

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

PTO-1449 REPRODUCED **INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **September 1, 2006** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO.	
	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE	
	EXAMINER	CONFIRMATION NO.	GROUP

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER Country Code-Number-Kind Code (if known)	DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT	TRANSLATION YES	NO
	B1	WO 01 90823 A1	11-29-01	Intelligent Pixels, Inc.		
	B2	WO 01 25848 A2	04-12-01	Thomas Swan & Co., Ltd.		
	B3	WO 01 25840 A1	04-12-01	Thomas Swan & Co., Ltd.		
	B4	WO 02 101451 A1	12-19-02	Honeywell International, Inc.		
	B5	WO 02 079870 A2	10-10-02	Thomas Swan & Co., Ltd.		
	B6	EP 1 050 775 A1	11-08-00	Thomas Swan & Co., Ltd.		
	B7	EP 1 053 501 B1	07-23-03	Thomas Swan & Co., Ltd.		
	B8					
	B9					
	B10					
	B11					
	B12					
	B13					
	B14					
	B15					
	B16					
	B17					
	B18					
	B19					
	B20					
	B21					
	B22					
	B23					
	B24					

EXAMINER	DATE CONSIDERED

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

TS0001317

PTO-1449 REPRODUCED **INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **September 1, 2006** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO.	
	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE	
	EXAMINER	CONFIRMATION NO.	GROUP

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*		
	C1	Mears, R. J., et al., "Telecommunications Applications of Ferroelectric Liquid-Crystal Smart Pixels," IEEE Journal of Selected Topics in Quantum Electronics, Vol. 2, No. 1, April 1996, pp. 35-46.
	C2	Mears, R. J., et al., "WDM Channel Management Using Programmable Holographic Elements," IEE Colloquim on Multiwavelength Optical Networks: Devices, Systems and Network Implementations," IEE, London, GB, 18 June 1998, pp. 11-1 - 11-6.
	C3	Pan, Ci-Ling, et al., "Tunable Semiconductor Laser with Liquid Crystal Pixel Mirror in Grating-Loaded External Cavity," Electronics Letters, IEE Stevenage, GB, Vol. 35, No. 17, 19 August 1999, pp. 1472-1473.
	C4	Marom, D.M., *et al.,* "Wavelength-Selective 1x4 Switch for 128 WDM Channels at 50 Ghz Spacing," *OFC Postdeadline Paper*, pp. FB7-1-FB7-3 (2002).
	C5	
	C6	
	C7	
	C8	
	C9	
	C10	
	C11	
	C12	
	C13	
	C14	
	C15	

EXAMINER	DATE CONSIDERED

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

PTO/SB/06 (12-04)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number: 11514725

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))			150			300	300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))			250			500	500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))			100			200	200
TOTAL CLAIMS (37 CFR 1.16(i))	8 minus 20 =	*	X$ 25		OR	X$50	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	5 minus 3 =	* 2	X$100			X$200	400
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			N/A			N/A	
			TOTAL			TOTAL	1400

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X =		OR	X =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X =		OR	X =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
					TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X =		OR	X =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X =		OR	X =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
					TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

TS0001319

UNITED STATES PATENT AND TRADEMARK OFFICE
UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002

CONFIRMATION NO. 4755
FORMALITIES LETTER

021005
HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

Date Mailed: 09/22/2006

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
  Applicant must submit $ **300** *to complete the basic filing fee for a non-small entity. If appropriate, applicant may make a written assertion of entitlement to small entity status and pay the small entity filing fee (37 CFR 1.27).*
- The oath or declaration is missing. *A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.*
  Note: If a petition under 37 CFR 1.47 is being filed, an oath or declaration in compliance with 37 CFR 1.63 signed by all available joint inventors, or if no inventor is available by a party with sufficient proprietary interest, is required.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- Additional claim fees of **$400** as a non-small entity, including any required multiple dependent claim fee, are required. Applicant must submit the additional claim fees or cancel the additional claims for which fees are due.
- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.16(f) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$1780** for a non-small entity

TS0001320

- **$300** Statutory basic filing fee.
- **$130** Surcharge.

- The application search fee has not been paid. Applicant must submit **$500** to complete the search fee.
- The application examination fee has not been paid. Applicant must submit **$200** to complete the examination fee for a non-small entity.
- The specification and drawings contain more than 100 pages. Applicant owes **$250** for **36** pages in excess of **100** pages for a non-small entity.

- Total additional claim fee(s) for this application is **$400**

  - **$400** for **2** independent claims over 3.

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199, or 1-800-972-6382
PART 3 - OFFICE COPY

TS0001321

IFW

OIPE IAP6 OCT 12 2006 PATENT & TRADEMARK OFFICE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002

CONFIRMATION NO. 4755

FORMALITIES LETTER

021005
HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

Date Mailed: 09/22/2006

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

10/13/2006 MBELETE1 00000028 11514725

01 FC:1011 300.00 OP
02 FC:1111 500.00 OP
03 FC:1311 200.00 OP
04 FC:1051 130.00 OP
05 FC:1081 250.00 OP
06 FC:1201 400.00 OP

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
  Applicant must submit $ **300** *to complete the basic filing fee for a non-small entity. If appropriate, applicant may make a written assertion of entitlement to small entity status and pay the small entity filing fee (37 CFR 1.27).*
- The oath or declaration is missing. *A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.*
  Note: If a petition under 37 CFR 1.47 is being filed, an oath or declaration in compliance with 37 CFR 1.63 signed by all available joint inventors, or if no inventor is available by a party with sufficient proprietary interest, is required.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- Additional claim fees of **$400** as a non-small entity, including any required multiple dependent claim fee, are required. Applicant must submit the additional claim fees or cancel the additional claims for which fees are due.
- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.16(f) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$1780** for a non-small entity

TS0001322

- **$300** Statutory basic filing fee.
- **$130** Surcharge.

- The application search fee has not been paid. Applicant must submit **$500** to complete the search fee.
- The application examination fee has not been paid. Applicant must submit **$200** to complete the examination fee for a non-small entity.
- The specification and drawings contain more than 100 pages. Applicant owes **$250** for **36** pages in excess of **100** pages for a non-small entity.

- Total additional claim fee(s) for this application is **$400**
  - **$400** for **2** independent claims over 3.

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199, or 1-800-972-6382
PART 2 - COPY TO BE RETURNED WITH RESPONSE

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;655132;1
TJM/jk(jam)
October 10, 2006

PATENT APPLICATION
Docket No.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2873
Filed:	September 1, 2006	Examiner:	Not yet assigned
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

OIPE OCT 12 2006 PATENT & TRADEMARK OFFICE

CERTIFICATE OF MAILING OR TRANSMISSION
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

10/10/06 [signature]
Date Signature

Julie Kertyzak
Typed or printed name of person signing certificate

REPLY TO NOTICE TO FILE MISSING PARTS OF APPLICATION

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In reply to the Notice to File Missing Parts dated September 22, 2006, the following documents and fees are being submitted for filing in the captioned application. A copy of the Notice is attached.

[X] **COPY OF EXECUTED DECLARATION FOR PATENT APPLICATION FOR PARENT APPLICATION**
(Separate transmittal letter and postcard not required)

[X] **COPY OF POWER OF ATTORNEY DOCUMENT FOR PARENT**
[ ] Granted by Inventor(s)
[X] Granted by Assignee, including Statement under 37 C.F.R. 3.73(b)
(Separate transmittal letter and postcard not required)

[ ] **PRELIMINARY AMENDMENT**
(Separate transmittal letter and postcard not required)

[X] **FILING FEE** - with Fee Transmittal for Patent Applications in duplicate
Fee calculations based on:
[X] Claims as originally filed
[ ] The Notice to File Missing Parts states an erroneous number of claims.
[ ] Claims upon entry of the Preliminary Amendment filed [herewith] [with the application]
(Separate transmittal letter and postcard not required)

[X] **SURCHARGE** - surcharge fee of $130.00
(Separate transmittal letter and postcard not required)

TS0001324

[ ] **SEQUENCE LISTING** - Filed concurrently and is attached

[ ] Preliminary Amendment included in Sequence Listing Transmittal
(Separate transmittal letter and postcard required)

[ ] **REPLACEMENT DRAWINGS** - [ ] sheets of replacement drawings consisting of Figs. 1 - [ ] are enclosed *(Separate transmittal letter and postcard not required)*

[ ] A Petition to Accept Color Drawings/Photographs (Fig(s). [ ]) are attached as required.
(Separate check for fees and postcard required)

[ ] **PETITION FOR EXTENSION OF TIME**

[ ] Applicant hereby petitions to extend the time to respond to the Notice to File Missing Parts dated [ ] for [ ] month(s) from [ ] to [ ]
The appropriate fee of $[ ] is included in the enclosed check

[ ] A [ ] month extension of time to respond to the Notice to File Missing Parts dated [ ] was filed on [ ] with payment of a $[ ] fee

[ ] Applicant hereby petitions for an additional [ ] month extension of time to respond to the Notice to File Missing Parts. The appropriate fee of $[ ] is included in the enclosed check

(Separate Petition for Extension of Time and postcard not required)

[ ] **REQUEST FOR CORRECTED FILING RECEIPT** - Filed concurrently and is attached
(Separate transmittal letter and postcard required)

[ ] **STATEMENT CLAIMING SMALL ENTITY STATUS**

[ ] Was filed on [ ]

[ ] Is enclosed herewith
(Separate transmittal letter and postcard not required)

[ ] In view of the small entity status of the captioned application, we hereby request a reimbursement of 50% of the filing fees in the amount of $[ ] which were paid on [ ] to be deposited in Deposit Account No. 08-0380

[ ] **OTHER** ______________________________

____

The fees required for filing the indicated documents are enclosed in the form of a check in the total amount of $1780.00. Please charge any deficiency or credit any overpayment in the fees that may be due in this matter to Deposit Account No. 08-0380. A copy of this letter is enclosed for accounting purposes.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]

Timothy J. Meagher
Registration No.: 39,302
Tel.: (978) 341-0036
Fax: (978) 341-0136

Concord, Massachusetts 01742-9133

Date: 10/10/06

TS0001325

OCT 12 2006 PATENT & TRADEMARK OFFICE

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

FEE TRANSMITTAL FOR PATENT APPLICATIONS	Attorney Docket Number	3274.1003-002
	Application Number	11/514,725
	First Named Inventor	Melanie Holmes

CLAIM CALCULATION (includes any preliminary amendment)

CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS (37 CFR 1.16(c) or (j))	8 − 20 =	0	x $ 50 =	$ 0
	INDEPENDENT CLAIMS (37 CFR 1.16(b) or (i))	5 − 3 =	2	x $200 =	$ 400
	MULTIPLE DEPENDENT CLAIMS (if applicable) (37 CFR 1.16(d))			+ $ 360 =	$ 0
			BASIC FEE Filed before 12/8/04 / Filed on/after 12/8/04		$ 300
	APPLICATION SIZE FEE (Applies if filed on or after 12/8/04) $250 for each add'l 50 sheets exceeding 100		Specification: 100 pages; Drawings: 36 sheets; Sequence Listing: 0 pages; Total No. Pages/Sheets 136		$ 250
			SEARCH FEE Filed before 12/8/04 / Filed on/after 12/8/04		$ 500
			EXAMINATION FEE Filed before 12/8/04 / Filed on/after 12/8/04		$ 200
			Total of above Calculations =		$ 1650
	Reduction by 50% for filing by small entity (37 CFR 1.9, 1.27, 1.28) =				$
	TOTAL =				$ 1650
	Surcharge - Late Filing of Declaration or Filing Fees (37 C.F.R. 1.16(f)) =				$ 130
	Petition for Extension of Time Fee (37 C.F.R. 1.17) =				$
	Assignment Recordation Fee = (only when filed with application)				$
	[Other]				$
	TOTAL =				$ 1780

1. Small entity status:
   - a. [ ] A small entity statement is enclosed.
   - b. [ ] A small entity statement was filed in the prior non-provisional application and such status is still proper and desired.
   - c. [ ] Is no longer claimed.
2. [X] Please charge any deficiency or credit any overpayment in the fees that may be due in this matter to Deposit Account No. 08-0380. A copy of this letter is enclosed for accounting purposes.
3. [X] A check is enclosed for **$1780.00**. [ ] Please charge **$[ ]** to Deposit Account No. 08-0380.
4. [ ] Other: ____________________

Signature	[signature]	Date	10/10/6
Submitted by Typed or Printed Name	Timothy J. Meagher	Reg. Number	39,302

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;655133;1

TS0001326

DOCKET NO. 3274.1003-000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Declaration for Patent Application

[ ] Supplemental (37 C.F.R. §1.67)

As a named inventor, I hereby declare that:

My residence, mailing address and citizenship are as stated next to my name;

I believe I am the original, first and sole inventor (if only one name is listed) or an original, first and joint inventor (if plural names are listed in the signatory page(s) commencing at page 2 hereof) of the subject matter which is claimed and for which a patent is sought on the invention entitled

OPTICAL PROCESSING

the specification of which (check one)

[ ] is attached hereto.

[ ] was filed on [ ] as United States Application Number [ ].

[X] was filed on 2 September 2002 as PCT International Application No. PCT/GB02/04011 and assigned United States Application No. **10/487,810**.

[ ] and was amended on [ ] (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. §1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119 or 365 of any foreign application(s) for patent or inventor's certificate, or of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Not Claimed	Certified Copy Filed? YES	NO
0121308.1 (Number)	Great Britain (Country)	03/September/2001 (Day/Month/Year filed)	[ ]	[ ]	[X]
(Number)	(Country)	(Day/Month/Year filed)	[ ]	[ ]	[ ]

TS0001327

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 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole
or first inventor Melanie Holmes
Inventor's Signature *Melanie Holmes* Date *20.08.04*
Residence 39 Orford Street
Ipswich IP1 3PE Great Britain
Citizenship Great Britain
Mailing Address Same as above

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;459016;1

 COPY

OIPE
OCT 12 2006
PATENT & TRADEMARK OFFICE

COPY FOR CONTINUING APPLICATION

POWER OF ATTORNEY OR AUTHORIZATION OF AGENT AND CORRESPONDENCE ADDRESS

Application Number	10/487,810
International Filing Date	2 September 2002
First Named Inventor	Melanie Holmes
Confirmation Number	
Group Art Unit	
Examiner Name	
Attorney Docket Number	3274.1003-000

Title	OPTICAL PROCESSING

I/We hereby appoint

[X] the attorneys/agents associated with **Customer No. 021005**

[ ] Practitioner(s) named below:

as my/our attorneys/agents to prosecute the application identified above, including any continuation or divisional applications thereof, and to transact all business in the United States Patent and Trademark Office connected therewith.

The correspondence address for the above-identified application is:

[X] Customer Number 021005
Hamilton, Brook, Smith & Reynolds, P.C.
530 Virginia Road
P.O. Box 9133
Concord, Massachusetts 01742-9133

[ ] Other

Please direct all telephone calls and facsimiles to:

Name Timothy J. Meagher, Esq. Tel. No. 978-341-0036 Fax No. 978-341-0136

I am the:

[ ] Applicant/Inventor.

[X] Authorized representative of the Assignee, Thomas Swan & Co. Ltd., of the entire interest. See 37 C.F.R. § 3.71. A Statement under 37 C.F.R. §3.73(b) is enclosed.

[ ] Authorized representative of the Assignee, [ ], together with [ ], of the entire interest. A Statement under 37 C.F.R. § 3.73(b) is enclosed.

SIGNATURE of Applicant or Assignee of Record	
Name & Title	IAN BONAS DIRECTOR
Signature	I G Bonas
Date	2 SEPTEMBER 2004

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;459090;1

TS0001329

Docket No. 3274.1003-000

STATEMENT UNDER 37 C.F.R. § 3.73(b)

Inventor(s): Melanie Holmes

Application No./Patent No.: 10/487,810 International Filing Date: 2 September 2002

For: OPTICAL PROCESSING

Thomas Swan & Co. Ltd. (Name of Assignee), a corporation (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.),

states that it is

A. [X] the assignee of the entire right, title and interest in the patent application identified above; or

B. [ ] an assignee together with [ ] of the entire right, title and interest in the patent application identified above.

The right, title and interest of the above-named assignee in the patent application identified above is established by virtue of:

A. [X] An assignment from the inventor(s) of the patent application identified above. The assignment was recorded in the Patent and Trademark Office at Reel __________, Frame __________, or a copy thereof is attached.

OR

B. [ ] A chain of title from the inventor(s) of the patent application identified above, to the current assignee as shown below:

1. From: __________ To: __________
   The document was recorded in the United States Patent and Trademark Office at Reel __________, Frame __________, or a copy thereof is attached.

2. From: __________ To: __________
   The document was recorded in the United States Patent and Trademark Office at Reel __________, Frame __________, or a copy thereof is attached.

3. From: __________ To: __________
   The document was recorded in the United States Patent and Trademark Office at Reel __________, Frame __________, or a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet.

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Date: 2 September 2004

Name: Ian Bonas

Title: Director

Signature: [signature]

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;459100;1

TS0001330

COPY
NOT FOR RECORDATION

Docket No. 3274.1003-000

Sole

ASSIGNMENT

WHEREAS, I, **Melanie Holmes**, have invented a certain improvement in **Optical Processing**, described in an application for Patent,

[ ] the specification of which is being executed on even date herewith and is about to be filed in the United States Patent Office *(use for 37 CFR §1.53(b) filings only)*;

[ ] is about to be filed in the United States Patent Office as a Provisional Application;

[ ] the specification of which is United States Application No.[ ], filed [ ];

[X] the specification of which is a Patent Cooperation Treaty Application, International Application No. **PCT/GB02/04011**, which designates the United States of America;

[ ] which was patented under United States Patent No. [ ].

WHEREAS, **Thomas Swan & Co. Ltd.** (hereinafter "ASSIGNEE"), a corporation organized and existing under the laws of the United Kingdom, and having a usual place of business at **Crookhall, Consett, Co. Durham DH8 7ND, United Kingdom,** desires to acquire an interest therein in accordance with agreements duly entered into with me:

NOW, THEREFORE, to all whom it may concern be it known that for and in consideration of said agreements and of other good and valuable consideration, the receipt of which is hereby acknowledged, I have sold, assigned and transferred and by these presents do hereby sell, assign and transfer unto said ASSIGNEE, its successors, assigns and legal representatives, the entire right, title and interest in and throughout the United States of America, its territories and all foreign countries. in and to said invention as described in said application, together with the entire right, title and interest in and to said application and such Letters Patent as may issue on said invention; said invention, application and Letters Patent to be held and enjoyed by said ASSIGNEE for its own use and behalf and for its successors, assigns and legal representatives, to the full end of the term for which said Letters Patent may be granted as fully and entirely as the same would have been held by me had this assignment and sale not been made; I hereby convey all rights arising under or pursuant to any and all international agreements, treaties or laws relating to the protection of industrial property by filing any such applications for Letters Patent. I hereby acknowledge that this assignment, being of the entire right, title and interest in and to said invention, carries with it the right in ASSIGNEE to apply for and obtain from competent authorities in all countries of the world any and all Letters Patent by attorneys and agents of ASSIGNEE's selection and the right to procure the grant of all such Letters Patent to ASSIGNEE for its own name as assignee of the entire right, title and interest therein;

AND, I hereby further agree for myself and my executors and administrators to execute upon request any other lawful documents and likewise to perform any other lawful acts which may be deemed necessary to secure fully the aforesaid invention to said ASSIGNEE, its successors, assigns and legal representatives, but at its or their expense and charges, including the

TS0001331

-2-

Docket No. 3274.1003-000

execution of applications for patents in foreign countries, and the execution of any further applications including substitution, reissue, divisional or continuation applications, and preliminary or other statements and the giving of testimony in any interference or other proceeding in which said invention or any application or patent directed thereto may be involved;

AND, I do hereby authorize and request each Patent Office and the Commissioner of Patents of the United States to issue such Letters Patent as shall be granted upon said invention to said ASSIGNEE, its successors, assigns, and legal representatives.

Inventor Melanie Holmes Date 20.08.04
Melanie Holmes

Address 39 Orford Street
Ipswich IP1 3PE Great Britain

Witness ARISTODIMOS KOURIS
Address 57 ROCEMILL END WILLINGHAM,
CAMBRIDGE, CB4 5HY

Witness JASON REICH
Address 109 KINGS HEDGES RD
CAMBRIDGE, CB4 2PL

@PFDesktop\::ODMA/MHODMA/HBSR03:iManage;459060;1

TS0001332

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	DRAWINGS	TOT CLAIMS	IND CLAIMS
11/514,725	09/01/2006	2873	1780	3274.1003-002	36	8	5

CONFIRMATION NO. 4755

UPDATED FILING RECEIPT

021005
HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA01742-9133

Date Mailed: 11/07/2006

Receipt is acknowledged of this regular Patent Application. It will be considered in its order and you will be notified as to the results of the examination. Be sure to provide the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION when inquiring about this application. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please mail to the Commissioner for Patents P.O. Box 1450 Alexandria Va 22313-1450. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections (if appropriate).**

Applicant(s)

Melanie Holmes, Ipswich, UNITED KINGDOM;

Assignment For Published Patent Application

Thomas Swan & Co. Ltd., Durham, UNITED KINGDOM

Power of Attorney: The patent practitioners associated with Customer Number 021005

Domestic Priority data as claimed by applicant

This application is a DIV of 10/487,810 09/10/2004
which is a 371 of PCT/GB02/04011 09/02/2002

Foreign Applications

UNITED KINGDOM 0121308.1 09/03/2001

If Required, Foreign Filing License Granted: 09/19/2006

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is
US11/514,725

Projected Publication Date: 02/15/2007

Non-Publication Request: No

Early Publication Request: No

Title

TS0001333

Optical processing

Preliminary Class

359

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002

CONFIRMATION NO. 4755

21005
HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA01742-9133

Title: Optical processing

Publication No. US-2007-0035803-A1
Publication Date: 02/15/2007

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 703-305-3028.

Pre-Grant Publication Division, 703-605-4283

TS0001336

IFW

765953_1
?JM/jk(jt)
November 7, 2007

PATENT APPLICATION
DOCKET NO.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2873
Filed:	September 1, 2006	Examiner:	Not Yet Assigned
Confirmation No.:	4755		
For:	Optical Processing		

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

11/7/07 Julie Kertyzak
Date Signature

Julie Kertyzak
Typed or printed name of person signing certificate

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Information Disclosure Statement is submitted:

☒ under 37 CFR 1.97(b), or
(Within any one of the following time periods: three months of filing national application (other than a CPA) or date of entry of the national stage in an international application; or before the mailing date of a first office action on the merits in a non-provisional application, including a CPA, or a Request for Continued Examination).

☐ under 37 CFR 1.97(c) together with either:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, or
- ☐ a $180.00 fee under 37 CFR 1.17(p), or

(After the 37 CFR 1.97(b) time period, but before final action or notice of allowance, whichever occurs first)

☐ under 37 CFR 1.97(d) together with:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, and
- ☐ a $180.00 fee under 37 CFR 1.17(p), or

(Filed after final action or notice of allowance, whichever occurs first, but on or before payment of the issue fee)

☐ under 37 CFR 1.97(i):
Applicant requests that the IDS and cited reference(s) be placed in the application file.
(Filed after payment of issue fee)

TS0001337

Statement Under 37 CFR 1.97(e)

☐ Each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement; or

☐ No item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned, after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

Statement Under 37 CFR 1.704(d) (Patent Term Adjustment)
Applies to original applications (other than design) filed on or after May 29, 2000

☐ Each item of information contained in the Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the Information Disclosure Statement.

☒ Enclosed herewith is a Listing of References:

- ☒ Copies of the cited references are enclosed.
  - ☐ Copies of issued U.S. patents and published U.S. applications are not required and are not being provided.

☐ Copies of the cited references are enclosed except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. **[OPTION]**[120][121][365(c)] is claimed. **[OPTIONAL** [The earlier application contains copies of the cited references.]

☐ The listed references were cited in the enclosed International Search Report in a counterpart foreign application.

☐ The "concise explanation" requirement (non-English references) for reference(s) [ ] under 37 CFR 1.98(a)(3) is satisfied by:

- ☐ the explanation provided on the attached sheet.
- ☐ the explanation provided in the Specification.
- ☐ submission of the enclosed International Search Report.
- ☐ submission of the enclosed English-language version of a foreign Search Report and/or foreign Office Action.
- ☐ the enclosed English language abstract.

☐ Applicant requests that the following non-published pending applications be considered:
(Affix a label or apply the stamp "Non-Published IDS Reference - Do Not Scan" to the front of each unpublished pending appl'n.)

Examiner's Initials

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

_____ U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

Examiner ____________________ Date ____________________

☐ A copy of each above-cited application, including the current claims, is enclosed, except any application filed on or after June 30, 2003, which has been scanned into the PTO's Image File Wrapper (IFW) system and is available to the examiner.

☐ A copy of each above-cited application, including the current claims, is enclosed, except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. **[OPTION]**[120][121][365(c)] is claimed.

The Examiner is requested to return a copy of the above list of pending applications indicating which references were considered with the next office communication.

It is requested that the information disclosed herein be made of record in this application.

Method of payment:

☐ A check for the fee noted above is enclosed, or the fee has been included in the check with the accompanying Reply. A copy of this Statement is enclosed.

☐ Please charge Deposit Account 08-0380 in the amount of $[ ]. A copy of this Statement is enclosed.

☒ Please charge any deficiency in fees and credit any overpayment to Deposit Account 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]
Timothy J. Meagher, Esq.
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 11/7/7

TS0001339

4 × 4 free-space optical switching using real-time binary phase-only holograms generated by a liquid-crystal display

Hirofumi Yamazaki and Masayasu Yamaguchi

NTT Communication Switching Laboratories, 9-11, Midori-Cho 3-Chome Musashino-Shi, Tokyo, 180 Japan

Received April 17, 1991

Experimental 4 × 4 free-space optical switching is successfully demonstrated by real-time binary phase-only holograms. The real-time holograms are generated by a twisted nematic liquid-crystal display, which is a binary phase-only modulator. This holographic free-space switching is applicable to optical interconnections and photonic switching systems.

Optical interconnections are becoming more important as signal speeds become higher in the fields of communication and computation, because optical interconnections have much broader bandwidth than do electronic interconnections.[1] Optics can offer a high degree of parallelism, which is suitable for free-space optical systems that have more input–output ports than do planar waveguide systems.

$N \times N$ free-space optical switches are classified into matrix types,[2] multistage network types (e.g., a crossover network),[3] and holographic switching types as shown Fig. 1. The problems of matrix types and multistage network types are that the switch volume and the loss of the signal intensity manifestly become larger as the number of terminals increases, because in a matrix-type switch, an input signal is distributed to all output ports, and in a multistage network type, an input signal goes through many 2 × 2 switches between the input and output terminals. Real-time hologram switches can be constructed in a one-stage structure and do not have to distribute input signals to all output ports. Therefore hologram switches can be compact and low-loss switches.

However, changing holograms at high speed, which is necessary for fast switching, has been difficult. Recently, some spatial light modulators [e.g., a liquid-crystal light valve and a liquid-crystal display (LCD)] that can be controlled in real time have become commercially available and have enabled holograms to be changed rapidly.[4,5] Marom and Konforti demonstrated an experimental holographic interconnection using a liquid-crystal light valve and a cathode-ray tube on which a computer-generated hologram is drawn.[6] Their research aims at signal distribution in electronic circuits, thus the demonstration corresponds to a star coupler with only one active input.

This Letter describes $N \times N$ free-space optical switching in which any point-to-point connection patterns can be provided between four inputs and four outputs. We use a twisted nematic LCD, which is a binary phase-only modulator that offers fast hologram modification by means of computer-generated holograms.

In the experiment, optical switching is achieved using spatial binary phase-only modulation with a twisted nematic LCD. The display that we used is an active-dot-matrix type manufactured by Hosidenki Corporation for an overhead projector. It has 640 horizontal and 400 vertical pixels (pixel size 0.33 mm × 0.33 mm), and the rise and fall times of the pixels are specified to be less than 50 ms, sufficient for call-by-call switching in communication switching systems. If a faster response time is required, it can be reduced to a few tens of microseconds by replacing the nematic liquid crystal by a ferroelectric liquid crystal.

The twist of the LCD is 90° in the off state (i.e., the polarization of the light signals through the LCD rotates 90°). Binary phase-only modulation is obtained by using the LCD without polarizers, where the light passes through the LCD twice (a round trip) to obtain no polarization change. If an untwisted LCD were used instead of the twisted nematic LCD, the return trip of the light through the LCD could be eliminated because the polarization of the beam would not rotate when it goes through the display. This improvement would make the optical setup simpler. According to the measurement with the grating interferometer,[7] the spatial phase modulation depth of the light through the LCD is approximately $\pi/3$ for a one-way trip and $2\pi/3$ for a round trip. The available depth of the phase modulation using this display is $2\pi/3$ because of the relation between the wavelength and the thickness of the liquid-crystal layer. The $2\pi/3$ depth is slightly less than the depth of π sufficient to give complete binary phase-only modulation.[8]

Figure 2 shows the optical setup that we used. The light source is a He–Ne laser with a wavelength of 633 nm. The polarization of the input light is aligned parallel with the liquid-crystal molecule director at the front of the display using a $\lambda/4$ plate and a polarizer. The beam is expanded by lenses L1, L2, L3, and L4 to be incident upon the LCD. The beam goes through lenses L5 and L6 and reflects off mirror M2 to be modulated twice by a grating pattern (a real-time hologram) on the display. The reflected light from mirror M2 is ex-

0146-9592/91/181415-03$5.00/0

05

TS0001340

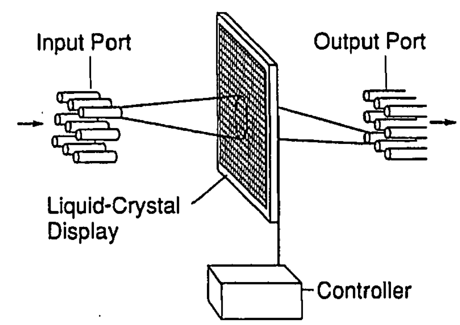

Fig. 1. Schematic diagram of a free-space optical switch using a LCD.

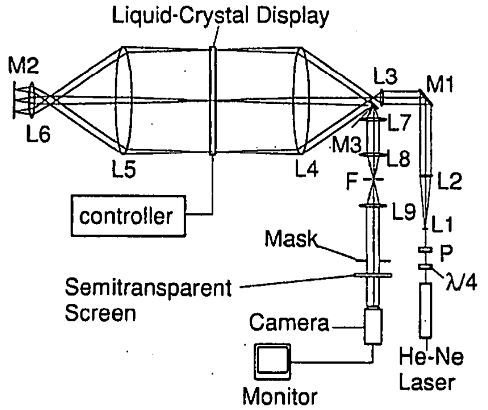

Fig. 2. Experimental setup for free-space optical switching using binary phase-only modulation with a LCD. L1–L9, lenses; M1–M3, mirrors; F, spatial filter; P, polarizer.

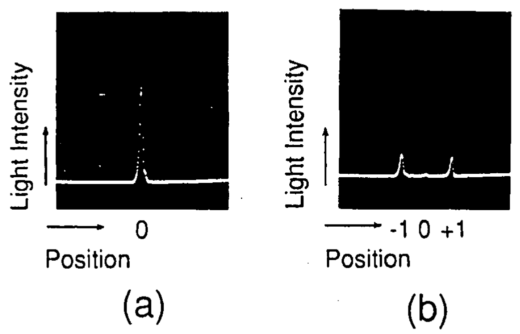

Fig. 3. Intensity distribution of the diffracted light on the output plane. (a) The output when nothing is drawn on the LCD. (b) The output when the phase grating (1.5 line pairs/mm) is drawn on the LCD.

tracted by mirror M3 and is reduced by lenses L4 and L7. The zero-order beam is extracted by lenses L8 and L9 and the spatial filter F from the diffracted light generated by the effect of the regular grid structure of the LCD.[9] The diameter of the beam at the LCD is 22 mm and is reduced to one tenth by lenses L4 and L7.

Figure 3(a) shows the intensity distribution of the diffracted light on the output plane (semitransparent screen) when nothing is drawn on the LCD. Figure 3(b) shows the light diffracted with a phase grating written at regular pixel intervals on the LCD. The spatial frequency of the phase grating on the LCD is 1.5 line pairs/mm, which corresponds to 15 line pairs/mm, because the diameter of the beam is reduced to one tenth in the optical setup. The first-order light is diffracted to 0.6° by the phase grating drawn on the display. The zero-order beam does not disappear completely in Fig. 3(b) because the depth of the phase modulation is $2\pi/3$. Its intensity is equivalent to 29% of the first-order intensity. If the depth could be π, the zero-order beam would completely disappear.

Next, 4 × 4 free-space optical switching is demonstrated by using the optical setup in Fig. 2. The incident lights are four parallel beams whose diameters are 1 mm. Each of the four beams is launched into a different area of the LCD and is indepen-

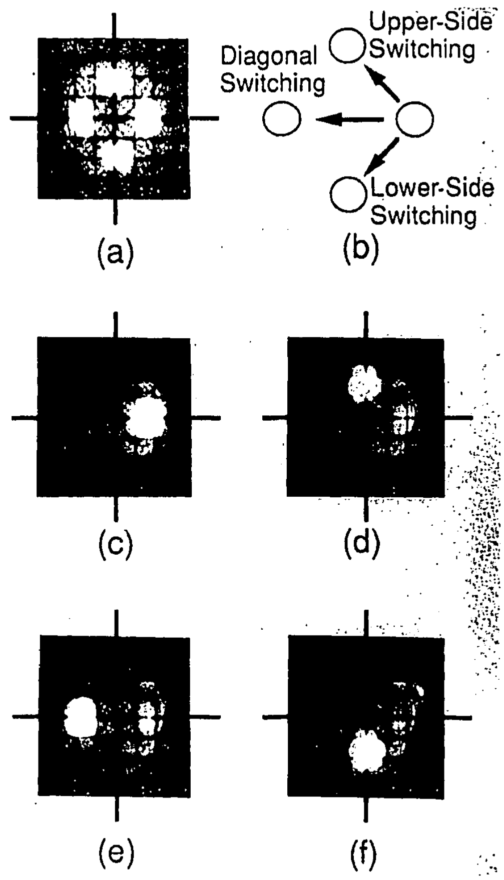

Fig. 4. Experimental results of 4 × 4 free-space optical switching. (a) Four outputs from four inputs when nothing is drawn on the LCD. (b) Movement of an output beam that results from 4 × 4 switching. (c) Output from a single input when nothing is drawn on the LCD. (d) Output switched to the upper-side port. (e) Output switched to the diagonal port. (f) Output switched to the lower-side port. The noise observed in the figures is caused by the lack of phase-modulation depth ($2\pi/3$) with our LCD.

dently controlled. The phase grating at each area is a square of 50 × 50 pixels. The maximum spatial frequency (1.5 line pairs/mm) of the phase grating can be obtained when a grating is vertically or horizontally drawn on the LCD. Any other orientation of a grating gives a spatial frequency smaller than 1.5 line pairs/mm. The positions of the incident beams are at the corners of a square inclined at 45° as shown in Fig. 4(a), because switching between beams at opposite corners of the square needs a larger diffraction angle than switching between the beams on the same side. The output beams are projected onto a semitransparent screen placed on the plane where the zero-order beams (when the grating is not drawn) intersect the first-order beams diffracted with the phase grating.

Figure 4(a) shows four outputs from four inputs when no phase grating is drawn. Figure 4(b) schematically shows one input beam being switched to three other possible output positions. Figures 4(c)–4(f) show the outputs when only one input enters the optical setup. Figure 4(c) shows the output when no grating is drawn, and Figs. 4(d)–4(f) show the outputs switched to the three other output ports when a grating is drawn. The noise observed in Fig. 4 is caused by the lack of phase-modulation depth ($2\pi/3$) with our LCD. If the phase-modulation depth becomes π, the noise could be reduced. An input can be directed to any of the four output ports using binary phase-only modulation. Similarly, the other output beams also switch to all the output ports. In this experiment, higher-order diffracted light, generated by the grating, is removed by the spatial filter F, and minus-first-order light is shut out by the mask.

It is important to estimate the achievable scale of the input–output array of a switch. In the experiment, 4 × 4 free-space optical switching is achieved by devising the arrangement of the input and output ports. However, it is more difficult to design a large-scale switch for which each input can be connected with all outputs and the output ports can avoid unwanted lights (minus- or higher-order diffracted light generated by the grating). A solution to this problem is to put a lens between the LCD and the output ports and to locate the output on the focal plane of the lens. In this case, each position on the focal plane corresponds to the orientation (diffraction angle) of the light diffracted by the hologram and is independent of the input position. Since the output ports can be arranged regardless of the input positions, this method makes it easier to design a large array. Therefore we estimate the achievable scale of an input–output array with this method as follows.

The input–output array scale is limited mainly by the achievable space bandwidth, which is restricted by the pixel size and the number of pixels on the LCD. Therefore, in order to increase the array scale, it is necessary to miniaturize the pixel size and to increase the number of the pixels on the LCD. Furthermore the space bandwidth can also be widened by introducing beam expansion/reduction optics as shown in Fig. 2. Assuming that the LCD has 330 μm × 330 μm pixels and the diameter of the light beam diffracted by a hologram is reduced to one tenth with the optics, we can achieve an array scale of approximately 10 (i.e., a 10 input/10 output switch). If the pixel size is 10 μm × 10 μm and the diameter of the diffracted light is reduced to one tenth, the LCD would be able to switch between several hundred terminals. However, further investigation is needed for such a large-scale switch.

References

1. J. W. Goodman, F. I. Leonberger, S. Y. Kung, and R. A. Athale, Proc. IEEE **72**, 850 (1984).
2. A. A. Sawchuk, B. K. Jenkins, C. S. Raghavendra, and A. Varma, Computer **20**, 50 (1987).
3. J. Jahns and M. J. Murdocca, Appl. Opt. **27**, 3155 (1988).
4. H. Farhoosh, Y. Fainman, K. Urquhart, and S. H. Lee, Proc. Soc. Photo-Opt. Instrum. Eng. **1052**, 172 (1989).
5. B. Fracasso, J. L. de Bougrenet de la Tocnaye, and P. Ambs, Opt. Lett. **15**, 1473 (1990).
6. E. Marom and N. Konforti, Opt. Lett. **12**, 539 (1987).
7. T. H. Barnes, T. Eiju, K. Matsuda, and N. Ooyama, Appl. Opt. **28**, 4845 (1989).
8. J. L. Horner and J. R. Leger, Appl. Opt. **24**, 609 (1985).
9. D. Casasent and S. F. Xia, Opt. Lett. **11**, 398 (1986).

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **November 7, 2007** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Not Yet Assigned	CONFIRMATION NO. 4755	GROUP 2873

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*		
	C5	Yamazaki, H., *et al.*, "4 x 4 Free Space Optical Switching Using Real-Time Binary Phase-Only Holograms Generated by a Liquid-Crystal Display," *Optical Society of America*, 16(18):1415-1417 (1991).

EXAMINER	DATE CONSIDERED

765954_1

TS0001343

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002	4755

21005 7590 01/28/2008
HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

EXAMINER	
ASSAF, FAYEZ G	
ART UNIT	**PAPER NUMBER**
2872	
MAIL DATE	**DELIVERY MODE**
01/28/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

TS0001344

Office Action Summary	Application No.	Applicant(s)
	11/514,725	HOLMES, MELANIE
	Examiner	**Art Unit**
	Fayez G. Assaf	2872

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 1 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-8 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☒ Claim(s) 1-8 are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

Election/Restrictions

Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-3, drawn to an optical add/drop or a monitoring device, classified in class 385, subclass 24.

II. Claims 4-8, drawn to a routing device, classified in class 385, subclass 15.

The inventions are distinct, each from the other because of the following reasons:

Inventions I and II are related as subcombinations disclosed as usable together in a single combination. The subcombinations are distinct if they do not overlap in scope and are not obvious variants, and if it is shown that at least one subcombination is separately usable. In the instant case, subcombination II has separate utility such as in a combination not requiring displays of holograms or the functionality of the multiplexer. See MPEP § 806.05(d).

The examiner has required restriction between subcombinations usable together. Where applicant elects a subcombination and claims thereto are subsequently found allowable, any claim(s) depending from or otherwise requiring all the limitations of the allowable subcombination will be examined for patentability in accordance with 37 CFR 1.104. See MPEP § 821.04(a).

Applicant is advised that if any claim presented in a continuation or divisional application is anticipated by, or includes all the limitations of, a claim that is allowable in the present application, such claim may be subject to provisional statutory and/or nonstatutory double patenting rejections over the claims of the instant application.

Restriction for examination purposes as indicated is proper because all these inventions listed in this action are independent or distinct for the reasons given above and there would be a serious search and examination burden if restriction were not required because one or more of the following reasons apply:

(a) the inventions have acquired a separate status in the art in view of their different classification;

(b) the inventions have acquired a separate status in the art due to their recognized divergent subject matter;

(c) the inventions require a different field of search (for example, searching different classes/subclasses or electronic resources, or employing different search queries);

(d) the prior art applicable to one invention would not likely be applicable to another invention;

(e) the inventions are likely to raise different non-prior art issues under 35 U.S.C. 101 and/or 35 U.S.C. 112, first paragraph.

Applicant is advised that the reply to this requirement to be complete <u>must</u> include (i) an election of a invention to be examined even though the requirement may be traversed (37 CFR 1.143) **and (ii) identification of the claims encompassing the elected invention.**

The election of an invention may be made with or without traverse. To reserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the restriction requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable on the elected invention.

If claims are added after the election, applicant must indicate which of these claims are readable upon the elected invention.

Should applicant traverse on the ground that the inventions are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103(a) of the other invention.

Applicant is advised that the reply to this requirement to be complete must include (i) an election of a species or invention to be examined even though the requirement be traversed (37 CFR 1.143) and (ii) identification of the claims encompassing the elected invention.

The election of an invention or species may be made with or without traverse. To reserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the restriction requirement, the election shall be treated as an election without traverse.

Should applicant traverse on the ground that the inventions or species are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions or species to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C.103(a) of the other invention.

Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Fayez G. Assaf whose telephone number is (571) 272-2307. The examiner can normally be reached on 8-5 M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephone Allen can be reached on (571) 272-2434. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Fayez G. Assaf
Primary Examiner
Art Unit 2872

1/19/2007

1/19/07

TS0001351

786966_1
TJM/jk
02/12/08

OIPE IAP39 FEB 28 2008 PATENT & TRADEMARK OFFICE

PATENT APPLICATION
Docket No.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	F. G. Assaf
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

CERTIFICATE OF MAILING OR TRANSMISSION
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

2/25/08 — Julie Kertyzak
Date — Signature

Julie Kertyzak
Typed or printed name of person signing certificate

REPLY TO RESTRICTION REQUIREMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Responsive to the Restriction Requirement dated January 28, 2008, the claims of Group II (Claims 4-8) drawn to a routing device are elected for prosecution. Applicant reserves the right to file a continuing application or take such other appropriate action as deemed necessary to protect the non-elected inventions. Applicant does not hereby abandon or waive any rights in the non-elected inventions.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 2/25/8

TS0001352

800586_1
TJM/jk(jam)
April 16, 2008

PATENT APPLICATION
DOCKET NO.: 3274.1003-002

OIPE APR 18 2008 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Melanie Holmes

Application No.: 11/514,725 Group: 2872

Filed: September 1, 2006 Examiner: Fayez G. Assaf

Confirmation No.: 4755

For: OPTICAL PROCESSING

CERTIFICATE OF MAILING OR TRANSMISSION
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

4/16/08 Julie Kertyzak
Date Signature

Julie Kertyzak
Typed or printed name of person signing certificate

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Information Disclosure Statement is submitted:

☒ under 37 CFR 1.97(b), or
(Within any one of the following time periods: three months of filing national application (other than a CPA) or date of entry of the national stage in an international application; or before the mailing date of a first office action on the merits in a non-provisional application, including a CPA, or a Request for Continued Examination).

☐ under 37 CFR 1.97(c) together with either:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, or
- ☐ a $180.00 fee under 37 CFR 1.17(p), or

(After the 37 CFR 1.97(b) time period, but before final action or notice of allowance, whichever occurs first)

☐ under 37 CFR 1.97(d) together with:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, and
- ☐ a $180.00 fee under 37 CFR 1.17(p), or

(Filed after final action or notice of allowance, whichever occurs first, but on or before payment of the issue fee)

☐ under 37 CFR 1.97(i):
Applicant requests that the IDS and cited reference(s) be placed in the application file.
(Filed after payment of issue fee)

TS0001353

Statement Under 37 CFR 1.97(e)

☐ Each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement; or

☐ No item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned, after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

Statement Under 37 CFR 1.704(d) (Patent Term Adjustment)
Applies to original applications (other than design) filed on or after May 29, 2000

☐ Each item of information contained in the Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the Information Disclosure Statement.

☒ Enclosed herewith is a Listing of References:

☒ A copy of the cited reference, B8, is enclosed.

☒ Copies of issued U.S. patents and published U.S. applications are not required and are not being provided.

☐ Copies of the cited references are enclosed except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. **[OPTION]**[120]**[**121**]**[365(c)**]** is claimed. **[OPTIONAL [**The earlier application contains copies of the cited references.**]**

☐ The listed references were cited in the enclosed Search Report in counterpart foreign application [add application number].

☐ The "concise explanation" requirement (non-English references) for reference(s) [ ] under 37 CFR 1.98(a)(3) is satisfied by:

☐ the explanation provided on the attached sheet.

☐ the explanation provided in the Specification.

☐ submission of the enclosed International Search Report.

☐ submission of the enclosed English-language version of a foreign Search Report and/or foreign Office Action.

☐ the enclosed English language abstract.

☒ Applicant requests that the following non-published pending applications be considered:
(Affix a label or apply the stamp "Non-Published IDS Reference - Do Not Scan" to the front of each unpublished pending appl'n.)

U.S. Patent Application No. 11/978,258, by Melanie Holmes, filed October 29, 2007, Docket No.: 3274.1003-003

U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

☒ A copy of each above-cited application, including the current claims, is enclosed, except any application filed on or after June 30, 2003, which has been scanned into the PTO's Image File Wrapper (IFW) system and is available to the examiner.

☐ A copy of each above-cited application, including the current claims, is enclosed, except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. **[OPTION]**[120][121][365(c)] is claimed.

It is requested that the information disclosed herein be made of record in this application.

Method of payment:

☐ A check for the fee noted above is enclosed, or the fee has been included in the check with the accompanying Reply. If this submission is in paper form, a copy of this letter is enclosed for accounting purposes.

☐ Please charge Deposit Account 08-0380 in the amount of $[ ]. If this submission is in paper form, a copy of this letter is enclosed for accounting purposes.

☒ Please charge any deficiency in fees and credit any overpayment to Deposit Account 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By_______________________
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 4/16/8

TS0001355

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **April 16, 2008** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO. 11/514,725	
	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE September 1, 2006	
	EXAMINER Fayez G. Assaf	CONFIRMATION NO. 4755	GROUP 2872

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
	A12	6,747,774 B2	06/08/2004	Kelly, *et al.*
	A13	6,760,511 B2	07/06/2004	Garrett, *et al.*
	A14	6,529,307 B1	03/04/2003	Peng, *et al.*
	A15	6,594,082 B1	07/15/2003	Li, *et al.*
	A16	5,960,133	09/28/1999	Tomlinson
	A17	2005/0270616 A1	12/08/2005	Weiner
	A18	2004/0126120 A1	07/01/2004	Cohen, *et al.*
	A19	2007/0268537 A1	11/22/2007	Holmes

EXAMINER	DATE CONSIDERED

800580 1

TS0001356

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **April 16, 2008** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Fayez G. Assaf	CONFIRMATION NO. 4755	GROUP 2872

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER Country Code-Number-Kind Code (if known)	DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT	TRANSLATION YES	NO
	B8	EP 1 207 418 A1	05/22/2002	Alcatel		

EXAMINER	DATE CONSIDERED

800580_1

TS0001357

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 207 418 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.05.2002 Bulletin 2002/21

(51) Int Cl.7: G02F 1/01, G02F 1/1334,
G02F 1/1335

(21) Application number: 00440299.6

(22) Date of filing: 20.11.2000

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: ALCATEL
75008 Paris (FR)

(72) Inventors:
- Bayart, Dominique
92140 Clamart (FR)
- Chevallier, Raymond
29217 Plougonvelin (FR)
- De Bougrenet De La Tocnaye, Jean-Louis
29290 Saint-Renan (FR)
- Dupont, Laurent
29280 Plouzané (FR)

(74) Representative: Rausch, Gabriele, Dr. et al
Alcatel
Intellectual Property Department, Stuttgart
70430 Stuttgart (DE)

(54) Dynamic spatial equalizer based on a spatial light modulator

(57) A spatial light modulator (SLM) is made up of a cell filled with a liquid crystal (LC) based substance. Latter has a variable scattering property with respect to an electric field present in the cell. By using a plurality of electrodes in the direct vicinity of said cell, it is then possible to build an electric field inside it which will permit advantageously to modulate a continuous spectrum from optical signals transmitted through said cell. The different pass bands present in said continuous spectrum while at least few of them comprise at least a respective different wavelength will have to be transmitted through said cell at different regions. Latter will correspond to different values of the amplitude of scattering such to be adapted to modulate the respective different pass bands. Such SLM is used to build a dynamic spectral equalizer. Latter contains a spectral dispersive element placed on an optical path of an incident light beam. This spectral dispersive element will spread continuously said incident light beam onto said SLM such that at least each different wavelength present in said incident light beam are focused or imaged towards a different spatial region of said SLM.

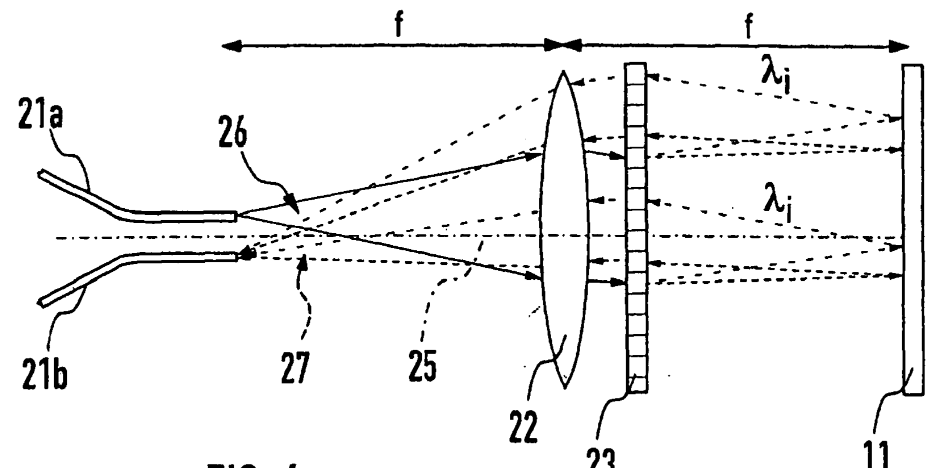

FIG. 6

Description

[0001] The present invention relates to a spatial light modulator as set forth in the preamble of claim 1, a dynamic spectral equalizer as set forth in the preamble of claim 10 and a telecommunications device.

[0002] Optical communication systems employing optical fibers have been rapidly put into practice because of the large capacity of information which can be transmitted through it at a very high speed. Specially for inter-continental transmission, optical fibers were used in building undersea networks already few decades ago. But the ever growing popularity of telecommunications e.g. on the Internet and a price dumping for telecommunications due to a liberalization of this economical sector end up of a need to increase substantially the telecommunications transmission possibilities without implying to high cost. The use of a technique called wavelength division multiplexing (WDM) shall be very promising since it permits to transmit in already lay down optical fibers, optical signals at multiple different wavelengths (more then 50 in a same optical fiber). As before, it is necessary to use from time to time (e.g. every 100km depending on several parameters) amplifiers like transponders for those optical signals. Many amplifiers will have to be used now for a high number of different wavelengths. These amplifiers are then concatenated which harden the condition of an acceptable spectral bandwidth.

[0003] To verify such condition, a spectral equalization must be performed on the different transmitted wavelengths. When only few different wavelengths are used a passive spectral equalization may be sufficient. In US6.084.695 is disclosed an example of passive spectral equalization based on the use of a filter like a Fabry-Perot filter, little selective (or Fizeau filter). Such filter is used in combination of a multiplexer while different wavelengths are transmitted through different input fibers. Each of these input fibers have then their ends located on an end plane. The multiplexer comprises a dispersing element or grating, a collimating optical element, a reflector system and produces an output beam collected by an output fiber. The reflector system is an adjustment element whose orientation enables the centering of the luminous beams with respect to the wavelengths considered on the elementary pass bands. The spectral equalization is performed here in order to bring each of these pass bands having a maximum closer to a rectangular shape. The filter is additionally placed to act on each of them such that the period of its transmission spectrum is equal to that of the central wavelengths of the elementary bands of the multiplexer. This filter can be accommodated in a superimposition region of the different wavelengths and will act on each of them in a same way.

[0004] However, as wavelength division multiplexed optical transmission systems begin to be deployed commercially, the need for active management of spectral gain is increasingly important. Indeed, individual channel powers comprising at least a respective different wavelength may vary over time. Furthermore, the gain spectrum varies with dynamical load. In WO98/06192 is disclosed a technique for active management of the spectral gain, based on a polarization-insensitive diffractive ferroelectric liquid crystal (FLC) in-line filter. It is made of a reconfigurable holographic filter arranged along an optical path between the optical inputs and the optical outputs. The equalization is based here on a spatial deflection such that the hologram will reshape the propagated beam correspondingly. The holographic filter comprises a FLC pixellated spatial light modulator (SLM) displaying dynamic holograms in conjunction with a fixed binary-phase high spatial frequency grating. The reconfiguration of the holographic filter is achieved in combination with processing means storing data on a number of predetermined holograms. Latter provide signal power equalization for a number of optical signals of predetermined different wavelengths. The active management disclosed in WO98/06192 is limited to these predetermined holograms defined for predetermined wavelengths. It cannot be successfully applied when a shift or a change of few or all of the wavelengths occurs. But this is just what becomes increasingly important with the actual high number of different wavelengths used simultaneously for the transmission of optical signals under WDM.

[0005] It is an object of the present invention to provide a dynamic spectral equalizer with a high dispersive capacity and applicable for optical signals made of a variable number of different wavelengths while being almost polarization and temperature independent.

[0006] This object is attained by a spatial light modulator as claimed in claim 1, a dynamic spatial equalizer and a telecommunications device as claimed respectively in claim 10 and 16.

[0007] It is taken advantage of the use of a spatial light modulator (SLM) made of a cell filled with a liquid crystal (LC) based substance having a variable scattering property with respect to the amplitude of an electric field present in that cell. In a paper from K. Takizawa et al., Applied Optics, Vol. 37, pp 3181-3189, 1998, is disclosed a polarization independent optical fiber modulator made of polymer-dispersed liquid crystals (PDLC). This PDLC materials has LC droplets of several micrometers or less in diameter dispersed within the polymer. By controlling the difference between the refractive indices of the LC droplets and the surrounding polymer, the state of the PDLC can be varied continuously from opaque to transparent. When no electric field is applied to this modulator, the LC molecules face different directions for each droplet. An optical beam that is transmitted through said modulator, will be strongly scattered. This reduces substantially the power of light that propagates, causing the modulator to be in an off state. Applying an adequately large electric field to the PDLC causes the LC molecules to be arranged in the direction of the electric field. Then, both the polymer and the LC droplets show nearly the same refractive index. In this case, the optical beam that propagates through said modulator is straight without scatter. Since such modulator is based on the light-scattering effect of the PDLC, it can be used to modulate an optical beam without depending on polarization.

[0008] In the present invention it is now a non uniform electric field which is applied on a cell filled with a similar LC based substance. In such a way, it is then take advantage of the variable scattering property (loss) of said substance to build a variable attenuator. Latter will then be adapted for a shaping of the transmission loss of a pass band comprising at least a wavelength at which an optical signal is transmitted through said cell e.g. by flattening or equalizing said pass band. By using a plurality of electrodes in the direct vicinity of said cell, it is then possible to build an electric field inside it which will permit advantageously to modulate a continuous spectrum from optical signals transmitted through said cell. For that, the different pass bands present in said continuous spectrum while at least few of them comprise at least a respective different wavelength will have to be transmitted through said cell at different regions. Latter will correspond to different values of the amplitude of scattering such to be adapted to modulate the pass bands of different wavelengths.

[0009] Such SLM is favorably used to build a dynamic spectral equalizer according to the present invention. Latter contains a spectral dispersive element placed on an optical path of an incident light beam. This spectral dispersive element will advantageously spread continuously said incident light beam onto said SLM such that at least each different wavelength present in said incident light beam are focused or imaged towards a different spatial region of said SLM. Since the plurality of electrodes with which an electric field is applied to the cell of said SLM can be controlled independently, it will be possible to adapt in real time the modulation of the continuous spectrum to a shift or even a drop of some or addition of few new wavelengths present in the light beam.

[0010] Further advantageous features of the present invention are defined in the dependent claims and will become apparent from the following description and the drawing.

[0011] One embodiment of the invention will now be explained in more detail with reference to the accompanying drawing, in which:

Fig.1 a and b are schematic cross sectional views of a cell from a spatial light modulator according to the present invention;

Fig.2 a and b are schematic cross sectional views of a cell according to fig.1 with an alternative liquid crystal based substance;

Fig. 3 is a front view of an embodiment of an electrode of the cell according to the present invention;

Fig. 4 is a perspective view of an electric field distribution inside the cell when using an electrode according to figure 3;

Fig.5 is a cross sectional view of a cell from a spatial light modulator used in reflection mode according to the present invention;

Fig. 6 is a representation of the optical diagram of a dynamic spectral equalizer in a Fourier configuration according to the present invention;

Fig. 7 is a representation of the optical diagram of a dynamic spectral equalizer in an imaging configuration according to the present invention;

Fig. 8 is a representation of the optical diagram of a dynamic spectral equalizer in a folded imaging configuration according to the present invention.

[0012] A spatial light modulator (SLM) according to the present invention is made up of a cell filled with a liquid crystal (LC) based substance. Latter has a variable scattering property with respect to an electric field present in the cell. As shown in figures 1, 2 and 4, said LC based substance consists of LC droplets 3, 3a, 3b (generally nematic, but possibly chiral) in a host medium 4 (generally a polymer) confined in said cell 1 made advantageously planar. In the direct vicinity are placed electrodes 2. Latter are used to applied a non-uniform voltage which gives rise to said electric field inside the cell 1.

[0013] The LC director axes within a droplet are determined by the polymer-LC interaction at the droplet boundary. For positive dielectric anisotropy, then the LC director axes vary nearly randomly from droplet to droplet 3a in absence of any applied electric field as shown in fig. 1a (off-field state). The index mismatch (discontinuity) between LC-droplets 3a and the host medium 4 results in scattering of an incident light 6. When the cell thickness (e.g. 10μm) is much larger than the droplet size (0.5 - 1μm), then the incident light 6 will be scattered many times before emerging 7a from the cell 1. The degree of scattering depends on the size, birefringence (e. g. 0.1 or less) and concentration of the droplets. By controlling the difference between refractive indices of the LC-droplets and the surrounding polymer (host medium 4) with respect of an applied voltage (see fig. 1b), the polymer-dispersed LC (PDLC) state can be varied continuously from opaque to transparent. In latter case, the incident light 6 is transmitted 7b without suffering any scattering. It is therefore possible to modulate light without using polarisers, by selecting non-scattering rays 7b from the light that passes through said cell.

[0014] On fig. 2a and 2b are shown a similar cell 1 of

TS0001360

a spatial light modulator as before but now using a nematic LC with a negative dielectric anisotropy, while the whole is in an homoetropic configuration. In this case, the LC-droplets 3b director axes are aligned parallel to the propagation axe of the light beam in the off-state i.e. in the absence of an electric field (s. fig. 2b). Any applied voltage will make the cell 1 more or less opaque (s. fig. 2a).

[0015] When choosing specific electrodes 2, such that the applied voltage is non-uniform in space, the electric field inside said cell 1 will have a variable spatial distribution along its plane. This is then adapted to modulate at least a pass band comprising at least a wavelength at which an optical signal is transmitted through said cell 1. The modulation will preferably chosen such that the cell acts as a variable attenuator by flattening or equalizing said pass band.

[0016] As a principal aim of the present invention is to modulate in a single step a high number of different pass bands comprising each at least a different respective wavelength at which optical signals are transmitted (WDM-technique) using a single SLM, at least one electrode 2 is then divided into a plurality of parallel electrodes 2a, 2b as shown in a front view on fig.3. If each of these electrodes 2a, 2b are controlled separately, it is then possible to apply on the PDLC a variable spatial distribution adapted to modulate a continuous spectrum. Latter may contain a high number of different pass bands, while at least few of them comprise at least a respective wavelength at which optical signals are transmitted through said cell 1. It is important that each pass band comprising a different wavelength which will be modulated are to be transmitted through the cell 1 at a different corresponding region along the plane.

[0017] On fig. 4 is visualized an example of an electric field distribution inside the cell 1. Ox is the modulation and dispersion axis i.e. the plurality of electrodes 2a, 2b are parallel to oy. And oz is the propagation axis of the light beam transmitted through such cell 1. As shown here on fig. 4, such distribution of the electric field will be adapted to modulate a continuous spectrum made of a number of different pass bands.

[0018] It is essential in the context of the present invention to ensure that the different wavelengths present in the incident light beam will be spread onto different regions of said SLM. For that, a dynamic spectral equalizer using such kind of SLM will further comprise a spectral dispersive element placed on an optical path of the incident light. This dispersive element in freespace can be a prism, a volume hologram, a grating or a combination of them. They provide an angular dispersion which is converted into a spatial multiplex (lateral shift as a function of the wavelength λ). It is of advantage also to ensure that the direction of propagation of each different wavelength when reaching said SLM are almost perpendicular to it. In that way, the used SLM will be almost polarization independent. Furthermore, it is preferable that the focus or image of each different wavelength on said SLM is adapted to give rise to a spot size of at least several times bigger than the average size of the LC droplets filling its cell 1. All these conditions will permit to optimize the modulation of the incident light beam (shaping permit to optimize the modulation of the incident light beam (shaping of the transmission loss).

[0019] To optimize the size and not least the cost of such dynamic spectral equalizer, a planar reflecting SLM will be used. On fig. 5 is shown a cross sectional view of an embodiment of such planar reflecting SLM 11. It is made of two planar glass substrates 10 which are placed parallel side-to-side. Between them are two electrodes 2, 8 while in between is confined the PDLC 9. When using such planar reflecting SLM 11, an incident light beam 6 will first come through the first electrode 2 which is transparent. Latter can be made advantageously of Indium Tin Oxide (ITO) . Afterwards, the incident light beam 6 will be modulated by the PDLC 9 before being reflected by the second electrode 8 made of a mirror again through the PDLC 9. The light beam reflected by said planar reflecting SLM 11 will therefore be transmitted twice through the PDLC 9.

[0020] The use of a reflecting SLM 11 according to the present invention has the big advantage to economize the number of optical elements needed for a dynamic spectral equalizer and permits therefore to optimize its compactness. On fig. 6 to 8 are shown different possible embodiments of such dynamic spectral equalizer. All of them comprise a grating 23, 24 as well as a similar reflecting SLM 11 but placed at a different region along an optical axis 25 of the incident light beam. The grating 23 is made of a demultiplexer (WDM dmux) which will act as a multiplexer on the reflected light beam. For efficiency a thick grating or volume hologram may be preferable. In addition, the Bragg selectivity of the such grating can be used to block parasitic PDLC back-scattering.

[0021] Fig. 6 represents a dynamic spectral equalizer in the Fourier configuration. A diverging incident light beam 26 is coming out of an input fiber 21a and reaches a lens 22 placed on an optical axis 25 parallel to the propagation direction of said light beam 26. Afterwards, it is transmitted through a grating 23 here a WDM dmux before reaching said SLM 11. Due to the lens 22 and the grating 23 two different wavelengths λ_i and λ_j will reach the SLM 11 at different spatial regions. The spot size is in this case equal to $\lambda f/\omega_0$ where f is the focal distance and ω_0 is the waist at the origin here of the input fiber 21b. Since the SLM 11 is a reflecting one, the transmitted light beam will be recombine by the same grating 23 acting now as a multiplexer and converged by the lens 22 toward an output fiber 21b which optical axis is parallel to the one of the input fiber 21a while symetric with respect to the optical axis 25. The angular chromatism will be balanced during the back pas. It can be of advantage to use a single mode fiber with extended core for the output fiber. In such a way, the convergence conditions are not that high.

[0022] Fig. 7 represents an alternative of a dynamic spectral equalizer now in the imaging 4-f configuration. A single fiber 21 is used for the incident diverging light beam 26 as well as the converging transmitted light beam. Latter is merged with former due to the use of a single fiber 21. In this configuration two lenses 22a and 22b respectively with focal distance f1 and f2 are used and placed along the optical axis 25 on each side of the grating 23. The different wavelengths e.g. λ_i and λ_j will then reach the reflecting SLM 11 placed also along said optical axis 25 at different regions. After being reflected by it, the different wavelengths will be recombined by the same grating 23 and the two same lenses 22a and 22b before leaving the dynamic spectral equalizer through the same fiber 21.

[0023] On fig. 8 is represented a dynamic spectral equalizer also in the imaging configuration but now as folded 4-f. Similar to the case shown in fig. 7, a single fiber 21 is used both for the incident diverging light beam 26 as well as the converging transmitted light beam 27. But now a single lens 22 will be sufficient in combination of a reflecting grating 24 both placed along the optical axis 25. The reflecting SLM is now close to the fiber 21 with its plane still perpendicular to the optical axis 25. In such a way, the reflecting SLM 11 is facing the lens 22 in a same way as the diverging light beam 26 along slightly shifted with respect to the fiber 21. In comparison to the case before (fig. 7) a clear gain in compactness is achieved.

[0024] In both imaging configuration shown on fig. 7 and 8, the spot size will be equal to $G\omega_0$ where G is an adjustable magnification factor equal to the focal distance ratio. Typical values for all three configurations (fig. 6-8) for $\Delta\lambda$ of about 0.8nm (distance between two different wavelengths at which optical signals in WDM are transmitted) are for the spot size about 10μm and focal distances of about 5cm.

[0025] The use of a SLM according to the present invention (a reflecting or not) requires a sufficient dispersive power to allow a good wavelength discrimination specially when the different wavelengths at which optical signals are transmitted in WDM technique are very close each other. Furthermore, a sufficient spot size must be ensured to take enough advantage of the scattering effect. And the incidence of the light beam on the used SLM must be normal (or almost normal) to its plane such to avoid any polarization dependence. All these conditions are perfectly guaranteed by the use of a dynamic spectral equalizer according to the present invention.

[0026] A telecommunications device according to the present invention incorporating such dynamic spectral equalizer will advantageously be used when transmission of telecommunications signals is managed in a WDM technique. The dynamic spectral equalizer will have to be inserted before e.g. an amplifier. Latter will then be able to work on the different wavelengths at which optical signals are sent in an optimized way.

Claims

1. Spatial light modulator comprising a planar cell filled with a liquid crystal based substance having a variable scattering property with respect to an electric field, and at least two electrodes enclosing said planar cell from each side of its plane to apply a voltage on said liquid crystal,
characterized in that
said applied voltage is non-uniform in space implying an electric field inside said cell with a variable spatial distribution along said plane.

2. Spatial light modulator according to claim 1, **characterized in that** said variable spatial distribution is adapted for the modulation of at least a pass band comprising at least a wavelength at which an optical signal is transmitted through said cell.

3. Spatial light modulator according to claim 1, **characterized in that** said variable spatial distribution is adapted for the modulation of at least two different pass bands comprising each at least a respective wavelength at which optical signals are transmitted through said cell respectively at two different regions along said plane.

4. Spatial light modulator according to claim 1, **characterized in that** at least on one side of said plane said electrode is divided into a plurality of adjacent electrodes giving rise to said variable spatial distribution adapted to modulate a continuous spectrum containing a number of different pass bands, while at least few of them comprise at least a respective wavelength at which optical signals are transmitted through said cell at a different region along said plane for each of these respective different wavelengths.

5. Spatial light modulator according to claim 4, **characterized in that** said plurality of adjacent electrodes are controlled independently with a variable voltage allowing to adapt said spatial light modulator to a change of optical properties of said incident light beam.

6. Spatial light modulator according to claim 2 to 5, **characterized in that** said modulation acts as a variable attenuator by flattening or equalizing said pass band comprising at least said respective wavelength.

7. Spatial light modulator according to claim 1, **characterized in that** said electrode being at the rear of said cell with respect to incident optical signals comprises a reflective plane for said incident optical signals.

TS0001362

8. Spatial light modulator according to claim 1, **characterized in that** said liquid crystal based substance filling said cell is made of a suspension of liquid crystal droplets generally nematic but possibly chiral, in a host medium generally polymer.

9. Spatial light modulator according to claim 2 and 8, **characterized in that** said droplets are of an average size comparable or smaller then said wavelength at which an optical signal is transmitted through said cell such that said droplets act as scatters when their liquid crystal director axes are not aligned with the propagation axes of said wavelength.

10. Dynamic spectral equalizer comprising an optical input for an incident light beam consisting of optical signals transmitted via at least a wavelength, an optical output for collecting a resulting light beam, **characterized in that** said dynamic spectral equalizer comprises further a spatial light modulator according to claim 1 on which said incident light beam is focused or imaged and out of which said resulting light beam is collected.

11. Dynamic spectral equalizer according to claim 10, **characterized in that** it comprises further a spectral dispersive element on an optical path of said incident light beam such that said spectral dispersive element spread continuously said incident light beam onto said spatial light modulator such that at least each different wavelength present in said incident light beam are focused or imaged towards a different spatial region of said spatial light modulator.

12. Dynamic spectral equalizer according to claim 11, **characterized in that** the direction of propagation of each different wavelength when reaching said spatial light modulator are almost perpendicular to it such that latter is almost polarization independent.

13. Dynamic spectral equalizer according to claim 12, **characterized in that** the focus or image of each different wavelength when reaching said spatial light modulator is adapted to give rise of a spot size of at least several times bigger than the average size of the liquid crystal droplets according to claim 8 such that said spatial light modulator is almost polarization independent.

14. Dynamic spectral equalizer according to claim 10, **characterized in that** said spatial light modulator is used in reflection mode such that said incident light beam will be transmitted through said cell twice before being collected as said resulting light beam.

15. Dynamic spectral equalizer according to claim 10, **characterized in that** said optical input and output are given by at least an optical fiber.

16. Telecommunications device **characterized by** incorporating a dynamic spectral equalizer according to claim 10.

TS0001363

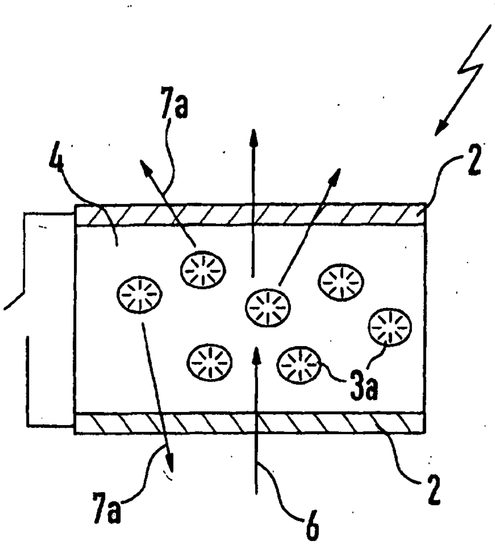

FIG. 1a

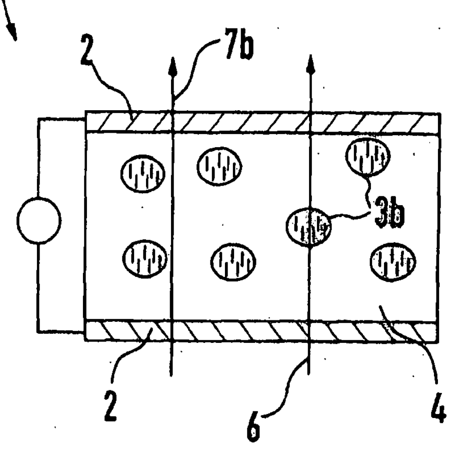

FIG. 1b

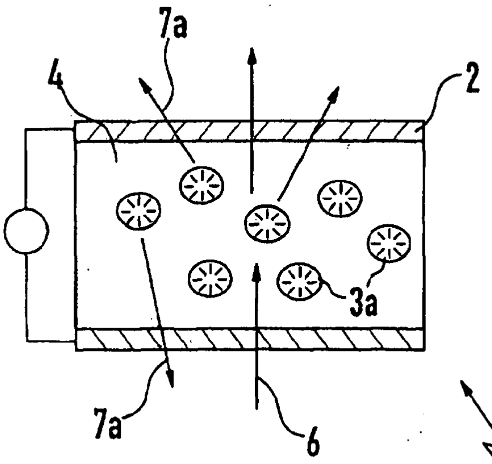

FIG. 2a

1

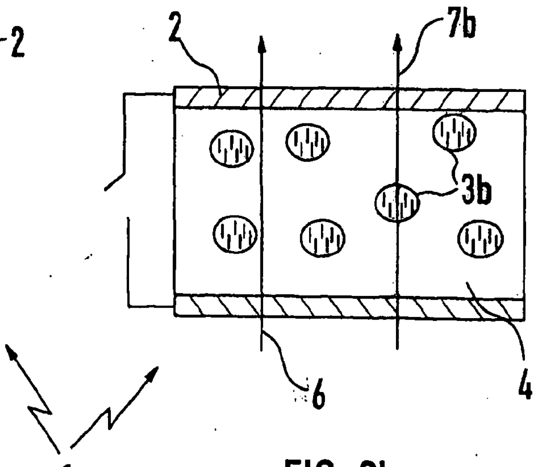

FIG. 2b

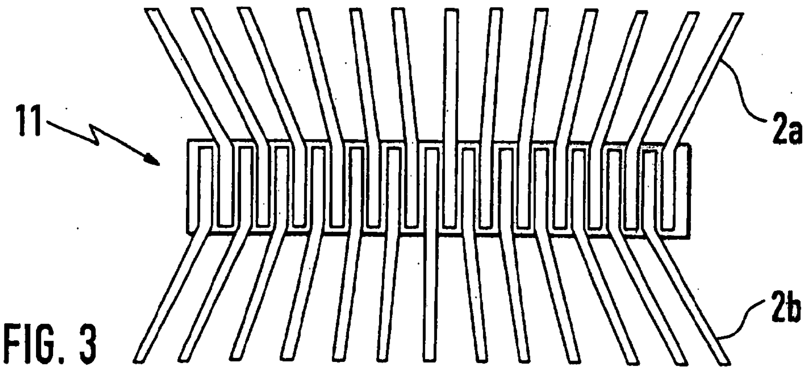

FIG. 3

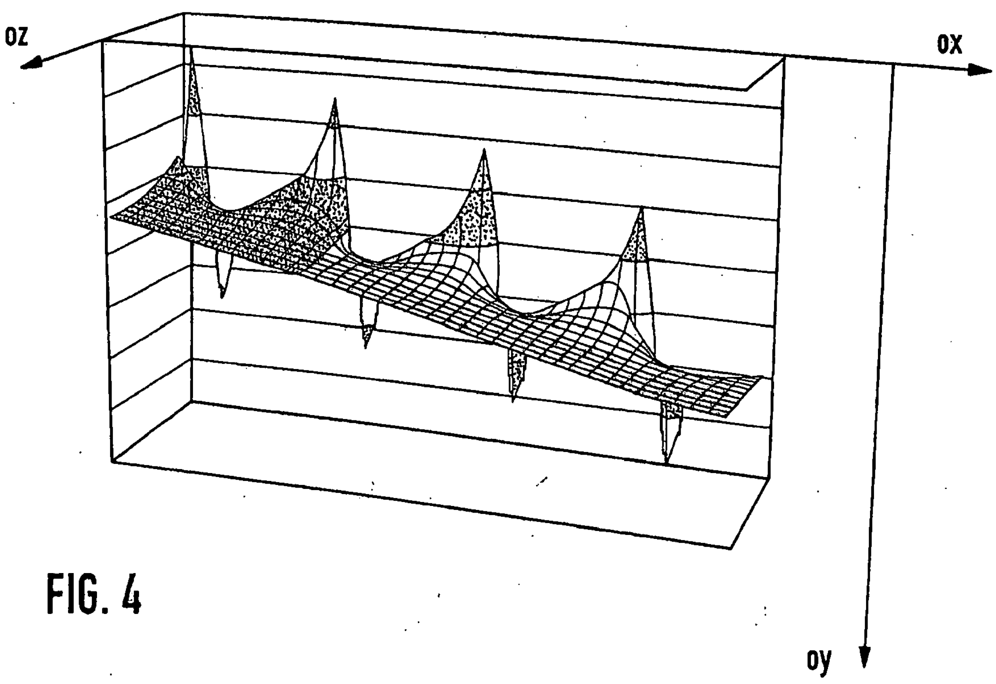

FIG. 4

TS0001365

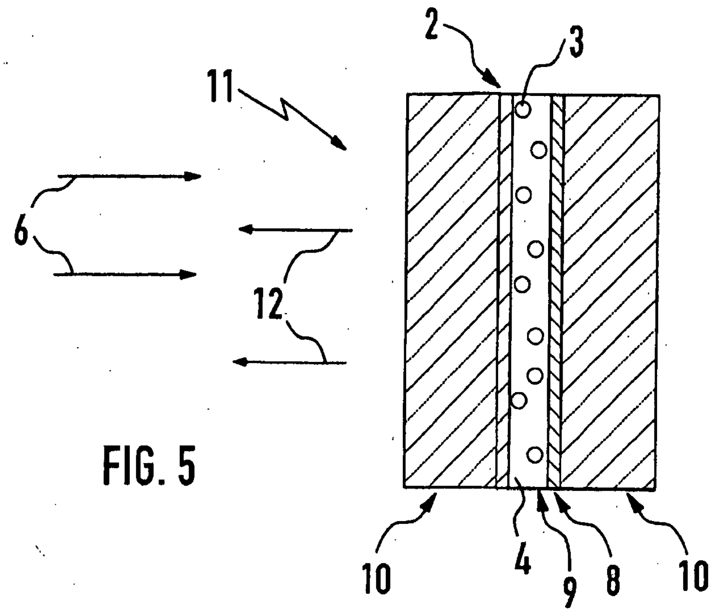

FIG. 5

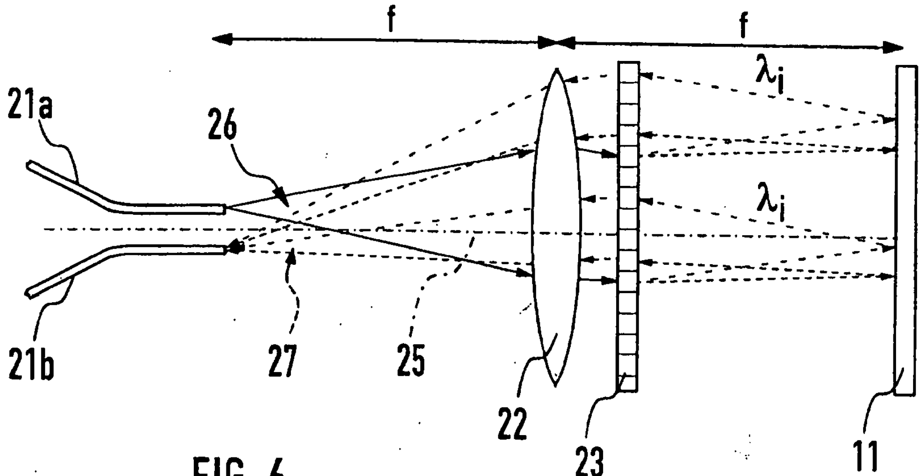

FIG. 6

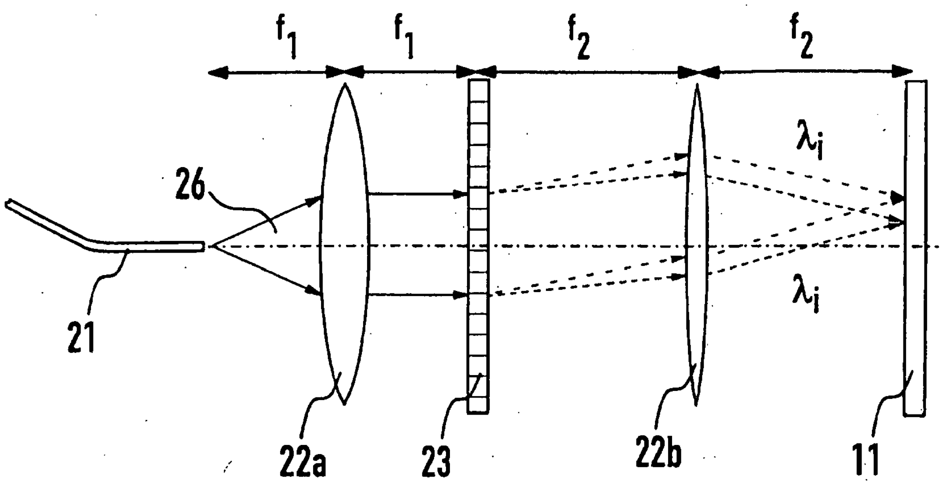

FIG. 7

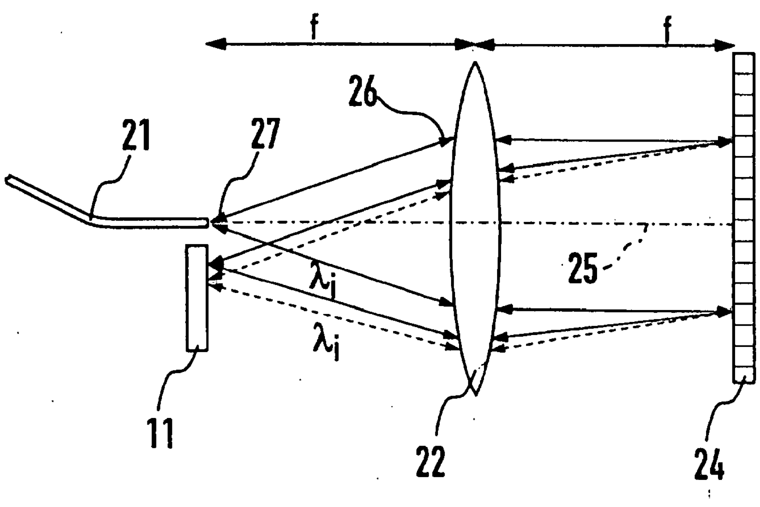

FIG. 8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 44 0299

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	US 4 193 691 A (FJARLIE EARL J) 18 March 1980 (1980-03-18) * column 2, line 25 - line 50 * * column 3, line 39 - line 49 * * figures 1,2B * ---	1-6,10, 11 7-9, 12-16	G02F1/01 G02F1/1334 G02F1/1335
Y	US 6 141 361 A (MEARS ROBERT JOSEPH ET AL) 31 October 2000 (2000-10-31) * column 1, line 9 - line 12 * * column 7, line 20 - line 42 * * figures 1,3,6 * ---	7,12, 14-16	
Y,D	TAKIZAWA K ET AL: "POLARIZATION-INDEPENDENT OPTICAL FIBER MODULATOR BY USE OF POLYMER-DISPERSED LIQUID CRYSTALS" APPLIED OPTICS,OPTICAL SOCIETY OF AMERICA,WASHINGTON,US, vol. 37, no. 15, 20 May 1998 (1998-05-20), pages 3181-3189, XP000765274 ISSN: 0003-6935 * paragraphs 2 and 3 with Figure 1 * -----	8,9,13, 15	TECHNICAL FIELDS SEARCHED (Int.Cl.7) G02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	24 April 2001	Petitpierre, O

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 44 0299

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-04-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4193691 A	18-03-1980	CA 1088343 A	28-10-1980
US 6141361 A	31-10-2000	AU 3573195 A	26-04-1996
		AU 3573295 A	26-04-1996
		DE 69515889 D	27-04-2000
		DE 69515889 T	07-12-2000
		EP 0783713 A	16-07-1997
		EP 0783724 A	16-07-1997
		WO 9610762 A	11-04-1996
		WO 9610776 A	11-04-1996
		US 5930012 A	27-07-1999

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

Notice of References Cited	Application/Control No. 11/514,725	Applicant(s)/Patent Under Reexamination HOLMES, MELANIE	
	Examiner Fayez G. Assaf	Art Unit 2872	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2001/0050787	12-2001	Crossland et al.	359/15
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002	4755

21005 7590 05/13/2008

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

EXAMINER	
ASSAF, FAYEZ G	

ART UNIT	PAPER NUMBER
2872	

MAIL DATE	DELIVERY MODE
05/13/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

TS0001371

Office Action Summary	Application No. 11/514,725	Applicant(s) HOLMES, MELANIE	
	Examiner Fayez G. Assaf	Art Unit 2872	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *28 February 2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *4-8* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *4-8* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *01 September 2006* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☒ Certified copies of the priority documents have been received in Application No. 10/487,810.

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *9/1/06; 11/09/07; 4/18/2008*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

Election/Restrictions

Applicant's election of Group II: Claims 4-8 in the reply filed on 2/28/2008 is acknowledged. Because applicant did not distinctly and specifically point out the supposed errors in the restriction requirement, the election has been treated as an election without traverse (MPEP § 818.03(a)).

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 4-6 and 8 are rejected under 35 U.S.C. 102(b) as being anticipated by Meras et al. "WMD Channel Management…Elements", IEE, June 1998.

Meras discloses an optical routing module having at least one input (input fiber array of Fig. 7) and at least two outputs (output fiber array of Fig. 7) and operable to select between the outputs, the module comprising a two dimensional SLM (the pixellated SLM of Fig. 6) having an array of pixels, with circuitry constructed and arranged to display holograms on the pixels to route beams of different frequency to respective outputs.

Regarding claim 6, Meras discloses the desired set being varied in use (i.e. dynamic, see "Future Work" paragraph.

Claims 5 and 8 are rejected under 35 U.S.C. 102(b) as being anticipated by Ohuchida (US 5,107,359).

Ohuchida discloses a routing device having an input (25of Fig 3) and plural outputs (26a, 26b of Fig. 3), the input constructed and arranged to receive a light beam having plural wavelengths, the device comprising an optical device (21 of Fig. 3) for selecting the wavelengths of the input beam to appear in the outputs, wherein each output may contain any desired set of the plural wavelengths (See Fig. 3).

Ohuchida discloses a device having plural input signals (26 of Fig. 3) and an output, the output (25 of Fig. 3) constructed and arranged to deliver a signal having plural wavelengths, the device comprising a device (21 of Fig. 3) for combining the wavelengths from the input signals to appear in the output, wherein each input signal may contain any desired set of the plural wavelengths of the output (See Fig. 3).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claim 6 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mears.

Mears discloses the claimed invention except for the at least two of the outputs containing at least one common wavelength.

However, the structure of the device can support such functionality which can be achieved by routine experimentation.

It would have been obvious, at the time the invention was made, to a person having ordinary skill in the art to provide to separate outputs with a common signal so as to share baseline information for every output channel.

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Crossland et al. (US 2001/0050787 A1)

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Fayez G. Assaf whose telephone number is (571) 272-2307. The examiner can normally be reached on 8-5 M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephone Allen can be reached on (571) 272-2434. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Fayez G. Assaf/
Primary Examiner, Art Unit 2872

May 10, 2008

Search Notes	Application/Control No. 11514725	Applicant(s)/Patent Under Reexamination HOLMES, MELANIE
	Examiner Fayez G Assaf	**Art Unit** 2872

SEARCHED

Class	Subclass	Date	Examiner
359	15,19	5/10/2008	/FA/

SEARCH NOTES

Search Notes	Date	Examiner
See attached	5/10/2008	/FA/

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **November 7, 2007** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Not Yet Assigned	CONFIRMATION NO. 4755	GROUP 2873

		OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*
/F.A./	C5	Yamazaki, H., *et al.*, "4 x 4 Free Space Optical Switching Using Real-Time Binary Phase-Only Holograms Generated by a Liquid-Crystal Display," *Optical Society of America*, 16(18):1415-1417 (1991).

EXAMINER /Fayez Assaf/	DATE CONSIDERED 05/10/2008

765954_1

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645500;1
TJM/jk
08/23/06

PATENT APPLICATION
DOCKET NO.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Melanie Holmes

Divisional Application of

Application No.: 10/487,810

371C File Date: September 10, 2004

For: OPTICAL PROCESSING

Date: 9/1/06
EXPRESS MAIL LABEL NO. EV214902601 US

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Information Disclosure Statement is submitted:

[ ] under 37 CFR 1.129(a), or
(First/Second submission after Final Rejection)

[X] under 37 CFR 1.97(b), or
(Within any one of the following time periods: three months of filing national application (other than a CPA) or date of entry of the national stage in an international application; or before the mailing date of a first office action on the merits in a non-provisional application, including a CPA, or a Request for Continued Examination).

[ ] under 37 CFR 1.97(c) together with either:

[ ] a Statement under 37 CFR 1.97(e), as checked below, or

[ ] a $180.00 fee under 37 CFR 1.17(p), or
(After the 37 CFR 1.97(b) time period, but before final action or notice of allowance, whichever occurs first)

[ ] under 37 CFR 1.97(d) together with:

[ ] a Statement under 37 CFR 1.97(e), as checked below, and

[ ] a $180.00 fee under 37 CFR 1.17(p), or
(Filed after final action or notice of allowance, whichever occurs first, but on or before payment of the issue fee)

[ ] under 37 CFR 1.97(i):
Applicant requests that the IDS and cited reference(s) be placed in the application file.
(Filed after payment of issue fee)

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

TS0001380

Statement Under 37 CFR 1.97(e)

[ ] Each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement; or

[ ] No item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned, after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

Statement Under 37 CFR 1.704(d) (Patent Term Adjustment)
Applies to original applications (other than design) filed on or after May 29, 2000

[ ] Each item of information contained in the Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the Information Disclosure Statement.

[X] Enclosed herewith is form PTO-1449:

- [ ] Copies of the cited references are enclosed.
  - [X] Copies of issued U.S. patents and published U.S. applications are not required and are not being provided.
- [X] Copies of the cited references are enclosed except those entered in prior application, U.S. Application No. 10/487,810, to which priority under 35 U.S.C. 120 is claimed.
- [ ] The listed references were cited in the enclosed International Search Report in a counterpart foreign application.
- [ ] The "concise explanation" requirement (non-English references) for reference(s) [ ] under 37 CFR 1.98(a)(3) is satisfied by:
  - [ ] the explanation provided on the attached sheet.
  - [ ] the explanation provided in the Specification.
  - [ ] submission of the enclosed International Search Report.
  - [ ] submission of the enclosed English-language version of a foreign Search Report and/or foreign Office Action.
  - [ ] the enclosed English language abstract.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

[ ] Applicant requests that the following non-published pending applications be considered:
(Affix a label or apply the stamp "Non-Published IDS Reference - Do Not Scan" to the front of each unpublished pending appl'n.)

Examiner's Initials	
_____	U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]
_____	U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]
_____	U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

Examiner _______________ Date _______________

[ ] A copy of each above-cited application, including the current claims, is enclosed, except any application filed on or after June 30, 2003, which has been scanned into the PTO's Image File Wrapper (IFW) system and is available to the examiner.

[ ] A copy of each above-cited application, including the current claims, is enclosed, except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. 120 is claimed.

The Examiner is requested to return a copy of the above list of pending applications indicating which references were considered with the next office communication.

It is requested that the information disclosed herein be made of record in this application.

Method of payment:

[ ] A check for the fee noted above is enclosed, or the fee has been included in the check with the accompanying Reply. A copy of this Statement is enclosed.

[ ] Please charge Deposit Account 08-0380 in the amount of $[ ]. A copy of this Statement is enclosed.

[X] Please charge any deficiency in fees and credit any overpayment to Deposit Account 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]

Timothy J. Meagher
Registration No.: 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133

Dated: 9/1/6

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

PTO-1449 REPRODUCED **INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **September 1, 2006** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO.	
	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE	
	EXAMINER	CONFIRMATION NO.	GROUP

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
	A1	5,107,359	04-21-92	Ohuchida
	A2	5,539,543	07-23-96	Liu, et al.
	A3	5,589,955	12-1996	Amako, et al.
	A4	5,428,466	06-1995	Rejman-Greene, et al.
	A5	4,952,010	08-1990	Healey, et al.
	A6	6,710,292 B2	03-2004	Fukuchi, et al.
	A7	6,975,786 B1	12-2005	Warr, et al.
	A8	6,115,123	09-2000	Stappaerts, et al.
	A9	5,995,251	11-19999	Hesselink, et al.
	A10	5,959,747	09-1999	Psaltis, et al.
	A11	6,072,608	06-2000	Psaltis, et al.
	A12			
	A13			
	A14			
	A15			
	A16			
	A17			
	A18			
	A19			
	A20			
	A21			
	A22			
	A23			
	A24			
	A25			

EXAMINER	DATE CONSIDERED
/Fayez Assaf/	05/10/2008

@PEDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

TS0001383

PTO-1449 REPRODUCED	ATTORNEY DOCKET NO. 3274.1003-002	APPLICATION NO.	
INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION	FIRST NAMED INVENTOR Melanie Holmes	FILING DATE	
September 1, 2006 (Use several sheets if necessary)	EXAMINER	CONFIRMATION NO.	GROUP

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER Country Code-Number-Kind Code (if known)	DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT	TRANSLATION YES	NO
	B1	WO 01 90823 A1	11-29-01	Intelligent Pixels, Inc.		
	B2	WO 01 25848 A2	04-12-01	Thomas Swan & Co., Ltd.		
	B3	WO 01 25840 A1	04-12-01	Thomas Swan & Co., Ltd.		
	B4	WO 02 101451 A1	12-19-02	Honeywell International, Inc.		
	B5	WO 02 079870 A2	10-10-02	Thomas Swan & Co., Ltd.		
	B6	EP 1 050 775 A1	11-08-00	Thomas Swan & Co., Ltd.		
	B7	EP 1 053 501 B1	07-23-03	Thomas Swan & Co., Ltd.		
	B8					
	B9					
	B10					
	B11					
	B12					
	B13					
	B14					
	B15					
	B16					
	B17					
	B18					
	B19					
	B20					
	B21					
	B22					
	B23					
	B24					

EXAMINER	DATE CONSIDERED
/Fayez Assaf/	05/10/2008

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

TS0001384

PTO-1449 REPRODUCED **INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **September 1, 2006** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO.
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE
	EXAMINER	CONFIRMATION NO.	GROUP

OTHER DOCUMENTS ***(Including Author, Title, Date, Pertinent Pages, Etc.)***		
	C1	Mears, R. J., et al., "Telecommunications Applications of Ferroelectric Liquid-Crystal Smart Pixels," IEEE Journal of Selected Topics in Quantum Electronics, Vol. 2, No. 1, April 1996, pp. 35-46.
	C2	Mears, R. J., et al., "WDM Channel Management Using Programmable Holographic Elements," IEE Colloquim on Multiwavelength Optical Networks: Devices, Systems and Network Implementations," IEE, London, GB, 18 June 1998, pp. 11-1 - 11-6.
	C3	Pan, Ci-Ling, et al., "Tunable Semiconductor Laser with Liquid Crystal Pixel Mirror in Grating-Loaded External Cavity," Electronics Letters, IEE Stevenage, GB, Vol. 35, No. 17, 19 August 1999, pp. 1472-1473.
	C4	Marom, D.M., *et al.,* "Wavelength-Selective 1x4 Switch for 128 WDM Channels at 50 Ghz Spacing," *OFC Postdeadline Paper*, pp. FB7-1-FB7-3 (2002).
	C5	
	C6	
	C7	
	C8	
	C9	
	C10	
	C11	
	C12	
	C13	
	C14	
	C15	

EXAMINER	DATE CONSIDERED
/Fayez Assaf/	05/10/2008

@PFDesktop\::ODMA/MHODMA/HBSR05;iManage;645166;1

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

TS0001385

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 4755

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/514,725	09/01/2006 **RULE**	359	2872	3274.1003-002

APPLICANTS
Melanie Holmes, Ipswich, UNITED KINGDOM;

**** CONTINUING DATA** *************************
This application is a DIV of 10/487,810 09/10/2004 PAT 7,145,710
which is a 371 of PCT/GB02/04011 09/02/2002

**** FOREIGN APPLICATIONS** **************************
UNITED KINGDOM 0121308.1 09/03/2001

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
09/19/2006

	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☑ Yes ❑ No 35 USC 119(a-d) conditions met ☑ Yes ❑ No Verified and Acknowledged /FAYEZ G ASSAF/ Examiner's Signature ❑ Met after Allowance ____ Initials	UNITED KINGDOM	36	8	5

ADDRESS

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133
UNITED STATES

TITLE

Optical processing

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
1780	FEES: Authority has been given in Paper No.___________ to charge/credit DEPOSIT ACCOUNT No.___________ for following:	❑ All Fees ❑ 1.16 Fees (Filing) ❑ 1.17 Fees (Processing Ext. of time) ❑ 1.18 Fees (Issue) ❑ Other _______________ ❑ Credit

BIB (Rev. 05/07).

TS0001386

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	63	"5107359"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2008/05/10 12:38
L2	673429	optical and (rout $5 filter multiplex $5)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/05/10 12:48
L3	292148	2 and input and output	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/05/10 12:50
L4	2499	3 and slm	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/05/10 12:50
L5	596	4 and hologram	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/05/10 12:51
L6	552	5 and (frequency wavelength)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/05/10 12:51

5/10/2008 2:23:09 PM
C:\Documents and Settings\fassaf\My Documents\EAST\Workspaces\11514725.wsp

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **April 16, 2008** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Fayez G. Assaf	CONFIRMATION NO. 4755	GROUP 2872

U.S. PATENT DOCUMENTS

EXAM-INER INI-TIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
	A12	6,747,774 B2	06/08/2004	Kelly, *et al.*
	A13	6,760,511 B2	07/06/2004	Garrett, *et al.*
	A14	6,529,307 B1	03/04/2003	Peng, *et al.*
	A15	6,594,082 B1	07/15/2003	Li, *et al.*
	A16	5,960,133	09/28/1999	Tomlinson
	A17	2005/0270616 A1	12/08/2005	Weiner
	A18	2004/0126120 A1	07/01/2004	Cohen, *et al.*
	A19	2007/0268537 A1	11/22/2007	Holmes

EXAMINER /Fayez Assaf/	DATE CONSIDERED 05/10/2008

800580_1

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

TS0001388

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **April 16, 2008** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Fayez G. Assaf	CONFIRMATION NO. 4755	GROUP 2872

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER Country Code-Number-Kind Code (if known)	DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT	TRANSLATION YES	NO
	B8	EP 1 207 418 A1	05/22/2002	Alcatel		

EXAMINER	DATE CONSIDERED
/Fayez Assaf/	05/10/2008

800580_1

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

TS0001389

825381_1
TJM/jk
September 15, 2008

OIPE IAP84
SEP 17 2008
PATENT & TRADEMARK OFFICE

PATENT APPLICATION
DOCKET NO.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	Assaf, Fayez G.
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

CERTIFICATE OF MAILING OR TRANSMISSION
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

9-15-08 — Julie Kertyzak
Date — Signature

Julie Kertyzak
Typed or printed name of person signing certificate

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Information Disclosure Statement is submitted:

☐ under 37 CFR 1.97(b), or
(Within any one of the following time periods: three months of filing national application (other than a CPA) or date of entry of the national stage in an international application; or before the mailing date of a first office action on the merits in a non-provisional application, including a CPA, or a Request for Continued Examination).

☒ under 37 CFR 1.97(c) together with either:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, or
- ☒ a $180.00 fee under 37 CFR 1.17(p), or

(After the 37 CFR 1.97(b) time period, but before final action or notice of allowance, whichever occurs first)

☐ under 37 CFR 1.97(d) together with:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, and
- ☐ a $180.00 fee under 37 CFR 1.17(p), or

(Filed after final action or notice of allowance, whichever occurs first, but on or before payment of the issue fee)

☐ under 37 CFR 1.97(i):
Applicant requests that the IDS and cited reference(s) be placed in the application file.
(Filed after payment of issue fee)

09/17/2008 LTRUONG 00000061 11514725

03 FC:1806 180.00 OP

TS0001390

Statement Under 37 CFR 1.97(e)

☐ Each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement; or

☐ No item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned, after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

Statement Under 37 CFR 1.704(d) (Patent Term Adjustment)
Applies to original applications (other than design) filed on or after May 29, 2000

☐ Each item of information contained in the Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the Information Disclosure Statement.

☒ Enclosed herewith is a Listing of References:

☐ Copies of the cited references are enclosed.

☒ Copies of issued U.S. patents and published U.S. applications are not required and are not being provided.

☐ Copies of the cited references are enclosed except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. **[OPTION]**[120][121][365(c)] is claimed. **[OPTIONAL** [The earlier application contains copies of the cited references.]

☐ The listed references were cited in the enclosed Search Report in counterpart foreign application [add application number].

☐ The "concise explanation" requirement (non-English references) for reference(s) [ ] under 37 CFR 1.98(a)(3) is satisfied by:

☐ the explanation provided on the attached sheet.

☐ the explanation provided in the Specification.

☐ submission of the enclosed International Search Report.

☐ submission of the enclosed English-language version of a foreign Search Report and/or foreign Office Action.

☐ the enclosed English language abstract.

☐ Applicant requests that the following non-published pending applications be considered:
(Affix a label or apply the stamp "Non-Published IDS Reference - Do Not Scan" to the front of each unpublished pending appl'n.)

U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

☐ A copy of each above-cited application, including the current claims, is enclosed, except any application filed on or after June 30, 2003, which has been scanned into the PTO's Image File Wrapper (IFW) system and is available to the examiner.

☐ A copy of each above-cited application, including the current claims, is enclosed, except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. **[OPTION]**[120][121][365(c)] is claimed.

It is requested that the information disclosed herein be made of record in this application.

Method of payment:

☒ A check for the fee noted above is enclosed, or the fee has been included in the check with the accompanying Reply. If this submission is in paper form, a copy of this letter is enclosed for accounting purposes.

☐ Please charge Deposit Account 08-0380 in the amount of $[ ]. If this submission is in paper form, a copy of this letter is enclosed for accounting purposes.

☒ Please charge any deficiency in fees and credit any overpayment to Deposit Account 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 9/15/8

TS0001392

825381_1
TJM/jk
September 15, 2008

SEP 17 2008

PATENT APPLICATION
DOCKET NO.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	Assaf, Fayez G.
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

CERTIFICATE OF MAILING OR TRANSMISSION
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

9-15-08 — Julie Kertyzak
Date — Signature

Julie Kertyzak
Typed or printed name of person signing certificate

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Information Disclosure Statement is submitted:

☐ under 37 CFR 1.97(b), or
(Within any one of the following time periods: three months of filing national application (other than a CPA) or date of entry of the national stage in an international application; or before the mailing date of a first office action on the merits in a non-provisional application, including a CPA, or a Request for Continued Examination).

☒ under 37 CFR 1.97(c) together with either:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, or
- ☒ a $180.00 fee under 37 CFR 1.17(p), or

(After the 37 CFR 1.97(b) time period, but before final action or notice of allowance, whichever occurs first)

☐ under 37 CFR 1.97(d) together with:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, and
- ☐ a $180.00 fee under 37 CFR 1.17(p), or

(Filed after final action or notice of allowance, whichever occurs first, but on or before payment of the issue fee)

☐ under 37 CFR 1.97(i):
Applicant requests that the IDS and cited reference(s) be placed in the application file.
(Filed after payment of issue fee)

TS0001393

Statement Under 37 CFR 1.97(e)

☐ Each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement; or

☐ No item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned, after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

Statement Under 37 CFR 1.704(d) (Patent Term Adjustment)
Applies to original applications (other than design) filed on or after May 29, 2000

☐ Each item of information contained in the Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the Information Disclosure Statement.

☒ Enclosed herewith is a Listing of References:

- ☐ Copies of the cited references are enclosed.
  - ☒ Copies of issued U.S. patents and published U.S. applications are not required and are not being provided.

☐ Copies of the cited references are enclosed except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. **[OPTION]**[120][121][365(c)] is claimed. **[OPTIONAL** [The earlier application contains copies of the cited references.]

☐ The listed references were cited in the enclosed Search Report in counterpart foreign application [add application number].

☐ The "concise explanation" requirement (non-English references) for reference(s) [ ] under 37 CFR 1.98(a)(3) is satisfied by:

- ☐ the explanation provided on the attached sheet.
- ☐ the explanation provided in the Specification.
- ☐ submission of the enclosed International Search Report.
- ☐ submission of the enclosed English-language version of a foreign Search Report and/or foreign Office Action.
- ☐ the enclosed English language abstract.

☐ Applicant requests that the following non-published pending applications be considered:
(Affix a label or apply the stamp "Non-Published IDS Reference - Do Not Scan" to the front of each unpublished pending appl'n.)

U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

U.S. Patent Application No. [ ], by [inventor(s)], filed [ ], Docket No.: [ ]

☐ A copy of each above-cited application, including the current claims, is enclosed, except any application filed on or after June 30, 2003, which has been scanned into the PTO's Image File Wrapper (IFW) system and is available to the examiner.

☐ A copy of each above-cited application, including the current claims, is enclosed, except those entered in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. **[OPTION]**[120][121][365(c)] is claimed.

It is requested that the information disclosed herein be made of record in this application.

Method of payment:

☒ A check for the fee noted above is enclosed, or the fee has been included in the check with the accompanying Reply. If this submission is in paper form, a copy of this letter is enclosed for accounting purposes.

☐ Please charge Deposit Account 08-0380 in the amount of $[ ]. If this submission is in paper form, a copy of this letter is enclosed for accounting purposes.

☒ Please charge any deficiency in fees and credit any overpayment to Deposit Account 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 9/15/8

TS0001395

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **September 15, 2008** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Assaf, Fayez G.	CONFIRMATION NO. 4755	GROUP 2872

U.S. PATENT DOCUMENTS

EXAM-INER INI-TIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
	A20	2008/0145053	06-19-2008	Holmes
	A21	US 5,629,802	05-13-1997	Clark, Natalie
	A22	US 3,773,401	11-20-1973	Douklias, et al.

EXAMINER	DATE CONSIDERED

825380 1

835181_1
TJM/jk
09/15/08

OIPE
SEP 17 2008
PATENT & TRADEMARK OFFICE

PATENT APPLICATION
DOCKET NO. 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	F. G. Assaf
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

9-15-08 (Date) — Julie Kertyzak (Signature)

Julie Kertyzak

Typed or printed name of person signing certificate

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith is an Amendment for filing in the above-identified application.

☐ Small entity status of this application under 37 CFR 1.9 and 1.27 has been established by a Small Entity Statement previously submitted.

☐ A Small Entity Statement to establish small entity status under 37 CFR 1.9 and 1.27 is enclosed.

TS0001397

The claims fee has been calculated as shown below:

	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NO. PREVIOUSLY PAID FOR	PRESENT EXTRA	SMALL ENTITY RATE	SMALL ENTITY ADDIT. FEE		OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDIT. FEE
TOTAL	30	MINUS	* 20	10	X $ 25	$	OR	X 50	$ 500
INDEP	5	MINUS	** 5	0	X $105	$		X $210	$ 0
☐ FIRST PRESENTATION OF MULTIPLE DEP. CLAIM					+ $185	$		+ $370	$
					TOTAL =	$ 0		TOTAL =	$ 500

* not fewer than 20
** not fewer than 3

The Application Size Fee has been calculated as shown below:
(Effective for cases filed on or after December 8, 2004)

Actual Sheets (Including current amendment)	Highest No. of Sheets Paid For (At least 100)	No. of Additional Units Required (Increments of 50 sheets)	SMALL ENTITY Rate	SMALL ENTITY Total Amount Owed	OTHER THAN SMALL ENTITY Rate	OTHER THAN SMALL ENTITY Total Amount Owed	Payment Sufficient for up to
139	150	0	X $130	$[ ]	X $260	$0	150 Sheets

Petition for Extension of Time

☒ Applicant hereby petitions to extend the time to respond to the Office Action dated May 13, 2008 for one month from August 13, 2008 to September 13, 2008. The appropriate fee is set forth below.

☐ *[For action-specific language in an extension of time, select the appropriate option from the Firm Templates]*

TS0001398

Please charge Deposit Account No. 08-0380 for the following fees:

☐	Petition for [ ] month Extension of Time	$
☐	Claims Fee	$
☐	Application Size Fee	$
☐	Other Fees:	
		$
		$
	TOTAL:	$

A check is enclosed in payment of the following fees:

☒	Petition for one month Extension of Time	$ 120
☒	Claims Fee	$ 500
☐	Application Size Fee	$
☒	Other Fees:	
	Supp. Information Disclosure Statement	$ 180
		$
	TOTAL:	$ 800

☒ Please charge any deficiency or credit any overpayment in the fees that may be due in this matter to Deposit Account No. 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]
Timothy J. Meagher
Registration No.: 39,302
Telephone (978) 341-0036
Facsimile (978) 341-0136

Concord, Massachusetts 01742-9133
Dated: 9/15/8

TS0001399

813964_1
TJM/jk
9/15/08

PATENT APPLICATION
Attorney's Docket No.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Melanie Holmes

Application No.: 11/514,725 Group: 2872

Filed: September 1, 2006 Examiner: F. G. Assaf

Confirmation No.: 4755

For: OPTICAL PROCESSING

OIPE SEP 17 2008 PATENT & TRADEMARK OFFICE

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

9/15/08 Julie Kertyzak
Date Signature

Julie Kertyzak
Typed or printed name of person signing certificate

AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Amendment is being filed in response to the Office Action mailed from the U.S. Patent and Trademark Office on May 13, 2008 in the above-identified application. Reconsideration and further examination are requested.

An extension of time to respond to the Office Action is respectfully requested. A Petition for Extension of Time and the appropriate fee are being filed concurrently with this Amendment.

Please amend the application as follows:

09/17/2008 LTRUONG 00000061 11514725

01 FC:1202 500.00 OP
02 FC:1251 120.00 OP

TS0001400

Amendments to the Claims

Please amend claims 4, 5, 7 and 8. Please add new claims 9-30. The Claim Listing below will replace all prior versions of the claims in the application:

Claim Listing

1. (Withdrawn) An optical add/drop multiplexer having a reflective SLM having a two-dimensional array of controllable phase-modulating elements, a diffraction device and a focussing device wherein light beams from a common point on the diffraction device are mutually parallel when incident upon the SLM, and wherein the SLM displays respective holograms at locations of incidence of light to provide emergent beams whose direction deviates from the direction of specular reflection.

2. (Withdrawn) A test or monitoring device comprising an SLM having a two-dimensional array of pixels, and operable to cause incident light to emerge in a direction deviating from the specular direction, the device having light sensors at predetermined locations arranged to provide signals indicative of said emerging light.

3. (Withdrawn) A test or monitoring device according to claim 2, further comprising further sensors arranged to provide signals indicative of light emerging in the specular directions.

4. (Currently Amended) An optical routing module having at least one input and at least ~~two outputs~~ one output and operable to select between the outputs, the module comprising:

a two dimensional SLM having an array of pixels,

a dispersion device disposed to receive light from said at least one input and constructed and arranged to disperse beams of said light of different frequencies to be incident upon respective different groups of the pixels of the two-dimensional SLM, and

~~with~~ circuitry constructed and arranged to display holograms on the ~~pixels~~ SLM to route beams of different frequency to respective outputs.

TS0001401

5. (Currently Amended) A routing device having an input and plural outputs, the input constructed and arranged to receive [[a]] an input light beam having plural ~~wavelengths~~ frequencies, the device comprising:

a two dimensional SLM having an array of pixels, and

a dispersion device disposed to receive light from said at least one input and constructed and arranged to disperse beams of said light of different frequencies to be incident upon a respective different group of the pixels of the two-dimensional SLM,

~~an optical device for selecting the wavelengths~~ wherein the routing device is operable to select the frequencies of the input light beam to appear in the outputs, wherein each output may contain any desired set of the plural ~~wavelengths~~ frequencies.

6. (Original) A routing device according to claim 5, wherein the members of the desired set may be varied in use.

7. (Currently Amended) A routing device according to claim 5, wherein at least two of the outputs contain at least one common ~~wavelength~~ frequency.

8. (Currently Amended) A routing device having plural input signals and an output, the output constructed and arranged to deliver a signal having plural ~~wavelengths~~ frequencies, the device comprising:

a two dimensional SLM having an array of pixels, and

a dispersion device disposed to receive light from the input signals and constructed and arranged to disperse beams of said light of different frequencies to be incident upon a respective different group of the pixels of the two-dimensional SLM,

~~a device for combining the wavelengths~~ wherein the routing device is operable to combine the frequencies from the input signals to appear in the output, wherein each input signal may contain any desired set of the plural ~~wavelengths~~ frequencies of the output.

9. (New) The optical routing module of claim 4, wherein the dispersion device comprises at least one reflective device and at least one transmissive device.

TS0001402

10. (New) The optical routing module of claim 4, wherein the dispersion device comprises at least one of: a blazed grating, a holographic grating, an etched grating, an arrayed waveguide grating and a prism.

11. (New) The optical routing module of claim 4, wherein the two dimensional SLM having an array of pixels is a reflective SLM incorporating a wave-plate whereby the reflective SLM is substantially polarisation independent.

12. (New) The optical routing module of claim 4, wherein the two dimensional SLM having an array of pixels is a reflective Liquid Crystal on Silicon Spatial Light Modulator (LCOS SLM).

13. (New) The optical routing module of claim 4, further comprising a wave-plate arranged such that light passes through the wave-plate first after passing through the dispersion device a first time, and second before passing through the dispersion device a second time.

14. (New) The optical routing module of claim 13, wherein the dispersion device comprises a first and a second dispersion element.

15. (New) The optical routing module of claim 4, further comprising a wave-plate arranged such that light passes through the wave-plate a first time after passing through a first dispersion element, and a second time before passing through a second dispersion element.

16. (New) The optical routing module of claim 15, wherein the first and second dispersion elements are provided by a single dispersive device.

17. (New) The optical routing module of claim 15, wherein the first and second dispersion elements are provided by separate dispersive devices.

18. (New) The optical routing module of claim 4, wherein the beams of different frequencies are spatially separated when incident upon the array of pixels according to their respective wavelengths.

19. (New) The optical routing module of claim 4, wherein a plurality of input beams are provided from a respective plurality of inputs and the beams are spatially separated when incident upon the array of pixels according to at least one of:

their respective input directions; and

their respective wavelengths.

20. (New) The optical routing module of claim 4, wherein at least one group of pixels defines a square.

21. (New) The optical routing module of claim 4, wherein at least one group of pixels defines an arbitrary shape.

22. (New) The optical routing module of claim 4, wherein at least one group of pixels defines a rectangle.

23. (New) The optical routing module of claim 4, wherein at least one group of pixels has a size between 10 and 50 phase modulating elements in at least one dimension.

24. (New) The optical routing module of claim 4, wherein at least one group of pixels has a size in one dimension that is at least 2 times a 1/e spot half-width of an amplitude distribution of an incident beam measured in the same dimension.

25. (New) The optical routing module of claim 4, wherein a property of at least one group of pixels is varied, the property including at least one of: size, shape and position.

26. (New) The optical routing module of claim 4, wherein each group of pixels comprises a plurality of subgroups, wherein at least one subgroup is controlled so as to have a phase effect different to at least one other subgroup.

27. (New) The optical routing module of claim 4, further comprising a control device operable to delineate groups of individual phase-modulating elements; to select, from stored control data, control data for each group of phase-modulating elements; to generate from the respective selected control data a respective hologram at each group of phase-modulating elements; and to vary at least one of the delineation of the groups and the selection of control data whereby upon illumination of said groups by respective light beams, respective emergent light beams from the groups are controllable independently of each other.

28. (New) The optical routing module of claim 4, having groups of pixels of the two-dimensional SLM assigned to respective wavelength channels, and further comprising a control circuit operable to delineate guard bands between said groups.

29. (New) The optical routing module of claim 28, wherein at least one guard band is configured to route light in a direction different to respective directions routed by said groups.

30. (New) The optical routing module of claim 28, wherein at least one guard band is effective to narrow a bandwidth of a wavelength channel carried by a group of pixels.

REMARKS

Claims 1-8 are pending in the application. Claims 1-3 are withdrawn. Claims 4, 5, 7 and 8 are amended. Claims 9-30 are new.

Claims 4-6 and 8 were rejected under 35 USC 102(b) as being anticipated by Mears et al. ("WDM Channel Management ... Elements." The rejection is respectfully traversed.

Claims 4-6 and 8, as amended, are distinguished from the cited Mears reference because of the claimed feature of a dispersion device disposed to receive light from at least one input and constructed and arranged to disperse beams of the light of different frequencies to be incident upon respective different groups of the pixels of a two-dimensional SLM.

The Mears reference describes a tunable holographic wavelength filter. A fixed blazed diffraction grating of high spatial frequency is used in conjunction with the SLM to yield a compact high resolution filter. A lens placed after the SLM and a fixed diffraction grating convert the angular separation of wavelengths to a spatial separation; a single-mode optical fiber acts as a fixed spatial filter to select desired wavelengths. This arrangement is illustrated in Figure 1 of Mears.

In the present invention as now claimed, the wavelengths of the input beam are dispersed by the dispersion device such that beams of light of different frequencies are incident upon respective different groups of the pixels of the two-dimensional SLM in order to allow independent routing of beams of different frequency to respective outputs.

With the apparatus disclosed in Mears, the wavelength channels cannot be controlled independently. What the Mears apparatus does with one channel impacts on the attenuation of the other channels, because all channels from the same input share the same hologram. It should be noted that Mears refers to holograms designed to have multiple spatial periods, and that Mears goes on to state that this allows multiple wavelength tuning. This statement in Mears is made with reference to the tunability of the filter. That is, the filter of Mears is tuned to select one of the multiple selectable wavelengths by applying to the SLM a hologram selected to have an appropriate one of the multiple of available spatial periods.

For at least the foregoing reasons, Mears does not anticipate claims 4-6 and 8. Withdrawal of the rejection under 35 USC 102(b) is respectfully requested.

Claims 5 and 8 were rejected under 35 USC 102(b) as being anticipated by Ohuchida (US5107359). The rejection is respectfully traversed.

Ohuchida discloses an optical wavelength-division multi/demultiplexer for use in an optical multiplex communication. A transmission off-axis diffraction grating is formed on one side of a substrate, for passing light incident thereon while diffracting and converging the same. A light reflecting element such as a transmission off-axis diffraction grating or flat specular reflection surface is provided on the other side of the substrate, for reflecting the light diffracted by the transmission off-axis diffraction grating toward the transmission off-axis diffraction grating.

Ohuchida does not disclose the two-dimensional SLM and the dispersion device, as recited in amended claims 5 and 8. Reconsideration of the rejection under 35 USC 102(b) is respectfully requested.

Claim 7 was rejected under 35 USC 103(a) as being unpatentable over Mears. The rejection is respectfully traversed.

The rejection referred to claim 6. However, it is understood from the reasons given that claim 7 was the claim rejected as being unpatentable over Mears. Claim 7 depends from base claim 5. For at least the reasons noted above addressing the patentability of amended claim 5, claim 7 is also patentable over Mears.

Accordingly, it is respectfully submitted that the claims as amended are novel and non-obvious over the cited references.

Information Disclosure Statement

An Information Disclosure Statement (IDS) is being filed concurrently herewith. Entry of the IDS is respectfully requested.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By ______________________
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Date: 9/15/08

TS0001408

835215_1
TJM/jk
09/15/08

OIPE
SEP 17 2008
PATENT & TRADEMARK OFFICE

PATENT APPLICATION
Docket No.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	F. G. Assaf
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

9-15-08 (Date) — Julie Kertyzak (Signature)

Julie Kertyzak

Typed or printed name of person signing certificate

TRANSMITTAL OF REPLACEMENT DRAWINGS

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith are replacement drawings consisting of a total of 36 sheets, figures 1-35, for filing in the subject patent application.

TS0001409

The enclosed drawings are of better quality than the originally submitted drawings; Applicant's Attorney advises that no substantive changes have been made. Therefore, annotated sheets are not required.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By ____________________
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Date: 9/15/8

TS0001410

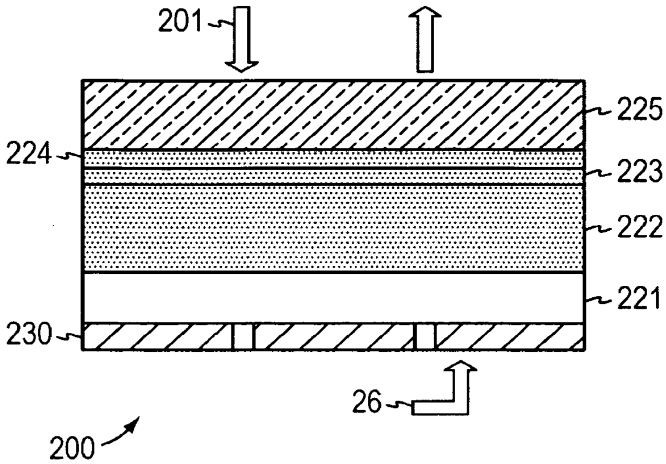

FIG. 1

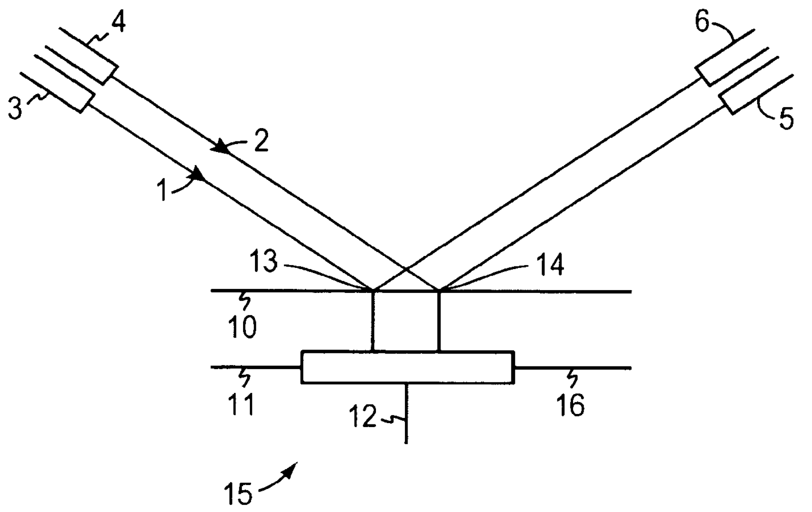

FIG. 2

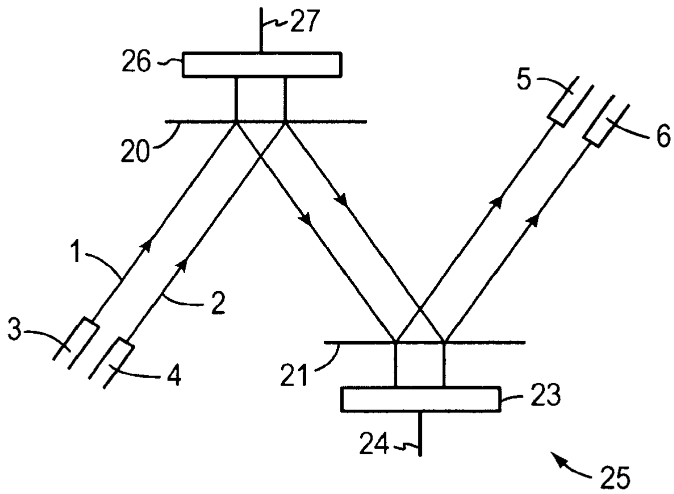

FIG. 3

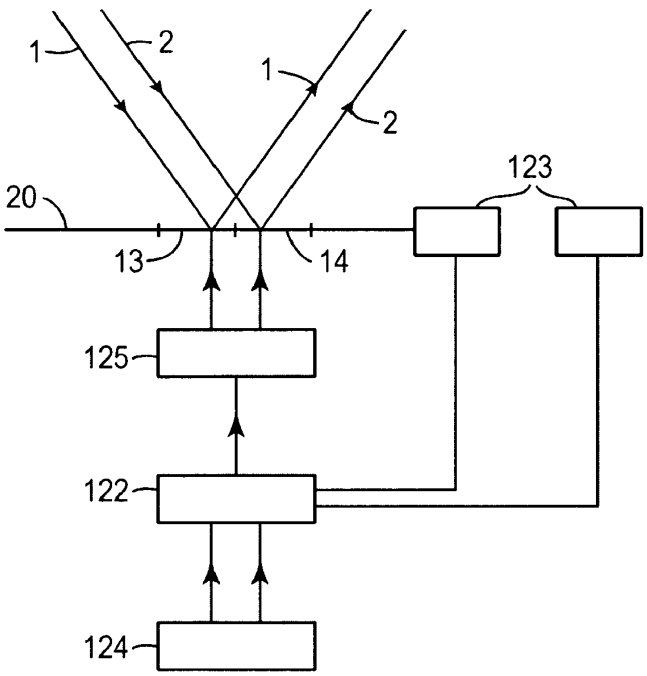

FIG. 4

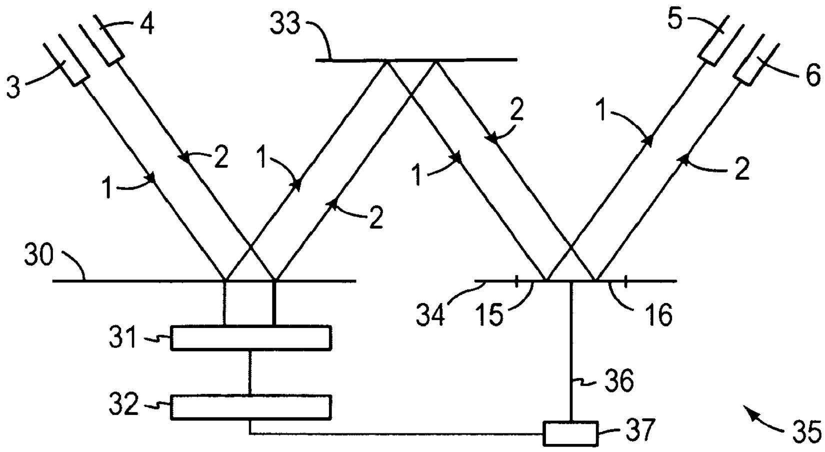

FIG. 5

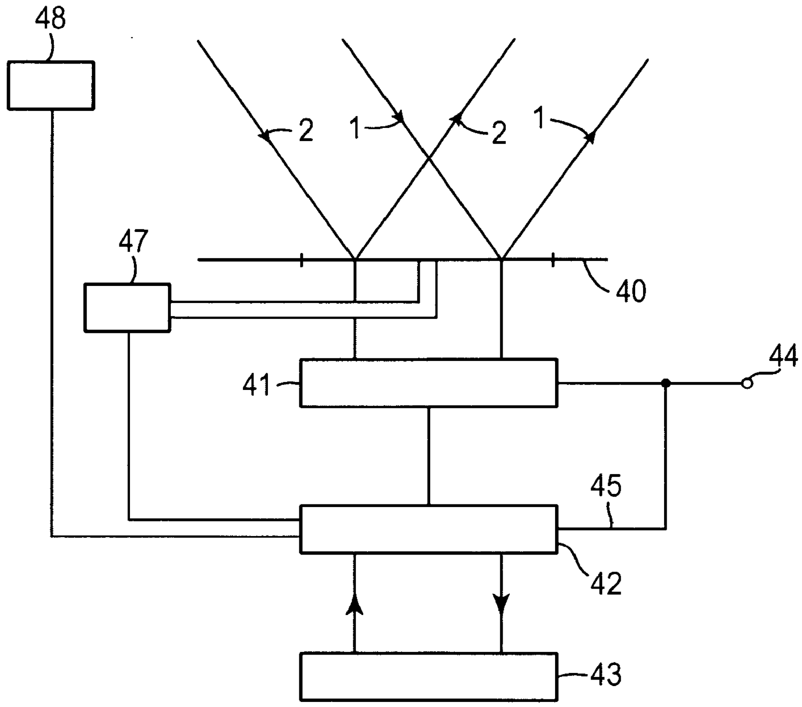

FIG. 6

TS0001416

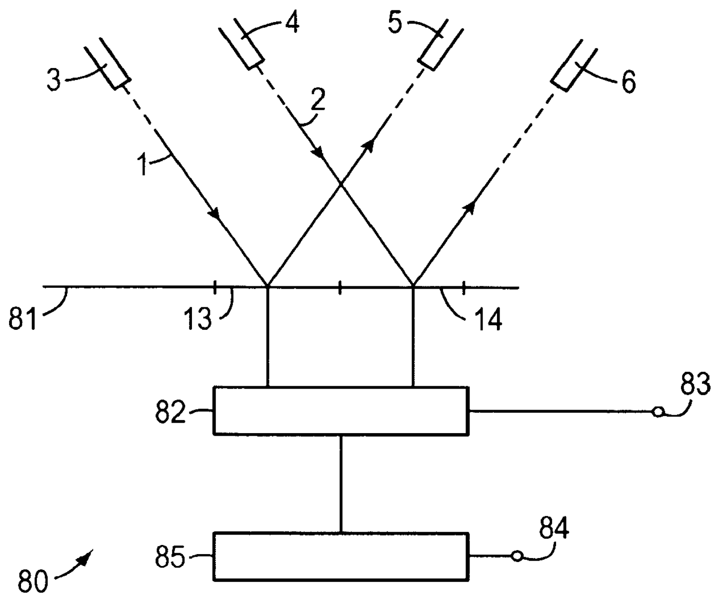

FIG. 7

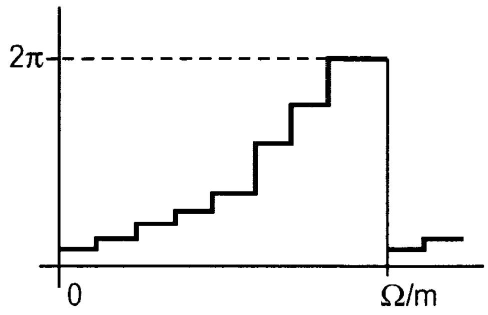

FIG. 8A

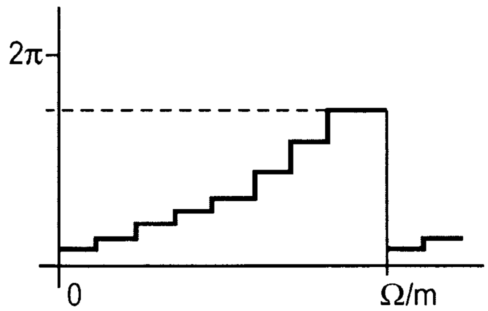

FIG. 8B

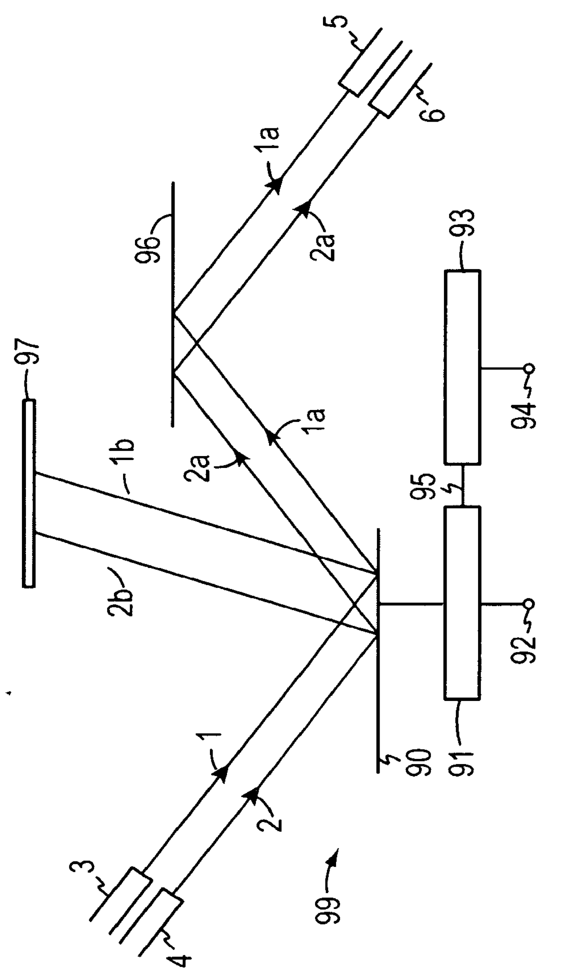

FIG. 9

TS0001419

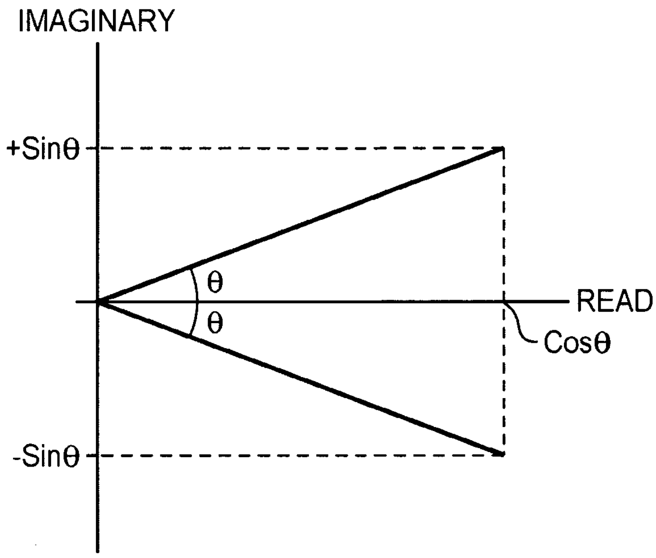

FIG. 10

TS0001420

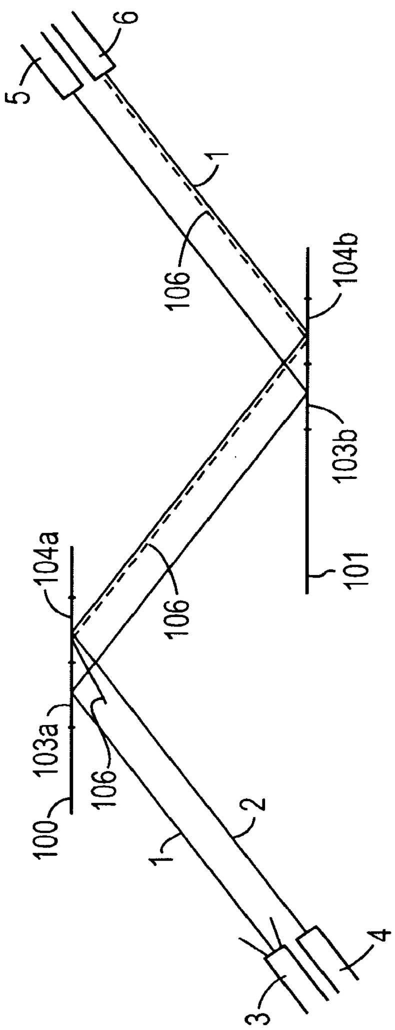

FIG. 11

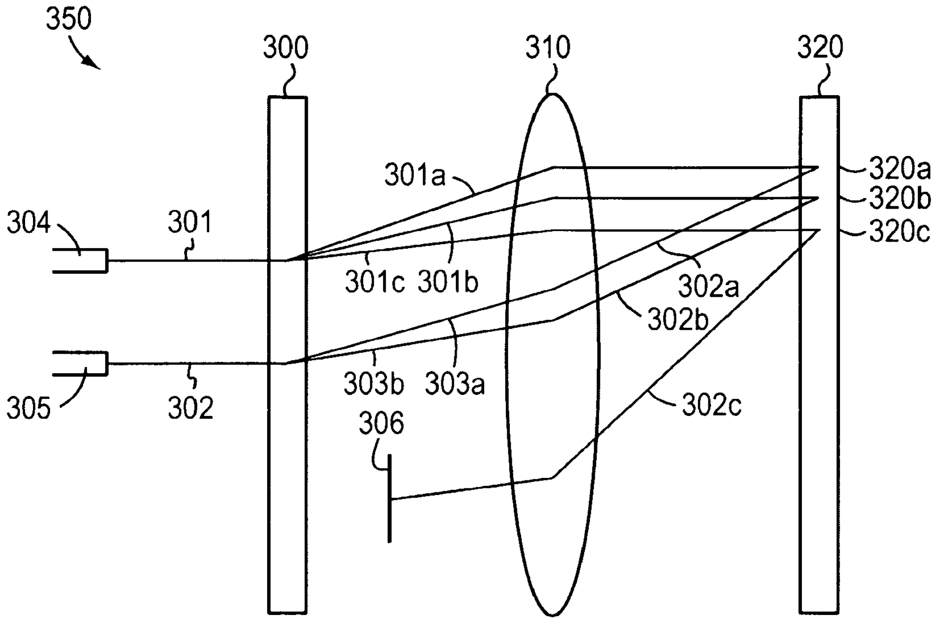
350
300
310
320
301a
320a
320b
320c
304
301
301c 301b
302a
302b
303b 303a
305
302
306
302c

FIG. 12

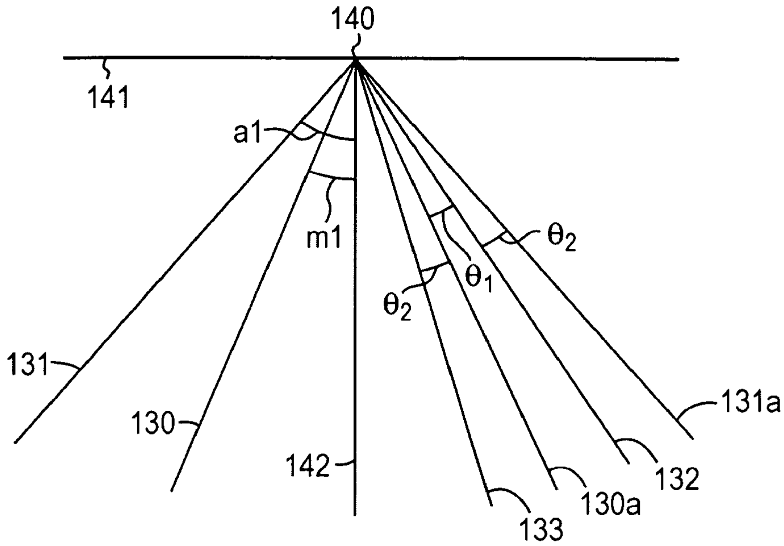

FIG. 13A

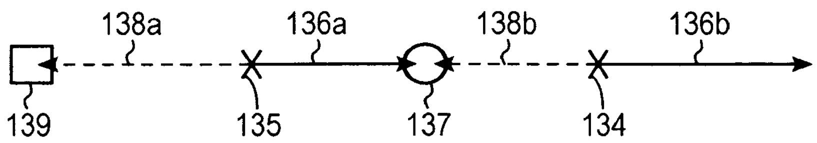

FIG. 13B

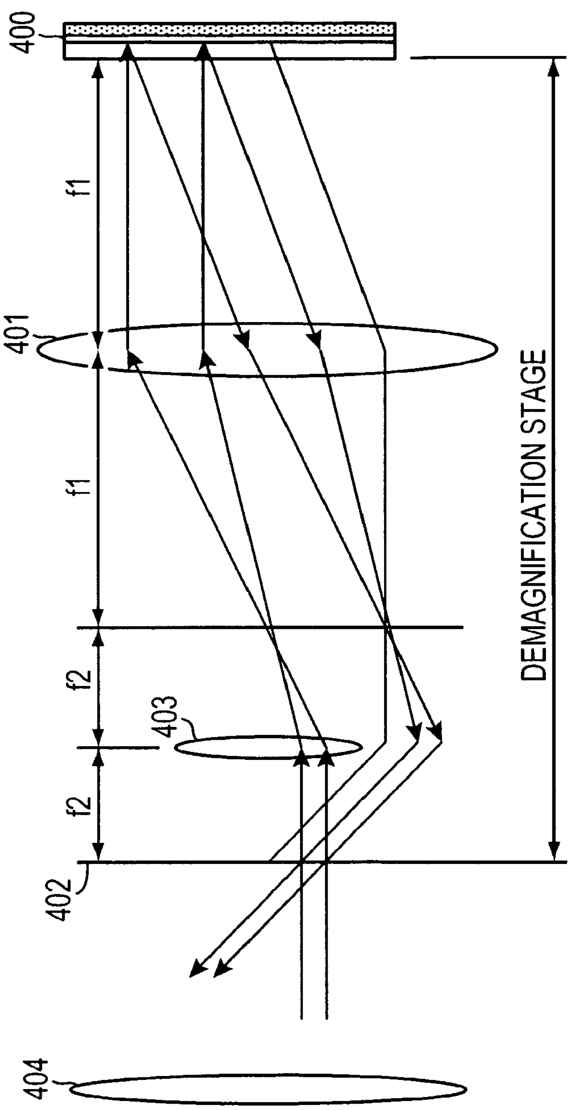

FIG. 14

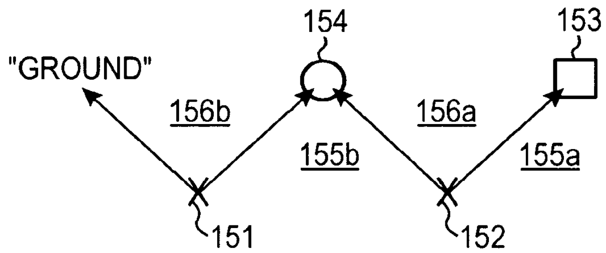

FIG. 15

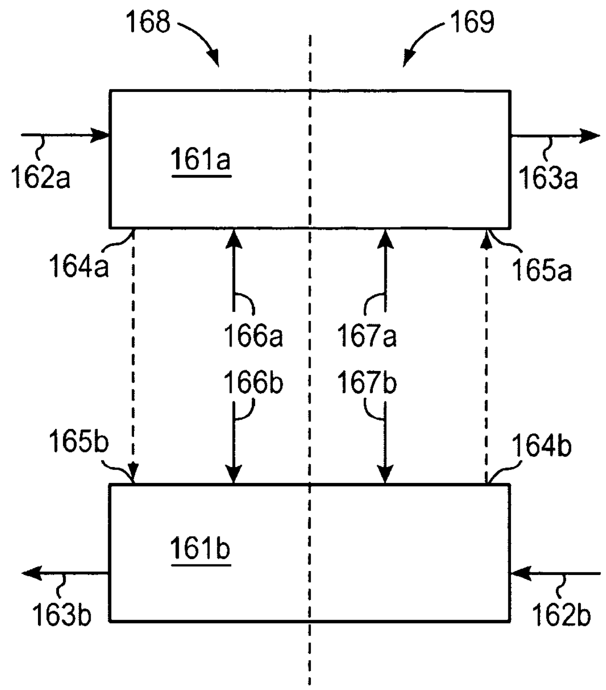
168
169
161a
162a
163a
164a
165a
166a
167a
166b
167b
165b
164b
161b
163b
162b

FIG. 16

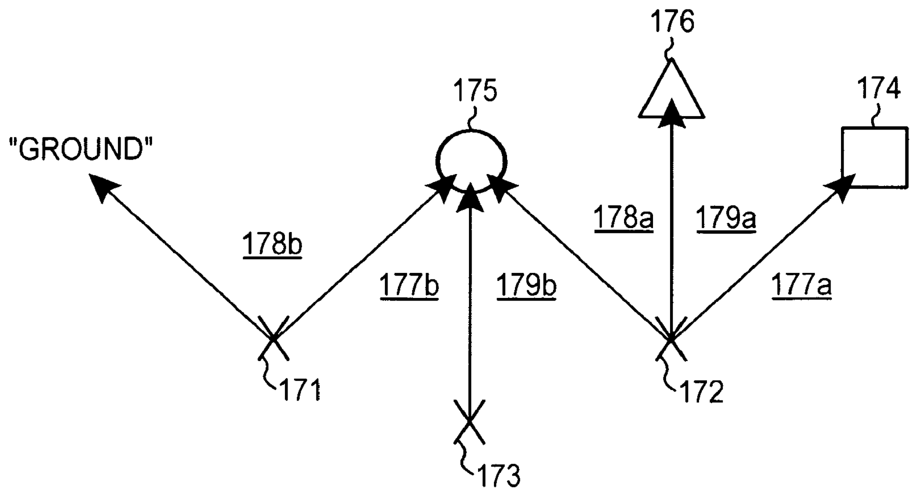

FIG. 17

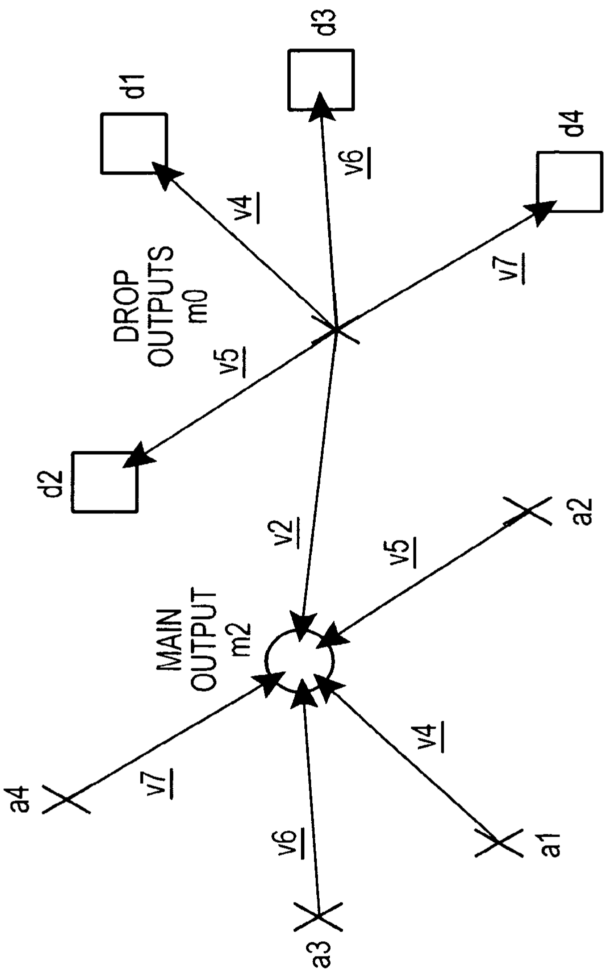

FIG. 18

TS0001429

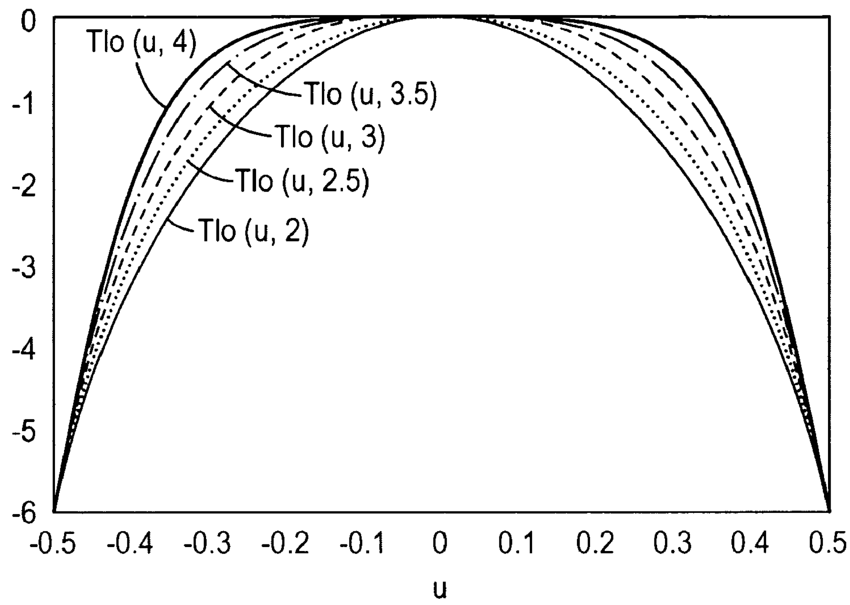
0
-1
-2
-3
-4
-5
-6
Tlo (u, 4)
Tlo (u, 3.5)
Tlo (u, 3)
Tlo (u, 2.5)
Tlo (u, 2)
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
u

FIG. 19

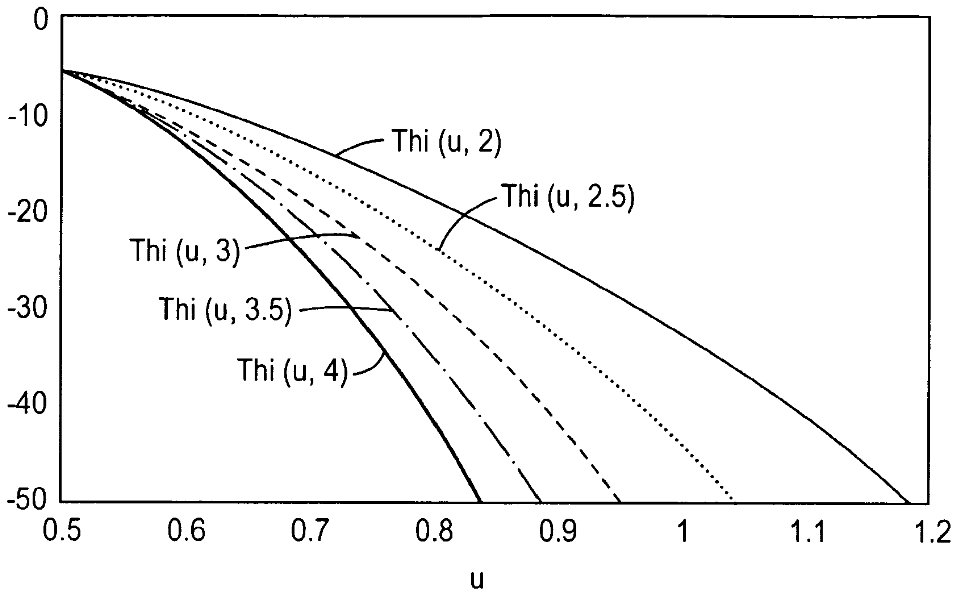
0
-10
-20
-30
-40
-50
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
u
Thi (u, 2)
Thi (u, 2.5)
Thi (u, 3)
Thi (u, 3.5)
Thi (u, 4)

FIG. 20

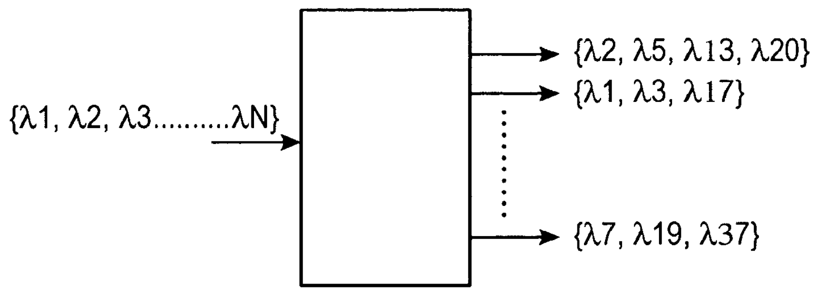

FIG. 21

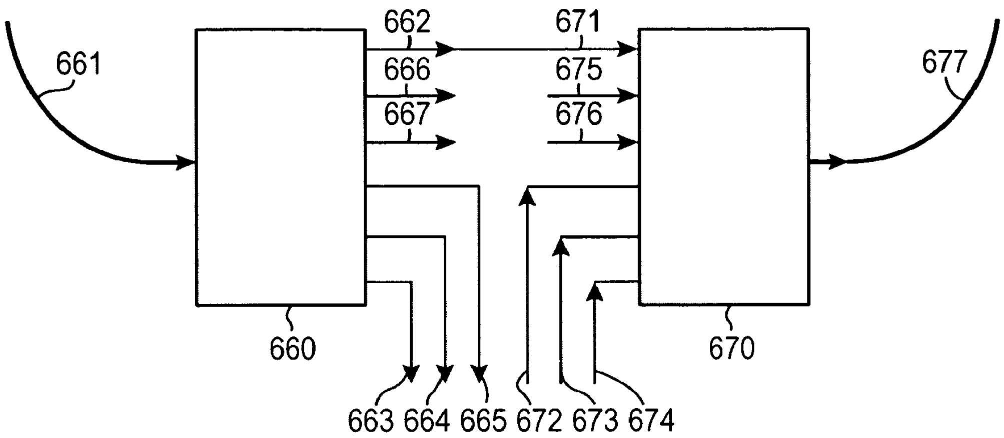

FIG. 22

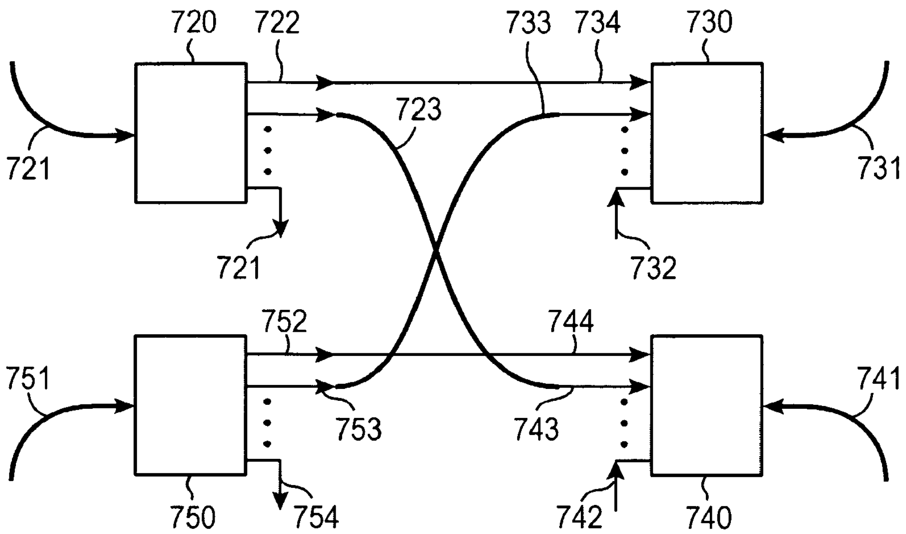
720
722
733
734
730
723
721
731
721
732
752
744
751
741
753
743
750
754
742
740

FIG. 23

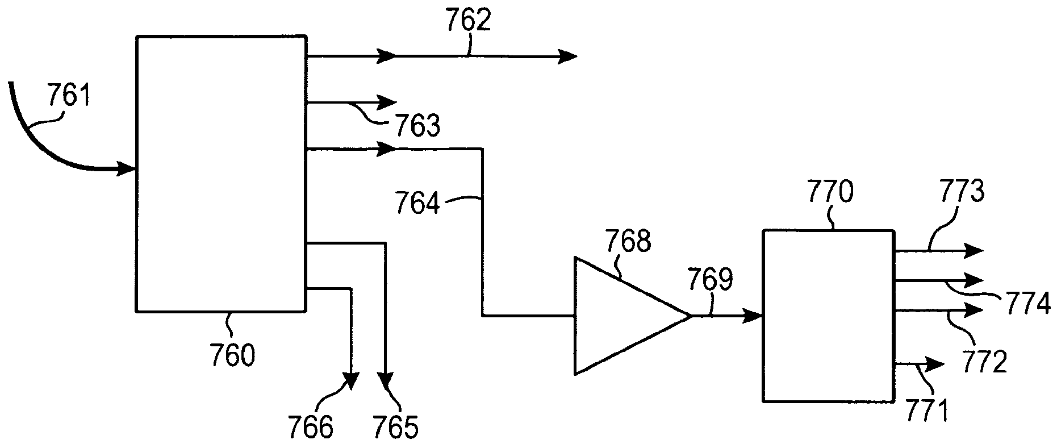

FIG. 24

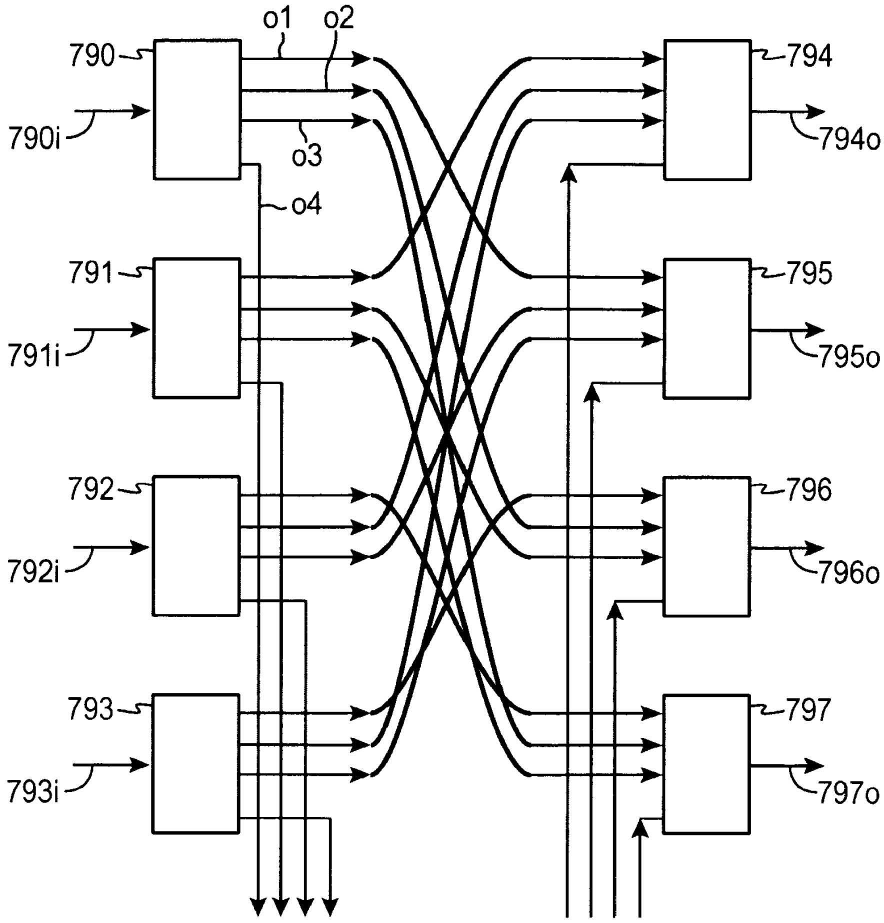
o1
o2
o3
o4
790
790i
791
791i
792
792i
793
793i
794
794o
795
795o
796
796o
797
797o

FIG. 25

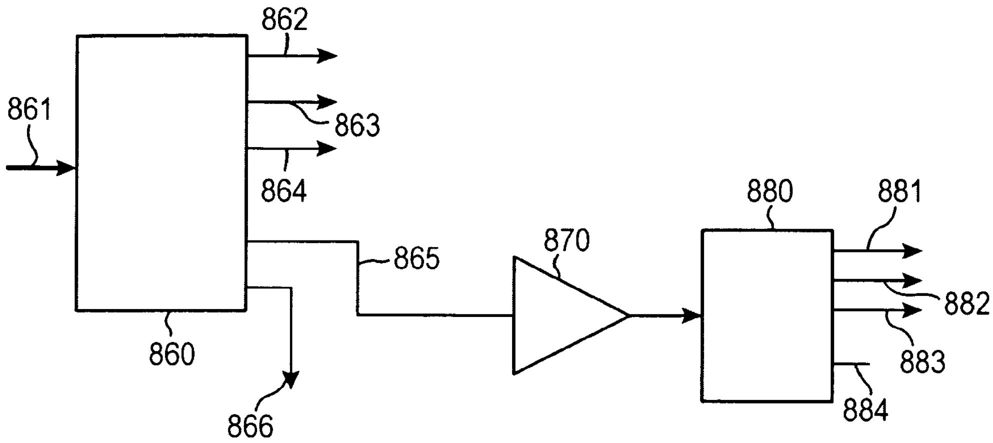

FIG. 26

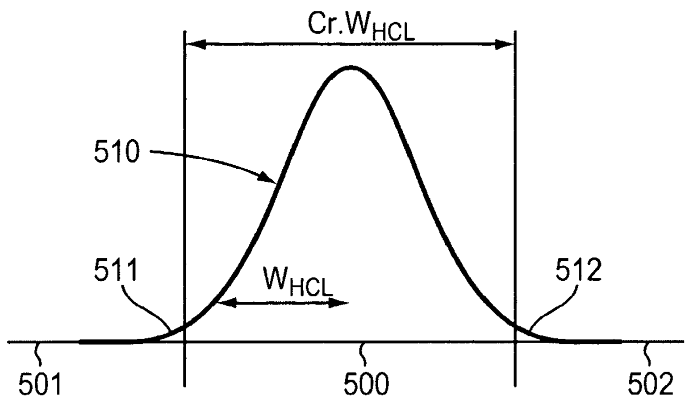

FIG. 27

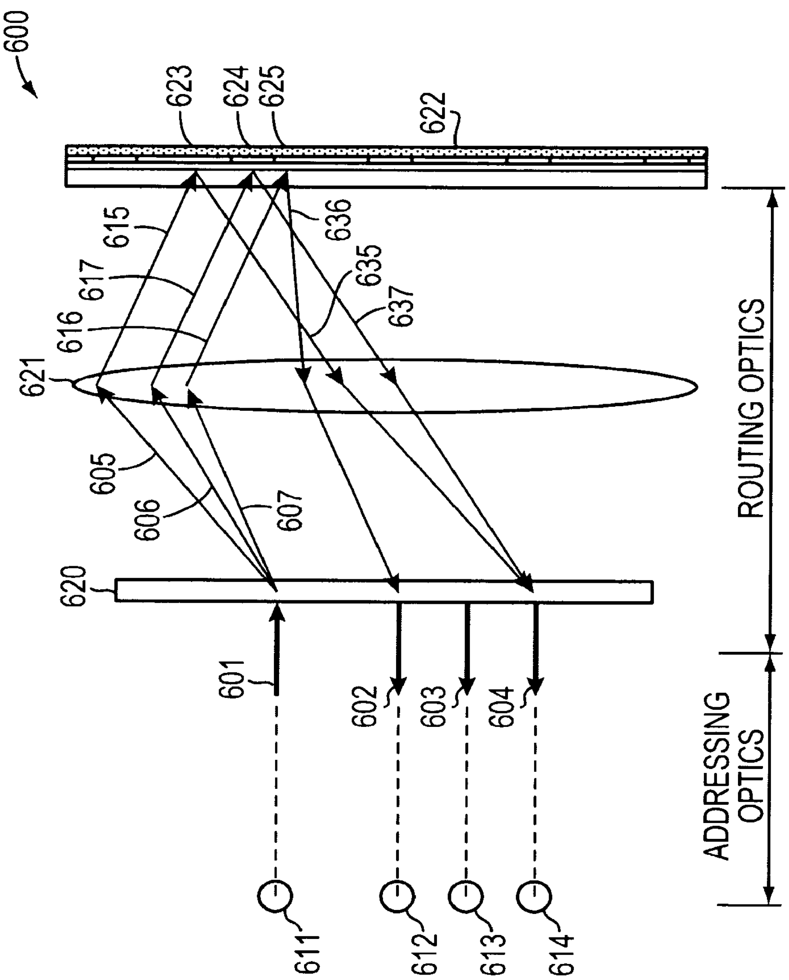
600
623
624
625
622
615
617
616
621
636
635
637
605
606
607
620
601
602
603
604
611
612
613
614
ROUTING OPTICS
ADDRESSING OPTICS

FIG. 28

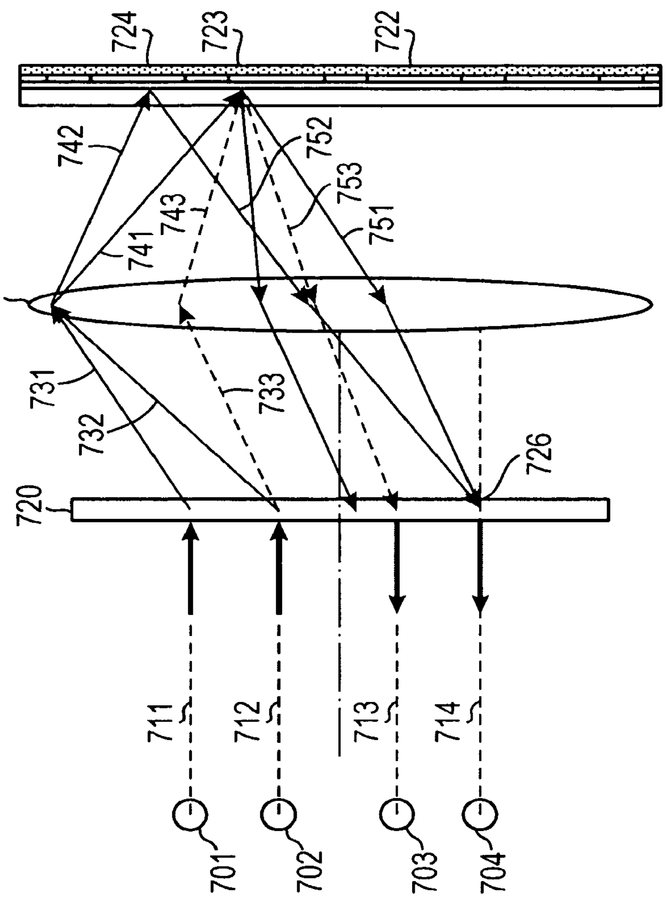

FIG. 29

TS0001440

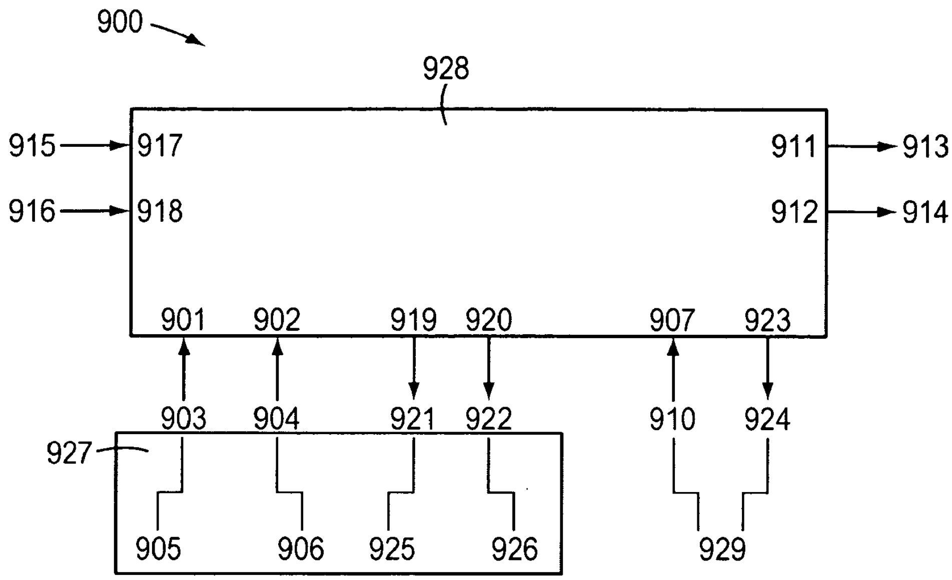
900
928
915
917
916
918
911
913
912
914
901
902
919
920
907
923
903
904
921
922
910
924
927
905
906
925
926
929

FIG. 30

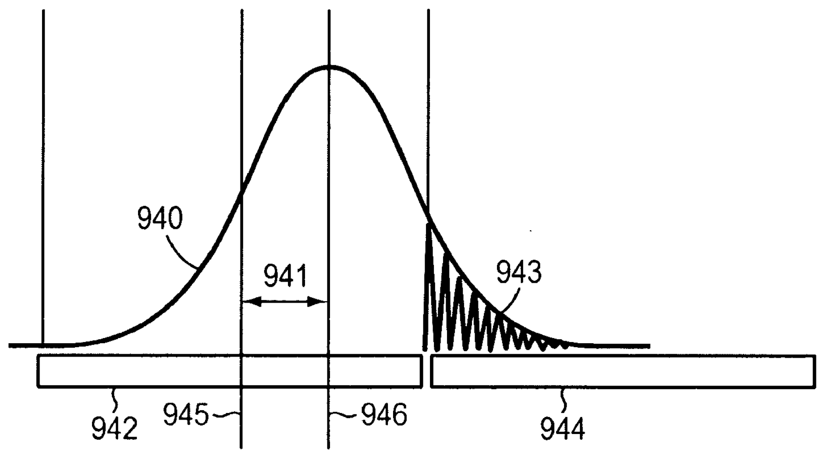

FIG. 31

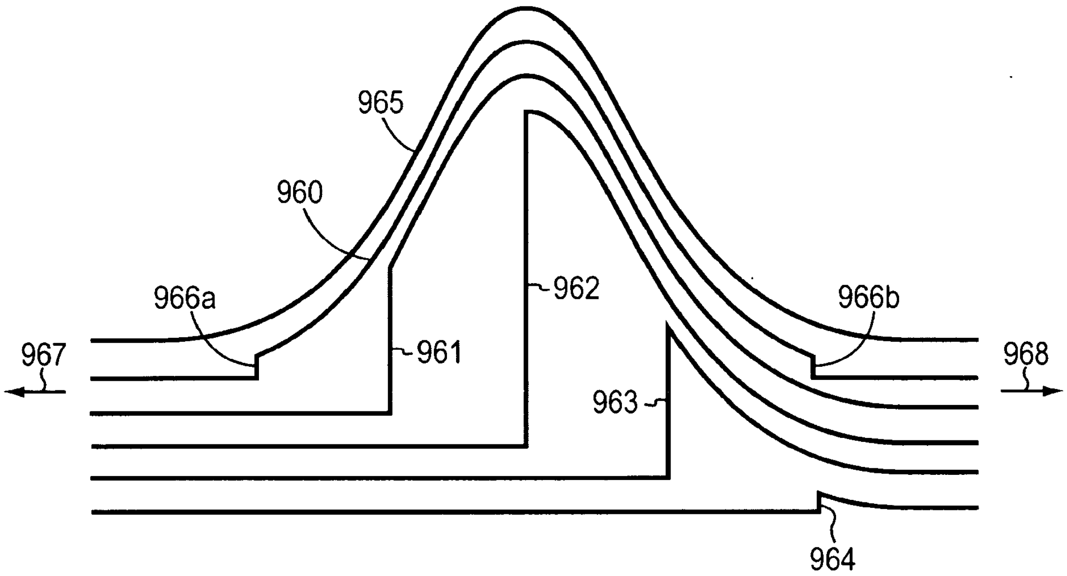

FIG. 32

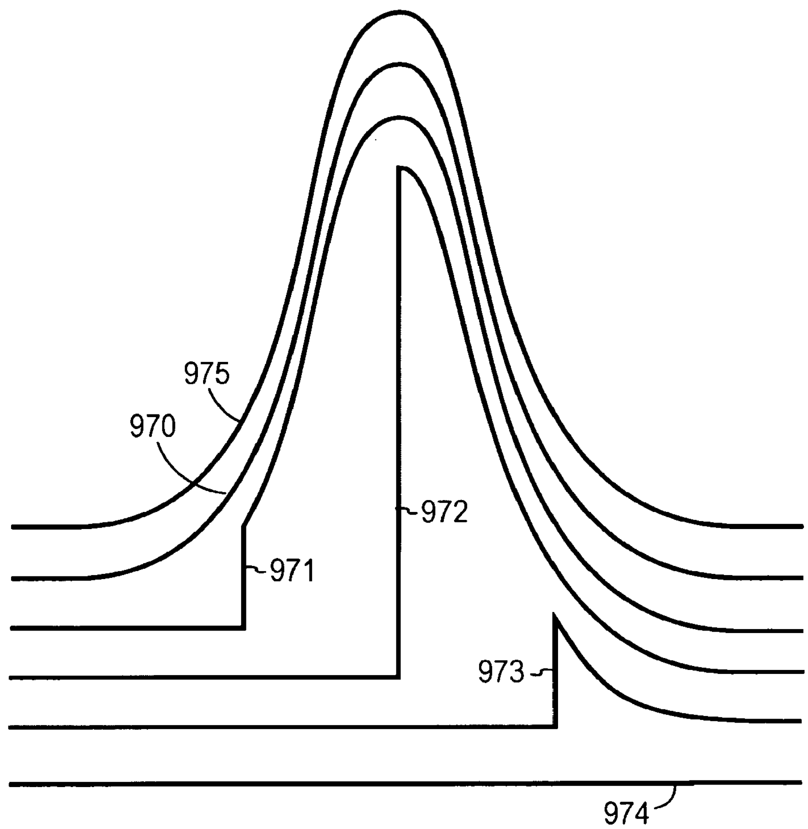

FIG. 33

TS0001444

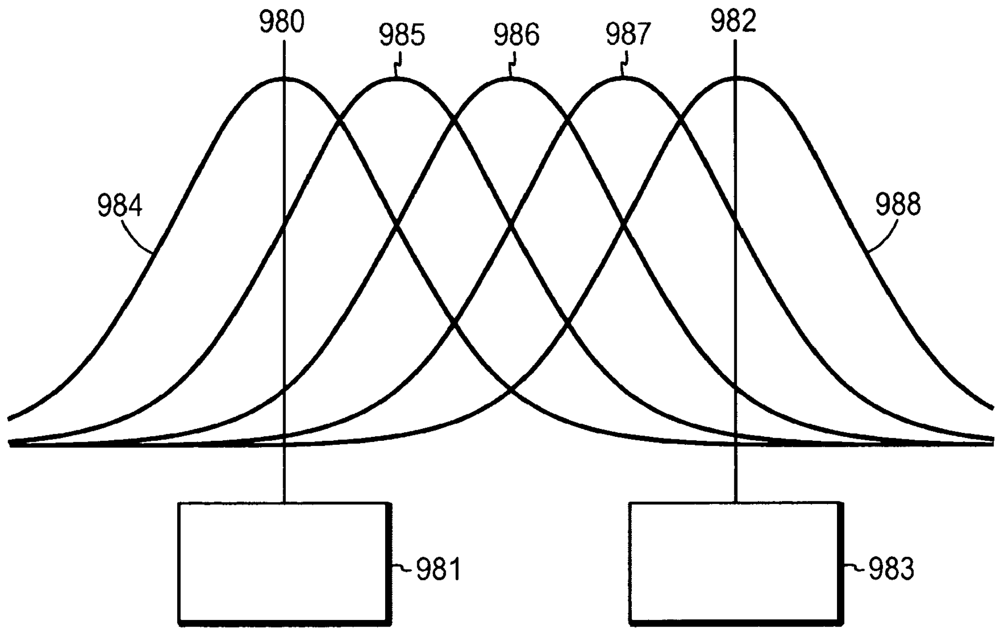

FIG. 34

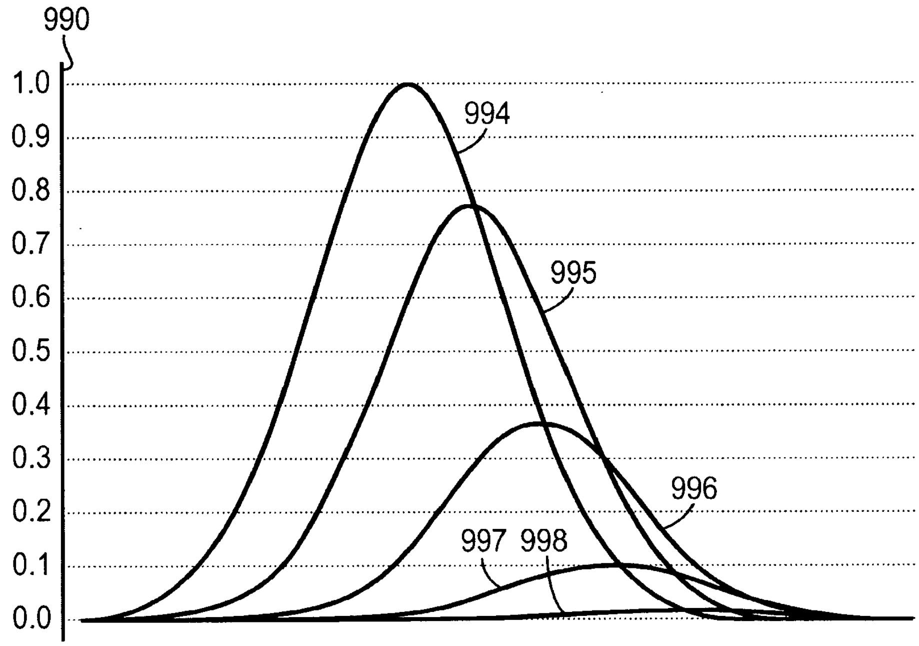

FIG. 35

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/514,725	Filing Date 09/01/2006	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	09/17/2008	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 30	Minus	** 20	= 10	X $ =		OR	X $50=	500
	Independent (37 CFR 1.16(h))	* 5	Minus	***5	= 0	X $ =		OR	X $210=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**500**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/BRENDA L. TURNER/

TS0001447

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11514725	HOLMES, MELANIE
	Examiner	**Art Unit**
	Fayez G Assaf	2872

SEARCHED

Class	Subclass	Date	Examiner
359	15,19	5/10/2008	/FA/

SEARCH NOTES

Search Notes	Date	Examiner
See attached	5/10/2008	/FA/

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002	4755

21005 7590 01/13/2009

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

EXAMINER	
ASSAF, FAYEZ G	

ART UNIT	PAPER NUMBER
2872	

MAIL DATE	DELIVERY MODE
01/13/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

TS0001449

Office Action Summary	Application No.	Applicant(s)	
	11/514,725	HOLMES, MELANIE	
	Examiner	Art Unit	
	Fayez G. Assaf	2872	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *1* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *17 September 2008*.

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-30* is/are pending in the application.

4a) Of the above claim(s) *1-3* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☒ Claim(s) *4-30* are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *09/17/2008*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

Election/Restrictions

This application contains claims directed to the following patentably distinct species.

Species 1: The devices utilizes a polarization independent SLM having a wave plate.

Species 2: The device utilizes an LCOS SLM.

The species are independent or distinct because claims to the different species recite the mutually exclusive characteristics of such species. In addition, these species are not obvious variants of each other based on the current record.

Applicant is required under 35 U.S.C. 121 to elect a single disclosed species for prosecution on the merits to which the claims shall be restricted if no generic claim is finally held to be allowable. Currently, at least claims 4, 5 and 8 are generic.

There is an examination and search burden for these patentably distinct species due to their mutually exclusive characteristics. The species require a different field of search (e.g., searching different classes/subclasses or electronic resources, or employing different search queries); and/or the prior art applicable to one species would not likely be applicable to another species; and/or the species are likely to raise different non-prior art issues under 35 U.S.C. 101 and/or 35 U.S.C. 112, first paragraph.

Applicant is advised that the reply to this requirement to be complete must include (i) an election of a species to be examined even though the requirement may be traversed (37 CFR 1.143) **and (ii) identification of the claims encompassing the elected species**, including any claims subsequently added. An argument that a claim is allowable or that all claims are generic is considered nonresponsive unless accompanied by an election.

The election of the species may be made with or without traverse. To preserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the election of species requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable on the elected species.

Should applicant traverse on the ground that the species are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the species to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the species unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103(a) of the other species.

Upon the allowance of a generic claim, applicant will be entitled to consideration of claims to additional species which depend from or otherwise require all the limitations of an allowable generic claim as provided by 37 CFR 1.141.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Fayez G. Assaf whose telephone number is (571) 272-2307. The examiner can normally be reached on 8-5 M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephone Allen can be reached on (571) 272-2434. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Fayez G. Assaf/
Primary Examiner, Art Unit 2872

December 12, 2008

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **September 15, 2008** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Assaf, Fayez G.	CONFIRMATION NO. 4755	GROUP 2872

U.S. PATENT DOCUMENTS

EXAM -INER INI- TIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
	A20	2008/0145053	06-19-2008	Holmes
	A21	US 5,629,802	05-13-1997	Clark, Natalie
	A22	US 3,773,401	11-20-1973	Douklias, et al.

EXAMINER	DATE CONSIDERED
/Fayez Assaf/	12/12/2008

825380_1

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

TS0001455

868628_1
TJM/jk
2/13/09

OIPE
FEB 17 2009
PATENT & TRADEMARK OFFICE

FYM

PATENT APPLICATION
Docket No.: 3274.1003-002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	F. G. Assaf
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or is being facsimile transmitted to the United States Patent and Trademark Office on:

2/13/09 Julie Kertyzak
Date Signature

Julie Kertyzak
Typed or printed name of person signing certificate

<u>REPLY TO RESTRICTION REQUIREMENT</u>

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Reply is being filed in response to the Office Action mailed from the U.S. Patent and Trademark Office on January 13, 2009 in the above-identified application. Reconsideration and further examination are requested.

TS0001456

REMARKS

The Office Action stated an election of species requirement and requested Applicant to elect one of two species for further prosecution: Species I - devices using a polarization independent SLM having a wave plate; and Species II - devices using an LCOS SLM.

The Office Action further stated that at least claims 4, 5 and 8 appear generic. Accordingly, it is Applicant's understanding that the requirement for an election of species was made for the purposes of searching. Applicant understands that a search of the prior art will be made based on the elected species and, if the rejection is not made, the search will be expanded to include non-elected species.

Responsive to the requirement for an election of species for searching purposes, Applicant hereby elects Species I. Claims readable on the elected species are claims 4-11 and 13-30. The requirement is being traversed for the reasons set forth in detail below.

The Office Action stated that the two identified species are independent or distinct because claims to the different species recite mutually exclusive characteristics of such species. The Office Action further stated that these species are not obvious variants of each other based on the current record. Applicant disagrees.

Paragraphs 157 to 165 of the application as filed refer to a polarization-independent (multiple phase) LCOS SLM (paragraph 157). Furthermore, the application goes on to describe, in connection with Figure 1, an SLM 200 comprising a quarter-wave plate 221 and a liquid crystal layer 222 (paragraph 158). Accordingly, it is respectfully submitted that an SLM that uses a wave plate and is polarization independent is not mutually exclusive with an SLM that is an LCOS SLM. In addition, this fact is apparent from the current record as described in paragraphs 157 to 165 of the application as filed.

Thus, for the reasons mentioned above, it is respectfully requested that the requirement for election of species be removed.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By ______________________
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: February 13, 2009

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/514,725	Filing Date 09/01/2006	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	02/17/2009	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 30	Minus	** 30	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 5	Minus	***5	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/LAVINIA JOHNSON/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002	4755

21005 7590 05/06/2009

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

EXAMINER	
AMARI, ALESSANDRO V	

ART UNIT	PAPER NUMBER
2872	

MAIL DATE	DELIVERY MODE
05/06/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No.	Applicant(s)	
	11/514,725	HOLMES, MELANIE	
	Examiner	Art Unit	
	ALESSANDRO AMARI	2872	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _17 September 2008_.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) _1-30_ is/are pending in the application.

4a) Of the above claim(s) _1-3_ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) _4-30_ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Election/Restrictions

1. Applicant timely traversed the restriction (election) requirement in the reply filed on 17 February 2009. Restriction requirement is hereby withdrawn and claims 4-30 will be examined in this office action.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

3. Claims 4, 9-11, 13-19, 21, 23 and 25-30 are rejected under 35 U.S.C. 102(e) as being anticipated by Weiner US 2002/0060760.

In regard to claim 4, Weiner discloses (see Fig. 1, 2) an optical routing module having at least one input and at least one output and operable to select between the outputs, the module comprising a two dimensional SLM (140, 240) having an array of pixels, a dispersion device (130, 230) disposed to receive light from said at least one input and constructed and arranged to disperse beams of said light of different frequencies to be incident upon respective different groups of the pixels of the two-dimensional SLM, and with circuitry (150) constructed and arranged to display holograms on the SLM to route beams of different frequency to respective outputs as described in paragraphs [0045] and [0063].

Regarding claim 9, Weiner discloses that the dispersion device comprises at least one reflective device (230) and at least one trans missive device (232) as shown in Figure 2.

Regarding claim 10, Weiner discloses that the dispersion device comprises at least one of: a blazed grating, a holographic grating, an etched grating, an arrayed waveguide grating and a prism as described in paragraph [0054].

Regarding claim 11, Weiner discloses that the two dimensional SLM having an array of pixels is a reflective SLM incorporating a wave-plate whereby the reflective SLM is substantially polarisation independent as described in paragraphs [0064] and [0073].

Regarding claim 13, Weiner discloses further comprising a wave-plate arranged such that light passes through the wave-plate first after passing through the dispersion device a first time, and second before passing through the dispersion device a second time as described in paragraph [0064].

Regarding claim 14, Weiner discloses that the dispersion device comprises a first and a second dispersion element as described in paragraph [0063] and [0064].

Regarding claim 15, Weiner discloses further comprising a wave-plate arranged such that light passes through the wave-plate a first time after passing through a first dispersion element, and a second time before passing through a second dispersion element as described in paragraph [0064] and [0073].

Regarding claim 16, Weiner discloses that the first and second dispersion elements are provided by a single dispersive device as described in paragraph [0064].

Regarding claim 17, Weiner discloses that the first and second dispersion elements are provided by separate dispersive devices as described in paragraph [0064].

Regarding claim 18, Weiner discloses that the beams of different frequencies are spatially separated when incident upon the array of pixels according to their respective wavelengths as described in paragraph [0045].

Regarding claim 19, Weiner discloses that a plurality of input beams are provided from a respective plurality of inputs and the beams are spatially separated when incident upon the array of pixels according to at least one of: their respective input directions; and their respective wavelengths as described in paragraph [0045].

Regarding claim 21, Weiner discloses that at least one group of pixels defines an arbitrary shape as described in para. [0063].

Regarding claim 23, Weiner discloses that at least one group of pixels has a size between 10 and 50 phase modulating elements in at least one dimension as described in para. [0063].

Regarding claim 25, Weiner discloses that a property of at least one group of pixels is varied, the property including at least one of: size, shape and position as described in para. [0063].

Regarding claim 26, Weiner discloses that each group of pixels comprises a plurality of subgroups, wherein at least one subgroup is controlled so as to have a phase effect different to at least one other subgroup as described in para. [0063].

Regarding claim 27, Weiner discloses further comprising a control device operable to delineate groups of individual phase-modulating elements; to select, from stored control data, control data for each group of phase-modulating elements; to generate from the respective selected control data a respective hologram at each group of phase-modulating elements; and to vary at least one of the delineation of the groups and the selection of control data whereby upon illumination of said groups by respective light beams, respective emergent light beams from the groups are controllable independently of each other as described in para. [0046].

Regarding claim 28, Weiner discloses having groups of pixels of the two-dimensional SLM assigned to respective wavelength channels, and further comprising a control circuit operable to delineate guard bands between said groups as described in para. [0063].

Regarding claim 29, Weiner discloses that at least one guard band is configured to route light in a direction different to respective directions routed by said groups as described in para. [0063].

Regarding claim 30, Weiner discloses that at least one guard band is effective to narrow a bandwidth of a wavelength channel carried by a group of pixels as described in para. [0063].

4. Claims 4-9, 11, 13-16, 18 and 19 are rejected under 35 U.S.C. 102(b) as being anticipated by Crossland et al (hereafter "Crossland") W001/25840 (cited as US 6,954,252).

In regard to claim 4, Crossland discloses (see Fig. 8, 9, 11, 12) an optical routing module having at least one input and at least one output and operable to select between the outputs, the module comprising a two dimensional SLM (141) having an array of pixels, a dispersion device (140) disposed to receive light from said at least one input and constructed and arranged to disperse beams of said light of different frequencies to be incident upon respective different groups of the pixels of the two-dimensional SLM, and with circuitry (150) constructed and arranged to display holograms on the SLM to route beams of different frequency to respective outputs as described in column 4, lines 1-23, column 9, lines 47-67 and column 10, lines 1-45.

In regard to claim 5, Crossland discloses (see Fig., 8, 9) a routing device having an input and plural outputs, the input constructed and arranged to receive an input light beam having plural frequencies, the device comprising: a two dimensional SLM (141) having an array of pixels, and a dispersion device (140) disposed to receive light from said at least one input and constructed and arranged to disperse beams of said light of different frequencies to be incident upon a respective different group of the pixels of the two-dimensional SLM, an wherein the routing device is operable to select the frequencies of the input beam to appear in the outputs, wherein each output may contain any desired set of the plural frequencies as described in column 4, lines 1-23, column 9, lines 47-67 and column 10, lines 1-45.

Regarding claim 6, Crossland discloses that the members of the desired set may be varied in use as described in column 4, lines 1-23, column 9, lines 47-67 and column 10, lines 1-45.

Regarding claim 7, Crossland discloses that at least two of the outputs contain at least one common wavelength frequency as described in column 4, lines 1-23, column 9, lines 47-67 and column 10, lines 1-45.

In regard to claim 8, Crossland discloses (see Figures 8, 9) a routing device having plural input signals and an output, the output constructed and arranged to deliver a signal having plural frequencies, the device comprising a two dimensional SLM (141) having an array of pixels, and a dispersion device (140) disposed to receive light from the input signals and constructed and arranged to disperse beams of said light of different frequencies to be incident upon a respective different group of the pixels of the two-dimensional SLM, wherein the routing device is operable to combine the frequencies from the input signals to appear in the output, wherein each input signal may contain any desired set of the plural frequencies of the output as described in column 4, lines 1-23, column 9, lines 47-67 and column 10, lines 1-45.

Regarding claim 9, Crossland discloses that the dispersion device comprises at least one reflective device (140) and at least one trans missive device (150, 152) as shown in Figures 8 and 9.

Regarding claim 11, Crossland discloses (see Figures 8, 9) that the two dimensional SLM having an array of pixels is a reflective SLM incorporating a waveplate whereby the reflective SLM incorporating a wave-plate whereby the reflective SLM is substantially polarisation independent as described in column 4, lines 1-23, column 9, lines 47-67 and column 10, lines 1-45.

Regarding claim 13, Crossland discloses (see Fig. 4) further comprising a wave-plate arranged such that light passes through the wave-plate (121) first after passing through the dispersion device a first time, and second before passing through the dispersion device a second time as shown in Figure 3 and as described in column 7, lines 45-67 and column 10, lines 26-29.

Regarding claim 14, Crossland discloses that the dispersion device comprises a first and a second dispersion element (hA, hC) as shown in Figure 11.

Regarding claim 15, Crossland discloses (see Fig. 4) further comprising a wave-plate (121) arranged such that light passes through the wave-plate a first time after passing through a first dispersion element, and a second time before passing through a second dispersion element as shown in Figure 3 and as described in column 7, lines 45-67 and column 10, lines 26-29.

Regarding claim 16, Crossland discloses that the first and second dispersion elements are provided by a single dispersive device (140) as shown in Figure 11.

Regarding claim 18, Crossland discloses that the beams of different frequencies are spatially separated when incident upon the array of pixels according to their respective wavelengths as described in column 4, lines 1-23.

Regarding claim 19, Crossland discloses that a plurality of input beams are provided from a respective plurality of inputs and the beams are spatially separated when incident upon the array of pixels according to at least one of: their respective input directions; and their respective wavelengths as described column 4, lines 1-23.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Weiner US 2002/0060760.

Regarding claim 12, Weiner teaches the invention as set forth above but does not teach that the two dimensional SLM having an array of pixels is a reflective Liquid Crystal on Silicon Spatial Light Modulator (LCOS SLM). It is well known to utilize LCOS SLMs in the optical communications art. It would have been obvious to one having ordinary skill in the art at the time the invention was made to utilize LCOS SLM in the optical routing module of Weiner in order to gain the predictable advantages of lower production cost and higher resolution.

7. Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Crossland W001/25840 (cited as US 6,954,252).

Regarding claim 12, Crossland teaches the invention as set forth above but does not teach that the two dimensional SLM having an array of pixels is a reflective Liquid Crystal on Silicon Spatial Light Modulator (LCOS SLM). It is well known to utilize LCOS

SLMs in the optical communications art. It would have been obvious to one having ordinary skill in the art at the time the invention was made to utilize LCOS SLM in the optical routing module of Crossland in order to gain the predictable advantages of lower production cost and higher resolution.

8. Claims 20, 22, and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Weiner US 2002/0060760.

Regarding claims 20, 22 and 24, Weiner teaches the invention as set forth above but does not teach that the group of pixels define a square or rectangle or at least one group of pixels has a size in one dimension that is at least 2 times a 1/e spot half-width of an amplitude distribution of an incident beam measured in the same dimension. It would have been obvious to one having ordinary skill in the art at the time the invention was made to adjust the shape or size of the pixels of the SLM of Weiner, since it has been held that adjustability, where needed involves only routine skill in the art. One would have been motivated to adjust the size and/or shape of the pixels in order to cause a change to an optical characteristic of the device such as phase or amplitude of the frequency components.

9. Claims 20-25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Crossland W001/25840 (cited as US 6,954,252).

Regarding claims 20-25, Crossland teaches the invention as set forth above but does not teach that the group of pixels define a square or rectangle or at least one group of pixels has a size in one dimension that is at least 2 times a 1/e spot half-width of an amplitude distribution of an incident beam measured in the same dimension. It would have been obvious to one having ordinary skill in the art at the time the invention was made to adjust the shape or size of the pixels of the SLM of Crossland, since it has been held that adjustability, where needed involves only routine skill in the art. One would have been motivated to adjust the size and/or shape of the pixels in order to cause a change to an optical characteristic of the device such as phase or amplitude of the frequency components.

Response to Arguments

10. Applicant's arguments with respect to claims 4-30 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

11. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Hong US 5,315,423 is considered relevant art.

12. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ALESSANDRO AMARI whose telephone number is (571)272-2306. The examiner can normally be reached on Monday-Friday 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephone B. Allen can be reached on (571) 272-2434. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

ava
04 May 2009

/Alessandro Amari/
Primary Examiner, Art Unit 2872

Notice of References Cited	Application/Control No. 11/514,725	Applicant(s)/Patent Under Reexamination HOLMES, MELANIE	
	Examiner ALESSANDRO AMARI	Art Unit 2872	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2002/0060760	05-2002	Weiner, Andrew M.	349/96
*	B	US-6,954,252	10-2005	Crossland et al.	349/196
*	C	US-5,315,423	05-1994	Hong, John H.	398/79
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	2388	(359/566,569,572).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/29 22:42
S2	2984	(398/48,49,79,81,82,84,87).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/29 22:42
S3	615	(398/84,87).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/29 22:42
S4	2	("20070035803").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/29 22:42
S6	724	(349/201,202).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/30 09:25
S8	2988	(398/48,49,79,81,82,84,87).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/30 09:25
S9	433	(359/9).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/30 09:38
S10	2587	(359/569,566,571,572).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/30 09:39
S11	255	(359/244).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/04/30 09:39
S12	20429	(wavelength near1 (multiplex$3 or demultiplex$3)) or optical rout$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 09:40
S13	18288	(wavelength near1 (multiplex$3 or demultiplex$3))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 09:40
S14	15081	spatial light modulator	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 09:40
S15	9	S6 and S12	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 09:40

S16	7	S9 and S12	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 10:20
S17	125	S10 and S12	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 10:22
S18	10	S14 and S17	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 10:22
S19	15	S11 and S12	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 10:34
S20	49	S8 and S14	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 10:35
S21	44	S20 and grating	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 10:55
S22	1	"7019883".PN.	USPAT; USOCR	ADJ	ON	2009/04/30 10:56
S23	1	"20030184843".PN.	US-PGPUB	ADJ	ON	2009/04/30 10:57
S24	4617	(spatial light modulator or SLM).clm.	US-PGPUB; USPAT	ADJ	ON	2009/04/30 11:06
S25	58825	dispersion.clm.	US-PGPUB; USPAT	ADJ	ON	2009/04/30 11:07
S26	108	S24 and S25	US-PGPUB; USPAT	ADJ	ON	2009/04/30 11:07
S27	25	S26 and pixel.clm.	US-PGPUB; USPAT	ADJ	ON	2009/04/30 11:07
S28	2693301	circuit$2 or control$3.clm.	US-PGPUB; USPAT	ADJ	ON	2009/04/30 11:08
S29	19	S27 and S28	US-PGPUB; USPAT	ADJ	ON	2009/04/30 11:08
S30	11	(US-20070268537-$ or US-20010050787-$ or US-20030184843-$).did. or (US-6954252-$ or US-6943950-$ or US-5315423-$ or US-7369773-$ or US-7262898-$ or US-6934069-$ or US-7019883-$ or US-7397980-$).did.	US-PGPUB; USPAT	ADJ	ON	2009/04/30 12:13
S31	7	S30 and (waveplate or wave plate or wave-plate)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/04/30 12:13
S32	20434	(wavelength near1 (multiplex$3 or demultiplex$3)) or optical rout$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/03 20:52

S33	34	(spatial light modulator or SLM) with (rout$3 or beam steering) with (wavelength or frequency)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/03 20:54
S34	16	S32 and S33	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/03 20:55
S35	15	S34 and grating	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/03 20:59
S36	2	("20020060760").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/05/03 21:42
S37	12	(US-20070268537-$ or US-20010050787-$ or US-20030184843-$ or US-20020060760-$).did. or (US-6954252-$ or US-6943950-$ or US-5315423-$ or US-7369773-$ or US-7262898-$ or US-6934069-$ or US-7019883-$ or US-7397980-$).did.	US-PGPUB; USPAT	ADJ	ON	2009/05/03 21:42
S38	8	S37 and (wave plate or waveplate)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/03 21:43
S39	0	("200100502787").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/05/03 21:50
S40	2	("20010050787").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/05/03 21:51
S41	2139	SLM with reflect$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/03 21:52
S42	6	S37 and S41	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/03 21:53
S43	2	("20070035803").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/05/03 22:10
S44	3	("2001/0050787").URPN.	USPAT	ADJ	ON	2009/05/03 22:15
S45	14899	drive circuitry	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 10:41

S46	12	(US-20070268537-$ or US-20010050787-$ or US-20030184843-$ or US-20020060760-$).did. or (US-6954252-$ or US-6943950-$ or US-5315423-$ or US-7369773-$ or US-7262898-$ or US-6934069-$ or US-7019883-$ or US-7397980-$).did.	US-PGPUB; USPAT	ADJ	ON	2009/05/04 10:41
S47	1	S45 and S46	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 10:41
S48	76931	demultiplex$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 10:43
S49	3	S46 and S48	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 10:43
S50	481879	multiplex$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 10:44
S51	12	S46 and S50	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 10:44
S52	8321	(liquid crystal on silicon) or LCOS	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 11:31
S53	2	S46 and S52	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 11:31
S54	93	(liquid crystal on silicon) or LCOS near3 (advantage or benefit)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 11:32
S55	6559730	pass$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 11:40
S56	11	S46 and S55	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	ADJ	ON	2009/05/04 11:40

5/4/2009 1:44:15 PM
C:\ Documents and Settings\ aamari\ My Documents\ EAST\ Workspaces\ 11514725.wsp

Index of Claims	Application/Control No. 11514725	Applicant(s)/Patent Under Reexamination HOLMES, MELANIE
	Examiner ALESSANDRO AMARI	Art Unit 2872

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/04/2009								
	1	N								
	2	N								
	3	N								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
	12	✓								
	13	✓								
	14	✓								
	15	✓								
	16	✓								
	17	✓								
	18	✓								
	19	✓								
	20	✓								
	21	✓								
	22	✓								
	23	✓								
	24	✓								
	25	✓								
	26	✓								
	27	✓								
	28	✓								
	29	✓								
	30	✓								

Search Notes	Application/Control No. 11514725	Applicant(s)/Patent Under Reexamination HOLMES, MELANIE
	Examiner Fayez G Assaf	**Art Unit** 2872

SEARCHED

Class	Subclass	Date	Examiner
359	15,19	5/10/2008	/FA/
359	9, 569, 566, 572, 571, 244	5/4/2009	/AA/
349	201, 202	5/4/2009	/AA/
398	48, 49, 79, 81, 82, 84, 87	5/4/2009	/AA/
Update	above	5/4/2009	/AA/

SEARCH NOTES

Search Notes	Date	Examiner
See attached	5/10/2008	/FA/
See attached	5/4/2009	/AA/

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

REMARKS

Claims 1-30 are pending in the application. Claims 1-3 are withdrawn. Claims 4, 5 and 8 are amended.

Claims 4, 9-11, 13-19, 21, 23 and 25-30 were rejected under 35 USC 102(e) as being anticipated by Weiner (US2002/0060760). Claims 4-9, 11, 13-16, 18 and 19 were rejected under 35 USC 102(b) as being anticipated by Crossland et al. (WO01/25840 cited as US6954252). The rejections are respectfully traversed.

Claim 4 has been amended to recite that "the or each input receives a respective light beam having an ensemble of different channels." Claim 4 has also been amended to change the recitation "a two-dimensional SLM" to read "an SLM having a two-dimensional array of pixels."

In addition, claim 4 has been amended to recite that the circuitry has the effect of determining the channels at the output, namely, "circuitry constructed and arranged to display holograms on the SLM to determine the channels at respective outputs." Support for this amended language is found in Figure 12 which has a single output 305. The input beam 301 contains three channels 301A-301C and, of these, only the light from channels 301A and 301B is provided to the output 305. Light from the channel figuratively shown as 301C is sent to an absorber 306 and therefore is not found at the output.

Weiner does not anticipate claim 4 as amended. First, the SLM of Weiner (see Figure 3) does not have a two-dimensional array of pixels. Second, Weiner does not teach or suggest "circuitry constructed and arranged to display holograms on the SLM to determine the channels at respective outputs." Rather, Weiner is concerned with compensation for polarization mode dispersion in wide band optical signals. There is no suggestion that the output signal 126 is anything other than a compensated version of the input signal 120.

Reconsideration of the rejection of amended claim 4, and claims dependent therefrom, under 35 USC 102(e) based on Weiner is respectfully requested.

Referring now to the rejection of base claims 4, 5 and 8 on the basis of Crossland, these claims have been amended to recite that the dispersion device is "constructed and arranged to disperse light beams of different frequencies in different directions." Support for this amended language is found at paragraph 0372 of the U.S. application where at page 62, line 8 it is recited that each wavelength channel is traveling "in a different direction."

Crossland at column 11, lines 34 to 41states that "the output SLM 141 is arranged such that the zero-order beam reflected from the centre of any hologram on the input SLM 140 is instant on the centre of an output hologram of the output SLM." Figure 11 shows a first input fiber fA that causes light to be incident on a first area hA of an SLM 140 with a hologram hA being provided so as to route the light from the fiber fA to an output hologram hB on a second SLM 141. A second input fiber fB causes light to be instant on a second region hC of the SLM 140 and the hologram hC at that location causes the light from the fiber fB to be incident at the same place on the output SLM 141.

Embodiments of the present invention use dispersion of channels onto an SLM, and has holograms formed at the incident locations to select channels for the output or outputs. There is no disclosure in Crossland nor suggestion that such channel selection can be done. Rather, Figure 11 shows how a half-wave plate causes this zero-order cross-talk component to be directed away from the output fiber.

Therefore, base claims 4, 5 and 8, as amended, are not anticipated by Crossland. Reconsideration of the rejection of base claims 4, 5 and 8, as amended, and dependent claims 6-9, 11, 13-16, 18 and 19, is respectfully requested.

Claim 12 was rejected under 35 USC 103(a) as being unpatentable over Weiner alone or Crossland alone. Claims 20, 22 and 24 were rejected under 35 USC 103(a) as being unpatentable over Weiner. Claims 20-25 were rejected under 35 USC 103(a) as being unpatentable over Crossland. The rejections are respectfully traversed.

Claims 12 and 20-25 are dependent from amended base claim 4. For at least the same reasons noted above for the patentability of claim 4 with respect to Weiner and Crossland, dependent claims 12 and 20-25 should also be allowable.

Reconsideration of the rejections under 35 USC 103(a) is respectfully requested.

<u>Information Disclosure Statement</u>

An Information Disclosure Statement (IDS) is being filed concurrently herewith. Entry of the IDS is respectfully requested.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]
Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Date: 8/6/9

Amendments to the Claims

Please amend claims 4, 5 and 8. The Claim Listing below will replace all prior versions of the claims in the application:

Claim Listing

1. (Withdrawn) An optical add/drop multiplexer having a reflective SLM having a two-dimensional array of controllable phase-modulating elements, a diffraction device and a focussing device wherein light beams from a common point on the diffraction device are mutually parallel when incident upon the SLM, and wherein the SLM displays respective holograms at locations of incidence of light to provide emergent beams whose direction deviates from the direction of specular reflection.

2. (Withdrawn) A test or monitoring device comprising an SLM having a two-dimensional array of pixels, and operable to cause incident light to emerge in a direction deviating from the specular direction, the device having light sensors at predetermined locations arranged to provide signals indicative of said emerging light.

3. (Withdrawn) A test or monitoring device according to claim 2, further comprising further sensors arranged to provide signals indicative of light emerging in the specular directions.

4. (Currently amended) An optical routing module having at least one input and at least one output and operable to select between the outputs, the or each input receiving a respective light beam having an ensemble of different channels, the module comprising:

~~a two~~ an dimensional SLM having ~~an~~ a two dimensional array of pixels,

a dispersion device disposed to receive light from said at least one input and constructed and arranged to disperse light beams ~~of said light~~ of different frequencies in different directions whereby different channels of said ensemble are ~~to be~~ incident upon respective different groups of the pixels of the ~~two-dimensional~~ SLM, and circuitry constructed and arranged to display holograms on the SLM to determine the channels at ~~route beams of different frequency to~~ respective outputs.

5. (Currently amended) A routing device having an input and plural outputs, the input constructed and arranged to receive an input light beam having plural frequencies, the device comprising:

a two dimensional SLM having an array of pixels, and

a dispersion device disposed to receive light from said at least one input and constructed and arranged to disperse beams of said light of different frequencies in different directions to be incident upon a respective different group of the pixels of the two-dimensional SLM,

wherein the routing device is operable to select the frequencies of the input light beam to appear in the outputs, wherein each output may contain any desired set of the plural frequencies.

6. (Original) A routing device according to claim 5, wherein the members of the desired set may be varied in use.

7. (Previously presented) A routing device according to claim 5, wherein at least two of the outputs contain at least one common frequency.

8. (Currently amended) A routing device having plural input signals and an output, the output constructed and arranged to deliver a signal having plural frequencies, the device comprising:

a two dimensional SLM having an array of pixels, and

a dispersion device disposed to receive light from the input signals and constructed and arranged to disperse beams of said light of different frequencies in different directions to be incident upon a respective different group of the pixels of the two-dimensional SLM,

wherein the routing device is operable to combine the frequencies from the input signals to appear in the output, wherein each input signal may contain any desired set of the plural frequencies of the output.

9. (Previously presented) The optical routing module of claim 4, wherein the dispersion device comprises at least one reflective device and at least one transmissive device.

10. (Previously presented) The optical routing module of claim 4, wherein the dispersion device comprises at least one of: a blazed grating, a holographic grating, an etched grating, an arrayed waveguide grating and a prism.

11. (Previously presented) The optical routing module of claim 4, wherein the two dimensional SLM having an array of pixels is a reflective SLM incorporating a wave-plate whereby the reflective SLM is substantially polarisation independent.

12. (Previously presented) The optical routing module of claim 4, wherein the two dimensional SLM having an array of pixels is a reflective Liquid Crystal on Silicon Spatial Light Modulator (LCOS SLM).

13. (Previously presented) The optical routing module of claim 4, further comprising a wave-plate arranged such that light passes through the wave-plate first after passing through the dispersion device a first time, and second before passing through the dispersion device a second time.

14. (Previously presented) The optical routing module of claim 13, wherein the dispersion device comprises a first and a second dispersion element.

15. (Previously presented) The optical routing module of claim 4, further comprising a wave-plate arranged such that light passes through the wave-plate a first time after passing through a first dispersion element, and a second time before passing through a second dispersion element.

16. (Previously presented) The optical routing module of claim 15, wherein the first and second dispersion elements are provided by a single dispersive device.

17. (Previously presented) The optical routing module of claim 15, wherein the first and second dispersion elements are provided by separate dispersive devices.

18. (Previously presented) The optical routing module of claim 4, wherein the beams of different frequencies are spatially separated when incident upon the array of pixels according to their respective wavelengths.

19. (Previously presented) The optical routing module of claim 4, wherein a plurality of input beams are provided from a respective plurality of inputs and the beams are spatially separated when incident upon the array of pixels according to at least one of:

their respective input directions; and

their respective wavelengths.

20. (Previously presented) The optical routing module of claim 4, wherein at least one group of pixels defines a square.

21. (Previously presented) The optical routing module of claim 4, wherein at least one group of pixels defines an arbitrary shape.

22. (Previously presented) The optical routing module of claim 4, wherein at least one group of pixels defines a rectangle.

23. (Previously presented) The optical routing module of claim 4, wherein at least one group of pixels has a size between 10 and 50 phase modulating elements in at least one dimension.

24. (Previously presented) The optical routing module of claim 4, wherein at least one group of pixels has a size in one dimension that is at least 2 times a 1/e spot half-width of an amplitude distribution of an incident beam measured in the same dimension.

25. (Previously presented) The optical routing module of claim 4, wherein a property of at least one group of pixels is varied, the property including at least one of: size, shape and position.

26. (Previously presented) The optical routing module of claim 4, wherein each group of pixels comprises a plurality of subgroups, wherein at least one subgroup is controlled so as to have a phase effect different to at least one other subgroup.

27. (Previously presented) The optical routing module of claim 4, further comprising a control device operable to delineate groups of individual phase-modulating elements; to select, from stored control data, control data for each group of phase-modulating elements; to generate from the respective selected control data a respective hologram at each group of phase-modulating elements; and to vary at least one of the delineation of the groups and the selection of control data whereby upon illumination of said groups by respective light beams, respective emergent light beams from the groups are controllable independently of each other.

28. (Previously presented) The optical routing module of claim 4, having groups of pixels of the two-dimensional SLM assigned to respective wavelength channels, and further comprising a control circuit operable to delineate guard bands between said groups.

29. (Previously presented) The optical routing module of claim 28, wherein at least one guard band is configured to route light in a direction different to respective directions routed by said groups.

30. (Previously presented) The optical routing module of claim 28, wherein at least one guard band is effective to narrow a bandwidth of a wavelength channel carried by a group of pixels.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	Amari, Alessandro V.
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

AMENDMENT

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Amendment is being filed in response to the Final Office Action mailed from the U.S. Patent and Trademark Office on May 6, 2009 in the above-identified application. In lieu of a Notice of Appeal, a Request for Continued Examination (RCE) is being filed concurrently herewith. Reconsideration and further examination are requested.

Please amend the application as follows:

REQUEST FOR CONTINUED EXAMINATION (RCE) TRANSMITTAL	Application Number	11/514,725
Subsection (b) of 35 U.S.C. § 132, effective on May 29, 2000, provides for continued examination of a utility or plant application filed on or after June 8, 1995. See The American Inventors Protection Act of 1999 (AIPA)	Filing Date	September 1, 2006
	Confirmation Number	4755
	First Named Inventor	Melanie Holmes
	Group Art Unit	2872
	Examiner Name	Amari, Alessandro V.
	Attorney Docket Number	3274.1003-002

This is a Request for Continued Examination (RCE) under 37 CFR § 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR § 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

a. ☐ Previously submitted
  i. ☐ Consider the amendment(s)/reply under 37 CFR § 1.116 previously filed on [ ].
  (Any unentered amendment(s) referred to above will be entered).
  ii ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on [ ].
  iii. ☐ Other - - [ ]
b. ☐ Please do not enter the amendment(s)/reply under 37 CFR § 1.116 previously filed on [ ]
c. ☒ Enclosed
  i. ☒ Amendment/Reply
  ii. ☐ Affidavit(s)/Declaration(s)
  iii. ☒ Supplemental Information Disclosure Statement (IDS)
  iv. ☐ Petition for Extension of Time - [ ] month(s) - [separate sheet] [included in amend. fee trans.]
  v. ☐ Other - - [ ]

2. Miscellaneous

a. ☐ Suspension of action on the above-identified application is requested under 37 CFR § 1.103(c) for a period of [ ] months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR § 1.17(i) **required**)
b. ☐ Other - - [ ]

3. Fees The RCE fee under 37 CFR § 1.17(e) is required by 37 CFR § 1.114 when the RCE is filed.

a. ☐ A check is enclosed for the fees indicated in b. in the total amount of $[ ]
  OR
  ☒ Authorization is granted to charge the fees indicated in b. in the total amount of $810 to Deposit Account No. 08-0380.
b. i. ☒ RCE fee required under 37 CFR § 1.17(e)
  ii. ☐ Extension of time fee (37 CFR §§ 1.136 and 1.17)
  iii. ☐ Amendment Fee
  iv. ☐ Other - - [ ]
c. ☒ Authorization is hereby granted to charge any deficiency in fees or credit any overpayments to Deposit Account No. 08-0380.

SIGNATURE OF APPLICANT, ATTORNEY OR AGENT REQUIRED

Signature	[signature]	Registration No. (Attorney/Agent)	39,302
Name (Print/Type)	Timothy J. Meagher	Date	8/6/09

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the U.S. Postal Service with sufficient postage as first class mail in an envelope addressed: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or facsimile transmitted to the US Patent & Trademark Office on the date shown below:

Signature			
Name (Print/Type)		Date	

- Rev. 09/14/08 912340_1

TS0001489

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	Amari, Alessandro V.
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith is Amendment for filing in the above-identified application.

☐ Small entity status of this application under 37 CFR 1.9 and 1.27 has been established by a Small Entity Statement previously submitted.

☐ A Small Entity Statement to establish small entity status under 37 CFR 1.9 and 1.27 is enclosed.

The claims fee has been calculated as shown below:

	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NO. PREVIOUSLY PAID FOR	PRESENT EXTRA	SMALL ENTITY RATE	SMALL ENTITY ADDIT. FEE		OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDIT. FEE
TOTAL	30	MINUS	* 30	0	X $ 26	$	OR	X $52	$ 0
INDEP	5	MINUS	** 5	0	X $110	$		X $220	$ 0
☐ FIRST PRESENTATION OF MULTIPLE DEP. CLAIM					+ $195	$		+ $390	$
					TOTAL =	$ 0		TOTAL =	$ 0

* not fewer than 20
** not fewer than 3

The Application Size Fee has been calculated as shown below:
(Effective for cases filed on or after December 8, 2004)

Actual Sheets (Including current amendment)	Highest No. of Sheets Paid For (At least 100)	No. of Additional Units Required (Increments of 50 sheets)	SMALL ENTITY Rate	SMALL ENTITY Total Amount Owed	OTHER THAN SMALL ENTITY Rate	OTHER THAN SMALL ENTITY Total Amount Owed	Payment Sufficient for up to
139	150	0	X $135	$[ ]	X $270	$[ ]	150 Sheets

Petition for Extension of Time

☐ Applicant hereby petitions to extend the time to respond to the [ ] dated [ ] for [ ] month(s) from [ ] to [ ]. The appropriate fee is set forth below.

☐ *[For action-specific language in an extension of time, select the appropriate option from the Firm Templates]*

TS0001491

Please charge Deposit Account No. 08-0380 for the following fees:

☐	Petition for [ ] month Extension of Time	$
☐	Claims Fee	$
☐	Application Size Fee	$
☒	Other Fees:	
	Request for Continued Examination	$ 810
		$
	TOTAL:	$ 810

A check is enclosed in payment of the following fees:

☐	Petition for [ ] month Extension of Time	$
☐	Claims Fee	$
☐	Application Size Fee	$
☐	Other Fees:	
		$
		$
	TOTAL:	$

☒ Please charge any deficiency or credit any overpayment in the fees that may be due in this matter to Deposit Account No. 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By [signature]
Timothy J. Meagher
Registration No.: 39,302
Telephone (978) 341-0036
Facsimile (978) 341-0136

Concord, Massachusetts 01742-9133
Dated: 8/6/9

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Melanie Holmes		
Application No.:	11/514,725	Group:	2872
Filed:	September 1, 2006	Examiner:	Amari, Alessandro V.
Confirmation No.:	4755		
For:	OPTICAL PROCESSING		

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Supplemental Information Disclosure Statement is submitted:

☒ under 37 CFR 1.97(b), or
(Within any one of the following time periods: three months of filing national application (other than a CPA) or date of entry of the national stage in an international application; or before the mailing date of a first office action on the merits; or before the mailing of a first office action after the filing of a Request for Continued Examination).

☐ under 37 CFR 1.97(c) together with either:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, or
- ☐ a $180.00 fee under 37 CFR 1.17(p), or

(After the 37 CFR 1.97(b) time period, but before any of a final action, notice of allowance, or an action that closes prosecution, whichever occurs first)

☐ under 37 CFR 1.97(d) together with:
- ☐ a Statement under 37 CFR 1.97(e), as checked below, and
- ☐ a $180.00 fee under 37 CFR 1.17(p), or

(Filed after final action, notice of allowance, whichever occurs first, or if prosecution otherwise closes, but on or before payment of the issue fee)

☐ under 37 CFR 1.97(i):
Applicant requests that the IDS and cited reference(s) be placed in the application file.
(Filed after payment of issue fee)

912356_1

Statement Under 37 CFR 1.97(e)

☐ Each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement; or

☐ No item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned, after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

Statement Under 37 CFR 1.704(d) (Patent Term Adjustment)
Applies to original applications (other than design) filed on or after May 29, 2000

☐ Each item of information contained in the Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the Information Disclosure Statement.

☒ Enclosed herewith is a Listing of References:

- ☐ Copies of the cited references are enclosed except as indicated below.
- ☒ Copies of issued U.S. patents and published U.S. applications are not required and are not being provided.
- ☐ Copies of the cited references submitted with an Information Disclosure Statement in prior application, U.S. Application No. [ ], to which priority under 35 U.S.C. 120 is claimed, are not required under 37 CFR 1.98(d)(1) and (2) and are thus not provided.
- ☐ Pending non-published applications are not being provided, since the applications are available to the examiner.

☐ The listed references were cited in the enclosed Search Report in counterpart foreign application [add application number], which is listed in the attached Listing of References.

☐ The "concise explanation" requirement (non-English references) for reference(s) [ ] under 37 CFR 1.98(a)(3) is satisfied by:

- ☐ the explanation provided on the attached sheet.
- ☐ the explanation provided in the Specification.
- ☐ submission of the enclosed International Search Report.
- ☐ submission of the enclosed English-language version of a foreign Search Report and/or foreign Office Action.
- ☐ the enclosed English language abstract.

Method of payment:

☐ A check for the fee noted above is enclosed, or the fee has been included in the check with the accompanying Reply.

☐ Please charge Deposit Account 08-0380 in the amount of $[ ].

☒ Please charge any deficiency in fees and credit any overpayment to Deposit Account 08-0380.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By

Timothy J. Meagher
Registration No. 39,302
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 8/6/09

912356_1

Electronic Acknowledgement Receipt

EFS ID:	5843447
Application Number:	11514725
International Application Number:	
Confirmation Number:	4755
Title of Invention:	Optical processing
First Named Inventor/Applicant Name:	Melanie Holmes
Customer Number:	21005
Filer:	Timothy J. Meagher/Dawn Myers
Filer Authorized By:	Timothy J. Meagher
Attorney Docket Number:	3274.1003-002
Receipt Date:	06-AUG-2009
Filing Date:	01-SEP-2006
Time Stamp:	17:07:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$810
RAM confirmation Number	3333
Deposit Account	080380
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

TS0001496

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	32741003002SIDS.pdf	137831 21c845f9e57c597e5ff2a89643e3a1af08926 93e	no	3
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Filed (SB/08)	32741003002LISTINGREFS.pdf	69363 bc0bfc252d363e07cf02600d6353fa3d8b25 f075	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Request for Continued Examination (RCE)	32741003002RCE.pdf	71347 36efcabdff84f7d006c51ffa0856490b796fcf c3	no	1
Warnings:					
This is not a USPTO supplied RCE SB30 form.					
Information:					
4		32741003002AMD.pdf	438624 7711d15b197b9273f55e48ed04f3e2e1d15 d12e9	yes	9

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment Submitted/Entered with Filing of CPA/RCE	1	1
Claims	2	6
Applicant Arguments/Remarks Made in an Amendment	7	9

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
Warnings:					
Information:					
5	Transmittal Letter	37241003002Trans.pdf	70465 ba58b9474212cf8c054f269d7b5a4c7e9303 a2bd	no	3
Warnings:					
Information:					
6	Fee Worksheet (PTO-875)	fee-info.pdf	29957 d5e9c7699782cadd72bc8076711b2f64bc7 d0cf1	no	2
Warnings:					
Information:					

TS0001497

Total Files Size (in bytes):	817587

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Patent Application Fee Transmittal

Application Number:	11514725
Filing Date:	01-Sep-2006
Title of Invention:	Optical processing
First Named Inventor/Applicant Name:	Melanie Holmes
Filer:	Timothy J. Meagher/Dawn Myers
Attorney Docket Number:	3274.1003-002

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

TS0001499

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	1801	1	810	810
		Total in USD ($)		**810**

TS0001500

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **August 6, 2009** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Amari, Alessandro V.	CONFIRMATION NO. 4755	GROUP 2872

U.S. PATENT DOCUMENTS

EXAM -INER INI- TIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
	A23	6,243,176 B1	06-05-2001	Ishikawa, et al.
	A24	5,938,309	08-17-1999	Taylor
	A25	6,714,309 B2	03-30-2004	May
	A26	5,526,171	06-11-1996	Warren

EXAMINER	DATE CONSIDERED

896557 1

TS0001501

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/514,725	Filing Date 09/01/2006	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	08/06/2009									
	Total (37 CFR 1.16(i))	* 30	Minus	** 30	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 5	Minus	***5	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**0**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/DEBORAH SCOTT/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

TS0001502

Substitute for form 1449B/PTO **SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT IN AN APPLICATION** **LISTING OF REFERENCES** **August 6, 2009** (Use several sheets if necessary)	ATTORNEY DOCKET NO. 3274.1003-002		APPLICATION NO. 11/514,725
	FIRST NAMED INVENTOR Melanie Holmes		FILING DATE September 1, 2006
	EXAMINER Amari, Alessandro V.	CONFIRMATION NO. 4755	GROUP 2872

U.S. PATENT DOCUMENTS

EXAM-INER INI-TIAL	REF. NO.	DOCUMENT NUMBER Number-Kind Code (if known)	ISSUE DATE / PUBLICATION DATE MM-DD-YYYY	NAME OF PATENTEE OR APPLICANT OF CITED DOCUMENT
/AA/	A23	6,243,176 B1	06-05-2001	Ishikawa, et al.
/AA/	A24	5,938,309	08-17-1999	Taylor
/AA/	A25	6,714,309 B2	03-30-2004	May
/AA/	A26	5,526,171	06-11-1996	Warren

EXAMINER	DATE CONSIDERED
/Alessandro Amari/	10/15/2009

896557 1

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	4915	(359/9,15,19,566,569,571,572,244).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/10/15 15:35
L2	729	(349/201,202).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/10/15 15:35
L3	3129	(398/48,49,79,81,82,84,87).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2009/10/15 15:35

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L10	5026	(spatial light modulator or SLM).clm.	US-PGPUB; USPAT; UPAD	ADJ	ON	2009/10/15 15:39
L11	61652	dispersion.clm.	US-PGPUB; USPAT; UPAD	ADJ	ON	2009/10/15 15:39
L12	418644	frequencies.clm.	US-PGPUB; USPAT; UPAD	ADJ	ON	2009/10/15 15:40
L13	936875	circuit$2.clm. or rout$3.clm.	US-PGPUB; USPAT; UPAD	ADJ	ON	2009/10/15 15:40
L14	1	10 and 11 and 12 and 13	US-PGPUB; USPAT; UPAD	ADJ	ON	2009/10/15 15:40

10/15/2009 3:41:20 PM
C:\ Documents and Settings\ aamari\ My Documents\ EAST\ Workspaces\ 11514725.wsp

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11514725	HOLMES, MELANIE
	Examiner	Art Unit
	ALESSANDRO AMARI	2872

ORIGINAL		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
398	49	H	0	4	J	14 / 00 (2006.01.01)						

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1	10	17												
	2	11	18												
	3	12	19												
1	4	13	20												
24	5	14	21												
25	6	15	22												
26	7	16	23												
27	8	17	24												
2	9	18	25												
3	10	19	26												
4	11	20	27												
5	12	21	28												
6	13	22	29												
7	14	23	30												
8	15														
9	16														

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 27	
/ALESSANDRO AMARI/ Primary Examiner.Art Unit 2872 (Primary Examiner)	10/15/2009 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 12

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

21005 7590 10/20/2009

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

EXAMINER	
AMARI, ALESSANDRO V	
ART UNIT	PAPER NUMBER
2872	

DATE MAILED: 10/20/2009

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002	4755

TITLE OF INVENTION: OPTICAL PROCESSING

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	01/20/2010

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

TS0001506

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

21005 7590 10/20/2009

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002	4755

TITLE OF INVENTION: OPTICAL PROCESSING

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	01/20/2010

EXAMINER	ART UNIT	CLASS-SUBCLASS
AMARI, ALESSANDRO V	2872	398-049000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

   1__________________
   2__________________
   3__________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies __________________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ________________________ Date ________________________

Typed or printed name ________________________ Registration No. ________________________

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002	4755

21005 7590 10/20/2009

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

EXAMINER	
AMARI, ALESSANDRO V	
ART UNIT	PAPER NUMBER
2872	

DATE MAILED: 10/20/2009

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 3 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 3 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

Notice of Allowability

	Application No.	Applicant(s)	
	11/514,725	HOLMES, MELANIE	
	Examiner	Art Unit	
	ALESSANDRO AMARI	2872	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to RCE of 8/6/2009.

2. ☒ The allowed claim(s) is/are 4-30.

3. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☒ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☒ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 8/6/2009
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 06 August 20098 has been entered.

EXAMINER'S AMENDMENT

2. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Mr. Timothy Meagher on 19 October 2009.

The application has been amended as follows:

Cancel claims 1-3.

Regarding claim 4, line 4, delete the phrase “an dimensional SLM” and replace with --a Spatial Light Modulator (SLM)--.

Regarding claim 5, line 3, delete “SLM” and replace with --Spatial Light Modulator (SLM)--.

Regarding claim 8, line 4, delete "SLM" and replace with --Spatial Light Modulator (SLM)--.

Allowable Subject Matter

3. Claims 4-30 are allowed.

4. The following is an examiner's statement of reasons for allowance:

Claim 4 is allowable for at least the reason, "a dimensional SLM having an a two dimensional array of pixels, a dispersion device disposed to receive light from said at least one input and constructed and arranged to disperse light beams of different frequencies in different directions whereby different channels of said ensemble are to-be incident upon respective different groups of the pixels of the SLM, and circuitry constructed and arranged to display holograms on the SLM to determine the channels at respective outputs" as set forth in the claimed combination. Claims 9-30 are allowable due to their dependence on claim 4.

Claim 5 is allowable for at least the reason, "a two dimensional SLM having an array of pixels, and a dispersion device disposed to receive light from said at least one input and constructed and arranged to disperse beams of said light of different frequencies in different directions to be incident upon a respective different group of the pixels of the two-dimensional SLM, wherein the routing device is operable to select the frequencies of the input light beam to appear in the outputs, wherein each output may contain any desired set of the plural frequencies" as set forth in the claimed combination. Claims 6 and 7 are allowable due to their dependence on claim 5.

Claim 8 is allowable for at least the reason, “a two dimensional SLM having an array of pixels, and a dispersion device disposed to receive light from the input signals and constructed and arranged to disperse beams of said light of different frequencies in different directions to be incident upon a respective different group of the pixels of the two-dimensional SLM, wherein the routing device is operable to combine the frequencies from the input signals to appear in the output, wherein each input signal may contain any desired set of the plural frequencies of the output” as set forth in the claimed combination.

The Applicant’s remarks (of 6 August 2009) on pages 7 and 8 were persuasive.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.”

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ALESSANDRO AMARI whose telephone number is (571)272-2306. The examiner can normally be reached on Monday-Friday 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner’s supervisor, Stephone B. Allen can be reached on (571) 272-2434. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

ava
19 October 2009

/Alessandro Amari/
Primary Examiner, Art Unit 2872

Search Notes	Application/Control No. 11514725	Applicant(s)/Patent Under Reexamination HOLMES, MELANIE
	Examiner Fayez G Assaf	Art Unit 2872

SEARCHED

Class	Subclass	Date	Examiner
359	15,19	5/10/2008	/FA/
359	9, 569, 566, 572, 571, 244	5/4/2009	/AA/
349	201, 202	5/4/2009	/AA/
398	48, 49, 79, 81, 82, 84, 87	5/4/2009	/AA/
Update	above	5/4/2009	/AA/
Update	above	10/15/2009	/AA/

SEARCH NOTES

Search Notes	Date	Examiner
See attached	5/10/2008	/FA/
See attached	5/4/2009	/AA/

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
	PG Pub text search	10/15/2009	/AA/

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

21005 7590 10/20/2009

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	09/01/2006	Melanie Holmes	3274.1003-002	4755

TITLE OF INVENTION: OPTICAL PROCESSING

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	01/20/2010

EXAMINER	ART UNIT	CLASS-SUBCLASS
AMARI, ALESSANDRO V	2872	398-049000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 Hamilton, Brook, Smith & Reynolds, P.C.
   2 ____
   3 ____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Thomas Swan & Co. Ltd.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Durham, United Kingdom

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☒ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies ____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 08-0380 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature [signature] Date 12/22/9

Typed or printed name Timothy J. Meagher Registration No. 39,302

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TS0001515

Electronic Patent Application Fee Transmittal

Application Number:	11514725
Filing Date:	01-Sep-2006
Title of Invention:	OPTICAL PROCESSING
First Named Inventor/Applicant Name:	Melanie Holmes
Filer:	Timothy J. Meagher/Christine Budd
Attorney Docket Number:	3274.1003-002

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	1501	1	1510	1510
Publ. Fee- early, voluntary, or normal	1504	1	300	300

TS0001516

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1810**

TS0001517

Electronic Acknowledgement Receipt

EFS ID:	6688568
Application Number:	11514725
International Application Number:	
Confirmation Number:	4755
Title of Invention:	OPTICAL PROCESSING
First Named Inventor/Applicant Name:	Melanie Holmes
Customer Number:	21005
Filer:	Timothy J. Meagher/Christine Budd
Filer Authorized By:	Timothy J. Meagher
Attorney Docket Number:	3274.1003-002
Receipt Date:	22-DEC-2009
Filing Date:	01-SEP-2006
Time Stamp:	16:11:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1810
RAM confirmation Number	3347
Deposit Account	080380
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)	

TS0001518

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	32741003002IFTransmittal.pdf	152014 51fdcac814df384a6b0db3c393f34285008ced50	no	1
Warnings:					
Information:					
2	Fee Worksheet (PTO-875)	fee-info.pdf	31656 2b7b09a5c553405cbea3fa3ef63e82ff13e5d7b3	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	183670		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

TS0001519

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/514,725	02/16/2010	7664395	3274.1003-002	4755

21005 7590 01/27/2010
HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 3 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Melanie Holmes, Ipswich, UNITED KINGDOM;

IR103 (Rev. 10/09)

Electronic Acknowledgement Receipt

EFS ID:	7120836
Application Number:	11514725
International Application Number:	
Confirmation Number:	4755
Title of Invention:	OPTICAL PROCESSING
First Named Inventor/Applicant Name:	Melanie Holmes
Customer Number:	21005
Filer:	Timothy J. Meagher/Dawn Myers
Filer Authorized By:	Timothy J. Meagher
Attorney Docket Number:	3274.1003-002
Receipt Date:	02-MAR-2010
Filing Date:	01-SEP-2006
Time Stamp:	16:43:32
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for PTA recalculation in view of Wyeth	32741003002PTA.pdf	56000 0c41c1713e71990acabed5b5e6044101819fe321	no	1

Warnings:

Information:

TS0001521

Total Files Size (in bytes):	56000

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc Code: PET.PTA.RCAL

Document Description: Request for Recalculation in view of Wyeth

PTO/SB/131 (01-10)

Approved for use through 02/28/2011. OMB 0651-0020

U.S. Patent and Trademark Office: U. S. DEPARTMENT OF COMMERCE

REQUEST FOR RECALCULATION OF PATENT TERM ADJUSTMENT IN VIEW OF *WYETH**

Attorney Docket Number: 3274.1003-002	Patent Number: 7,664,395 B2
Filing Date (or 371(b) or (f) Date): September 1, 2006	Issue Date: February 16, 2010
First Named Inventor: Melanie Holmes	
Title: Optical Processing	

PATENTEE HEREBY REQUESTS RECALCULATION OF THE PATENT TERM ADJUSTMENT (PTA) UNDER 35 USC 154(b) INDICATED ON THE ABOVE-IDENTIFIED PATENT. THE PATENTEE'S SOLE BASIS FOR REQUESTING THE RECALCULATION IS THE USPTO'S PRE-*WYETH* INTERPRETATION OF 35 U.S.C. 154(b)(2)(A).

Note: This form is only for requesting a recalculation of PTA for patents issued before March 2, 2010, if the sole basis for requesting the recalculation is the USPTO's pre-*Wyeth* interpretation of 35 U.S.C. 154(b)(2)(A). See Instruction Sheet on page 2 for more information.

Patentees are reminded that to preserve the right to review in the United States District Court for the District of Columbia of the USPTO's patent term adjustment determination, a patentee must ensure that he or she also takes the steps required under 35 U.S.C. 154(b)(3) and (b)(4) and 37 CFR 1.705 in a timely manner.

**Wyeth v. Kappos*, No. 2009-1120 (Fed. Cir., Jan. 7, 2010).

Signature [signature]	Date 2/23/10
Name (Print/Typed) Timothy J. Meagher	Registration Number 39,302

Note: *Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature. If necessary, submit multiple forms for more than one signature, see below*.*

☑ *Total of 1 forms are submitted.

957252_1

TS0001523

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
530 VIRGINIA ROAD
P.O. BOX 9133
CONCORD, MA 01742-9133

Mail Date: 04/21/2010

Applicant : Melanie Holmes
Patent Number : 7664395
Issue Date : 02/16/2010
Appliction No : 11/514,725
Filed : 09/01/2006

: DECISION ON REQUEST FOR
: RECALCULATION of PATENT
: TERM ADJUSTMENT IN VIEW
: OF WYETH AND NOTICE OF INTENT TO
: ISSUE CERTIFICATE OF CORRECTION
:

The Request for Recalculation is **GRANTED** to the extent indicated.

The patent term adjustment has been determined to be **3** days. The USPTO will *sua sponte* issue a certificate of correction reflecting the amount of PTA days determined by the recalculation.

Prior to the issuance of the certificate of correction, the USPTO will afford patentee an opportunity to be heard and request reconsideration. Accordingly, patentee has **one month or thirty (30) days**, whichever is longer, to file a request for reconsideration of this patent term adjustment calculation. See 35 U.S.C. 154(b)(3)(B)(ii) and 37 CFR 1.322(a)(4). No extensions of time will be granted under 37 CFR 1.136.

Patentee should use document code PET.OP if electronically filing a request for reconsideration of this patent term adjustment calculation. The patentee must also include the information required by 37 CFR 1.705(b)(2) and the fee required by 37 CFR 1.18(e). If patentee does not file a timely request for reconsideration of this patent term adjustment calculation including the information required by 37 CFR 1.705(b)(2) and the fee required by 37 CFR 1.18(e), the USPTO will issue a certificate of correction reflecting the PTA determination noted above.

Patentee should be aware that in order to preserve the right to review in the United States District Court for the District of Columbia of the USPTO patent term adjustment determination, patentee must ensure that he or she also take the steps required under 35 U.S.C. 154(b)(4)(A) in a timely manner. Nothing in the request for recalculation should be construed as providing an alternative time frame for commencing a civil action under 35 U.S.C. 154(b)(4)(A).

Any questions concerning this decision should be directed to the Office of Patent Legal Administration at 571-272-7702.