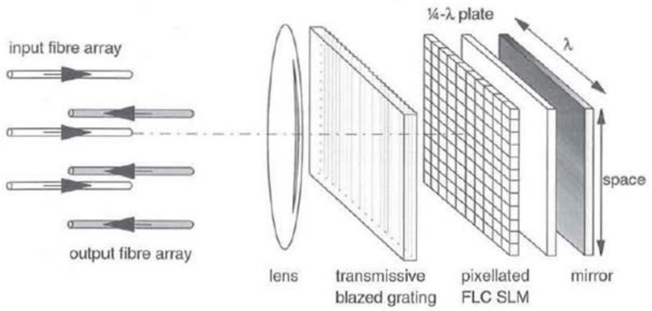
1. **Ground 1: Claims 1-17, 20, and 24-27 are rendered obvious by the combination of Parker Thesis and Warr Thesis and Tan Thesis**

<u>’395 Claim Language</u> Followed by corresponding features in the reference, with emphasis added.
[1pre.] 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:
Parker Thesis discloses a space-wavelength switch that includes 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.  Figure 6.1: Exploded 2*f* compact 3 × 3 space-wavelength switch Parker Thesis at 96. “The currently unused extra dimension of the SLM can also be used to add functionality to the switch, such as to make it into ***a space-wavelength switch***. This would serve a very important function in dynamic wavelength-routed optical networks as ***an add-drop node***. Figure (6.1) shows an ‘exploded’ concept for a polarisation-insensitive, optically transparent, compact, low-loss space-wavelength switch, ***utilising all the ideas developed in chapters 2 and 4***. The switch acts as a 3 x 3 fibre cross-connect, but can also ***perfectly shuffle wavelengths between the various fibres***.” Parker Thesis at 97. Warr Thesis also teaches an optical routing module having at least one input and at least one output and operable to select between the outputs. “This is achieved by the use of ***programmable computer-generated holograms (CGHs) displayed*** on a ferroelectric liquid crystal (FLC) spatial light modulator (SLM). The SLM provides fast 2-dimensional binary modulation

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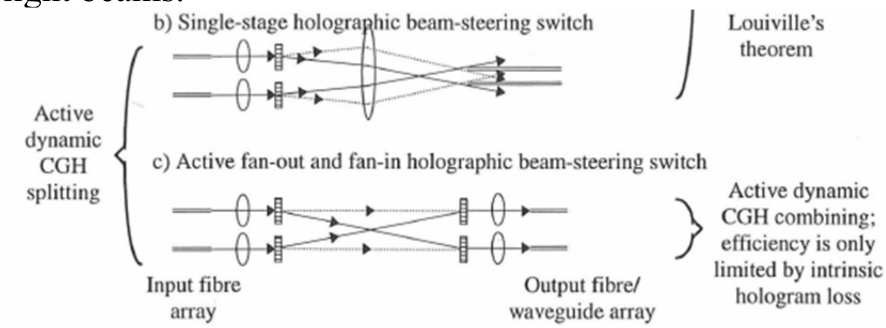
of coherent light and acts as a ***dynamically reconfigurable diffraction pattern***." Warr Thesis at viii.

The optical setups disclosed in Tan Thesis include selecting an output for light beams.



Tan Thesis at 12.

Tan Thesis discloses an SLM with a two dimensional array of pixels. "Typically, a large number of holograms for dynamically reconfigurable routing applications are generated with a small number of phase levels. These are then written onto ***2-D pixellated SLMs*** with a limited spatial bandwidth product (SBWP or equivalently number of pixels) and other processing limitations such as dead-space and phase uniformity of each modulating element." Tan Thesis at 44.
See Hall Decl. at ¶¶ 47-49, 53-59, 61-63.

[1a.] a Spatial Light Modulator (SLM) having a two dimensional array of pixels,

Parker Thesis discloses "a Spatial Light Modulator (SLM) having a two dimensional array of pixels." See "pixelated FLC SLM" illustrated in Fig. 6.1 (Parker Thesis at 96).

To operate an optical device comprising a two dimensional SLM, Warr Thesis teaches "the use of ***programmable computer-generated holograms*** (CGHs) displayed on a ferroelectric liquid crystal (FLC) ***spatial light modulator*** (SLM). The SLM provides fast ***2-dimensional binary modulation*** of coherent light and acts as a dynamically ***reconfigurable diffraction pattern***." Warr Thesis at viii.

Warr Thesis also discloses an SLM with an array of pixels. "SLMs typically consist of ***an array of individually controllable pixels***…Ferroelectric liquid crystal SLMs…can also be readily configured as ***phase-*** or as intensity-***modulators***." Warr Thesis at 7. "To obtain maximum light efficiency, the

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SLM pixels ***should only modulate the phase of the incident Gaussian beam*** and not the intensity." Warr Thesis at 13. "Because each pixel now acts as a ***perfect (0, π) binary phase modulator***, the input polariser may also be removed." Warr Thesis at 25. See Hall Decl. at ¶¶ 47-49, 53-59, 64-66.
[1b.] 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
Parker Thesis discloses "a dispersion device," described as a "transmissive blazed grating" in Figure 6.1. Parker Thesis at 96. The function of the transmissive blazed grating in Parker Thesis is to receive light from at least one input and to disperse light beams of different frequencies. "The principle of operation of the tunable holographic wavelength filter is based on the wavelength-dispersive nature of gratings. ***Polychromatic light is angularly dispersed by a grating***, since the different wavelengths are diffracted through different angles." Parker Thesis at 47. See Hall Decl. at ¶¶ 47-49, 53-59, 67-69.
[1c.] whereby different channels of said ensemble are incident upon respective different groups of the pixels of the SLM, and
Parker Thesis discloses angular dispersion by a grating. "The principle of operation of the tunable holographic wavelength filter is based on the wavelength-dispersive nature of gratings. ***Polychromatic light is angularly dispersed by a grating***, since the different wavelengths are diffracted through different angles." Parker Thesis at 47. The use of a grating disperses the light into its component frequencies, providing separation of the channels and allowing a different set of pixels to operate on each channel. See "transmissive blazed grating" in Fig. 6.1 (Parker Thesis at 96). "The currently unused extra dimension of the SLM can also be used to add functionality to the switch, such as to make it into ***a space-wavelength switch***. This would serve a very important function in dynamic wavelength-routed optical networks as ***an add-drop node***. Figure (6.1) shows an 'exploded' concept for a polarisation-insensitive, optically transparent, compact, low-loss space-wavelength switch, utilising all the ideas developed in chapters 2 and 4. The switch acts as a 3 x 3 fibre cross-connect, but can also ***perfectly shuffle wavelengths between the various fibres***." Parker Thesis at 97.

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Warr Thesis discusses the use of separate groups of pixels having separate light beams incident thereon. "The collimation array in plane P2 is arranged exactly one focal distance in front of the fibre ends so that the Gaussian signal beams are individually collimated through the FLC-SLM. The ***SLM display area is then divided into distinct sub-holograms***, such that every input source is deflected by a different CGH." Warr Thesis at 89.

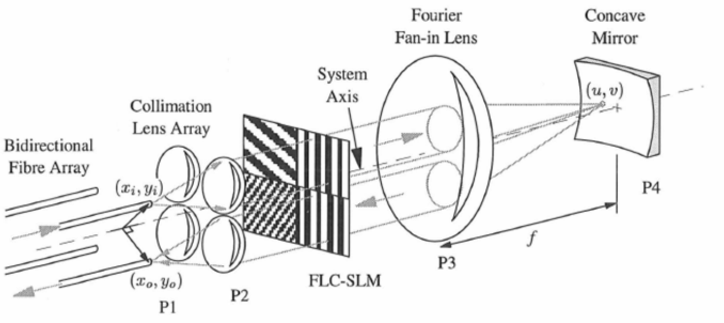

Figure 5.4: A double-pass holographic crossbar structure for single-mode fibres.

Warr Thesis at 89. "Each of the four beams was ***deflected by a separate 80x80 pixel region*** of the 2DX320IR SLM. This transmissive FLC device has 80μm pixels, a 28° FLC switching angle, and exhibits a peak response around λ = l.lμm wavelength." Warr Thesis at 103.

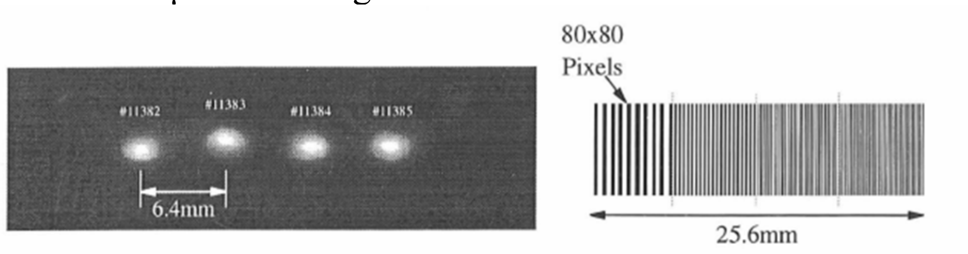

Figure 5.11: The array of Gaussian input beams and associated sub-hologram patterns.

Warr Thesis at 103.

Tan Thesis also teaches the use of channels incident on different groups of pixels on the SLM. "The second design seeks to avoid the replication loss by using a holographic fan-out stage as shown in Figure 2.5(b) [15]. A micro-lens array collimates the input channels to ***a sub-hologram array***. Each sub-hologram ***steers its respective beam to the desired output fibre port***. The same hologram pattern diffracts the light from any input channels to a particular output port due to the shift-invariant property of holograms using a single Fourier transform lens." Tan Thesis at 11-12. See Fig. 2.5(b) (Tan Thesis at 12).

See Hall Decl. at ¶¶ 47-49, 53-59, 70-72.

[1d.] circuitry constructed and arranged to display holograms on the

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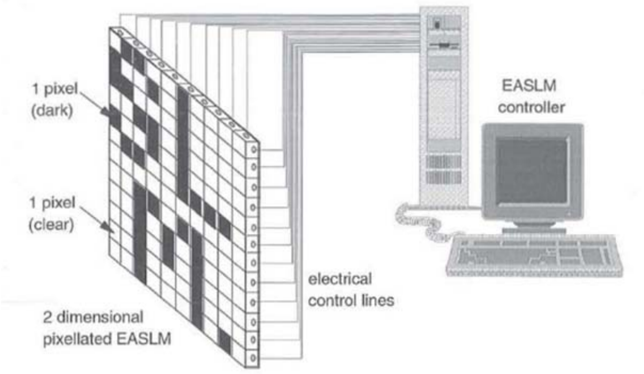
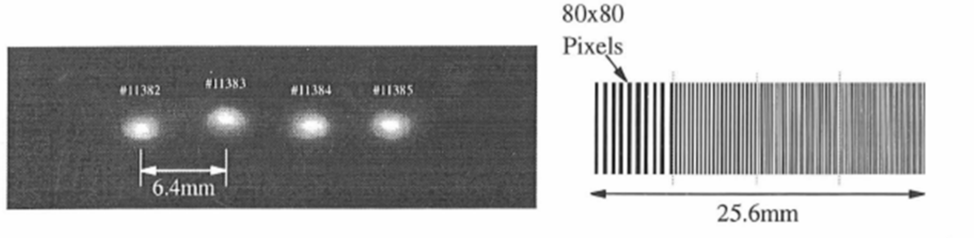
SLM to determine the channels at respective outputs.
Parker Thesis describes the use of circuitry to display holograms on the SLM.  Figure 2.1: Generic electrically addressed spatial light modulator (EASLM) "The SLM was controlled by a PC via the printer port…This is illustrated in figure (2.3) where a desired hologram, and the actual displayed SLM hologram are shown." Parker Thesis at 14. Warr Thesis describes circuitry to display holograms, where the device "***displays one frame from a set of phase CGHs*** which have been calculated off-line at an earlier stage and placed in a frame store to be recalled on demand." Warr Thesis at 33. "This is achieved by the use of programmable computer-generated holograms (CGHs) ***displayed on a ferroelectric liquid crystal (FLC) spatial light modulator (SLM)***. The SLM provides fast 2-dimensional binary modulation of coherent light and acts as a ***dynamically reconfigurable diffraction pattern***." Warr Thesis at viii. The holograms in Warr Thesis are used to steer beams. "Each of the four beams was deflected by a ***separate 80x80 pixel region*** of the 2DX320IR SLM. This transmissive FLC device has 80µm pixels, a 28° FLC switching angle, and exhibits a peak response around λ = l.lµm wavelength." Warr Thesis at 103.  **Figure 5.11:** The array of Gaussian input beams and associated sub-hologram patterns. Warr Thesis at 103. "The collimation array in plane P2 is arranged exactly

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