### A. Ground 1: Claims 1, 2, 4-6, 8, 9, 11, 12, and 14 are anticipated by Warr Thesis

| **'710 Claim Language**<br>Followed by corresponding features in the reference.[1] |
| --- |
| **[1 pre.] A method of operating an optical device comprising an SLM having a two dimensional array of controllable phase modulating elements, the method comprising:** |
| 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.<br>Warr Thesis also discloses an SLM with an array of phase modulating elements. "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 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.<br>The phase modulating elements in Warr Thesis are also controllable. "Essentially backplane SLMs operate as ***optically-readable memory***. Although the integration of photodiodes onto the silicon circuitry also introduces the possibility of optically addressed 'smart pixels' [50], usually we are only concerned with electronic addressing schemes (EASLMs). Two ***binary storage schemes are well known*** in conventional silicon memory technology, and ***these have been incorporated into EASLM design***s. The dynamic RAM pixel circuitry [15], figure 2.7(a), has a single transistor per pixel and the 1-bit binary memory state is stored as a capacitive charge polarity on the actual mirror contact." Warr Thesis at 19-20.<br>*See also* Warr Thesis at 17, 18, 107. *See* Hall Decl. at ¶ 56. |
| **[1a.] delineating groups of individual phase-modulating elements;** |
| The delineation of groups of individual phase-modulating elements is found in Warr Thesis. "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*** |

[1] Bold and italicized text are for emphasis in the claim charts in this petition, unless stated otherwise.

***divided into distinct sub-holograms***, such that every input source is deflected by a different CGH." Warr Thesis at 89.

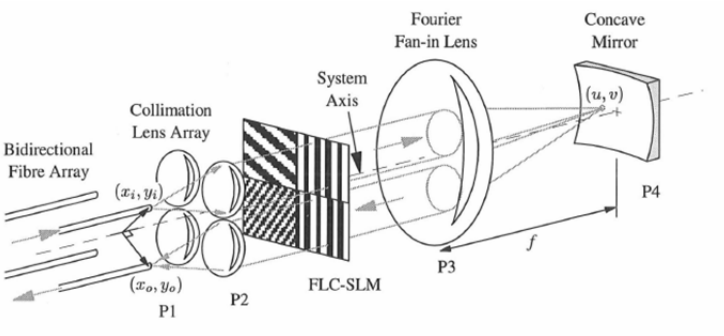


**Figure 5.4:** A double-pass holographic crossbar structure for single-mode fibres.

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 = 1.1µm wavelength." Warr Thesis at 103.

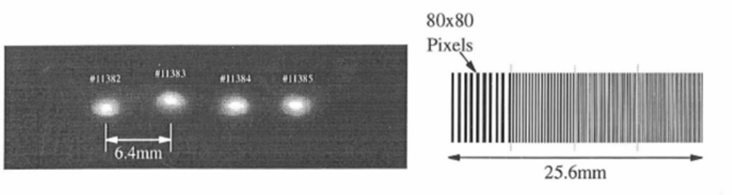


**Figure 5.11:** The array of Gaussian input beams and associated sub-hologram patterns.

Warr Thesis at 103. *See* Hall Decl. at ¶ 57.

**[1b.] selecting, from stored control data, control data for each group of phase-modulating elements;**

The devices disclosed in Warr Thesis have stored control data. "Essentially backplane SLMs operate as ***optically-readable memory***…Two ***binary storage schemes are well known*** in conventional silicon memory technology, and these have been incorporated into EASLM designs. The dynamic RAM pixel circuitry [15], figure 2.7(a), has a single transistor per pixel and the 1-bit binary memory state is stored as a capacitive charge polarity on the actual mirror contact." Warr Thesis at 19-20. "The FLC 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.

Selecting control data for each group of phase modulating elements is also present in Warr Thesis. "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.

Also see claim [1a.] for the discussion of ***each group of phase-modulating***

***elements***. *See* Hall Decl. at ¶ 58.

**[1c.] generating from the respective selected control data a respective hologram at each group of phase-modulating elements; and**

To generate a hologram from the selected control data, Warr Thesis "***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.

Warr Thesis also teaches the generation of a respective hologram at each group of phase-modulating elements. "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.

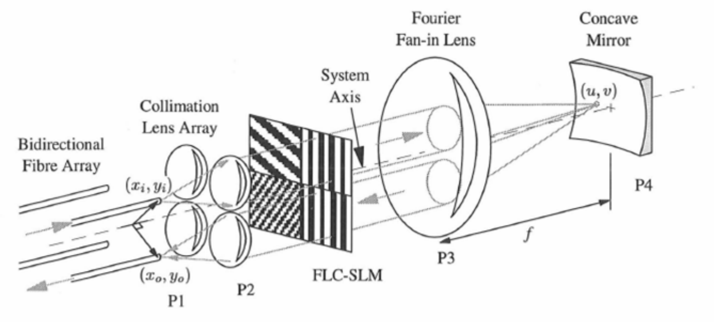


**Figure 5.4:** A double-pass holographic crossbar structure for single-mode fibres.

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 = 1.1μm wavelength." Warr Thesis at 103.

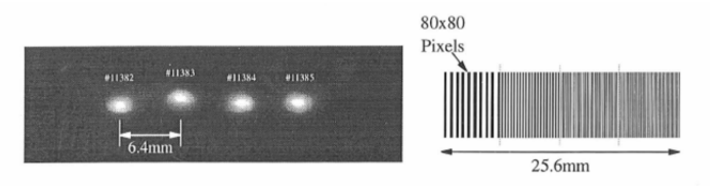


**Figure 5.11:** The array of Gaussian input beams and associated sub-hologram patterns.

Warr Thesis at 103. *See* Hall Decl. at ¶¶ 59-60.

**[1d.] varying the delineation of the groups and/or the selection of control data**

To vary the selection of control data, Warr Thesis discloses, "This is achieved by

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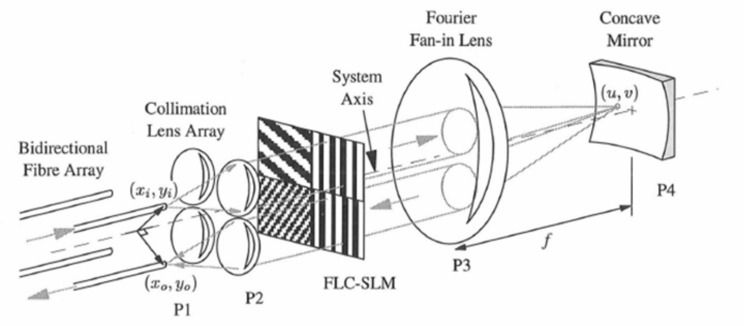
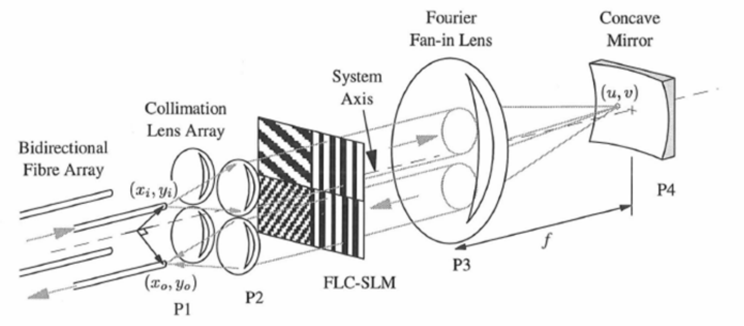
|---|
| the use of programmable computer-generated holograms (CGHs) displayed on a ferroelectric liquid crystal (FLC) spatial light modulator (SLM). The SLM provides fast 2-dimensional binary modulation of coherent light and acts as a ***dynamically reconfigurable diffraction pattern***." Warr Thesis at viii. "The FLC 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. "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. *See* Hall Decl. at ¶ 61. |
| **[1e.] whereby upon illumination of said groups by respective light beams, respective emergent light beams from the groups are controllable independently of each other.** |
| Warr Thesis discloses the illumination of said groups by respective light beams. "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. The emergent light beams are also independently controlled by the devices in Warr Thesis. "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 = 1.1μm wavelength." Warr Thesis at 103.

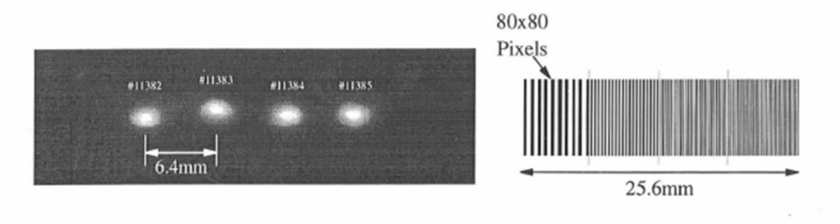



**Figure 5.11:** The array of Gaussian input beams and associated sub-hologram patterns.

Warr Thesis at 103. Warr Thesis also teaches fine tuning of routing holograms. "The ***hologram frame set can again be designed to compensate*** for manufacturing tolerances as was demonstrated during the 1-to-15 experiment. As well as compensating for beam offsets (using the hologram splitters) and tilts (using the hologram combiners), the CGHs may be 'exclusive-OR' combined with Fresnel zone-like patterns [116] to counteract experimental differences in lateral positioning or focal length of the GRINs." Warr Thesis at 107. "The optical configuration might therefore ***enable the construction of dense optical switches*** that have a large enough aperture to simultaneously interconnect several FLC-over-silicon backplane SLMs, encompassing a huge number of interconnect pixels." Warr Thesis at 107. *See* Hall Decl. at ¶ 62.

**[2.] A method of operating an optical device according to claim 1, wherein control of said light beams is selected from the group comprising: control of direction, control of power, focussing, aberration compensation, sampling and beam shaping.**

Claim 2 depends from claim 1, which is anticipated for the reasons discussed above.

The disclosure found in Warr Thesis discussed in claim [1e.] above includes control of direction and control of power as discussed above. *See* Hall Decl. at ¶¶ 70-72.

**[4a.] A method of operating an optical device according to claim 1, comprising: providing a discrete number of voltages available for application to each phase modulating element;**

Claim 4 depends from claim 1, which is anticipated for the reasons discussed above.

A discrete number of voltages available for application to each phase modulating element is disclosed in Warr Thesis. "Addressing takes place by applying an enabling voltage to a single row and then ***writing data on all columns***. The full frame is addressed by repeating this process down all rows. The inherent bistability of fully surface-stabilised FLC materials means that the data will be

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