[0030] If the thickness of the retarder produces a linear displacement less than the wavelength, the retarder produces a phase angle of less than π and is said to be of the first order. If the resultant phase angle is between π and 2π then the retarder is said to be of the second order, if between 2π and 3π it is a third order retarder and so forth. The mean wavelength of the visible spectrum (560 nm) is used as the reference wavelength for optical retarders.

[0031] Correspondingly, a retarder may be employed as a polarisation form converter to rotate the output polarised light from the rear most liquid crystal display of a multi-screened LCD unit through the required angle to align with the polarisation plane of the rear surface of the front liquid crystal display. Polyesters such as polycarbonate are known retarders with a low intrinsic cost, though they are difficult to produce with sufficient chromatic uniformity to avoid the appearance of coloured 'rainbow-like' interference patterns when viewed between crossed polarisers. This is due (at least in part) to the thickness to which such sheets of polycarbonate are available, which result in second or higher order retarders.

[0032] In second, third or higher order retarders, the different wavelengths of the spectrum constituents of white light are retarded to by the same linear displacement, but by different phase angles such that pronounced coloured interference fringes result.

[0033] There are further complications with the manufacture of such multi-focal plane LCD displays. The fine regular structures formed by the coloured filters and black pixel matrix on the alignment layers of each liquid crystal display produce a specific pattern in the light transmitted which, when combined with the corresponding pattern created by the second liquid crystal display, causes an interference effect—i.e. moiré interference, degrading the resulting image seen by the viewer.

[0034] In order to eliminate these interference effects, a diffuser is inserted between the two liquid crystal displays. This may take the form of an individual layer/sheet or alternatively be formed by the application of a particular pattern or structure to the surface of the retarder. Chemical etching is a relatively cheap means of applying the required pattern, though in practice it has been found deficient for producing acceptable results in combination with a polyester or polyester retarder.

[0035] Alternatives to chemical etching include embossing, impressing or calendering of the said pattern by a holographically-recorded master onto the surface of the polyester retarder, forming a random, non-periodic surface structure. These randomised structures may be considered as a plurality of micro lenslets diffusing incident light to eliminate moiré interference and colour defraction. This method is however significantly more expensive than conventional methods such as chemical etching. Further alternatives include specifically engineered retarder films with no diffusive capability but these are also costly and have chromatic uniformity problems.

[0036] It is also possible to assemble the front liquid crystal display panel with the polarising plane of the rearward surface aligned with that of the front surface of the rear-most liquid crystal display. Unfortunately, this involves a large non-refundable engineering cost as it cannot be accommodated in the manufacture of conventional LCD units and thus requires production as custom units. In practice it is not possible to rotate the polarisers on the forward display panel without changing the rubbing axis on the glass as the contrast ratio of the image would deteriorate. However, there would be no physical indication of the rubbed orientation of an LCD mother glass (as the process literally involves rubbing the polyimide layer on the glass with a rotating velvet cloth) without labelling and this would cause significant disruption to the manufacturing process.

[0037] By contrast, use of a retarder enables the requisite polarization orientation change to be discerned by examining the polarization/glass finish to aclimate the retarder adhesive. This is clearly visible by the unaided eye and is one of the last production stages, thus reducing potential risk.

[0038] It is also possible to utilise a third party (i.e., not the original manufacturer) to realign the respective polarising screens though this is also expensive and runs the risk of damaging the display panels. Damage can occur during numerous steps in such a third party procedure, including any or all of the following;

[0039] 1. removing the LCD panel from its surround:—possible damage to TAB drivers or the glass;

[0040] 2. removing the polarizer:—heating of the polariser is required to reduce its adhesion and can damage the glass, damage individual pixels from excessive pressure, and the liquid crystals may be overheated;

[0041] 3. misalignment of the new polariser;

[0042] 4. replacing the panel in the original packaging—again causing possible damage to tab boards or the glass; and

[0043] 5. electrical static damage at any point of the procedure.

[0044] Furthermore, some or all of the interstitial optical elements located between the display layers (i.e. the LCD panels) may change the optical path length of light incident on the second (or successive) screen having passed through the first display. This alteration in path length leads to chromatic aberrations that require correction to ensure a clear display image.

[0045] Interstitial elements which may introduce such optical path length changes include:

[0046] Air;

[0047] nitrogen, or any other inert gas;

[0048] a selective diffusion layer;

[0049] Polymer Dispersed Liquid Crystal;

[0050] Ferroelectric Liquid Crystal;

[0051] Liquid Crystal between random homogeneous alignment layers;

[0052] Acrylic, Polycarbonate, Polyester;

[0053] Glass;

[0054] Antireflective coating;