[0549] In general, the redundancy-check algorithm of **FIG. 24**(*a*) and the anti-shadowing algorithm of **FIG. 25**(*a*) allow one to make beneficial use of sensor designs employing redundant coordinate measurements.

Example 20

[0550] If a touch is sensed with more than one acoustic mode, then an additional characteristic beyond touch position and "Z axis" touch pressure may be determined. Such information may be used, for example, to reject false touches due to water drops on the touch surface.

[0551] **FIG. 26** outlines the basic parts of a dual-mode touch characteristic rejection algorithm. The first box, delay times from different sensor subsystems for a touch are associated as a byproduct of the touch-position reconstruction algorithms **2601**; more generally, the first box represents the group of delay times from different sensors that correspond to a single touch regardless of whether the touch location is actually computed. The second box represents the determination of the magnitude of the signal perturbations for the delay times associated with the touch **2602**; it may be that the magnitudes of the signal perturbations have already been calculated as part of a test of perturbation significance. Here it is assumed that not all signal perturbations involve the same acoustic mode in the touch region. In the third box the signal perturbations are compared with expected characteristics, e.g. ratios of perturbation amplitudes, of valid touches **2603**.

[0552] **FIG. 26** illustrates the basic features of a dual-mode algorithm. In practice, the dual-mode feature may be incorporated in various ways into algorithms that reconstruct touch positions, perhaps determine touch pressure, perhaps provide anti-shadowing and multiple features, etc. The essential feature here is the comparison with expectations of the relative magnitudes of coupling of two or more acoustic modes to a touch.

[0553] As an example, consider the sensor shown in **FIG. 14** for an embodiment in which the X and Y sensor subsystems sense touches with a horizontally polarized shear wave (ZOHPS, HOHPS, or Love), and in which the U and V sensor subsystems sense touches with an acoustic mode with vertical particle motion at the surface, such as Rayleigh and Lamb waves. To be more specific one may, for example, use a 0.090 inch thick soda-lime substrate at an operating frequency of 5.53 MHz for which the Rayleigh wavelength is 0.0226 inches where the U and V reflector angles and spacings are given in **FIG. 13**(*b*) and **FIG. 14** and the X and Y reflector spacings are integer multiples of the Rayleigh wavelength and the X and Y reflector angles are about 52.5° as needed to couple Rayleigh waves to n=4 HOHPS waves traversing the touch region.

[0554] If such a sensor is subjected simultaneously to a water drop and a finger touch, due to viscosity damping, the finger touch will result in expected amplitudes of signal perturbations in both the (X, Y) and (U, V) subsystems. However due to the weak coupling of horizontally polarized shear waves to water, the (X, Y) signal perturbations due to the water drop will be weak while the (U, V) signal perturbations will be strong. The weak (X, Y) signal for the water drop will not be interpreted as a light finger touch because the corresponding (U, V) touch is strong. The ratios of signal perturbations for the same touch thus provides a characteristic of a touch that differentiates between water drops and finger touches. With empirically determined thresholds for such ratios, the algorithm can respond to finger touches and yet reject touches from water drops.

[0555] The algorithm of **FIG. 26** has other uses besides water rejection. For example, such an algorithm can be used to verify that a user is properly wearing gloves provided that the type of glove is constructed of a material that has a ratio of radiation-damping to viscosity damping characteristics that is sufficiently distinct from bare finger touches. This feature could be used, for example, to assure compliance with safety procedures for equipment where the wearing of gloves is mandatory.

Example 21

[0556] A test reflective array is provided having continuously varying reflector angles, from 45° to 56° with respect to the axis of the array. Other ranges of reflector angles may also be of interest. This array serves to produce, at various portions of the substrate, increasing reflector angles that may be experimentally tested for mode-conversion scattering at 90° of an incident Rayleigh wave to a plurality of propagation modes. A useful feature of 90° scattering is that the reflector spacing along the axis of the array depends only the in incident mode and not the reflected mode. The reflective array acts as a diffraction grating, directing waves having varying phase velocities at different positions along the arrays.

[0557] It has been found that the optimal chevron angle from the axis of propagation of an incident Rayleigh wave for scattering at right angles, for a shear wave of n=0 is about 46°, n=1 is about 47-48°, n=2 is about 48°, n=3 is about 50°, n=4 is about 52-53°, and n=5 is about 56°, for glass thickness of 0.085" to 0.090", with increasing thickness tending to smaller angles. The ratio of the phase velocity of a Raleigh wave and an n=4 HOHPS is about 0.92.

Example 22

[0558] The output of a dual-mode algorithm as represented by **FIG. 26** need not be limited to a simple pass/reject judgment on the nature of the touch. The dual-mode algorithm may categorize valid touches amongst a discrete set of categories, or even provide an analog measure of a touch characteristic.

[0559] "Dual-mode" algorithms need not be limited to the use of only two distinct acoustic modes. Use of three or more acoustic modes is also within the scope of this invention. In this context "distinct acoustic modes" may refer to the same acoustic mode at a significantly different frequencies, e.g. Rayleigh waves at 2 and 5 MHz. The essential feature is that not all sensor subsystems couple to a touch in the same way.

[0560] A dual-mode algorithm with a discrete-set output has application with sensor systems used with multiple styli. For example, a set of styli may be provided in which each stylus has a tip with a unique acoustic coupling properties. The unique acoustic coupling properties may be, for example, a particular ratio of coupling strength to Rayleigh-waves via dominant leaky-wave damping mechanism to the coupling strength horizontal-shear motion via viscous damping. When a user draws on the touch surface with a stylus, the dual-mode algorithm enables determination of the