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Magnetostrictive Transducers (MsT) Utilizing Reversed Wiedemann Effect

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Magnetostrictive transduction has been widely utilized in NDE applications and, specifically, for generation and reception of guided waves for long-range inspection of components such as pipes, vessels, and small tubes. Transverse-motion guided wave modes (e.g., torsional vibrations in pipes) are the most typical choice for long-range inspection applications because the wave motion is in the plane of the structure. Magnetostrictive-based sensors have been available for the last several years for these wave modes based on the Wiedemann effect. For these sensors, a permanent magnetic bias is applied that is perpendicular to the direction of the propagated guided wave. This bias field strains the material preferentially in the desired particle motion direction. A time-varying magnetic field that is much smaller than the bias field is induced in the material and is oriented parallel to the direction of guided wave propagation. This time-varying field is induced using an electric coil located near the surface. The interaction of these two fields produces the guided waves and an inverse effect is present for the receive process. An alternative configuration of a sensor for generating and receiving these traverse-motion guided waves is to reverse the biasing and time-varying magnetic fields directions. Since transverse-motion guided wave sensors are typically much wider in the particle motion direction, the net effect is the magnetic biasing length is shorter and different coil designs can be used. Because of this, the alternative design known as a magnetostrictive transducer (MsT), exhibits a number of unique features compared to the Wiedemann sensor described above, such as: 1) the ability to use smaller rare earth permanent magnets and achieve uniform and self-sustained bias field strengths, 2) the choice of more efficient electric coil arrangements to induce a stronger time-varying magnetic field for a given coil impedance, 3) more easily exhibit nonlinear operating characteristics given the efficiency improvements in both magnetic fields, and 4) the ability to generate unidirectional guided waves when the field arrangement is combined with a magnetostrictive patch. MsT designs will be presented that are suitable for different inspection applications, one using electromagnetic generation and reception directly in a ferromagnetic material and another design that integrates a magnetostrictive patch to improve the efficiency and allow special operating characteristics.