frequency) and D is the largest dimension of the transducer face **32** associated with the member **40**. For circular transducers, D will be the diameter of the face **32** whereas for rectangular transducers D will be the larger length dimension of the rectangle. In one form of the invention, the near field of the transducer **30** is selected to encompass one or more of the reflections used to calculate the decay rate. In a preferred form, a plurality of the echoes used to calculate the decay rate are within the near field length estimated by equation (8). In a further preferred form, the majority of the echoes used to calculate the decay rate are within this length. Most preferably, substantially all of the echoes are within this length.

From an examination of equation (8) one possibility for increasing the near field length is to increase the frequency of the ultrasound. However, there is a practical limit to the effectiveness of this approach, at least because losses due to attenuation of the ultrasound generally increase with increasing frequency. The near field length is therefore preferably maintained at a desired relative length by adjusting the ratio of the size of transducer size D to thickness T. Increasing the transducer size D increases the near field length whereas decreasing T decreases the pathlength of the echoes, allowing more echoes to be detected inside a given near field length. It is to be understood that the pathlength for each echo is the distance the pulse travels for each reflection (2T) times the echo number (the first echo has a pathlength of 2T, the second 4T, the third 6T, etc.). While any ratio can be utilized as would occur to those of skill in the art, in one form of the invention the ratio of D/T is preferably greater than about one. In other forms, the ratio D/T is about 2 or above.

An advantage is realized by using the decay rate of the echo amplitudes (represented by the two slopes ΔF and ΔC) in determining fluid properties. It has been found that, unlike the absolute magnitude of individual echo amplitudes, the slope of echo amplitude versus echo number is substantially independent of characteristics of the ultrasound pulse used to create the echoes. This independence was confirmed experimentally utilizing a 1 inch diameter longitudinal transducer in contact with a 0.25 inch thick stainless steel plate. The transducer operated at 5 MHz and the opposed surface of the plate was in contact with water.

In one set of experiments, the width of a −300 volt square wave input to the transducer was varied. It was found that, while the absolute value of the 6^{th} echo amplitude changed by about 21% when the width of the voltage input was changed from 102 nanoseconds to 68 nanoseconds, the slope of the natural log of the FFT amplitude versus echo number changed by less than 0.1%.

In a second set of experiments the voltage of a 100 nanosecond square wave input was changed from −300 volts to −50 volts and the slopes of the amplitude versus echo number log plots were determined. While the magnitude of the voltage input was decreased by a factor of six, the calculated slope of the log of amplitude versus echo number changed by less than 2%.

In one application of the invention, the transducer **30** and solid member **40** are provided as a spool piece that is fixed in place in a pipeline. In other applications of the present invention, preexisting pipe or container walls as utilized as member **40**, and transducer **30** is configured as a clamp-on sensor that can be retrofit to existing equipment and/or readily moved from one pipeline or container to the next. In these latter applications, where preexisting walls provide member **40**, the use of the slope of the log of echo amplitude versus echo number is particularly advantageous.

Turning now to FIG. **5**, an exemplary clamp on sensor **220** for use on a pipeline is illustrated. Sensor **220** includes an ultrasonic transducer **130** which is used in place of transducer **30** in system **20**. Transducer **130** is curved to correspond to the outer diameter of pipe **140**, and transducer **130** is held to the outside surface of a pipe **140** with clamps **150** that extend around pipe. Transducer **130** is generally rectangular with its longer dimension D oriented parallel to the flow direction of the pipe **140**. This longer length D is preferably greater than the pipe wall thickness T for the reasons described above. As one example, a curved rectangular transducer 0.4 inches by 1 inch could be chosen for a stainless steel pipe with an outside diameter of 2.375 inches and a wall thickness of 0.15 inches. An acoustic couplant, not shown, is optionally provided between transducer **130** and pipe **140**. It is to be understood that the strength of any particular signal from transducer **130** might depend on, for example, the pressure exerted by clamps **150**, which in turn could depend on additional factors, such as the care with which transducer **130** is attached to pipe **140**. However, the slope of the log of echo amplitude versus echo number would be relatively independent of variables such as connection pressure, leading to increased accuracy of the device.

In use, clamp on sensor **220** can be calibrated with any fluid present in pipe **140**. If the pipe is empty, air can be the calibration fluid. If the pipeline is conveying a process fluid, the process fluid can be the calibration fluid. Subsequent changes in the process fluid can then be quantitatively or qualitatively determined according to the present invention.

It is to be understood that, while in a retrofit system such as system **220**, the existing material of the pipe or container wall dictates the choice of solid material used, a wide variety of materials can serve as the member **40** as would occur to those of skill in the art. Exemplary materials for solid member **40** include aluminum, stainless steel, fused quartz, and plastics. Preferably member **40** is non-porous is does not absorb fluid **25**. In particular applications, such as food processing and the transport of toxic material, stainless steel or other non-corrosive materials are preferred materials for solid member **40**.

In a further variation, data transmission between computer **80** and transducer **30** can be achieved wirelessly by provision of appropriate wireless communication devices.

It is also to be understood that another embodiment of the present invention is a unique technique to determine fluid properties wherein an ultrasonic transducer **30** is provided on a surface **42** of a solid member **40** having an opposed second surface **44** in contact with the fluid **25**. This technique can include delivering an ultrasonic pulse through the solid member, detecting a multiplicity of pulse echoes caused by reflections of the ultrasonic pulse between the solid-fluid interface and the transducer-solid interface, and determining the decay rate of the detected echo amplitude as a function of echo number. The determined decay rate is compared to a calibrated decay rate to determine an acoustic property of the fluid. In one form, the speed of ultrasound in the solid is also determined and the fluid viscosity and/or the fluid density is determined as a function of the speed of ultrasound and the determined acoustic property.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes, equivalents, and modifications that come within the scope of the inventions described herein or defined by the following claims are desired to be protected. Any experiments, experimental examples, or experimental results provided herein are intended to be illustrative of the present invention and should not be construed to limit or restrict the invention scope. Further, any theory, mechanism of operation, proof, or finding stated herein is meant to further enhance understanding of the present invention and is not intended to limit