

CLAIMS

We claim:

1. A method for determining a lateral mode stiffness of one or more fluid tubes in a vibrating meter, comprising steps of:
 - 5 vibrating at least one of the one or more fluid tubes in a drive mode vibration;
receiving drive mode sensor signals based on a vibrational response to the drive mode vibration;
 - vibrating at least one of the one or more fluid tubes in a lateral mode vibration,
wherein the lateral mode is approximately perpendicular to the drive
10 mode;
 - receiving lateral mode sensor signals based on a vibrational response to the lateral mode vibrations; and
 - determining a lateral mode stiffness based on the lateral mode sensor signals.
- 15 2. The method of claim 1, wherein the step of vibrating at least one of the one or more fluid tubes in the lateral mode vibration comprises vibrating the at least one fluid tube at more than one lateral mode frequency.
3. The method of claim 1, wherein the step of vibrating at least one of the one or
20 more fluid tubes in the lateral mode vibration comprises vibrating two fluid tubes in a lateral mode vibration with respect to one another.
4. The method of claim 1, wherein the step of vibrating at least one of the one or
more fluid tubes in the lateral mode vibration comprises vibrating a fluid tube in the
25 lateral mode vibration with respect to a case.
5. The method of claim 1, wherein the step of determining the lateral mode stiffness is based on the lateral mode sensor signals and the drive mode sensor signals.
- 30 6. The method of claim 1, further comprising a step of comparing the determined lateral mode stiffness to an expected lateral mode stiffness.

7. The method of claim 6, wherein the expected lateral mode stiffness is based on a measured density of a fluid within the one or more fluid tubes.

8. A meter electronics (200) for a vibrating meter (5) including a processing system (303) configured to:

generate a drive mode drive signal (311) to vibrate at least one fluid tube (103A, 103B) in a drive mode vibration;

receive drive mode sensor signals (310) based on a vibrational response to the drive mode vibration;

generate a lateral mode drive signal (316) to vibrate the at least one fluid tube (103A, 103B) in a lateral mode vibration, wherein the lateral mode is approximately perpendicular to the drive mode;

receive lateral mode sensor signals (317) based on a vibrational response to the lateral mode vibrations; and

determine a lateral mode stiffness (318) based on the lateral mode sensor signals (317).

9. The meter electronics (200) of claim 8, wherein the processing system (303) is configured to generate more than one lateral mode drive signal (316) at more than one lateral mode frequency.

10. The meter electronics (200) of claim 8, wherein the processing system (303) is configured to apply the generated lateral mode drive signal (316) to two fluid tubes (103A, 103B) to vibrate the two fluid tubes (103A, 103B) in a lateral mode vibration with respect to one another.

11. The meter electronics (200) of claim 8, wherein the processing system (303) is configured to apply the generated lateral mode drive signal (316) to a fluid tube (103A, 103B) to vibrate the fluid tube (103A, 103B) in a lateral mode vibration with respect to a case (500).

12. The meter electronics (200) of claim 8, wherein the processing system (303) is further configured to determine the lateral mode stiffness based on the lateral mode sensor signals (317) and the drive mode sensor signals (310).

5 13. The meter electronics (200) of claim 8, wherein the processing system (303) is further configured to compare the determined lateral mode stiffness to an expected lateral mode stiffness.

14. The meter electronics (200) of claim 13, wherein the expected lateral mode
10 stiffness is based on a measured density of a fluid within the one or more fluid tubes.

15. A vibrating meter (5) including a sensor assembly (210) and a meter electronics (200), comprising:

one or more fluid tubes (103A, 103B);

15 a first driver (104) coupled to the one or more fluid tubes (103A, 103B) and oriented to induce a drive mode vibration in the one or more fluid tubes (103A, 103B);

one or more pick-offs (105, 105') coupled to the one or more fluid tubes (103A, 103B) and oriented to sense a drive mode vibration in the one or more
20 fluid tubes (103A, 103B);

a second driver (205) coupled to the one or more fluid tubes (103A, 103B) and oriented to induce a lateral mode vibration in the one or more fluid tubes (103A, 103B); and

one or more pick-offs (205) coupled to the one or more fluid tubes (103A, 103B)
25 and oriented to sense a lateral mode vibration in the one or more fluid tubes (103A, 103B).

16. The vibrating meter (5) of claim 15, wherein a first portion of the second driver (205) is coupled to a first fluid tube (103A) and a second portion of the second driver
30 (205) is coupled to a second fluid tube (103B).

17. The vibrating meter (5) of claim 16, wherein a first portion of the one or more pick-offs (205) oriented to sense a lateral mode vibration is coupled to the first fluid tube (103A) and a second portion is coupled to a second fluid tube (103B).
- 5 18. The vibrating meter (5) of claim 15, wherein a first portion of the second driver (205) is coupled to a first fluid tube (103A) and a second portion of the second driver (205) is coupled to a case (500).
- 10 19. The vibrating meter (5) of claim 18, wherein a first portion of the one or more pick-offs (205) oriented to sense a lateral mode vibration is coupled to the first fluid tube (103A) and a second portion is coupled to the case (500).

CLAIMS

We claim:

1. A method for determining a lateral mode stiffness of one or more fluid tubes in a vibrating meter, comprising steps of:

5 vibrating at least one of the one or more fluid tubes in a drive mode vibration;
receiving drive mode sensor signals based on a vibrational response to the drive mode vibration;

vibrating at least one of the one or more fluid tubes in a lateral mode vibration,
wherein the lateral mode is approximately perpendicular to the drive
10 mode;

receiving lateral mode sensor signals comprising a lateral mode vibrational frequency based on a vibrational response to the lateral mode vibrations;
and

determining a lateral mode stiffness based on the lateral mode sensor signals.

15 2. The method of claim 1, wherein the step of vibrating at least one of the one or more fluid tubes in the lateral mode vibration comprises vibrating the at least one fluid tube at more than one lateral mode frequency.

20 3. The method of claim 1, wherein the step of vibrating at least one of the one or more fluid tubes in the lateral mode vibration comprises vibrating two fluid tubes in a lateral mode vibration with respect to one another.

4. The method of claim 1, wherein the step of vibrating at least one of the one or
25 more fluid tubes in the lateral mode vibration comprises vibrating a fluid tube in the lateral mode vibration with respect to a case.

5. The method of claim 1, wherein the step of determining the lateral mode stiffness is based on the lateral mode sensor signals and the drive mode sensor signals.

30 6. The method of claim 1, further comprising a step of comparing the determined lateral mode stiffness to an expected lateral mode stiffness.

7. The method of claim 6, wherein the expected lateral mode stiffness is based on a measured density of a fluid within the one or more fluid tubes.

5 8. A meter electronics (200) for a vibrating meter (5) including a processing system (303) configured to:

generate a drive mode drive signal (311) to vibrate at least one fluid tube (103A, 103B) in a drive mode vibration;

10 receive drive mode sensor signals (310) based on a vibrational response to the drive mode vibration;

generate a lateral mode drive signal (316) comprising a lateral mode vibrational frequency to vibrate the at least one fluid tube (103A, 103B) in a lateral mode vibration, wherein the lateral mode is approximately perpendicular to the drive mode;

15 receive lateral mode sensor signals (317) based on a vibrational response to the lateral mode vibrations; and

determine a lateral mode stiffness (318) based on the lateral mode sensor signals (317).

20 9. The meter electronics (200) of claim 8, wherein the processing system (303) is configured to generate more than one lateral mode drive signal (316) at more than one lateral mode frequency.

25 10. The meter electronics (200) of claim 8, wherein the processing system (303) is configured to apply the generated lateral mode drive signal (316) to two fluid tubes (103A, 103B) to vibrate the two fluid tubes (103A, 103B) in a lateral mode vibration with respect to one another.

30 11. The meter electronics (200) of claim 8, wherein the processing system (303) is configured to apply the generated lateral mode drive signal (316) to a fluid tube (103A, 103B) to vibrate the fluid tube (103A, 103B) in a lateral mode vibration with respect to a case (500).

12. The meter electronics (200) of claim 8, wherein the processing system (303) is further configured to determine the lateral mode stiffness based on the lateral mode sensor signals (317) and the drive mode sensor signals (310).

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13. The meter electronics (200) of claim 8, wherein the processing system (303) is further configured to compare the determined lateral mode stiffness to an expected lateral mode stiffness.

10 14. The meter electronics (200) of claim 13, wherein the expected lateral mode stiffness is based on a measured density of a fluid within the one or more fluid tubes.

15. A vibrating meter (5) including a sensor assembly (210) and a meter electronics (200), comprising:

15 one or more fluid tubes (103A, 103B);
a first driver (104) coupled to the one or more fluid tubes (103A, 103B) and oriented to induce a drive mode vibration and generate a lateral mode vibrational frequency in the one or more fluid tubes (103A, 103B);
one or more pick-offs (105, 105') coupled to the one or more fluid tubes (103A,
20 103B) and oriented to sense a drive mode vibration in the one or more fluid tubes (103A, 103B);
a second driver (205) coupled to the one or more fluid tubes (103A, 103B) and oriented to induce a lateral mode vibration in the one or more fluid tubes (103A, 103B); and
25 one or more pick-offs (205) coupled to the one or more fluid tubes (103A, 103B) and oriented to sense a lateral mode vibration in the one or more fluid tubes (103A, 103B).

16. The vibrating meter (5) of claim 15, wherein a first portion of the second driver (205) is coupled to a first fluid tube (103A) and a second portion of the second driver (205) is coupled to a second fluid tube (103B).

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17. The vibrating meter (5) of claim 16, wherein a first portion of the one or more pick-offs (205) oriented to sense a lateral mode vibration is coupled to the first fluid tube (103A) and a second portion is coupled to a second fluid tube (103B).

5 18. The vibrating meter (5) of claim 15, wherein a first portion of the second driver (205) is coupled to a first fluid tube (103A) and a second portion of the second driver (205) is coupled to a case (500).

10 19. The vibrating meter (5) of claim 18, wherein a first portion of the one or more pick-offs (205) oriented to sense a lateral mode vibration is coupled to the first fluid tube (103A) and a second portion is coupled to the case (500).