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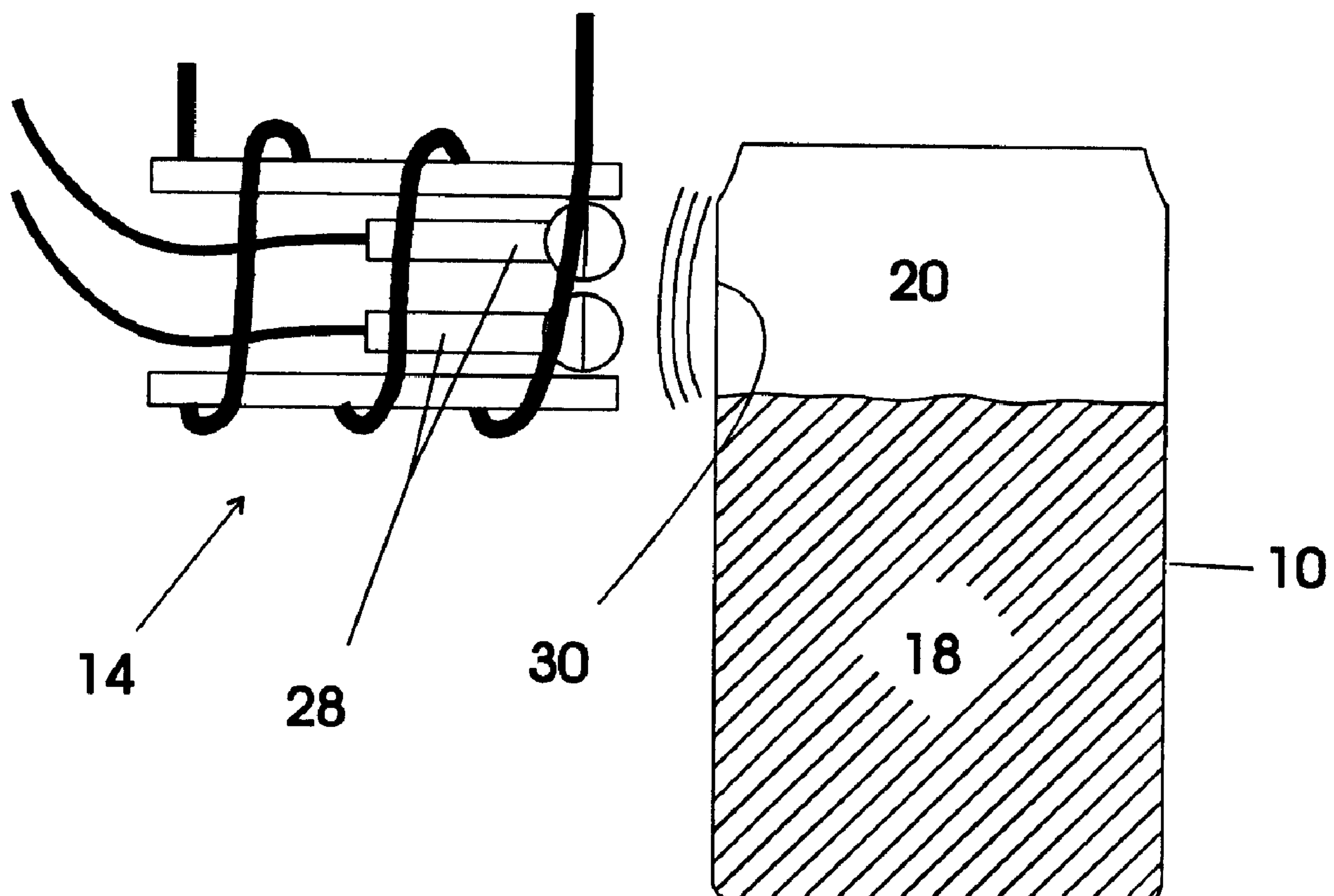
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(54) Titre : PROCEDE ET DISPOSITIF POUR DETERMINER LE NIVEAU DE REMPLISSAGE DE RECIPIENTS
(54) Title: METHOD AND DEVICE FOR DETERMINING THE FILLING LEVEL IN CONTAINERS



(57) Abrégé/Abstract:

In order to determine the filling level in containers, mechanical vibrations are generated in the wall of a container (30) and the course of said vibrations is analyzed. The wall of a container in which the vibration is produced is touched at a different distance according to filling level. The vibration pattern is subsequently evaluated according to the distance at which the inside of the container wall (30) is touched. It is thus possible to determine the relaxation time, frequency, intensity and/or the time integral of the intensity or the point of maximum intensity of the mechanical vibrations in the container wall.





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(54) Title: METHOD AND DEVICE FOR DETERMINING THE FILLING LEVEL IN CONTAINERS (54) Bezeichnung: VERFAHREN UND VORRICHTUNG ZUM ERMITTELN DES FÜLLSTANDS VON BEHÄLTERN The diagram shows a cross-section of a container (10) partially filled with a substance (18). A sensor (30) is mounted on the inner wall of the container. A coil (14) is connected to the sensor (28) via a cable (14). The sensor (30) is positioned at a distance from the filling level (18).				
(57) Abstract In order to determine the filling level in containers, mechanical vibrations are generated in the wall of a container (30) and the course of said vibrations is analyzed. The wall of a container in which the vibration is produced is touched at a different distance according to filling level. The vibration pattern is subsequently evaluated according to the distance at which the inside of the container wall (30) is touched. It is thus possible to determine the relaxation time, frequency, intensity and/or the time integral of the intensity or the point of maximum intensity of the mechanical vibrations in the container wall.				

Description

The invention relates to a method and a device for
ascertaining the fill level in vessels, wherein mechanical
vibrations are produced without contact in a vessel wall, the
produced mechanical vibrations are recorded without contact
5 and the recorded vibrations are analysed.

Such a method is known from GB 2 298 279 A, based on the
finding that, in gas vessels of a certain type, it is not the
resonance frequency, but only the frequency amplitude, that
10 changes depending on the contained residual amount. To
establish the residual amount, sound waves of this resonance
frequency are therefore directed onto the vessel by means of a
loudspeaker and the intensity of the reflected sound waves of
this frequency, is ascertained and compared with a threshold
15 value.

It is known from DE 40 04 965 A1 to test vessels for the
tightness of attached below-atmospheric pressure closures, by
producing mechanical vibrations without contact in the below-
20 atmospheric pressure closure by a short time magnetic field
and evaluating the produced vibration with regard to
frequency, duration and/or attenuation.

It is known from US-A-3 802 252, US-A-4 811 595, US-A-5 353
25 631 and GB-A-2 293 450 to ascertain the internal pressure of a
vessel by mechanically or magnetically impacting a vessel wall
and measuring the resonance frequency of the vessel, from
which the internal pressure is then derived.

A method for establishing a minimum and maximum fill level is known from DE-A-40 08 135 in which the resonance frequency is ascertained in each case at a certain point on the external
5 wall of the vessel. Piezo- crystal are used to produce the vibrations and to scan the vibrations.

A method is known from DE-A-41 00 338 in which the degree of the filling of the vessel with the free-flowing product is
10 ascertained by measuring the frequency of the mechanical sound vibrations of the vessel housing by a sensor fitted directly onto the vessel wall.

A method is known from DE-A-197 11 093 (=EP 0 831 308 A) in
15 which the contents of a liquefied gas bottle are determined by directing a sound signal onto the gas bottle by means of a sound transmitter placed against the outside of the gas bottle, recording the sound signal given off by the gas bottle, and comparing both signals. The transmitted signal
20 passes through a substantial frequency range and the resonance frequency is established by measuring the amplitude of the received signal.

A method is known from WO 94/24526 in which even ultrasonic
25 waves are produced in a liquid sample in a vessel and the dependence on frequency of the amplitude and/or the phase of the resonances are measured.

In the earlier application DE-A-196 46 685 (= WO 98/21557)
30 which is still not published, a method for determining the fill level of closed vessels is described, primary mechanical vibrations being excited in a vessel wall and the secondary vibrations which are excited by the primary mechanical

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vibrations of the vessel wall inside the vessel, and occur inside the space between the closure and the liquid, then being analysed. The fill level can be ascertained from the frequency of these secondary vibrations.

5

In the earlier application DE-A 197 36 869 (= WO 99/10722) which is still not published, a method for testing the residual air volume of vessels which are sealed by a closure, is described. The liquid for expulsion of the residual air

10 volume is foamed in the vessels before sealing. The residual air volume is ascertained by exciting mechanical vibrations in the closure, which are analysed directly after the closure is attached,

before a major change in the internal pressure takes place in the vessel. The frequency, the decay time, the vibration amplitude and/or the time integral of the vibration amplitude are included in the vibration analysis.

5

The present invention has been developed to determine the fill level of vessels, in particular cans, in as easy and rapid a manner as possible.

10 The present invention provides a method in which a vibration is produced in a vessel wall which is contacted by the contents to an extent which varies depending on the fill level. The recorded vibrations are then analysed to discover to what extent the vessel wall is contacted on the inside by
15 the contents. This analysis includes the evaluation of the decay time, the frequency, the intensity and/or the time integral of the intensity or the ascertaining of the site of the maximum intensity of the mechanical vibration.

20 Accordingly, the present invention provides a method for ascertaining the fill level by contents of a vessel, wherein mechanical vibrations are produced without contact in a vessel wall, the produced mechanical vibrations being recorded without contact, and the recorded vibrations being
25 analysed, characterized in that the mechanical vibrations are produced by a brief, pulse-like deflection of the vessel wall which is contacted by the contents to an extent which varies depending on the fill level, and the analysis of the recorded vibrations is carried out for the purpose of discovering to
30 what extent the vessel wall is contacted on the inside by the contents and includes the evaluation of at least one of the decay time, the frequency, the intensity, the time integral of the intensity and the ascertaining of the site of the

3a

maximum intensity of the mechanical vibration, wherein, to ascertain the site of the maximum intensity of the mechanical vibrations, the mechanical vibrations are recorded by two microphones arranged at a distance from each other and the
5 vibration phases of the vibrations recorded by each microphone are compared.

The present invention also provides apparatus to carry out the above method having a device for producing mechanical
10 vibrations in the vessel wall and a device for recording and evaluating the mechanical vibrations, wherein the device for producing mechanical vibrations in the vessel wall has a magnetic coil which is arranged such that the coil generates a magnetic pulse to create a deflection in the side wall of a
15 passing vessel for producing the mechanical vibrations, characterized in that the magnetic coil is controlled such that the coil emits the magnetic pulse when the passing vessel is closest to the magnetic coil.

20 The mechanical vibrations in the vessel wall are produced in known manner by a short magnetic pulse emanating from a magnetic coil. The magnetic pulse briefly deflects the vessel wall and the vessel wall vibrates back after the magnetic pulse has ended. The mechanical vibration of the vessel wall
25 produces acoustic vibrations, which, for their part, can be received by a microphone, magnetic recorder or the like. This measuring technique has long been known in connection with the determination of the internal pressure of vessels. These mechanical vibrations decay with a certain time constant. The
30 time constant is relatively small, i.e. the attenuation is great when the vessel is full. The lesser the contents, the

greater the time constant of the vibration. The fill level has a particularly significant effect on the vibration attenuation.

- 5 The increased attenuation also has an effect on the time integral of the vibration amplitude. This time integral is proportional to the area under the curve representing the vibration in a diagram showing the vibration amplitude over time. The smaller this area, the higher the fill level.

10

In addition, shifts in the vibration frequency also result which can likewise be evaluated. It is generally the case that the frequency becomes higher as the fill level rises.

- 15 Because the mechanical vibrations are produced without contact e.g. by a magnetic pulse, in the vessel wall and the vibrations are also recorded without contact, the method according to the invention is suitable in particular for ascertaining the fill level of vessels which are conveyed
20 along a conveyor belt or other transport device.

- In a preferred version of the invention, the vibrations of the vessel wall are recorded by two microphones arranged at a distance one above the other and the site of the sound source
25 is ascertained by a comparison of the vibration phases. This exploits the fact that the vibrations in the vessel wall are markedly attenuated below the surface of the liquid, so that it is principally the part of the vessel wall lying above the surface of the liquid that vibrates, so that the centre of the
30 vibrations produced in the vessel shifts upwards as the fill level rises. Information about the fill height can therefore also be obtained by locating the sound source.

The distance between magnetic coil and vessel as well as between vessel and microphone does not play a major role in the evaluation of the vibration with regard to attenuation and frequency. These two distances must however be taken into
5 account when the vibrations are evaluated with regard to the time integral of the amplitude, as here the absolute intensity of the vibration affects the measurement result. Therefore, the distance between magnetic coil and vessel wall and between vessel wall and microphone are preferably taken into account
10 in the evaluation of the vibration with regard to the time integral of the intensity or amplitude. The distance can be measured in known manner by a laser beam, inductively or by ultrasound.

15 Due to wave motions and sloshing effects of the liquid in the vessel, measurement inaccuracies result. To improve the measurement accuracy, several measuring devices are therefore preferably linked, each measuring device consisting of a magnetic coil and one or two microphones. As the costs of
20 individual measuring devices are relatively low, a clear improvement in the accuracy can be achieved by a larger number, e.g., 10 or more, of measuring devices and the formation of the average value from the results of all measuring devices. Not only the inaccuracy caused by the
25 sloshing of the liquid, but also the inherent measuring inaccuracies of the system, is reduced by a larger number of measuring devices. The measuring devices can thus be arranged on both sides of the vessel or the can.

30 Embodiments of the invention are explained in the following using the drawing. It is shown in:

Fig. 1 an arrangement for producing mechanical vibrations

in a can and for receiving the acoustic signals produced by these vibrations;

Fig. 2 an arrangement similar to Fig. 1, but with two microphones for determining the centre of the acoustic vibrations in the case of underfilling and

Fig. 3 the arrangement of Fig. 2 with the can normally filled.

10

In the embodiments shown in the Figures, cans 10 are advanced on a conveyor 12 past a measuring device 14. In Fig. 1, the cans are also guided by fixed side-rails 16. The cans 10 are partly filled with liquid 18 and an air space 20 is located above the liquid.

15

The measuring device 14 consists of a magnetic coil 22 and a core 24, which has an axial recess 26. Located in the recess 26 are one or two microphones 28. Short electric pulses can be applied to the magnetic coil 22 by means of a source of current, not represented, so that the magnetic coil emits corresponding short magnetic pulses. The measuring device 14 is arranged at the smallest distance possible from a side wall of the passing cans 10 and the magnetic coil 22 is controlled so that it emits the magnetic pulse when the distance from a passing can 10 is at its smallest. The side wall 30 of the can 10 is thereby deflected for a short period towards the magnetic coil 22, as a result of which a mechanical vibration, which very rapidly decays again, is impacted in the side wall 30. The measuring device 14 is arranged at roughly the height of the liquid level when the cans 10 are filled normally.

20

25

30

The vibrations impacted by the magnetic pulse are recorded by

the microphone(s) 28 as acoustic vibrations and evaluated by an evaluation device, not represented.

The measuring device 14 with the magnetic coil 22 and the microphones 28 is only schematically represented in the Figures. The magnetic coil 22 can actually have any customary shape, e.g. pot shape or horseshoe shape, by which the magnetic field is concentrated on the side directed towards the cans 10.

10

The decay time of the mechanical vibrations depends on the fill level. The higher the fill level in the can 10, the shorter the decay time. The vibration signal received by the microphones 28 is evaluated in the evaluation device. By means of customary electronic evaluation devices, the decay time of the vibration can be ascertained. A table of values can be compiled by means of some test runs with cans 10 filled to different levels, and this can then be used to read off the fill level from the decay time.

20

Likewise, the frequency of the impacted mechanical vibration changes depending on the fill level, so that the fill level can also be read off from the ascertained frequency of the mechanical vibration using a corresponding table of values.

25

The intensity of the vibration also depends on the fill level, so that information about the fill level can also be provided by its measurement. As the intensity also depends, however, on the distance of the magnetic coil 22 and the microphone 28 from the can 10, the measured intensity value must firstly be adjusted using these distances and standardized. The distance can be measured e.g. by means of transit time measurement of a laser beam.

30

Finally, the time integral of the amplitude or intensity of the impacted mechanical vibration also very clearly depends on the fill level. Here, too, there must be an adjustment
5 reflecting the distance of the measuring device 14 from the can 10.

There are two microphones 28 present in the embodiment shown in Figures 2 and 3. The direction from which the acoustic
10 signal comes can be established by a phase comparison of the vibration signals recorded by the two microphones 28 and the site within the side wall 30 of the can 10 from which the strongest acoustic signal starts can be ascertained, taking into account the distance of the can 10 from the measuring
15 device 14. It transpired that the impacted mechanical vibration has its greatest intensity and amplitude roughly in the middle of the section of the side wall 30 which lies above the fill level. By using two microphones 28, this site of the strongest intensity of the mechanical vibrations can therefore
20 be established and the fill level can be ascertained therefrom, taking into account the overall height of the cans 10.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method for ascertaining the fill level by contents of a
5 vessel (10), wherein mechanical vibrations are produced
without contact in a vessel wall (30), the produced
mechanical vibrations being recorded without contact, and
the recorded vibrations being analysed, characterized in
that

10 the mechanical vibrations are produced by a brief,
pulse-like deflection of the vessel wall (30) which is
contacted by the contents to an extent which varies
depending on the fill level, and

15 the analysis of the recorded vibrations is carried
out for the purpose of discovering to what extent the
vessel wall (30) is contacted on the inside by the
contents and includes the evaluation of at least one of
the decay time, the frequency, the intensity, the time
integral of the intensity and the ascertaining of the
20 site of the maximum intensity of the mechanical
vibration, wherein, to ascertain the site of the maximum
intensity of the mechanical vibrations, the mechanical
vibrations are recorded by two microphones arranged at a
distance from each other and the vibration phases of the
25 vibrations recorded by each microphone are compared.

2. The method according to claim 1, characterized in
that the fill level of the vessel (10) is
ascertained several times and the average value of
30 the ascertained fill levels is calculated.

3. The method according to claim 1 or 2, characterized in that the mechanical vibration is produced at a point on the vessel wall (30) which is roughly at the height of a normal fill level of the vessel.

4. The method according to any one of claims 1 to 3, characterized in that for the analysis of the recorded vibrations with regard to the intensity or the time integral of the intensity, the distance between the device for producing the mechanical vibrations and the vessel wall and the distance between the vessel wall and the device for recording the vibrations are taken into account.

5. The method according to claim 4, characterized in that the distance is measured by means of a laser beam.

6. The method according to claim 4, characterized in that the distance is measured inductively.

7. The method according to claim 4, characterized in that the distance is measured by ultrasound.

8. Apparatus for carrying out the method according to any one of claims 1 to 7, with a device (22) for producing mechanical vibrations in the vessel wall (30) and a device (28) for recording and evaluating the mechanical vibrations, wherein the device (22) for

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producing mechanical vibrations in the vessel wall (30) has a magnetic coil which is arranged such that the coil generates a magnetic pulse to create a deflection in the side wall of a passing vessel for producing the mechanical vibrations, characterized in that the magnetic coil (22) is controlled such that the coil emits the magnetic pulse when the passing vessel is closest to the magnetic coil.

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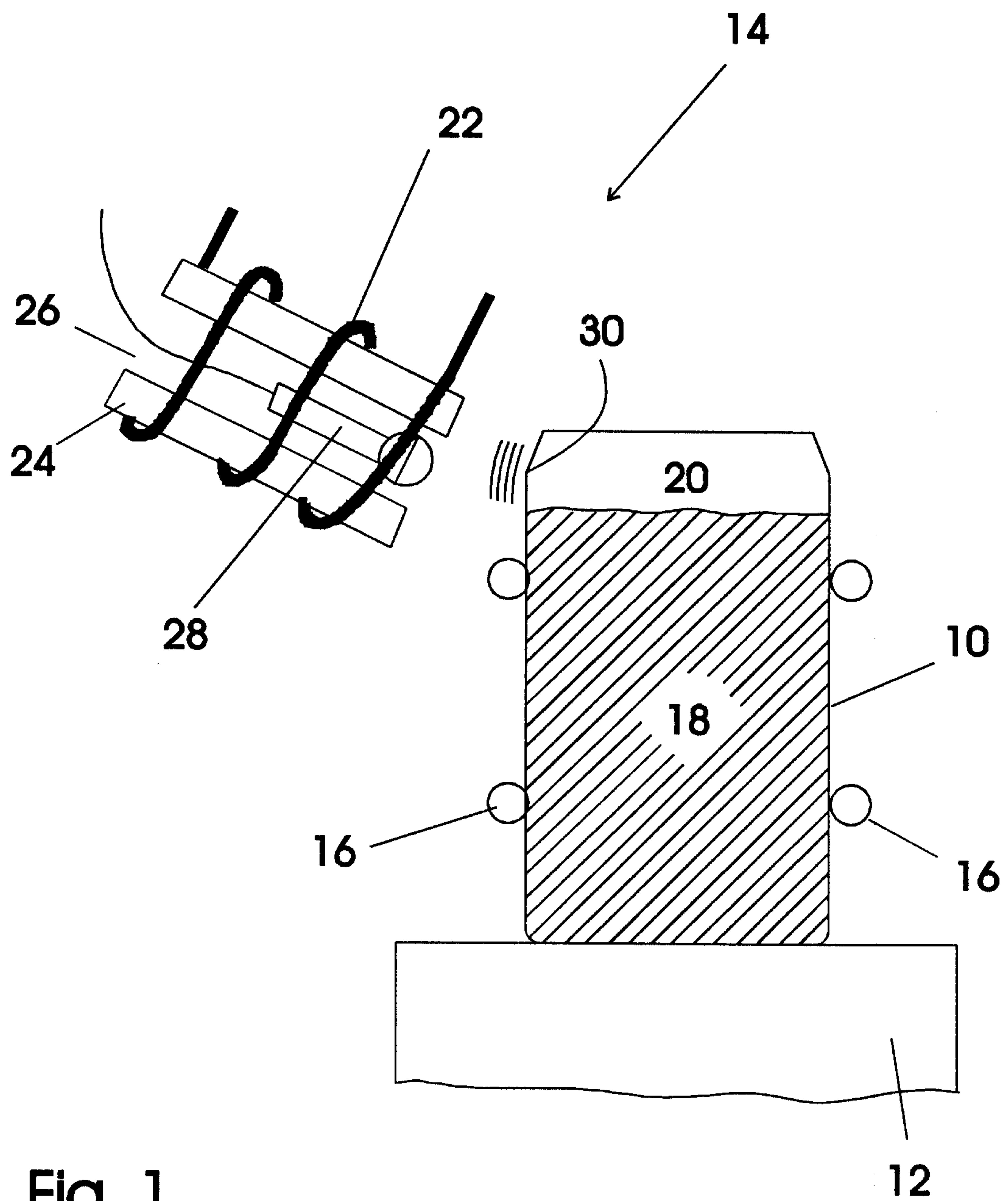


Fig. 1

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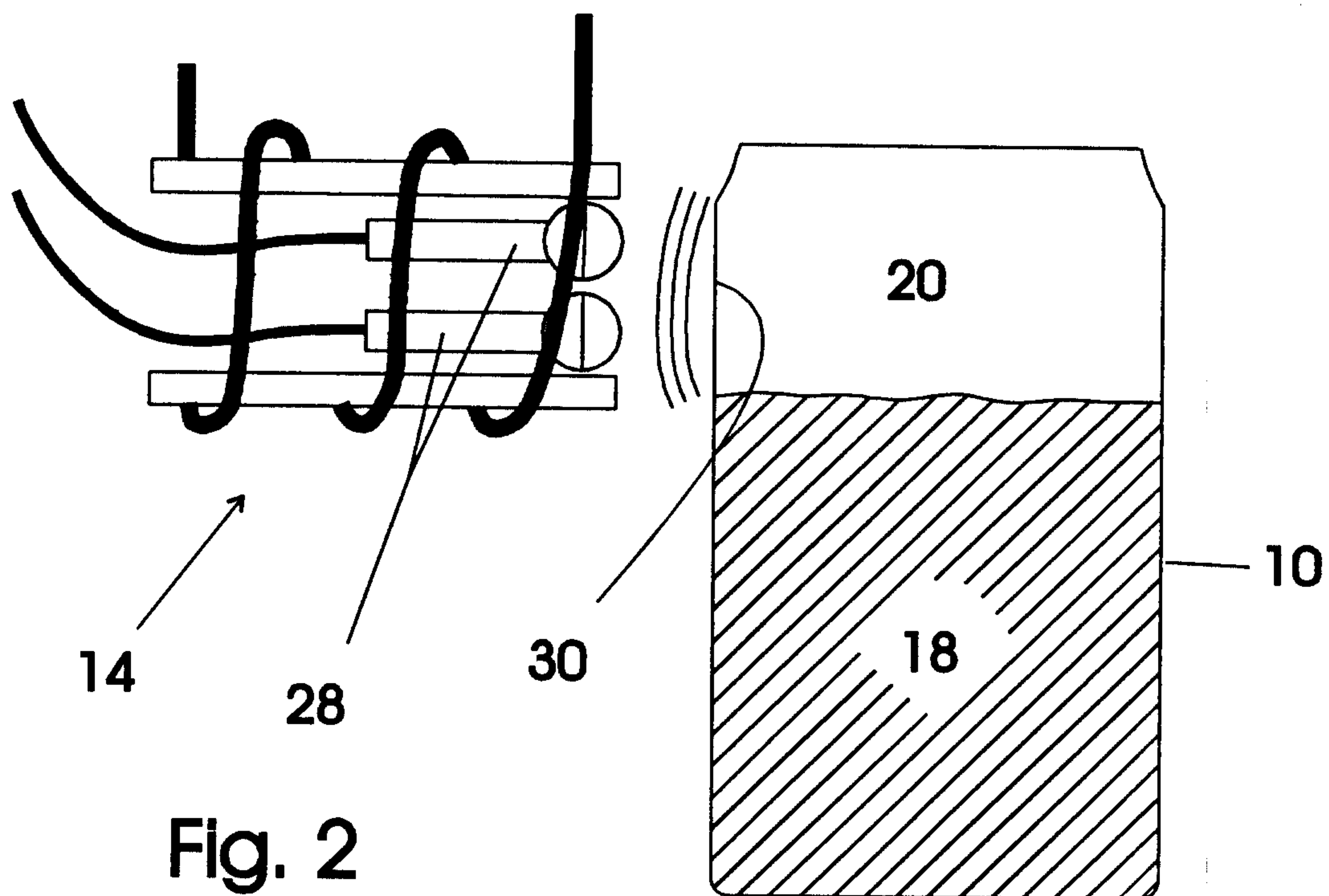


Fig. 2

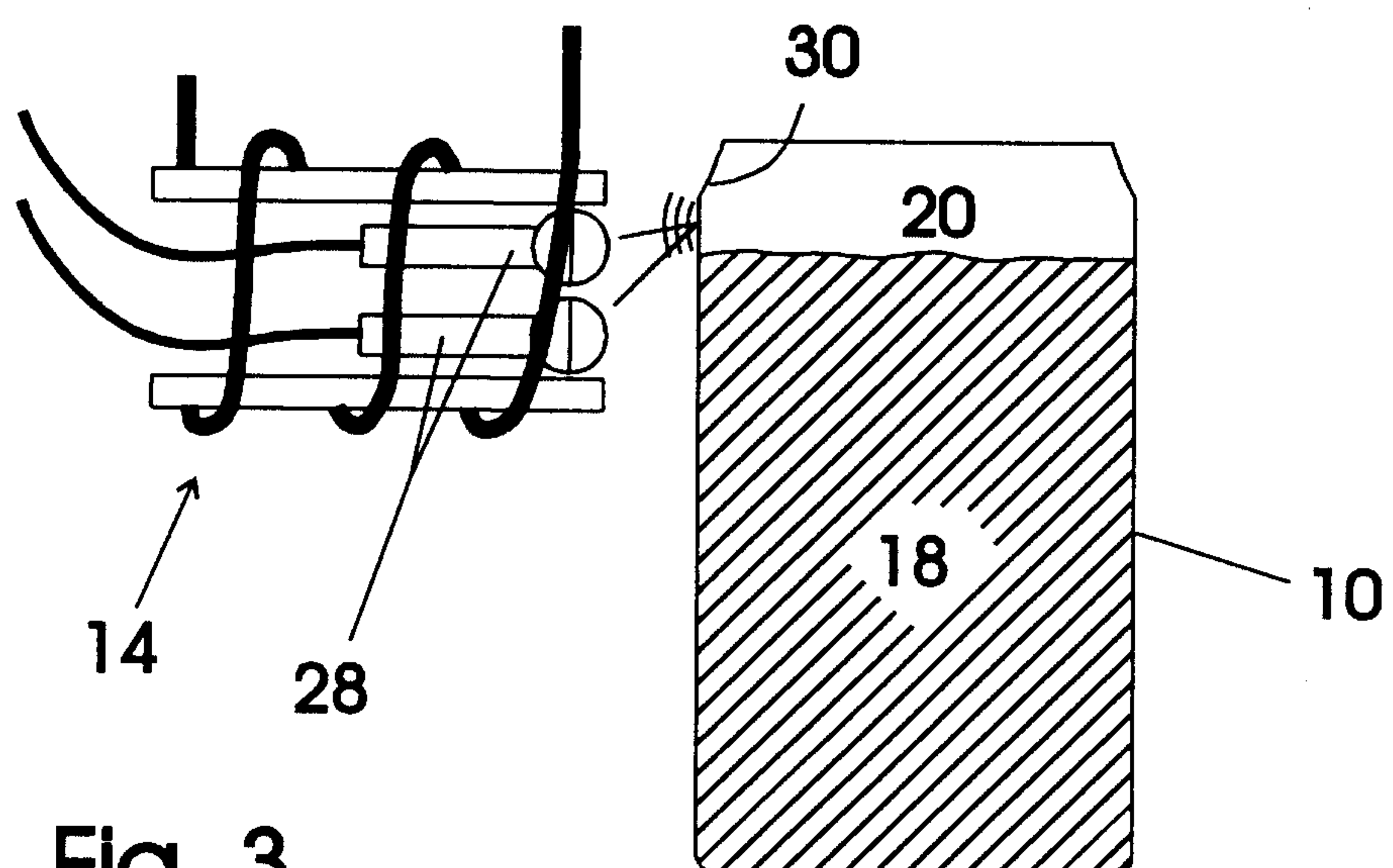


Fig. 3

