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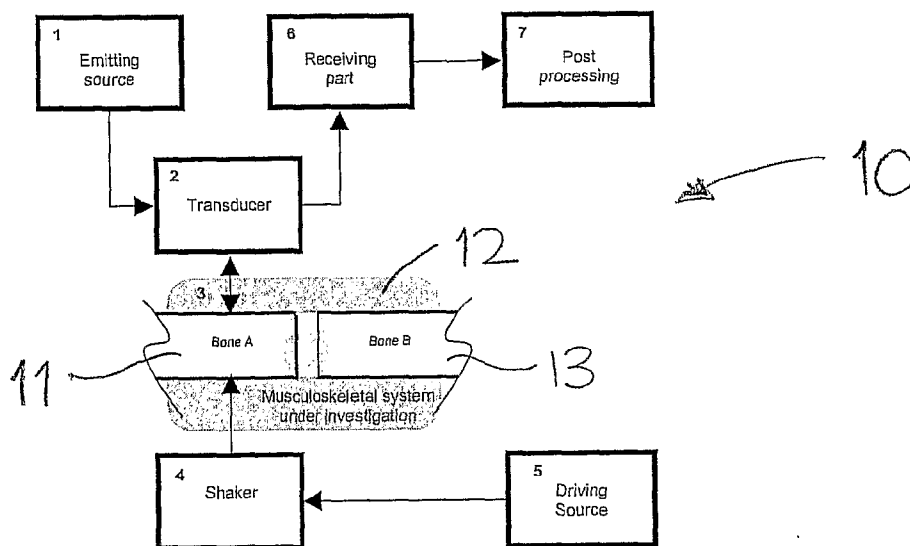
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(54) Title: METHOD AND APPARATUS FOR THE ASSESSMENT OF BIOMECHANICAL PROPERTIES USING ULTRA-
SOUND



(57) Abstract: A method and apparatus for measuring mechanical properties of a system under investigation, such as the biomechanical properties and dynamic characteristics of a musculoskeletal system in the human body. The system under investigation includes multiple component parts (eg. bones, muscles, ligaments, etc) having differing ultrasound reflection / transmission properties and whose relative spatial relationship can vary due to the resilience, plasticity and or elasticity of at least one of the component parts. Movement in the system is induced by way of a mechanical stimulator. Ultrasound detection signals are directed into the system at times such that at least some induced movement has occurred in target structures within the system, between a first detection signal and a second detection signal. Ultrasound echo signals are used to determine mechanical properties of the system.

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**METHOD AND APPARATUS FOR THE ASSESSMENT OF
BIOMECHANICAL PROPERTIES USING ULTRASOUND**

The present invention relates particularly, though not exclusively, to
5 methods and apparatus for assessing biomechanical properties of joints and
other movable structures of the human and animal body.

Mobility tests, provocation tests and palpation are techniques that are
frequently used in physiotherapy to obtain information on the hypermobility
10 or hypomobility of joints. In specific joints, such as the sacroiliac, carpal
and tarsal joints, these clinical examinations are impaired by limited
excursion of the joints and by restricted accessibility to the region of
interest.

15 To describe microscopic movements in the sacroiliac joints under different
static loads, an x-ray technique as well as a conventional light photography
technique has previously been used.

In the x-ray technique, radio-opaque markers can be inserted into the sacrum
20 and ilium, and displacement of the markers after joint manipulation is
measured on x-ray photographs.

In the conventional photography technique, external markers are introduced
percutaneously.

25 In different physiological exercises, rotations and translations of the ilium in
relation to the sacrum can be measured using either of these techniques.

There are several problems associated with the techniques described above
30 for joint functionality assessment.

One important source of information for the determination of biomechanical properties is the dynamic characteristics of a joint or other system under investigation, *in vivo* (e.g. in the pelvic girdle), derived from the dynamic response of system components. By 'dynamic response', we refer to the time-dependent response of the system to mechanical stimulus in which inertia and damping forces make a significant contribution to the response. In general terms, we refer to data identifying the relative displacement of one or more parts or 'components' of a structure in response to displacement or force stimulus that changes as a function of time. All of the methods to determine joint movements discussed above are only suitable for the determination of the static response of the joint. By 'static response', we refer to a response of the system in which inertia and damping forces do not make a significant contribution to the response.

The order of magnitude of displacement of the bones connected by a joint is much smaller in a dynamic response (typically in the range of microns), than in a static response (typically in the range of millimetres). The methods of measurement of static response discussed above are not sufficiently sensitive to measure displacements in the lower order of magnitude required for dynamic response.

In mobility and provocation tests, neither the applied stimulus nor the resulting response is quantified. The diagnosis depends upon the perception and experience of the clinician. Mobility and provocation tests are therefore highly subjective and their diagnostic value is generally quite low, particularly in joints with limited excursions.

In addition, any diagnostic procedure using x-radiation is subject to the well-established problems, hazards and restrictions of such techniques, and can cause collateral damage to the subjects under examination.

- 5 The positioning of markers for assessment of range of motion in joints with limited accessibility requires at least minimally invasive procedures, which increase the costs and risks of the procedures and discomfort to the patient.

10 Estimation of minimal movements of structures in the human body is a common issue in the medical field. Ultrasound techniques have proven to be suitable for such measurements for medical diagnostic purposes. The underlying principle of ultrasound displacement measurements is based on time delay estimation of ultrasound waves.

- 15 For example, time delay estimation is one of the common operations in ultrasound signal and image processing and can be performed by different algorithms. Examples are normalized and non-normalized cross correlation, normalized covariance, polarity-coincidence correlation and hybrid-sign correlation. For instance sophisticated signal processing is used to improve
20 image quality or to extract information usually not available in the grey scale B-Mode image.

Various applications are known where time delay is used for estimating displacement. For example, measurement of blood flow velocity using
25 Doppler ultrasound is well known, where the time delay is estimated by cross-correlation of subsequent echoes. In this method, a packet of short ultrasound 'detection' pulses is transmitted into the vessel or heart, and reflected signals are received sequentially after a certain delay. Due to movement of ultrasound scattering entities in the blood, the time between

the transmitted detection pulse and the returning echo will change, and can be used to estimate the velocity.

5 In intravascular contour or vessel wall detection, stationary (vessel wall) and non-stationary (blood) structures can be distinguished by correlating their signals throughout sequential image frames.

10 A recent technology that takes advantage of time delay estimations is intravascular ultrasound elastography. In this technique, local strain in the artery wall and plaques are assessed by looking at the deformation of the tissue.

In obstetrics time delay estimation is used to monitor the foetal heart rate.

15 In all of these medical applications for assessing displacement, it will be noted that the movement of the structures under examination is generated by self-moving parts, e.g. heart beats and consequential blood flow.

20 In the non-medical field, time delay estimation is used for on-line measurements of the density of ceramic tiles. In this case, the time of flight of the ultrasonic waves is measured in transmission mode using cross-correlation algorithms between transmitted and received signals.

25 Other devices that use a similar approach are ultrasound cross-correlation-based flow metering systems. These systems, used as non-destructive testing systems, indicate the value of the convection velocity of turbulent structures in pipe flows.

30 It is an object of the present invention to provide methods and apparatus for determining the dynamic response of a system under investigation including

target structures and components thereof such as joints, particularly within the human or animal body, using ultrasound techniques. This enables assessment of the biomechanical properties of such systems and/or components thereof, and more generally assessment of a system under
5 investigation.

In general terms, the expression 'system under investigation' is intended to encompass exemplary systems such as the musculoskeletal system including the bones, muscles, ligaments etc. An example of such a system is the
10 pelvic musculoskeletal system.

The system under investigation includes multiple component parts which have differing ultrasound reflection / transmission properties and whose relative spatial relationship can vary due to the resilience, plasticity and or
15 elasticity of at least one of the component parts. In the present specification, we refer to structures having the requisite ultrasound properties from which ultrasound information can be recovered as 'target structures', such as bones in the musculoskeletal system. The dynamic response of the target structures (e.g. bones) within the system can be measured with the
20 ultrasound signals and the biomechanical properties of the system under investigation (e.g. joints) can be deduced therefrom.

According to one aspect, the present invention provides a method for measuring mechanical properties of a system under investigation,
25 comprising the steps of:

inducing movement in a target structure in the system over a predetermined period of time;

directing ultrasound detection signals into the system at times such that at least some induced movement has occurred in the target structure
30 between a first detection signal and a second detection signal; and

receiving ultrasound echo signals from the target structure.

According to another aspect, the present invention provides an apparatus for the measurement of mechanical properties of a system under investigation,

5 comprising:

a mechanical stimulator for inducing movement in a target structure in the system over a predetermined period of time; and

an ultrasound transducer for directing ultrasound detection signals into the system at times such that at least some induced movement has
10 occurred in the target structure between a first detection signal and a second detection signal and for receiving echo signals therefrom.

Embodiments of the present invention will now be described by way of example and with reference to the accompanying drawings in which:

15 Figure 1 is a schematic block diagram of the components of an apparatus for assessment of the dynamic response of a target structure to a time-dependent external stimulus;

Figure 2 is a graph illustrating a packet of ultrasound detection pulses together with corresponding echo pulses;

20 Figure 3 is a graph illustrating a first and a second ultrasound echo from a target structure in which movement is induced in the structure between first and second detection pulses;

Figure 4 is a schematic block diagram of the components of apparatus for assessment of the dynamic response of a target structure to a time
25 dependent external stimulus, according to a second embodiment of the present invention; and

Figures 5a and 5b are graphs depicting (a) the time delay between two echoes returned from the target structure and (b) the displacement-time plot of a component within the target structure.

30

With reference to figure 1, there is shown a first arrangement of apparatus 10 for the measurement of the dynamic response of a target structure 11 within a system under investigation 3, e.g. a human or animal joint 12. The system 12 incorporates one or more ultrasound reflecting surfaces or components, such as bones 11, 13 within one or more resilient or otherwise deformable softer components such as tissue, cartilage, synovial fluid and the like. It will be understood that the more rigid bone components are relatively displaceable under physical displacement stimulus, as a result of the softer components therebetween.

10

A pulse generator or emitting source 1 is adapted to produce a series of ultrasound detection pulses to be directed onto the target structure 11, 13 in the system under investigation. The pulse generator 1 is connected to a transducer 2 for generating ultrasound detection signals that are directed into the system 3, 12. Ultrasound echo signals received from the system 3 are sensed by transducer 2 and received at receiver 6 connected thereto. The received echo signals are analysed and processed by post-processing circuits 7.

20 A mechanical stimulator 4 is provided for inducing movement in the system 3, driven by a driving source 5. The mechanical stimulator 4 may be of an electromagnetic type adapted to generate a continuous or impulsive / transient physical displacement in a drive head portion of the stimulator. The physical displacement is communicated to the system 3 under investigation by contact with the drive head of the stimulator 4. The mechanical stimulator may comprise a vibrator for inducing periodic aperiodic or impulsive motion; or an impact device for inducing an impulsive motion. The impact device could include a hammer action device.

30

In general, the mechanical stimulation may be continuous or transient / impulsive. The stimulation may be random or deterministic in frequency and/or amplitude. The deterministic stimulation may be periodic or non-periodic. The periodic stimulation may have any particular profile, and may
5 have a single frequency component or multiple frequency components (referred to herein as 'harmonic').

In use, the mechanical stimulator 4 will impart physical displacement forces into the system under investigation. More rigid components, or target
10 structures of the system, such as bones 11, 13, will be displaced according to forces transmitted to them through the surrounding soft tissue, which will generally exhibit resilient elastic or plastic properties. The rigid components will reflect any ultrasound pulses directed at them, which provides detailed information regarding their precise displacement as a function of time. In
15 turn, this will reveal information regarding the surrounding medium through which the externally generated physical displacement excitation has been transmitted.

The profile of the physical displacement excitation (i.e. its shape and its
20 continuous or impulsive character), its force and the exact location of any input or contact point with the system depends upon a number of factors such as the type of target structure and system under investigation and on the type of data being sought.

25 Preferably, the profile of the physical displacement excitation is sinusoidal (for a periodic waveform) or random. Preferably, the magnitude of the displacement is of the order of microns, (e.g. 1 to 1000 microns). Preferably, the frequency of any periodic physical displacement excitation waveform is in the range 5 to 500 Hz.

The physical displacement excitation is applied at any suitable location for effective coupling of the motion into the system. By way of example, for examination of pelvic joints in the human body, the mechanical stimulator could be positioned at the spina iliaca superior anterior. By way of further
5 example, for examination of the tarsal joints, the mechanical stimulator would be positioned at the medial side of the head of the first metatarsal, near the metatarsophalangeal joint.

As shown in figure 2, during the physical displacement of components of the
10 system 3, a number of short ultrasound detection pulses 20 is transmitted into the system by the pulse generator 1 and transducer 2. The number N of pulses and the pulse repetition frequency are preferably such that at least a whole cycle of vibration is covered by a plurality of ultrasound pulses 20. Preferably, the number of pulses per cycle is at least 30.

15 The target structure (e.g. bone 11) beneath the surrounding soft tissue acts as a reflector and echoes 21 are returned to the transducer 2. The pulse repetition frequency is preferably tuned so that for a given distance of the bone from the transducer and the speed of sound within the intervening
20 medium, each echo 21 is returned to the transducer 2 before the transmission of the next pulse 22. When a second target structure (e.g. bone 13) is to be measured simultaneously, the apparatus may be expanded with a second transducer (not shown) and accompanying pulse generator (not shown) in similar manner.

25 Due to the movement of the bone 11 and/or other parts of the system under investigation as induced by the mechanical stimulator 4, the time for the transmitted pulses 20, 22 to travel to the bone 11 and back to the transducer 2 varies. The echoes 21 are recorded subsequently by post-processing
30 circuits 7 and analysed.

With reference to figure 3, two successive echoes n and $n+1$, separated by time Δt , will vary according to the difference in time of flight arising from the movement of the ultrasound reflecting part of the structure caused by the mechanical stimulator 4 in at least the period intervening the successive detection pulses that caused the two successive echoes n and $n+1$. Information about the difference in time of flight can be obtained by a number of possible mathematical algorithms, such as correlation algorithms. Other techniques are available to the person skilled in the art.

10

These variations of time are used to estimate the displacement of the bone at each pulse reflection, which can be given in displacement-time plots.

The variations in bone displacement as a function of time are dependent upon the waveform of the movement induced by the mechanical stimulator 4 and upon the physical attributes of the surrounding soft tissue. For example, any elasticity or resilience in the surrounding tissue determines the movement profile of rigid structures such as the bone and contribute to the significance of inertia and damping forces in the measured response.

20

This enables determination of physical displacement data on the various components of the system under analysis. A comparison between the motion (amplitude, frequency and phase) of the two ultrasound reflecting bone structures linked by the soft tissue in the system under investigation enables the assessment of various properties of the system. For example, the stiffness and damping characteristics of a joint may be assessed.

25

In general terms, it is possible to make an assessment of the elasticity and/or resiliency of a 'softer' structure connecting two harder or more rigid structures.

30

Other configurations of apparatus are possible for measuring physical properties of a system. With reference to figure 4, apparatus 40 comprises a trigger source 41 that is connected to a pulse generator 42 for producing a series of ultrasound pulses to be directed into the system 45 under analysis. The pulse generator 42 is connected, by way of switch 43, to a transducer 44 for generating ultrasound detection signals that are directed into the system under investigation 45 and onto a target structure therein. Ultrasound echo signals 21 received from the target structure in the system 45 are sensed by transducer 44 and passed, via switch 43 to an amplifier and filter 48. The switch 43 acts as a directional filter in which output signals for generating ultrasound output pulses 20 having a magnitude greater than a predetermined threshold level (eg. 0.5 V) are passed to the transducer 44, while echo pulses 21 having a magnitude less than the predetermined threshold level are passed through to the receiver circuits of amplifier and filter 48. The output of the amplifier and filter 48 is fed to an analysis or post-processing circuit comprising a digitising oscilloscope 49 and thence to a computer system 50 for storage and analysis of the data.

In common with the embodiment of figure 1, a mechanical stimulator 46 is provided for inducing movement in the system 45, driven by a driving source 47. Like in the arrangement of figure 1, the mechanical stimulator 46 may be of any suitable type adapted to generate a continuous or impulsive physical displacement. The physical displacement is communicated to the system 45 under investigation by interfacing with the mechanical stimulator 46.

In this arrangement, the trigger source 41 provides a trigger pulse 51 to both the pulse generator 42 and the oscilloscope 49. This is amplified and possibly shaped by the pulse generator 42 and directed to the transducer 44

by the switch 43. The transducer directs a resulting series of ultrasound detection signals into the system 45 during one or more cycles of the physical displacement waveform of the vibrator 46. These ultrasound signals are reflected from certain components 11, 13 in the system 12 and
5 received at transducer 44. The switch 43 directs the received echo signals to the amplifier and filter 48. The amplifier and filter 48 removes noise and improves the signal to noise ratio and the output therefrom is directed to the oscilloscope 49.

10 The oscilloscope 49 also receives the trigger pulse 51 that generated the ultrasound detection signals and therefore provides a reference against which the time delays between successive output pulses 20 and echoes 21 can be measured. The oscilloscope, in sequence mode, displays and stores the echo signals after a preset delay. A digital output from the oscilloscope
15 49 enables the storage of results to the computer system 50 for subsequent analysis.

With reference to figure 5, in one study, an electromagnetic stimulator 46 was covered with a gel pad representing soft tissue and vibrating structure
20 beneath and operated to give a periodic physical displacement excitation of 200 Hz, having a sinusoidal waveform at a constant amplitude.

For the analysis, a packet of ultrasound pulses of 62 pulses each of ultrasound frequency 5 MHz and with a pulse repetition rate of 5 kHz was
25 transmitted through the gel pad by means of a transducer placed on the pad. The returning echoes, reflected by the vibrator 46, were recorded by the oscilloscope 49. Cross-correlation was used to estimate the differences in time of flight due to the motion of the vibrator 46. The displacement was then deduced from these time delays. The displacement-time plot was
30 reconstructed.

Figure 5a shows the measured echoes corresponding to the first and tenth ultrasound detection pulses. The time delays between subsequent echoes were then used to generate the displacement-time plot of figure 5b which
5 illustrates the displacement of the ultrasound reflecting structure as a function of time at 200 Hz and an amplitude of 3.7 microns.

The experiment was performed for different vibration amplitudes of 0.6, 1.2, 2.4, 3.7, 4.9 and 6.2 microns. Good agreement was found between the
10 estimated vibration amplitude and the measured displacements. The measured values differed at maximum by 5% for displacements as low as 0.6 μm .

A pilot in vivo experiment was performed in order to assess the protocol and
15 the detectability of the bone vibration in the pelvic girdle system. The physical displacement excitation was introduced into the pelvic system by means of an electromagnetic stimulator placed in direct contact with the spina iliaca superior anterior.

20 Sinusoidal vibrations were applied at 100 and 200 Hz with amplitudes ranging from 6.2 to 200 microns. The vibrations were detected in the ilium and on the sacrum on the dorsal side of the patient. The ultrasound technique was able to detect the induced vibrations of the pelvic bones ranging from 50 nm to 2 microns.

25

The mechanical stimulator 46 may be of any suitable size having a driving surface suitable for making sufficient contact with an external surface of the body or system under examination. It may be also designed to support a body or part of a body in question. The contact between the body and the

mechanical stimulator may be continuous in the case of a periodic or aperiodic stimulus, or transient in the case of an impulsive stimulus.

5 The stimulator is preferably adapted for coupling to the body at a location of minimal distance from the bone and joint under examination, eg. at a location where the thinnest soft tissue layer intervenes. The stimulator may also be adapted to include means for ensuring optimal position and/or orientation, such as a shaped surface or engagement structure for attachment to the body.

10

The position and orientation of ultrasound transducers for transmitting detection pulses and receiving echoes is preferably optimised with respect to the motion induced by the mechanical stimulator, so as to detect maximum vibration amplitude. Preferably, the direction of the ultrasound beam is
15 orthogonal to the surface of the reflecting structure for receiving maximum echo signal.

In a preferred arrangement for the assessment of the pelvic region of the human body, the subject is placed in a prone position on a bed. The pelvis is
20 unilaterally supported by a mechanical stimulator or shaker. The support preferably protrudes through an aperture in the bed surface, located at the SIAS (spina iliaca anterior superior). For detection of the vibrations of the ilium and sacrum, the ultrasound transducer is preferably positioned respectively at the posterior superior iliac spine (SIPS) and on the line
25 through the left and right SIPS near the processus spinosus of S2. The ultrasound transducer may be manipulated until a clear echo is observed on an oscilloscope, then the subsequently received signals stored.

In preferred arrangements, the mechanical stimulator 46 is adapted to operate at frequencies within the range 5 Hz to 500 Hz, and more preferably in the range 5 Hz and 300 Hz.

- 5 In preferred arrangements, the pulse generator 42 is adapted to produce ultrasound detection signals of frequency in the range 1 MHz to 30 MHz, and with pulse repetition rates of between 150 and 125,000 per second, or between 30 and 250 per cycle of the stimulator frequencies.
- 10 Other embodiments are intentionally within the scope of the accompanying claims.

CLAIMS

1. A method for measuring mechanical properties of a system under investigation, comprising the steps of:
 - 5 inducing movement in a target structure in the system over a predetermined period of time;
directing ultrasound detection signals into the system at times such that at least some induced movement has occurred in the target structure between a first detection signal and a second detection signal; and
 - 10 receiving ultrasound echo signals from the target structure.
2. The method of claim 1 further including the step of analysing the received signals to determine a dynamic response of the system.
- 15 3. The method of claim 1 in which the target structure comprises one or more ultrasound reflecting surfaces or components within one or more resilient or otherwise deformable softer components.
4. The method of claim 3 in which the ultrasound reflecting components
20 comprise bone.
5. The method of claim 3 in which the resilient or otherwise deformable components include one or more of tissue, cartilage, synovial fluid and the like.
- 25 6. The method of claim 1 in which the step of inducing movement in the system comprises displacing a peripheral surface of the system using a mechanical stimulator.

7. The method of claim 6 in which the movement induced in the system is a continuous movement or a transient movement.
8. The method of claim 6 in which the movement induced in the system is a random movement or a deterministic movement.
9. The method of claim 6 in which the movement induced in the system is a periodic movement or a non-periodic movement.
10. The method of claim 6 in which the movement induced in the system has a single frequency component or multiple frequency components.
11. The method of claim 6 in which the ultrasound signals comprise pulses, further including the step of directing a plurality of pulses into the structure during said predetermined period of time of induced movement.
12. The method of claim 1 further including the step of determining, from the received echo signals, the displacement of ultrasound reflecting components within the structure as a function of time.
13. The method of claim 7 in which the movement induced has a frequency within the range 5 Hz to 500 Hz.
14. The method of claim 13 in which the movement induced has a frequency in the range 5 Hz to 300 Hz.
15. The method of claim 1 in which the ultrasound detection signals comprise pulses having a frequency in the range 1 MHz to 30 MHz, and with pulse repetition rates of between 150 and 125,000 per second.

16. Apparatus for the measurement of mechanical properties of a system under investigation, comprising:

a mechanical stimulator for inducing movement in a target structure in the system over a predetermined period of time; and

5 an ultrasound transducer for directing ultrasound detection signals into the system at times such that at least some induced movement has occurred in the target structure between a first detection signal and a second detection signal and for receiving echo signals therefrom.

10 17. The apparatus of claim 16 in which the mechanical stimulator is adapted to induce a periodic motion in the system, and in which the transducer is adapted to direct a plurality of detection pulses into the system during at least one cycle of the periodic motion.

15 18. The apparatus of claim 16 in which the mechanical stimulator is adapted to induce a transient or impulsive motion in the system.

19. The apparatus of claim 18 in which the transducer is adapted to direct a plurality of detection pulses into the system during said transient or
20 impulsive motion in the system.

20. The apparatus of claim 16 further including a signal generator for generating said detection signals, and a receiver for detecting said echo signals.

25

21. The apparatus of claim 16 in which the mechanical stimulator comprises an electromagnetic device having a driving surface for displacing a surface of the system.

22. The apparatus of claim 16 in which the mechanical stimulator is adapted for mounted on or supporting part of the system.

23. Apparatus substantially as described herein with reference to the
5 accompanying drawings.

24. A method substantially as described herein with reference to the accompanying drawings.

10

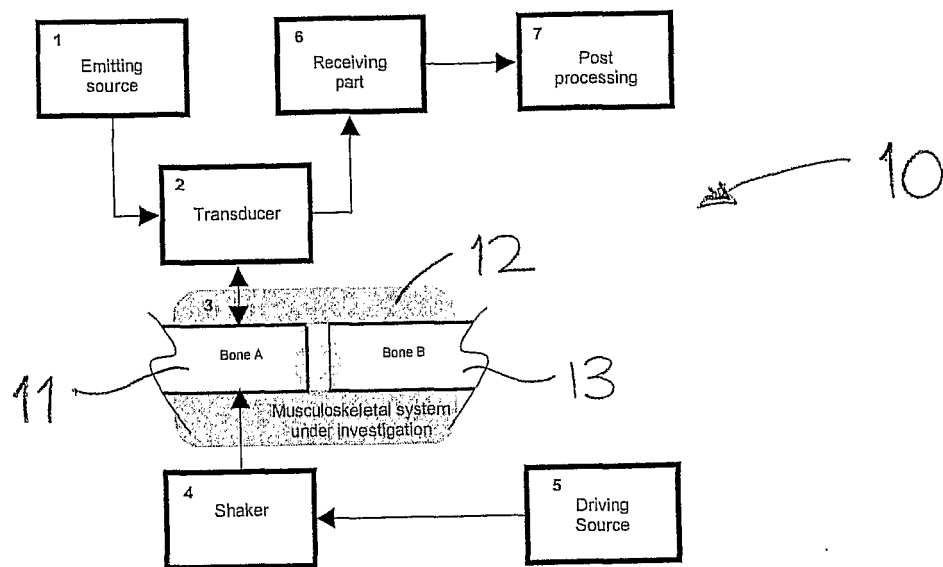
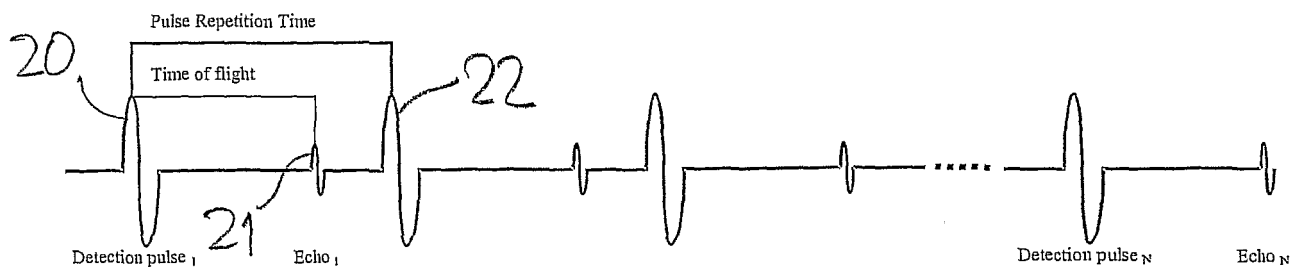


Fig. 1

Fig. 2



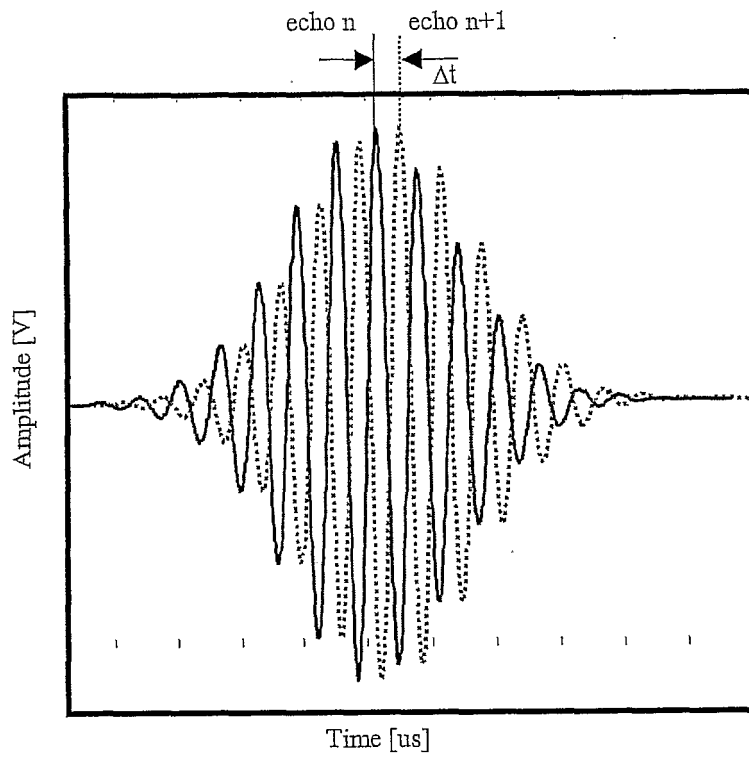


Fig. 3

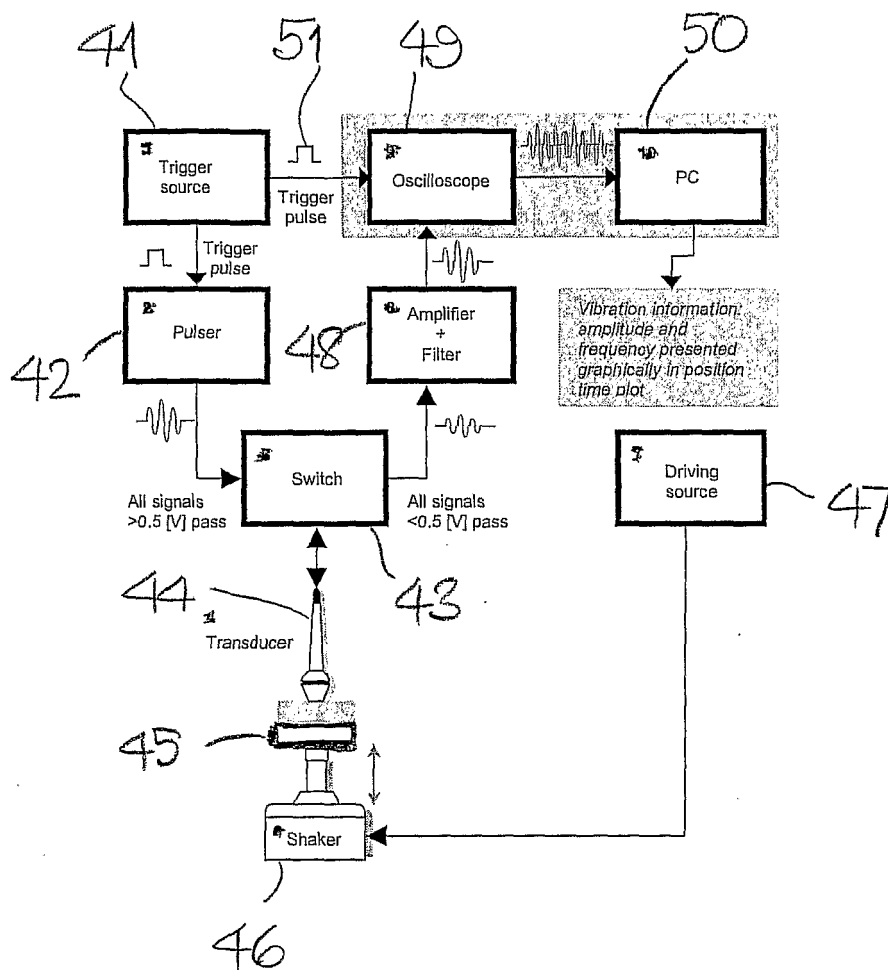


Fig. 4

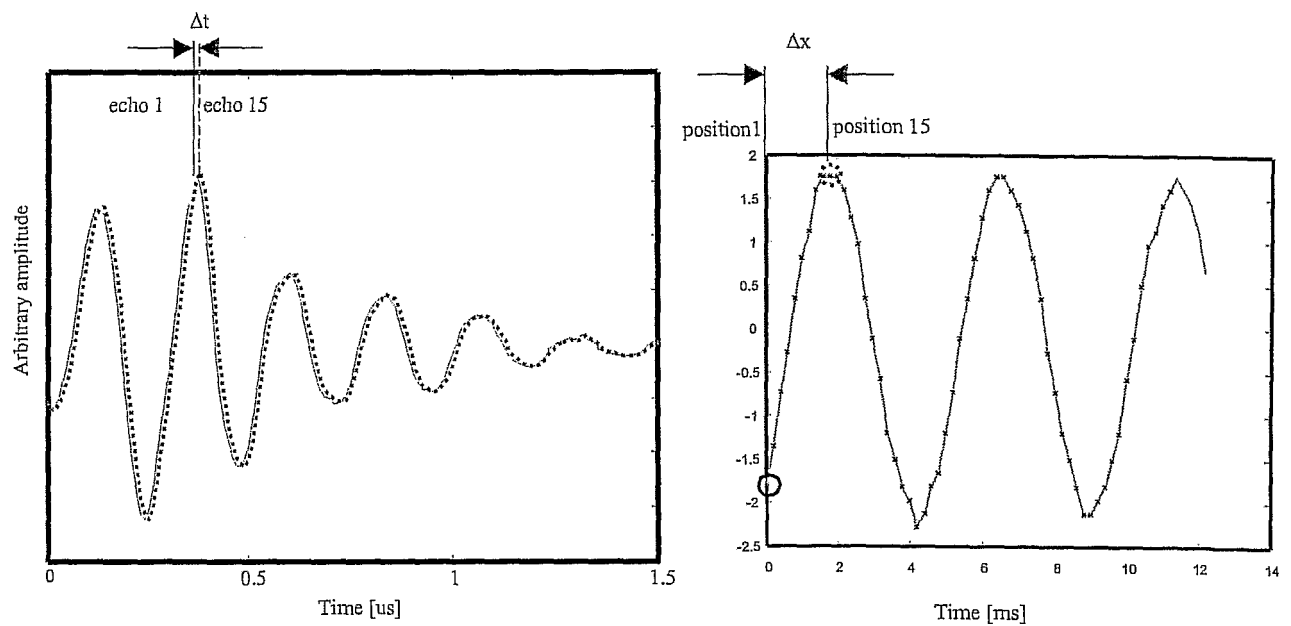


Figure 5

- a. Measured echoes corresponding to detection pulses 1 and 15
- b. Position -time plot constructed from the measured time delayed echo's reflected by a structure vibrating at a frequency of 200 Hz and amplitude 3.7

INTERNATIONAL SEARCH REPORT

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 569 098 B2 (KAWCHUK GREGORY N) 27 May 2003 (2003-05-27) the whole document column 4, line 25 - line 61 column 5, line 33 - line 39 -----	1-11, 13-16, 18-20,22
X	US 2002/068870 A1 (KING MARVIN ET AL) 6 June 2002 (2002-06-06) paragraph '0023! - paragraph '0026! paragraph '0030! - paragraph '0033!; figures -----	1,3-11, 13-17, 20-22
X	WO 92/21023 A (UNIV TEXAS) 26 November 1992 (1992-11-26) page 25, line 29 - page 26, line 17 page 18, line 20 - line 27; figure 6 -----	1,6-9, 11, 16-20,22

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Manschot, J

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2004/007576

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 23, 24
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 23,24

The subject-matter of claims 23 and 24 is defined by reference to the description and drawings and do not contain any clear feature. The claims are, therefore not clear (see Article 5 PCT and Rule 6.2 PCT).

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

 International Application No
 PCT/EP2004/007576

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专利名称(译)	使用超声评估生物力学性质的方法和设备		
公开(公告)号	EP1656066A1	公开(公告)日	2006-05-17
申请号	EP2004740857	申请日	2004-07-06
[标]申请(专利权)人(译)	技術科學基金會		
申请(专利权)人(译)	STICHTING VOOR DE TECHNISCHE WETENSCHAPPEN		
当前申请(专利权)人(译)	STICHTING VOOR DE TECHNISCHE WETENSCHAPPEN		
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IPC分类号	A61B5/103 A61B8/08 G01N29/07 G01N29/12 G01N29/34		
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优先权	2003016722 2003-07-17 GB		
外部链接	Espacenet		

摘要(译)

一种用于测量被研究系统的机械特性的方法和设备，例如人体中肌肉骨骼系统的生物力学特性和动态特性。所研究的系统包括具有不同超声反射/透射特性的多个组成部分（例如，骨骼，肌肉，韧带等），并且其相对空间关系可以由于至少一个组成部分的弹性，可塑性和/或弹性而变化。。通过机械刺激器诱导系统中的运动。超声检测信号有时被引导到系统中，使得在第一检测信号和第二检测信号之间在系统内的目标结构中发生至少一些诱导运动。超声回波信号用于确定系统的机械特性。