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Burkhalter et al.

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[54] **LIMB HOLDER POSITIONER FOR BONE MINERAL ANALYZER**

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[73] Assignee: **Norland Corporation,** Fort Atkinson, Wis.

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[52] **U.S. Cl.** .....**250/50,** 250/65 R, 250/86

[51] **Int. Cl.** **G03b 41/16**

[58] **Field of Search** .....250/50, 65 R, 86

[56] **References Cited**

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3,524,057 8/1970 Hammonds 250/50

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[57] **ABSTRACT**

The disclosure relates to instruments for performing in vivo analysis of bone mineral content by measuring the absorption of a scanning beam of monoenergetic photons. Novel means are used for supporting and positioning a limb so that a predetermined increment of a bone therein can be scanned under repeatable conditions. Scanning is done with a tissue equivalent material surrounding the corresponding portion of the limb so that radiation transmission is substantially uniform through the tissue regions of the scan but has a sharp discontinuity where bone is in the beam.

10 Claims, 6 Drawing Figures

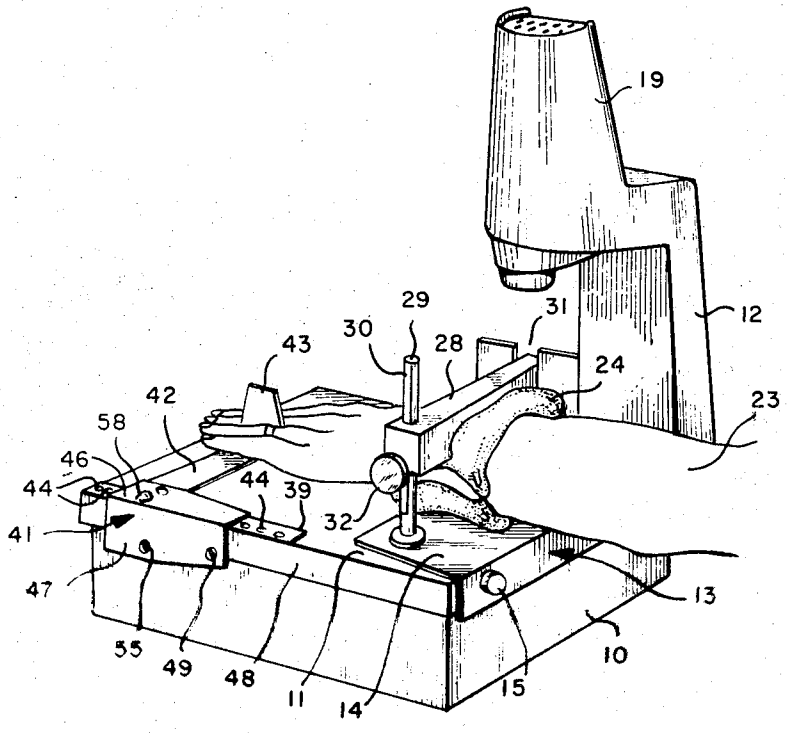


FIG. 1

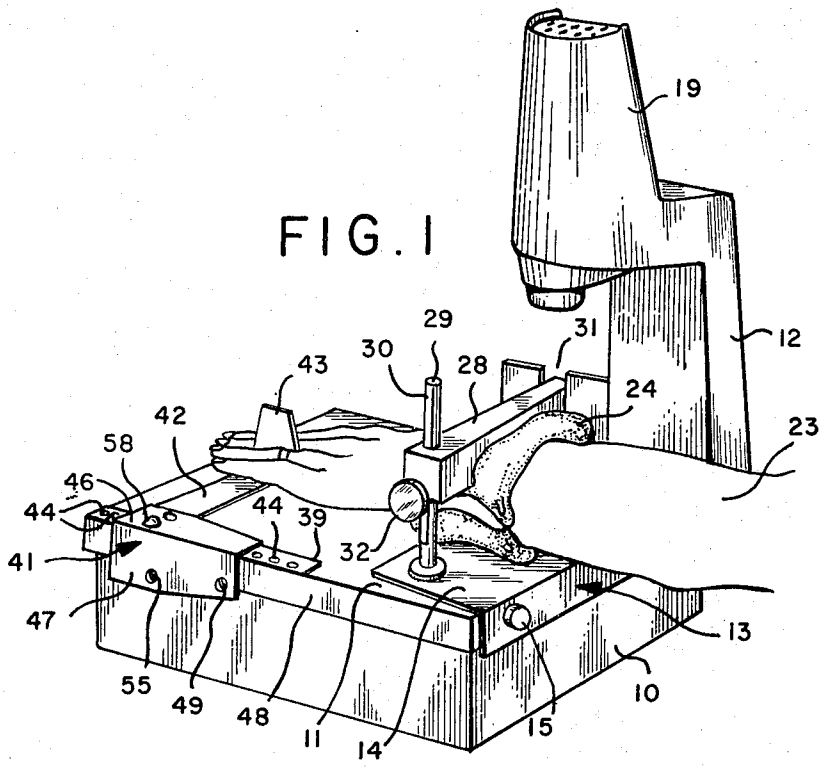
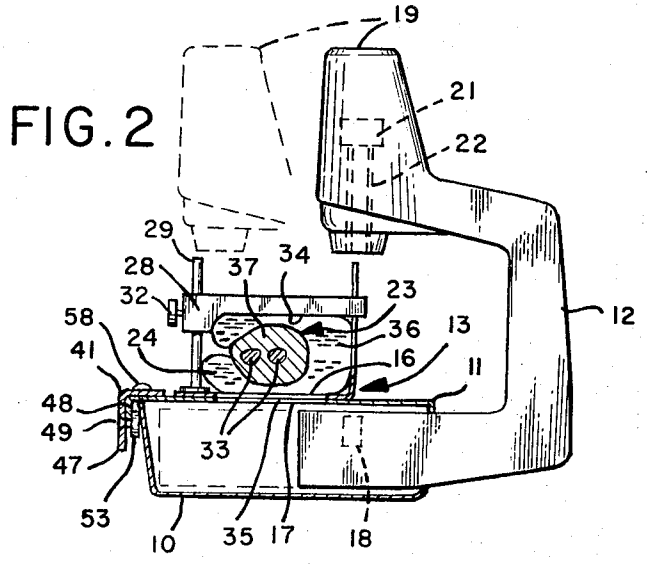


FIG. 2



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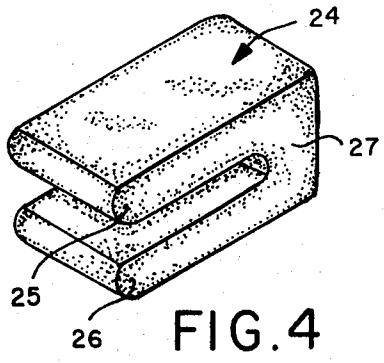

FIG. 4

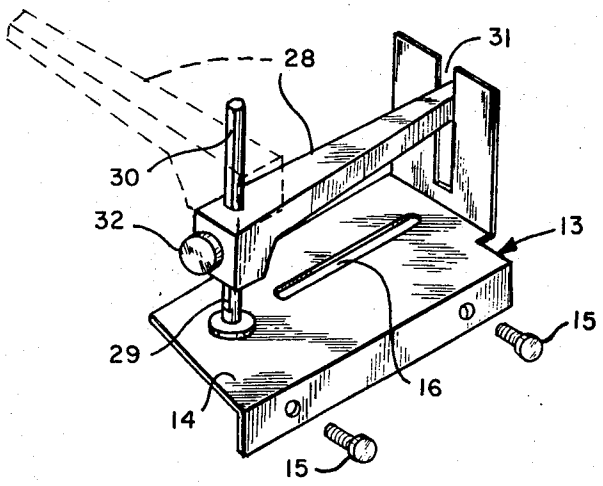

FIG. 3

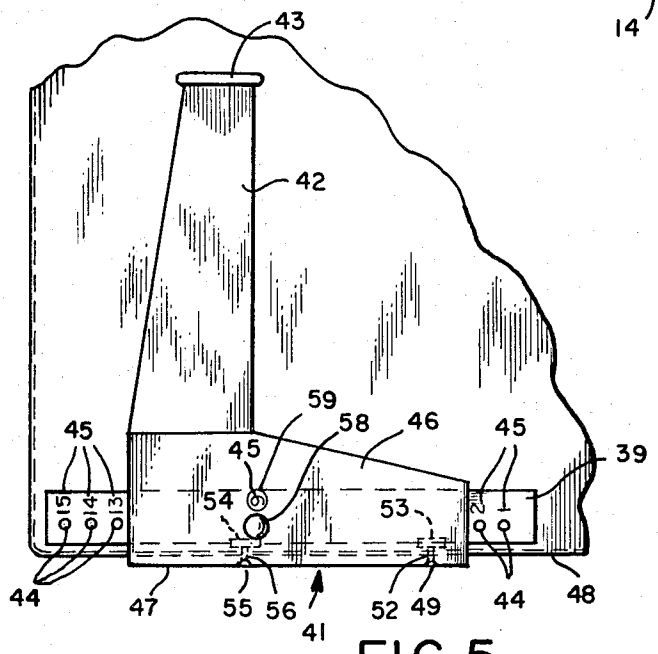

FIG. 5

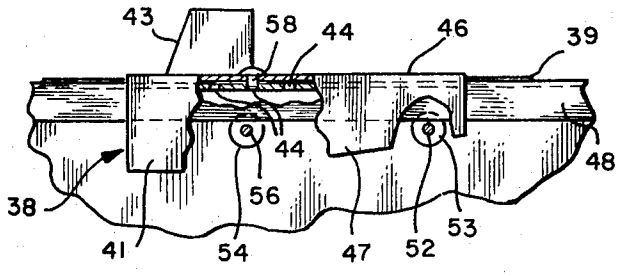

FIG. 6

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LIMB HOLDER POSITIONER FOR BONE MINERAL ANALYZER

BACKGROUND OF THE INVENTION

The invention relates to instruments for performing in vivo analysis of bone mineral content by measuring the absorption of a scanning beam of monoenergetic photons and more particularly to novel means for supporting and positioning a limb so that a predetermined increment of a bone therein can be scanned through tissue and intervening tissue equivalent material, the latter of which is caused to surround the limb in such manner that radiation absorption will be substantially uniform everywhere but through the bone being analyzed.

The determination of total bone mineral content in humans can be of considerable assistance in the diagnosis of certain diseases. In the past, accurate measurements of bone mineral content required the excision, ashing, and weighing of a bone sample, which obviously cannot be employed as a method of routine or continuous diagnostic procedure. Recently, however, accurate and convenient in vivo determination of bone mineral content has been made possible by the development of the so-called "Cameron Technique" in which a collimated beam of monoenergetic radiation such as gamma rays from a radioisotope is scanned across a limb and the unabsorbed radiation is detected. The detector is associated with an appropriate electronic system which records the resulting absorption curve. The limb, usually the forearm, has heretofore been submerged in a tissue equivalent material, such as water, which has parallel upper and lower surfaces and about the same absorption as tissue so that uniform absorption is obtained except where bone is traversed by the scanning beam. Accordingly, variations in the radiation absorption are functionally related to the mineral content of the bone intercepting the beam. As described more fully in copending U. S. patent application of Frederick A. Rose, Ser. No. 83,944, filed Oct. 26, 1970, and entitled Bone Mineral Analyzer, and which is assigned to the same assignee as this invention, substantially automatic means can be provided to control the scanning operation and to provide a direct digital readout of the size and mineral content of the scanned bone increment.

SUMMARY OF THE INVENTION

To eliminate the need for submerging or surrounding the forearm or other limb in a liquid or putty-like tissue equivalent material, which is obviously a rather inconvenient and messy process, the present invention provides a scanning device of the type previously described with a limb holder comprising a flexible casing or bag permanently filled with a tissue equivalent fluid and adapted to surround the portion of the limb being scanned. The bag is preferably made of low absorption material as is the case with many plastics. The bag is squeezed from opposite sides of the limb between parallel support members that are transmissive of the scanning beam, thus providing the required parallel surfaces and uniform radiation absorption by the real and simulated body tissue and also serving to immobilize the limb during the scanning operation. Additionally, the limb holding device also includes a novel adjustable means for positioning a predetermined bone

increment in alignment with the scanning means so that measurements of the mineral content of that particular bone increment can be made at other times under repeatable conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings furnished herewith illustrate the best mode presently contemplated by the inventors and clearly disclose the above advantages and features as well as others which will be readily understood from the detailed description thereof.

In the drawings:

FIG. 1 is a perspective view of a bone scanning instrument provided with a limb holder and positioner according to a preferred embodiment of the present invention;

FIG. 2 is a schematic cross sectional end view illustrating the principle of operation of the instrument shown in FIG. 1;

FIG. 3 is a perspective view of the limb holder shown in FIG. 1 with the flexible tissue simulating bag removed;

FIG. 4 is a perspective view of the flexible tissue simulating bag illustrated in FIG. 1;

FIG. 5 is a fragmentary plan view of the limb positioning device illustrated in FIG. 1; and

FIG. 6 is a fragmentary front elevational view of the limb positioner structure illustrated in FIG. 5.

DESCRIPTION OF THE PREFERRED ILLUSTRATED EMBODIMENT

As best illustrated in FIGS. 1 and 2, the illustrated bone scanning instrument comprises a base housing 10 provided with a flat cover member or table 11. A movable column 12 is supported with respect to housing 10 by a slide connected to a drive mechanism, not shown, adapted to move the column between a rearward position depicted in solid lines in FIGS. 1 and 2, and a forward position shown in broken lines in the latter figure.

The limb holder 13 comprises a support plate 14 removably attached to table 11 by thumb screws 15 and is provided with a beam transmissive window 16 positioned directly above a similar window 17 in the table. A suitable source of penetrating electromagnetic radiation such as from a radioisotope in container 18 is supported by the lower portion of column 12. Isotope container 18 emits a monoenergetic beam of gamma rays upwardly through the superimposed beam transmissive windows as the movement of the column carries the isotope container along a path aligned with those windows. The beam transmissive windows 16 and 17 can simply be openings in the metal table 11 and the support plate 13 but it is preferable to provide such openings with plastic window inserts that are opaque to ordinary light but substantially transparent to gamma radiation.

The head portion 19 of movable column 12 is provided with a radiation detector 21 aligned with a collimator tube 22 positioned directly above the radioisotope container 18 so that the detector senses the intensity of a small vertical radiation beam emitted upwardly through the beam transmissive windows 16 and 17 and the other intervening elements. Accordingly, when a human forearm 23 is located in the scanning path of the radiation beam as shown in FIGS.

1 and 2, the response of the detector 21 varies as a function of the absorption of the radiation beam, which is automatically translated into a numerical indication of bone size and mineral content by an electronic computer means, not shown, which are described in detail in the previously identified commonly assigned patent application.

In order that the detected beam intensity will not vary because the beam passes through different thicknesses of body tissue, a body tissue equivalent material is adapted to surround the body tissue to simulate a limb having parallel surfaces though which the scanning beam passes. In accordance with the present invention, this objective is accomplished by means of a flexible casing in the form of a plastic or rubber bag or bladder 24, shown in FIGS. 1, 2 and 4, which is filled with water or some other fluid having substantially the same radiation absorbing characteristics as human body tissue. Bag 24 preferably comprises two end sections 25 and 26 joined by an intermediate section 27. When the forearm is positioned as shown in FIG. 1, the two end sections 25 and 26 of the liquid filled bag are located above and below the portion of the arm in the path of the scanning beam. The intermediate section 27 of the flexible casing is not imperative as the casing could be variously shaped such as with a uniform cross section since it is compressed to the desired shape anyway.

A clamping member 28 is adjustably carried by a post 29 extending upwardly from support plate 14 and can be raised and turned aside as shown in broken lines in FIG. 3 to allow the flexible bag 24 and the forearm 23 to be located in scanning position. The clamping member is then moved to the position shown in solid lines in FIG. 3 and is temporarily held in that position by a spring loaded detent ball, not shown, which engages the flat surface 30 of post 29. Accordingly, the clamping member 28 is aligned with the path of the scanning beam and with vertical slot 31 in the support plate 13. Thereupon, the clamping member is pressed firmly downwardly and is locked in place by means of locking screw 32, thereby compressing the end portions of the bag against the forearm and substantially immobilizing the latter against accidental movement during the scanning operation. Member 28 is made of plastic or other material capable of transmitting gamma radiation and is of substantially uniform thickness in a vertical direction along the portion thereof located in the path of the scanning beam. Consequently, as illustrated schematically in FIG. 2, the movement of column 12 causes the radiation beam to scan the forearm bones 33 through a constant quantity of clamping member 28 material and through the parallel surfaces 34 and 35 of the simulated parallel faced forearm profile provided by the tissue equivalent fluid 36 in bag 24 and by the body tissue 37 of the forearm. If the radiation absorption characteristics of the clamping member 28 are equivalent to those of the body tissue, it will be apparent that the clamping member need not be of uniform thickness as long as its upper surface is parallel to the horizontal surface of support plate 14.

If meaningful diagnostic information is to be obtained, it is often necessary to monitor the bone mineral content of a patient repeatedly over a considerable period of time. Since the size and profile of the bone under investigation varies along the length of that bone, the accuracy of such repetitive monitoring depends on the ability to repetitively scan the same bone increment, which is initially selected in accordance with the size and skeletal characteristics of the particular patient.

To facilitate repetitive scanning of the same increment of bone as tests are made from time to time, the present invention provides the scanning instrument with a limb positioning device, best shown in FIGS. 1, 5 and 6, which enables repeatable location of the limb. The device comprises adjustable bracket member 41 provided with a horizontal tongue 42 supporting a vertical abutment ear 43. The index bar 39 is fixed to the edge of the top surface of table or cover member 11 and includes a series of spaced indexing holes 44 associated with a series of reference indicia 45. Bracket member 41 includes a horizontal top portion 46 attached to tongue 42 and a vertical portion 47 positioned adjacent the depending vertical lip 48 along the front edge of housing cover member 11. Behind lip 48 is a free space where the lip overhangs housing 11.

As shown in FIGS. 1, 2 and 6, a screw 49 screws endwise into a spacer 52 on which there is a disc flange 53. Screw 49 holds spacer 52 against the back of the vertical portion of the bracket member 41 adjacent the lower edge of lip 48 so that flange 53 projects behind the lip. A similar flange 54 is likewise supported on a spacer 56 to the bracket by screw 55. The flange 54 projects behind lip 48 but with its spacer 56 spaced from the lower edge of the cover member lip 48. An index pin 58 projects downwardly from the horizontal portion of the bracket member above the disc flange 54 and is selectively registered in an index hole 44 in the index bar 39. The reference numeral visible through bracket member hole 59 when pin 58 is registered may be recorded as the position of abutment ear 43 between the patient's fingers. Because of the clearance between flange 54 and the edge of table lip 48, the bracket member 41 can be tilted to retract the index pin 58 from the index bar 39, thus permitting the abutment ear 43 to be adjusted toward or away from the beam scanning path to different predetermined positions identified by indicia 45.

The patient's forearm is positioned with the abutment ear 43 received all the way between the ring and middle fingers and the bracket member is adjusted to locate the desired bone increment in alignment with the scanning path before the arm is immobilized by means of the limb holder. Accordingly, the indicium visible through the bracket hole 59 when the limb positioning device is properly adjusted allows that adjustment to be noted and repeated so that the same bone increment of that particular patient can be scanned during subsequent examinations. If desired, the upper arm or lower leg can also be scanned in the same manner, in which case the elbow or heel is engaged by the abutment ear 43 of the positioning device to allow repeatable measurements of the mineral content of the same bone increment.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

We claim:

1. A bone mineral analyzer instrument to scan a portion of a human limb over a predetermined scanning path, with a flexible casing means covering the limb and filled with a fluid having substantially equivalent radiation absorption characteristics as body tissue to define an artificial surface simulating a predetermined body tissue surface through which a bone increment within said limb is scanned by a monitored radiation beam for determining the mineral content of said bone increment as a function of its radiation absorption, said instrument comprising,

a support for said limb,

a closeable flexible casing means, a fluid filling said casing means and having radiation absorption characteristics that are substantially equivalent to the absorption characteristics of the tissue, said casing means being sufficiently pliable with fluid inside to be formed about said limb and deformed into a shape which results in a predetermined tissue absorption characteristic being presented to the beam in said scanning path,

a beam source means for establishing said radiation beam,

means to relatively move the source means and the support to scan the limb, and

clamping means including a beam transmissive member to squeeze said flexible casing means against said limb in the area being scanned.

2. A device according to claim 1, wherein said casing means comprises two fluid filled end portions connected by an intermediate portion.

3. A device according to claim 2, in which said fluid material is substantially pure water.

4. A device according to claim 1, in which said clamping means includes

a base means having a beam transmissive window, and

clamp support means for supporting said clamping member parallel to said base means and in alignment with said beam transmissive window for adjustable movement toward and away from said base.

5. A device according to claim 4, including means for removably attaching said base means to said instrument with said clamping member and said beam transmissive window in alignment with the scanning path of said beam.

6. A device according to claim 4, in which said clamp support means is adapted for being positioned out of alignment with said beam transmissive window.

7. A device according to claim 5, in which said base means comprises a horizontal portion provided with said beam transmissive window and a vertical portion extending upwardly from said horizontal portion, said clamp support means including

a vertical post supported by said horizontal portion of said base means,

means providing said vertical portion of said base means with a vertical slot,

means slidably supporting said clamping member to said post with the opposite end of said clamping member receivably in said slot to thereby align with said clamping member with the scanning path of said radiation beam, and

locking means for securing said clamping member to said post at any selected vertical position of said clamping member.

8. A bone mineral analyzer instrument according to claim 1 further comprising,

an abutment member adapted to abut with a predetermined extremity surface of said portion of said limb when the latter is located in transverse alignment with said scanning path,

adjustment means attaching said abutment member to said instrument for adjustable movement relative to said scanning path, and

indicia means for identifying different adjusted positions of said abutment member to enable that member to be adjusted repeatedly to any position so identified.

9. A device according to claim 8, in which said abutment member is adapted to be received between two outstretched fingers of the hand of a forearm located in transverse alignment with said scanning path.

10. A device according to claim 8, including

a bracket member supported with respect to said instrument for adjustable movement in generally parallel relation to a limb located in scanning position on said instrument,

means supporting said abutment member in fixed relation to said bracket member, and

means defining a plurality of predetermined adjustment positions of said bracket member along its path of adjustment movement.

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