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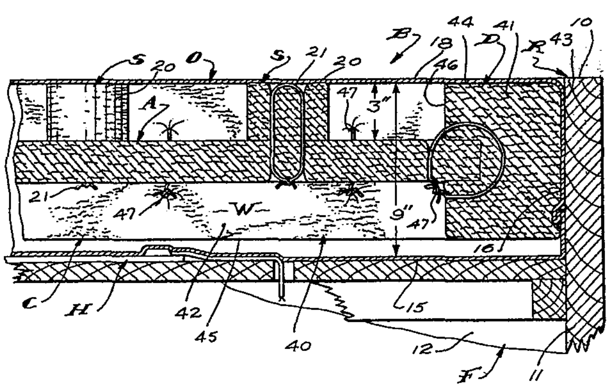
(54) **Water bed mattress with wave motion control means.**

(57) The invention deals with a water bed mattress with wave motion control means.

A water bed comprising a water bed mattress including a bladder (0) with vertically spaced top (18) and bottom (15) walls, vertical side and end walls and a volume of water slackly filling the bladder; a frame structure supporting the bottom side and end walls; and wave motion control means (C) comprising a body of soft, resilient and compactable water permeable reticulate material (A) immersed in the water and arranged to extend through those portions of the water where wave motion induces high velocity movement of water particles in orbital trajectories and which operates to stop, slow and reduce the movement of water particles and cause the rapid decay of wave propagating energy.



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WATER BED MATTRESS WITH WAVE MOTION CONTROL MEANS

This invention has to do with a water bed mattress and is particularly concerned with a water bed mattress with novel wave motion control structure.

BACKGROUND OF THE INVENTION

Ordinary water bed mattresses consist of flat, horizontally disposed bladders established of imperforate flexible sheet material, such as polyvinylchloride film stock and volumes of water slackly filling the bladders. Such mattress bladders commonly include or define flat, horizontal, vertically spaced top and bottom walls and vertical side walls about the perimeter of and extending between the top and bottom walls.

Mattresses of the character referred to above are commonly arranged atop and supported by flat, horizontal bed frame platforms and are retained about their vertical sides by rigid vertical frame-like walls or retainers about the perimeters of and projecting upwardly from the platforms.

In practice, the depth or vertical extent between the top and bottom walls of water bed mattresses should be such that when the bodies of persons using the mattresses are engaged on top of the mattresses, the weight of their bodies depresses the top walls downwardly and displaces the water within the mattresses to an extent that their bodies are buoyantly supported, without the top walls moving down and into engagement with or "bottoming out" on the bottom walls and their related platforms.

In the case of most water bed structures, which commonly measure from about 150 cm x 200 cm to 180 cm x 210 cm in plane configuration, it has been determined that mattress depths of from 20 cm to 25 cm with a mean depth of about 23 cm is suitable to provide desired buoyed body support without "bottoming out". As a result of the foregoing and as a result of developing standards in the art, an average or mean mattress depth of about 23 cm can be fairly accepted as a standard.

The principal shortcoming found to exist in most water beds provided by the prior art is the ever-occurring generation and propagation of undesirable and discomforting wave motion in and throughout the mattresses each time portions of the top walls and/or surfaces thereof are disturbed. Wave generating surface disturbances are normally the result of downward displacement of portions of the top walls of the mattresses, by externally applied forces which results in the downward displacement of water therebelow and the attending introduction of energy which propagates in the form of waves. The externally applied forces are normally the dynamic weight of persons moving into supported engagement atop the mattresses and/or the dynamic weight of persons engaged on and moving or shifting their body weight relative to the surface of the mattresses.

It is the apparent erroneous understanding of many in the water bed industry that wave motion generated and propagated in water bed mattresses results in or is accompanied by continuous horizontal movement of water or water particles in the direction or lines of propagation in which waves can be seen to progress across the tops of the mattresses. In fact, apart from some lateral displacement of water which might occur at the point or area of surface disturbance, the predominant movement of water in progressive waves is the orbital movement of water particles. The illusion of horizontal movement of water in such waves is the result of the progressive forward transfer of wave energy between adjacent water particles in the direction of wave motion (unattended by any significant horizontal movement of water).

For many years, many of those who are active in the water bed art have sought to develop and provide effective and practical means to eliminate and/or dampen waves in bed mattresses. The overwhelming majority of wave dampening means in the prior art thus far provided have been characterized by the provision and/or inclusion of various kinds and/or forms of partitions and/or baffles fixedly arranged within mattresses to stop, slow or otherwise control horizontal flow and/or movement of water within the mattresses. It is believed apparent that the adoption and use of such partitions and/or baffles was adopted and has been pursued with the mistaken belief that waves are primarily the result of progressive horizontal movement of water and that waves can be most effectively stopped, dampened or controlled by stopping or slowing such movement of water. Since wave propagation results from orbital motion of water particles and is not accompanied by a continuing horizontal movement of water, the ability of partitions and/or baffles (arranged to stop horizontal movement of water) to stop or dampen waves has been limited to their ability to absorb and stop those minor horizontal compononents of water particle motion which is derected into and through them. To effectively absorb and dissipate wave energy, such partitions and/or baffles must be and as a general rule are, fixed within their related mattresses in such a manner that they are held substantially stationary within the mattresses and so that wave energy directed into and absorbed by them is transmitted directly into the walls of the mattresses where it might be suitably dispersed and spent.

In accordance with the foregoing, those wave dampening means provided by the prior art which are characterized by partitions and/or baffles fixed within their related mattresses operate to reduce waves compartmentalizing the mattresses throughout their horizontal planes so that the water therein is divided into many independent volumes of water, each of whcih is of insufficient volume and surface area to sustain formation of significant waves and wherein the effectiveness of such means to stop the propagation of waves throughout the entire planes of the mattresses is dependent upon the ability of the partitions and/or baffles to absorb and transmit wave energy to the exterior walls of the mattresses where it can be effectively spent.

In practice, where vertical baffles and/or partitions are provided in wave dampening means in water bed mattresses and where those baffles and/or partitions are fixed to the walls of the mattresses, the wave propagating energy imposed up and absorbed by the partitions and/or baffles is transmitted to and is concentrated at those points or lines of joinder between the bladders and the partitions and/or baffles. Due to the limited strength and durability of the materials commonly used in the manufacture of water bed mattresses, the concentrated forces at the noted points or lines of joinder between the partitions or baffles and their related mattress walls frequently result in tearing or rupturing of the mattresses. The potential or likelihood that such structures will tear and/or rupture is sufficiently great so that it is the considered opinion of many experts in the water bed art that the provision of such wave dampening means is poor practice and should be avoided.

Other so-called "wave dampening means" provided by the prior art consist of thick, soft, resilient pads of foam plastic arranged within water bed mattresses. Such pads are in the nature of fillers which reduce the depth and volume of free standing water in the mattresses in which waves can be generated and propagated. In practice, such thick, resilient filler pads, to effectively attain the end sought to be attained, must be so thick and deep that they establish obstructions within the mattresses on or with which the top walls "bottom out" when depressed by the weight of persons engaged thereon and therefore prevent the mattresses from establishing that sought after and desired conforming buoyed support which they are intended to afford.

In addition to the above, such filler pads are sufficiently large, bulky and dimensionally stable so that their related mattresses cannot be collapsed and folded into neat, small and compact packages which are easy and economical to handle, transport and store, but necessarily remain large and bulky units which are inconvenient and costly to handle, transport and/or store.

In those water bed mattresses in which filler pads of the character referred to above are provided, the pads normally occur within the mattresses adjacent the top or bottom walls thereof to become, in effect, parts of those walls with respect to the hydraulic dynamic characteristics of the mattress structures.

As a result of the foregoing, those wave dampening means provided by the prior art which include resilient foam filler pads have met with limited success.

In the art of water beds, it is common practice to employ electric resistance heater units to temper or heat the water within the mattresses for creature comfort. The most common resistance heater units are thin, flat, blanket-type heater units arranged in flat bearing and heat conducting contact with and between the bottom walls of the mattresses and their supporting platforms. The surface area of the heater units is limited and such that only small areas of the bottom walls of the mattresses are heated. For effective heating of the entire mattress structures by means of such heater units, convective heat transfer within the mattresses is utilized and must not be blocked or unduly impeded. In practice, substantially all of those wave dampening means provided by the prior art block and/or impede convective heat transfer within their related mattresses so that effective heating of the mattresses, by conventional heating units, is prevented or adversely affected. Accordingly, it is not infrequent that the purchaser and users of water beds must elect to equip their beds with mattresses having no wave dampening means for assured effective and efficient heating of their beds.

In furtherance of our invention, a study of wave mechanics encountered in water beds was undertaken and the findings of that study were utilized in the development and reductions of our invention to practice. Notable and applicable findings of our study are set forth below:

Background Wave Mechanics
Water Particle Motion

Progressive waves propagate by means of orbital motion of individual water particles. When the wave length is small relative to the water depth (see Fig. 6 of the accompanying drawings), a so-called "deep-water wave", typically defined as a wave in which the ratio of water depth to wave length is greater than 0.5, the particles describe circular orbits (see Fig. 7 of the accompanying drawings). When the wave length is large relative to the water depth, a so-called "shallow-water wave", typically defined as a wave in which the ratio of water depth to wave length is less than 0.04, the particle orbits become flattened in the vertical dimension to form ellipses. For intermediate depths, particle orbits assume an ellipsoid shape between the circles and flattened ellipses of deepened shallow water waves; such waves are referred to as "transitional" (see Fig. 8 of the accompanying drawings). Due to the relatively shallow depth (23 cm) of water bed mattresses, the waves of major concern in a water bed lie in the transitional and shallow-water categories.

The orbits associated with wave propagation decrease in size as one moves downward in the water column from the surface. Since the entire water column responds to the same periodicity of wave passage, one might expect the velocities of the water particles to similarly decrease with increasing depth. This intuitive conclusion is substantiated in Table 1 (below) which presents the maximum horizontal velocities attained by the water particles at 2.54 cm intervals from the surface to the bottom (depth = 0 cm to depth = 23 cm) for the following wave condition:

Period = 2.0 seconds

Height = 6.35 cm

This condition was selected as typical of waves encountered in an undamped water bed, based on measurements made with apparatus developed for the express purpose of water bed testing. Linear theory, a free surface, and shallow-water wave propagation were assumed for the calculation, producing an approximation sufficiently accurate for an effective and practical design of water beds.

Because the typical design wave selected for analysis is transitional in nature, with a water depth to wave length ratio of about 0.08, the water particle orbits are elliptical with the horizontal component predominant. In consequence, the maximum horizontal particle velocities presented in Table 1, below, are in fact the maximum particle velocities induced by the wave form. Vertical particle velocities are reduced in magnitude but follow a similar pattern of exponential decrease with depth.

The kinetic energy of a wave form is the sum of the kinetic energies of all particles undergoing orbital motion, with the kinetic energy of each particle being proportional to the square of its velocity. In consequence, particle kinetic energy decreases with increasing depth even more rapidly than particle velocity. The energy distribution associated with horizontal particle velocities in the selected design wave is presented in Table 1, below, with energies normalized relative to the surface energy. It is apparent that approximately 60% of the kinetic energy is concentrated in the top half (11.43 cm) of the water column. In consequence, any mechanism intended to dissippate wave energy is most effective if placed in the upper portion of the water column.

TABLE 1

Maximum Horizontal Particle Velocity and Normalized Energy Distribution

Depth (cm)	Max. Horizontal Particle Velocity** (cm /Second)	Normalized Energy**
0 (surface)	22.3	1.0
2.54	21.9	0.96
5.08	21.4	0.92
7.62	21.1	0.89
10.16	20.7	0.86
12.70	20.5	0.84
15.24	20.2	0.82
17.78	20.1	0.81
20.32	20.0	0.80
22.86 (bottom)	-0-	0-

* Computed According to Linear Wave Theory

** "Normalized Energy" represents the kinetic energy associated with horizontal particle velocity at a given depth relative to kinetic energy at the surface.

Depth Limitation

The maximum wave height which may exist in a particular circumstance is governed by the depth of water. In the case of a free surface (a surface subjected only to atmospheric pressure and not to additional restraints such as a vinyl cover) and a non-sloping bottom, a maximum wave height on the order of 75% of the water depth is expected. The above is stated in U.S. Army Corps of Engineers, 1973 publication: Shore Protection Manual, Volume I, (p.p. 2-121 - 2-123) U. S. Government Printing Office, Washington, D. C.

In the case of a water bed, the presence of a vinyl top sheet should be expected to alter this maximum wave height to depth ration. Empirical findings with appropriate wave measurement apparatus have indicated a maximum height to depth ratio on the order of 30% for an undamped bed. In other words, a 23 cm water bed depth will permit a maximum wave height of about 7.62 cm. While this ratio is expected to vary somewhat, depending upon the tautness of the top sheet, we may use 30% as a first approximation to estimate the maximum wave height possible in a mattress of specified depth.

From a water bed design standpoint, this depth limitation is extremely significant since it points to the fact that the maximum wave height in a water bed mattress may be reduced by decreasing the effective depth below the surface.

Reflection

When a progressive wave train encounters a vertical wall or barrier, a standing wave system results as the leading waves in the group reflect off the barrier and pass through the trailing incident waves (see Fig. 8 of the accompanying drawings). It is significant to note that particle velocities are significantly higher in standing waves than in the progressive waves which cause them. The foregoing is particularly noted and discussed in the publication of Wiegel, R.L., 1964: Oceanographic Engineering, Englewood Cliffs, New Jersey, Prentice Hall, Inc., page 28.

When the water surface is unrestrained and the vertical wall or barrier is impervious, virtually all of the incoming energy is reflected with little dissipation. Experimental results indicate reflected wave heights of between 90 and 100 percent of the incident wave heights. The foregoing is noted and discussed at page 54 of the above cited 1964 Wiegel publication.

The above noted mechanics of wave reflection offer two apparent opportunities for wave suppression in water bed mattresses:

1. Because particle velocities associated with standing waves tend to be higher than those with progressive waves, and because drag increases as the square of the velocity, the introduction of drag-inducing material near the barrier or wall supported side edges of the mattress will be particularly effective to suppress wave reflection.

2. Because particle motion is primarily vertical at the wall supported reflective boundary or sides of a mattress, restraint of vertical motion of the water surface through stiffening of the side or edge portions of the

mattress will suppress wave reflection and dissipate energy.

OBJECTS AND FEATURES OF THE INVENTION

It is an object of our invention to provide novel wave motion control means in a water bed mattress which conforms to the following criteria:

1. Inhibits propagation of large-amplitude waves, which create an undesirable rocking sensation;

2. Permits propagation of small-amplitude waves, which maintain a feeling of surface liveliness;

3. Supresses wave reflection from the sides or boundaries of the mattress;

4. Permits free circulation of water to facilitate convective transfer of heat away from a related mattress heater; and

5. Maintains structural integrity and functional effectiveness of the mattress and wave damping system after extensive use and repeated fill-drain cycles.

It is an object and feature of our invention to provide a wave motion control means of the general character referred to above which includes a flat, horizontal, flexible, flow-limiting, water pervious panel within a related water bed mattress in limited spaced relationahip below the top wall of the mattress, to limit the amplitude of the maximum wave which can exist in the mattress by reducing the effective depth of the mattress.

Another object and feature of our invention is to provide wave motion control means of the character referred to above wherein the water pervious flow-limiting panel impedes the orbital motion of water particles in waves through which it extends, thereby absorbing and dissipating the wave propagating energy thereof.

Still another object and feature of our invention is to provide wave motion control means of the character referred to above wherein the panel is normally in limited predetermined spaced relationship below the top wall of the mattress whereby the substantial free generation and propagation of small ripple-like, low energy waves can occur adjacent and across the top of the mattress and so that surface liveliness of the mattress and its capacity to rapidly conform to the shape of bodies engaged thereon is not adversely affected.

A further object and feature of our invention is to provide a mattress structure of the general character referred to above wherein the wave motion control means is spaced below the top wall of the mattress whereby the energy of the small, ripple-like waves allowed to propagate across the top of the mattress is limited in such a manner that those waves, when working and acting upon the bodies of persons engaged on and supported by the top wall of the mattress, cannot impart forces upon those bodies which is likely to be discomforting or annoying.

In accordance with the above, it is an object and feature of our invention to provide wave motion control means in a water bed mattress which operates effectively to allow or permit the generation and propagation of non-objectionable low energy waves and which inhibits generation and rapidly dampens and stops the propagation of undesirable high energy waves.

Another object and feature of our invention is to provide a wave motion control means which includes a buoyant, flexible, flow limiting, water pervious structure within a related water bed mattress, which contacts the side and top walls of the mattress to inhibit wave reflection by both inhibiting vertical motion of the top wall by pre-tensioning the top wall, and impeding the vertical motion of water particles responding to reflection of the wave form off the side walls, thereby dissipating energy.

Further, it is an object and feature of our invention to provide wave motion control means in a water bed mattress which operates effectively to dissipate wave energy at the periphery of the mattress by impeding the reflection of incident waves.

The foregoing and other objects and features of our invention will be apparent and will be understood from the following detailed description of typical preferred forms and applications of our invention, throughout which description reference is made to the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is an isometric view of a water bed with a mattress embodying our invention;

Fig. 2 is an enlarged sectional view taken substantially as indicated by line 2-2 on Fig. 1;

Figs. 3, 4 and 5 are views similar to Fig. 2 showing other forms and embodiments of our invention; and

Figs. 6, 7, 8 and 9 are diagrammatic views illustrating features of Wave Mechanics discussed in the preamble of this disclosure.

DETAILED DESCRIPTION OF THE INVENTION

In Fig. 1 of the drawings, we have illustrated a typical water bed structure B comprising a bed frame F and a mattress M.

The bed frame F includes a rectangular outside frame 10 with vertical longitudinal and lateral extending side and end boards 11 and 12 and a flat horizontal mattress supporting platform P within the frame 10. The platform P is arranged and supported within the frame 10 with its top surface spaced below the upper rim or top edge of the frame a distance substantially equal to the vertical extent or depth of the mattress M. The upper portion of the frame 10, projecting above the platform P, defines or establishes a retainer R which occurs about the perimeter of and supports opposing related sides of the mattress M.

The mattress M comprises a flat, rectangular bladder O having a flat, horizontal bottom wall 15 in flat supported engagement with the platform P, flat vertical side and end walls 16 and 17 in flat supported and retained engagement with the inside surfaces of the retainer R and a normally flat horizontal top wall 18 in vertical spaced relationship above the bottom wall.

For example, and for purposes of this disclosure, the retainer R and the mattress M will be considered to be about 23 cm in vertical extent and depth, which is close to the average vertical extent and depth for water bed retainers and mattresses.

The bladder O of the mattress M can be established of any one of several commercially available and suitable thin, soft, flexible, water-proof sheet materials.

The bladder can be established of flexible and supple polyvinylchloride sheet stock about 0.508 mm thick. The sheet stock is cut to establish pieces which define certain of the walls of the bladder and the related pieces going up to make the bladder have edge portions which are joined together by heat sealing procedures or the like whereby the finished bladder is an integrated water-proof bladder structure.

In accordance with common practice, the mattress bladder is provided with a normally closed water filling fitting (not shown) to facilitate introducing water into it or draining water from it, as circumstances require.

In the form of the invention shown, the bed structure B is provided with a flat blanket-type electric resistance heater unit H arranged in flat heat-conducting contact with and between the bottom wall 15 of the mattress and the platform P. The heater H has an elongate power cord which, for example, is shown extending from the heater and thence downwardly through a vertical through opening in the platform P, from which it can be made to extend to some suitable heater control means and/or power source (not shown).

In practice, it might be required or preferred that a water-proof liner be arranged between the mattress M and the platform P and retainer R, to prevent the escape of water from the bed structure, should the mattress rupture or leak.

The bed structure thus far described can vary widely in details of construction without departing from or in any way affecting the present invention and is intended to show but one typical form of bed structure in and/or with which our invention can be advantageously related.

Our invention comprises novel wave motion control structure C in combination with the mattress bladder O to dampen, control and/or modify the generation and propagation of waves in and throughout the upper and lower portions of the mattress M.

The wave motion control structure C first includes a normally flat, horizontal, flexible, resilient and compactable water-permeable flow limiting and/or restricting panel A arranged within the upper portion of the mattress bladder O in limited, predetermined spaced parallel relationship below the top wall 18 of the bladder. The structure C, in addition to the panel A, includes spacer means S to normally maintain the panel in spaced relationship below the wall 18.

In the preferred form and embodiment of our invention, the panel A is a flat, horizontal open work pattern or net-like pad of thin, flexible and resilient garnetted polyester fibers. The fibers are preferably fixed or bonded together as by a means of a suitable resinous cement to impart into the pad-like panel desired dimensional stability and memory.

The fibrous pad-like panel A presents a large open work pattern of fibers which is sufficiently water-permeable so that water can and will flow in and through it, substantially freely and without appreciable resistance when a slight pressure differential occurs across it and is such that it establishes notable and increasing resistance to the flow of water through it when substantial pressure differentials, caused by externally applied dynamic forces, are imposed across it. Accordingly, the panel is such that it will not slow or impede slow, low energy movement of water such as convection currents generated by the heater unit H, but will resist and slow water forcibly urged through it, absorbing energy therefrom and dissipating it.

The panel A is preferably (normally) at least 2.54 cm thick and can be as much as 10 cm or 13 cm thick, as desired or as circumstances require.

It is desirable that the panel A be sufficiently resilient, soft and formable so its resistance to being moved and formed under applied forces, during normal use of the mattress, is normally insufficient to be sensed by persons engaged on the mattress, in the normal course of its use.

In the preferred carrying out of our invention, the panel A is buoyant and is such that if it is not held or retained down and in spaced relationship below the top walls 18 of the mattress, it will float up and into engagement with that wall of the mattress.

In one effective form and carrying out of our invention, buoyancy can be imparted into the fibrous pad-like panel A by the use of light-weight and buoyant fibers, such as polypropylene fibers. Alternatively, buoyancy can be imparted into the panel by the use of light-weight and buoyant resin cements to fix or bind the fibers together; and/or by the addition and inclusion of buoyant particulate materials, such as styrofoam beads, to the gar-netted and cemented fibrous mat structure. Still further, buoyancy can be imparted into the panel by the fixing of buoyant float parts to the panel, as shown in the forms of our inventuon illustrated in Figs. 3 and 4 of the drawings.

The above means for imparting buoyancy into the panel are examples of some, but not all, means that might be used for imparting buoyancy into the panel without departing from the broader scope and spirit of our invention.

While we have found that gar-netted polyester fiber padding of the character described above is particularly suitable to establish the panel A in carrying out our invention, we have also obtained promising, though not wholly satisfactory, results with panels of soft, reticulated foam plastic and with various forms of pierced and perforated plastic sheeting. While those substitute panel materials we have utilized have attained promising results, those results were not as good as the results obtained through the use of gar-netted fibrous matting such as described above. Further, use of the noted substitute materials presented certain functional, mechanical and structural disadvantages which were not encountered in the use of the gar-netted fibrous mat panels.

The spacer means S provided to normally maintain the panel A in predetermined spaced relationship with and below the top wall 18 of the bladder C can vary widely in practice. In Figs. 1 and 2 of the drawings, the means S comprises a plurality of longitudinally and laterally spaced, soft, resilient, readily deformable spacer blocks 20 fixed to and projecting upwardly from the top of the panel A and establishing stopped engagement with the bottom surface of the top wall 18. The blocks 20 are preferably established of the same gar-netted polyester fiber matting used to establish the panel A and can be fixed to the panel A in any desired manner. In the case illustrated, the blocks 20 are tied to the panel by tie strings 21, but can, if desired, be cemented or otherwise fixed to the panel without departing from the spirit of our invention.

In practice, the spacer blocks 20 can be buoyant float-like units utilized to impart desired buoyancy into the panel structure.

Further, it is highly desirable, if not necessary, that the spacer blocks 20 be extremely soft and flexible so that they will readily deform and compact between the top wall 18 and the panel A, when the top wall 18 is forcibly urged downwardly and so that their presence beneath the top wall 18 cannot ordinarily be sensed by the users of the mattress.

In Fig. 3 of the drawings, we have shown another form of spacer means S'. The spacer means S' includes a plurality of laterally and longitudinally spaced elongate, vertical, ribbon-like hangers 23 of soft, flexible sheet plastic. The hangers 23 have upper ends which can be fixed directly to the bottom of the panel A or can, as shown, be secured to pad-like float parts or elements 30 arranged adjacent the bottom of the panel A, to depend freely therefrom. The lower end portions of the hangers are formed to define flexible sealed envelopes 25 in which volumes of high density particulate materials, such as bird shot 26, is deposited. The shot-filled envelopes establish weights W at the lower ends of hangers which drop to and rest upon the bottom wall 15 of the mattress and thereby anchor the platform in desired vertical relationship above the bottom wall and below the top wall 18 of the mattress.

It will be apparent that the hangers 23 can be established of string or the like and that the weights w at the lower ends thereof can be established of metal washers or the like, without departing from the broader aspects and spirit of our invention.

In practice, and in carrying out of our invention, the panel A is spaced below the top wall 18 of the mattress bladder O a predetermined limited distance so that the vertical column or depth of the water between the top wall 18 and the panel A is limited and capable of supporting only low amplitude waves. Through empirical testing, it has been determined that spacing the panel A from 5 cm to 7.6 cm below the top wall 18 of the mattress provides a vertical column or depth of water between the panel and the top wall which is sufficient to impart desired liveliness and suppleness to the portion of the mattress structure above the panel A and positions the panel a sufficient distance below the top wall 18 so that its presence is not readily felt or detected by persons using the mattress. Further, such positioning of the panel limits the wave motion that can be established and propagated throughout the upper portion of the mattress, above the platform A, to ripple-like low energy with, for example, a maximum height of approximately 2.54 cm (one inch) and which are so weak that they cannot noticeable move a person's body engaged atop the mattress and do not deliver work forces onto such a body which might be considered discomforting or annoying.

When a downwardly directed force of sufficient magnitude to propagate waves greater than, for example 2.54 cm (one inch) is imposed upon the top wall 18 of the mattress, that force is directed down through the panel A.

That downward force and the accompanying downard movement and/or displacement of water in and through the panel causes the worked upon portion of the panel A to compact and to move downwardly an appreciable extent and results in the panel absorbing some of that force. The residual energy of that force, remaining within the mattress, and propagating in the form of progressive waves, is dissipated by the inhibiting influence which the panel exerts on water particle orbital motion. Thus, the propagation of large amplitude waves introduced into the mattress structure is interfered with in such a manner that they cannot and will not sustain their original amplitude and progressively decay at a rapid rate.

It is to be noted that the panel A, spaced below the top wall 18 of the mattress and above the bottom wall 15 thereof, impedes the propagation of all large amplitude waves due to its flow-restricting or limiting characteristics which slows the orbital motion of water particles in each wave, with resulting rapid decay of wave energy. Accordingly, the panel A appears and is believed to work to progressively alter and modify the forward progression of waves within the mattress in a controlled mannner and results in the rapid decay and termination of wave energy at a rate which is such that wave propagation within the mattress is not let to continue or progress to an extent that it is likely to work discomforting effect upon the bodies of persons engaged atop the mattress.

It is to be noted that the panel A is not an impervious partition through which water cannot move and does not divide the volume of water in the bladder O into separate (upper and lower) volumes of water. Further, the panel A does not function to prevent or stop movement of the water within the bladder through which the panel extends and does not function to absorb energy from the water and conduct that energy to a part of the bladder O, to be spent therein. Rather, the water pervious panel, of reticulate material, allows movement of water through it (affording some resistance thereto) and functions to stop, slow or alter that orbital movement of water particles associated with waves in the water within it and to thereby absorb and rapidly dissipate wave propagating energy in the water.

It is to be further noted that the panel A is a soft, easily compactible yielding and deformable element or part freely suspended in the water within the mattress bladder and is therefore such that it moves substantially freely in advance of and with water which is displaced and caused to move within the bladder and is therefore such that its presence within the bladder does not afford undesired and readily noticeable resistance to the normal and desired working of the mattress structure in the course of its normal use.

In addition to the above described panel A, our wave motion control means C includes wave damper means or structure D which functions to suppress the reflection of wave energy by or at the several vertical side and end walls 16 and 17 of the bladder O, which walls are backed and supported by the retainer R of the bed frame F and are stationary barriers with respect to waves propagated in the bladder O. The structure D functions to suppress the reflection of wave energy by pretensioning the top wall 18 of the bladder O so that the top wall yieldingly resists and/or restricts that vertical or upward movement of the surface of the water within the bladder which is necessary for the reflection of wave energy and further, induces energy dissipating turbulence in the water of standing waves which develop adjacent the side and end walls of the bladder and beneath the side edge portions of the top wall 18.

In the form of the invention shown in Figs. 1 and 2 of the drawings, the structure D comprises a soft, resilient, water permeable and buoyant rectangular frame 40 arranged within the mattress bladder O to extend about the perimeter of the bladder and immersed within the water therein.

The frame 40 is shown as including elongate side and end rails 41 and 42 which occur adjacent to and extend parallel with related side and end walls 16 and 17 of the bladder O. The rails 41 and 42 have outside surfaces 43 which oppose and preferably engage the inside surfaces of their related side and end walls 16 and 17; top surfaces 44 which oppose and establish stopped engagement with their related edge portions of the top wall 18, bottom surfaces 45 opposing the bottom wall 15 and inside surfaces 46 which are disposed toward the volume of free water within the mattress through which the panel A extends.

In the preferred carrying out of our invention, the panel A and frame 40 are fixedly joined together to establish a unitary structure in which the frame 40 affords dimensional stability to the panel A, the panel affords dimensional stability to the frame 40 and wherein each of said elements or parts functions to normally maintain the other element or part in effective functioning disposition within the bladder O. Further, the upper portion of the frame 40 projects above the top plane of the panel A and engages the top wall 18 of the bladder and thereby functions to maintain the outer edge portions of the panel A in proper spaced relationship below the top wall 18. Accordingly, the frame 40 supplements and/or can be looked upon as a part of the spacer means S for the panel A.

The frame 40 is sufficiently buoyant so that it floats up into positive engagement with the top wall 18 and exerts sufficient force into and through that wall to move and to draw that free slack out of the top wall which normally occurs in properly filled common water bed mattresses.

When the top wall 18 is drawn or pre-tensioned in the manner set forth above, the surface of the water in the mattress is restrained and held down by the top wall and the reflection of wave energy and development of standing waves about the perimeter of the mattress is effectively and efficiently resisted.

The upward force exerted on and tension imparted into the top wall 18 by the buoyant frame 40 of the means D is sufficient to normally maintain the top wall flat and free of slackness which would otherwise permit free vertical movement of the water surface and such that the top wall 18 is maintained set to counter and resist vertical movement of water at the time vertical movement of the water is initiated. The wall 18 is not pre-tensioned to such an extent that substantial free movement of the top wall under applied loads is adversely resisted.

In addition to the above, the frame 40 is sufficiently soft, resilient and yieldingly formable so that it affords insufficient resistance to externally applied forces to adversely affect normal intended functioning of the mattress or resistance that is likely to be perceived by the ordinary user of the mattress.

The frame 40 or the several rails thereof are established of a sufficiently open and porous reticulate material so that wave propagating energy transmitted through the water in the mattress and advancing toward the frame will continue to travel into and through the water within the frame, but is such that it stops, slows and/or modifies the orbital movement of the particles of water, associated with waves and thereby causes the rapid dissipation or decay of wave energy. The material of which the frame is established is such that when a standing wave is developing in the water in which the frame 40 is immersed or through which said frame extends, and the surface of the water is caused to move upwardly against the resistance afforded by the pre-tensioned top wall 18 of the bladder, the water moving into and through the frame to effect elevation of the surface of the water is caused to turbulate within the frame. Such turbulence of water in the frame 40 slows and counters the water particle movement associated with waves and results in the rapid decay of wave energy within and adjacent to the frame 40.

The pre-tensioning of the top wall 18 afforded by the frame 40 and the energy dissipating turbulence afforded by that frame combine with apparent synergistic effect to substantially dampen and notably reduce the reflection of wave energy and/or the establishment and maintenance of standing waves at and about the sides of the mattress bladder O.

Emperical testing and observation indicates clearly that the wave dampening means or structure D that we provide is so effective that waves of extraordinary high amplitude and great energy caused to propagate in and throughthe frame 40 and to adjacent related side and end walls of the bladder O result in upward vertical movement of the water surface at the side of the mattress structure which is notably less and which is notably slower than similarly induced corresponding movement of water in common undamped water bed mattresses. The noted reduced and limited vertical movement of water that does occur appears to be slow and sluggage and is such that little rebound waves can be detected in and across the top of the mattress structure.

In the preferred carrying out of our invention the material used to establish the frame 40 is the same gar-netted polyester fiber matting that is used to establish the panel A.

It is to be noted that the frame 40 is made to occur in the upper portion of the mattress bladder, that is, in the upper portion of the water column in which wave propagating energy and particle motion are the greatest and that it need not extend down from the top 18 of the mattress and through the water column below that point where water particle movement in the waves worked upon ceases to be such that interference with water particle movement will bring about notable wave damping effect.

In accordance with the foregoing, while it is preferred that the frame 40 be substantially coextensive with the vertical extent of its related side and end walls 16 and 17 of the mattress bladder O, as shown in Figs. 1 and 2 of the drawings, it can, as shown in the different and/or modified form of our invention illustrated in Fig. 4 of the drawings, be limited or restricted to extend vertically through the upper onehalf portion of the side and end walls, without materially affecting its ability to dampen wave reflection and cause notable rapid decay of wave energy about the perimeter of the mattress.

The lateral extent of the rails 41 and 42 of the frame 40 and the distance it extends laterally inwardly from the side and end walls of the bladder, beneath the top wall 18 thereof, can vary substantially. For most satisfactory end results, it has been determined that the lateral extent of the rails of the frame is prefereably equal or close to being the same as the wave length of waves of maximum amplitude that can be established and propagated in the mattress, which is best determined by empirical testing procedures which include the measurement of waves induced in undampened mattress bladders but which is fairly estimated to be close to or between one-half and two-thirds the normal depth of the mattress bladder. Accordingly, in a mattress which is 23 cm deep, the lateral extent of the rails of the frame 40 should be at least 11.43 cm wide and are preferably

15.24 cm or more in width, if most effective and efficient functioning of the means D is to be assured.

To clearly show that the details of construction of our wave motion control means C can be varied substantially without departing from the spirit of our invention, we have, in Figs. 3, 4 and 5 of the drawings, illustrated several different or modified embodiments of the invention.

In Fig. 3 of the drawings, and as described in the foregoing, buoyancy is imparted into the panel A' by pads 30 of highly buoyant foamed plastic secured to the bottom surface of the panel A'. Further, in this embodiment of our invention, the spacer means S' comprises the above described weighted hangers which are related to the pads 30 and serve to anchor the panel in desired vertical position in the bladder O'.

The frame 40' of the damper means D' in Fig. 3 of the drawings is formed in part by the outer side and end edge portions of the panel A' and by elongate upper and lower rail portions secured to and extending longitudinally of their related side and end portions of the panel. Buoyancy is imparted into the laminated structure described above by elongate, flat, ribbon-like strips or pads 48 of soft, resilient and buoyant foam plastic material arranged between the top surface of the lower rail portion and adjacent portions of the bottom surface of the panel. The several adjacent and related parts and portions of the fabricated frame structure described above are fixed one to the other by means of a suitable cement as indicated at 49.

In the form of our invention shown in Fig. 4 of the drawings, the spacer means S" for the panel A" is essentially the same as the means S in the first considered form of our invention, except that the spacer blocks 20" are cemented to the panel A", as indicated at 50. In this third form of our invention, buoyancy is imparted to the panel A" by flotation pads 30" similar to the pads 30 in the second form of the invention shown in Fig. 3 of the drawings, but the pads 30" are cemented to the panel as indicated at 51.

The frame structure 40" of the damper means D" in the form of the invention shown in Fig. 4 of the drawings is close to being the same as the frame structure 40' in the second embodiment of our invention. The frame structure 40" does not include the lowermost laminate or rail portion and is therefore of reduced vertical extent and is such that it does not extend an appreciable distance below the bottom plane of the panel A".

In Fig. 5 of the drawings, we have shown a wave damper means or structure D^2 which includes an independent frame structure 40^A of non-buoyant water-permeable reticulate material, such as gar-netted plastic fiber matting. Buoyancy is imparted into the several rails of the frame 40^A by elongate, flexible, preferably soft and resilient cores 53 of lightweight buoyant cellular foam plastic, which cores are coextensive with their related rails and impart desired dimensional stability into the frame structure.

The wave damper structure D^2 can be arranged in its related mattress bladder O^2 separate from and independent of a panel structure such as is provided in the other forms and embodiments of our invention and functions to impede the reflection of wave energy and dampen standing waves at the several sides of the bladder in the same manner that the means D and D' do.

It has been determined that provision and use of the damper structure that we provide, when used independent of any other wave motion control means, affords notable and highly desirable results which are unattainable by other wave dampening means provided by the prior art and which impart that degree of wave motion control which a large number of persons would prefer or be satisfied with.

In Figs. 1 through 5 of the drawings, like reference characters have been applied and directed to like or equivalent structures and means where appropriate.

In Figs. 6 through 9 of the drawings, we have diagrammatically illustrated that water particle motion which is associated with waves in water bed mattresses; and the water particle trajectory which is normally found to occur in deep, transitional and standing waves. Reference to Figs. 6 through 9 of the drawings is to be made for better understanding of our discussion of wave dynamics presented in the preamble of our disclosure and for a clear understanding of the function of and work performed by our new wave motion control structure.

Having described typical preferred forms and embodiments of our invention, we do not wish to be limited to the specific details of design and construction of our invention illustrated and described above, but wish to reserve to ourselves any and all modifications and/or variations of our invention that might appear to those skilled in the art and which fall within the scope of the following claims:

CLAIMS

1. A water bed structure comprising a mattress (M) including a bladder (0) with a substantially horizontal bottom wall (15), substantially vertical side and end walls (16 and 17), a normally flat, horizontal soft and flexible top wall (18) in spaced relationship above the bottom wall and having outer side and end edge portions joining the side and end walls and a body supporting inner portion spaced inward from said side and end walls and a volume of water in and slackly filling the bladder and yieldingly supporting said top wall up; a bed frame (F) with means supporting the bottom, side and end walls substantially stationary; and wave motion control structure (C) in the bladder to control the propagation of waves therein upon disturbance of the top wall and adjacent surface of the water and comprises a body of soft, resilient, water-permeable reticulate material immersed in and extending through the volume of water within the bladder in spaced relationship from the body supporting inner portion of the top wall and buoyed up and normally occurring within the upper portion of the bladder and extending through the upper portion of the column of the water in the mattress in which the trajectory of water particles in waves propagated in the bladder between the top and bottom walls thereof is orbital and which stops, slows and alters the orbital trajectory of water particles and rapid decay of wave propagating energy in the water.

2. The water bed structure set forth in Claim 1 wherein the body of water-permeable reticulate material defines a flat, horizontal panel (A) normally arranged in spaced parallel relationship between the bottom wall and the body supporting top wall whereby said top wall can move vertically free from restraint by the body of material and a volume of water of limited depth is defined between the panel and the top wall in which ripple-like low energy waves of limited amplitude can form and propagate free of restraint by the panel and which preferably further includes spacer means (S) fixed to and carried by said panel and engaging the bladder to normally maintain the panel in predetermined spaced relationship below the top wall.

3. The water bed structure set forth in Claim 2 wherein the spacer means includes a plurality of spaced support blocks (20) of soft, resilient material fixed to and projecting up from the panel and

in stopped engagement with the top wall.

4. The water bed structure set forth in Claim 2 wherein the spacer means includes a plurality of spaced apart elongate flexible, normally vertically extending hangers (23) with upper ends fixed to the panel and weights (W) at the lower ends of the hangers normally establishing stopped engagement on the bottom wall and anchoring the panel down in the water.

5. The water bed structure set forth in any one of Claims 1, 2, 3, 4 or 5 which further includes a plurality of buoyant flotation pads (30) of soft, resilient foam plastic fixed to the reticulate material in spaced relationship from each other throughout the horizontal extent of the wave motion control structure and buoying the reticulate material up in the water.

6. The water bed structure set forth in Claim 1 wherein the water permeable reticulate material defines a horizontal frame outward of and about the perimeter of said body supporting inner portion of the top wall in substantial uniform supported engagement with said side and end walls and in yielding pressure engagement with the bottom surfaces of the side and end edge portions of the top wall and yieldingly lifting and pre-tensioning said top wall whereby said top wall is substantially free of slack and is set to restrain that vertical upward movement of the surface of the water necessary to allow for reflection of wave energy and the propagation of reflected waves at said side and end walls and which preferably further includes flotation parts of soft, resilient and buoyant foam plastic secured to and carried by the frame and buoying the frame up in the water.

7. The water bed structure set forth in Claim 1 wherein the water permeable reticulate material defines a horizontal frame outward of and about the perimeter of said body supporting inner portion of the top wall in substantial uniform supported engagement with said side and end walls and in yielding pressure engagement with the bottom surfaces of the side and end edge portions of the top wall and yieldingly lifting and pre-tensioning said top wall whereby said top wall is substantially free of slack and is set to restrain vertical upward movement of the surface of the water necessary to allow for reflection of wave energy and the propagation of reflected waves at said side and end walls; and

defines a flat, horizontal panel (A) inward of said frame and normally arranged in predetermined spaced parallel relationship between the bottom wall and the body supporting inner portion of the pre-tensioned top wall, whereby said inner portion of the top wall can move vertically free from restraint by said panel and a volume of water of limited depth is defined inward of the frame and between the panel and said inner portion of the top wall in which ripple-like waves of limited amplitude can form and propagate free from restraint by the panel.

8. The water bed structure set forth in any one of Claims 1, 2, 3, 4, 6 or 7 wherein the water permeable reticulate material has a specific gravity less than water.

9. The water bed structure set forth in Claim 11 which further includes flotation parts of soft, resilient and buoyant foam plastic fixed to and carried by the reticulate material in spaced relationship about the horizontal extent of said control structure and buoying that structure up in the water.

10. The water bed structure set forth in any one of Claims 7, 8 or 9 which further includes a plurality of spacer blocks (20) of soft, resilient reticulate material fixed to the top of the panel and in stopped engagement with the top wall and normally maintaining the panel spaced below the top wall or which includes a plurality of spaced, vertically extending flexible hangers (23) with upper ends fixed to the panel and having weights (W) at their lower ends normally stopped on the bottom wall and anchoring the panel in vertical position within the mattress bladder.

Fig. 1.

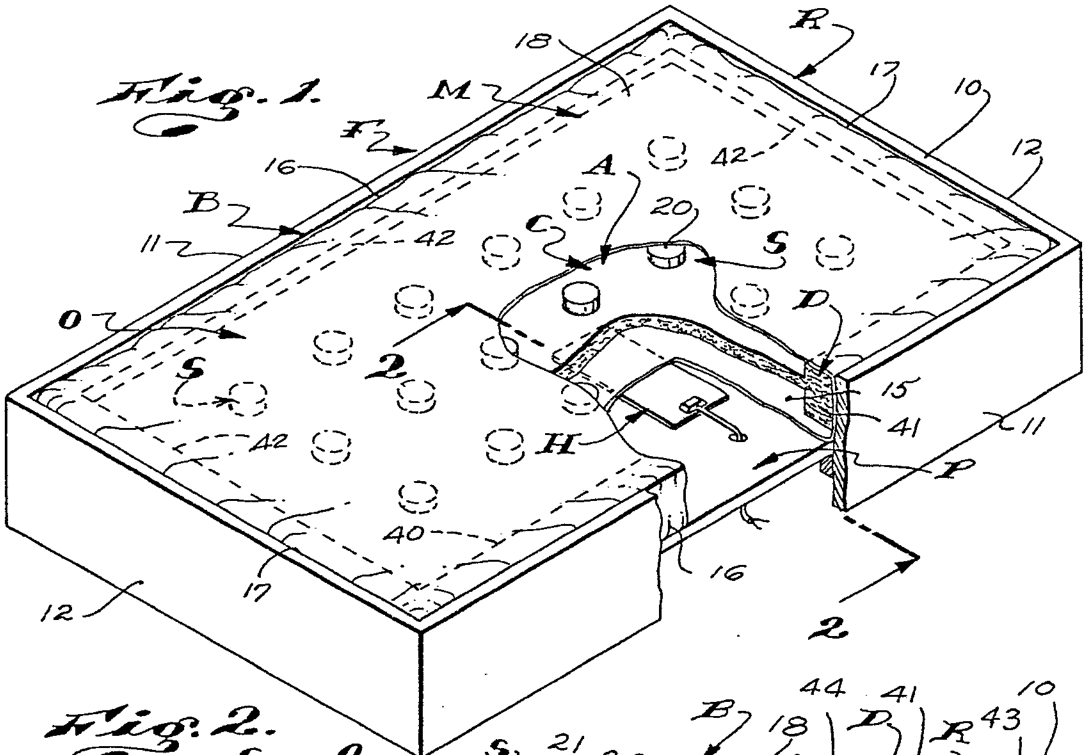

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Fig. 2.

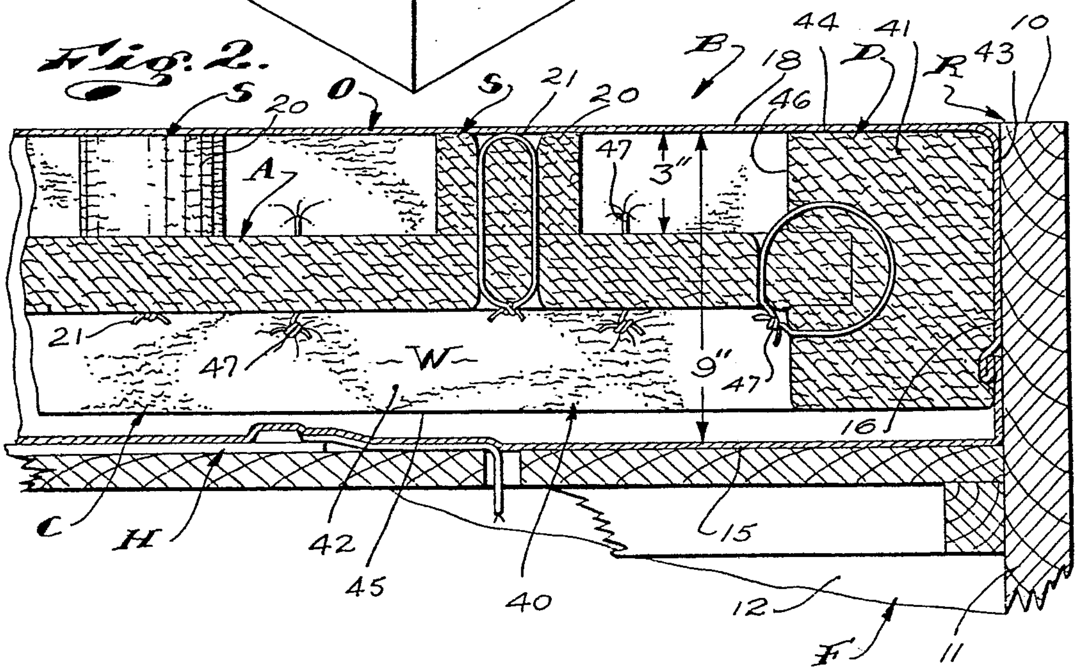

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Fig. 3.

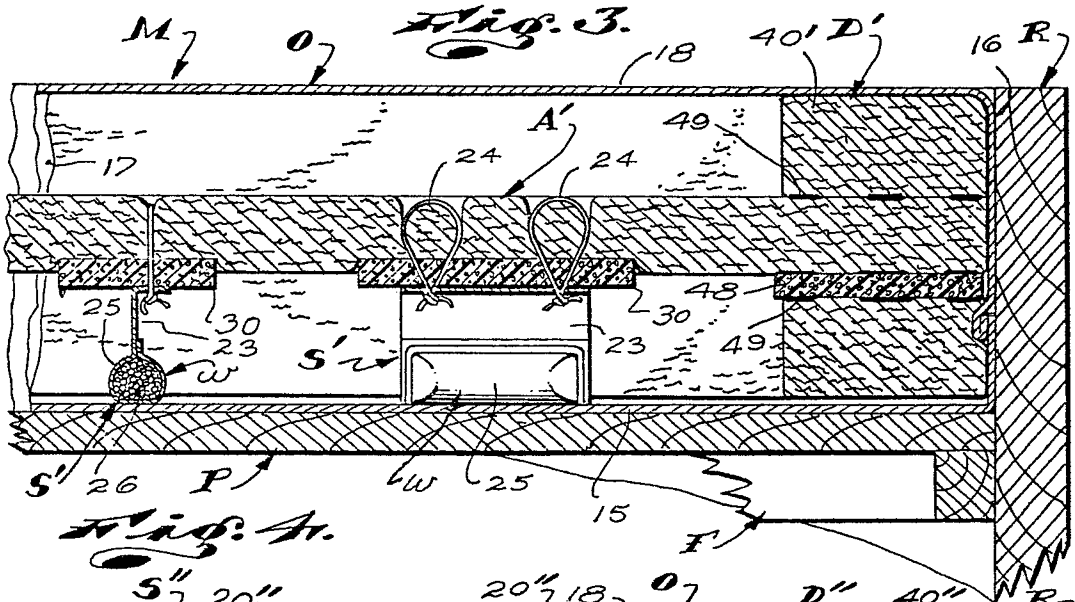


Fig. 4.

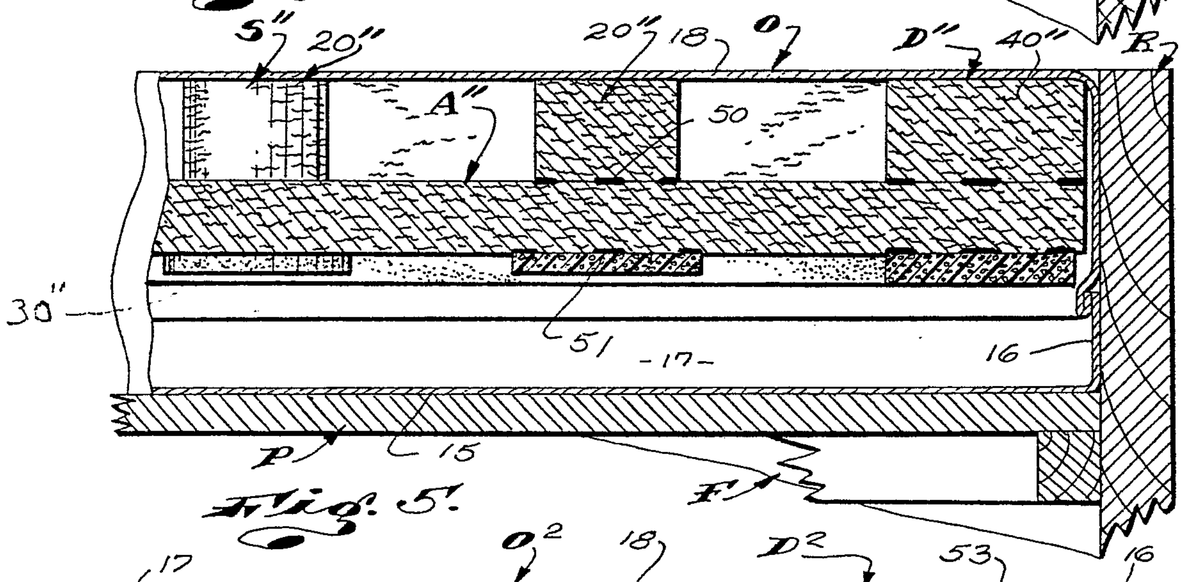


Fig. 5.

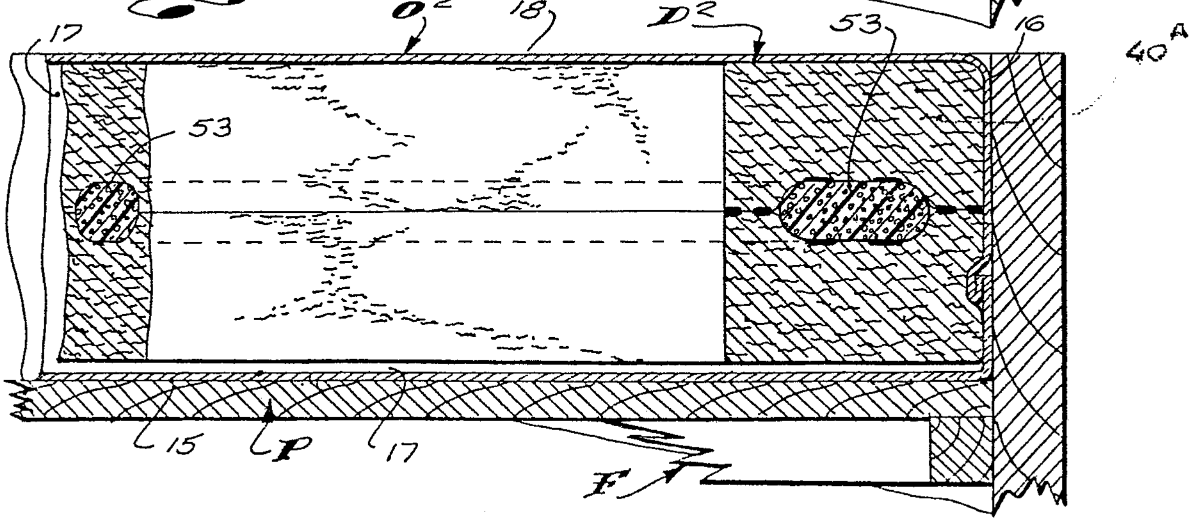


Fig. 6.

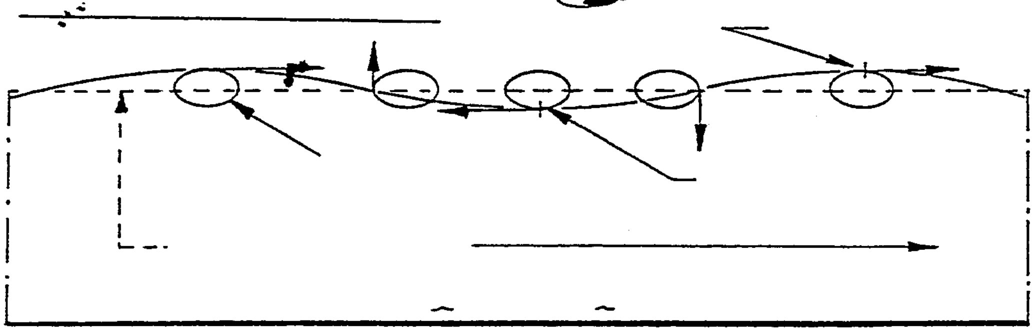


Fig. 7.

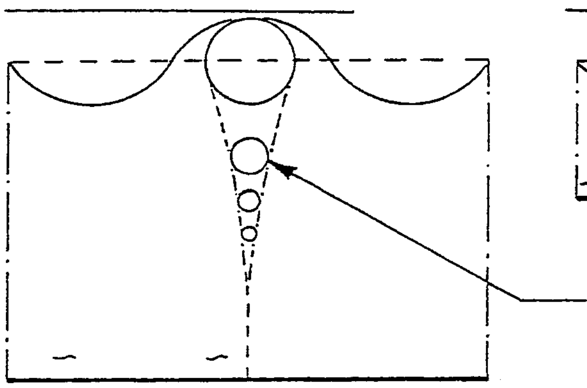


Fig. 8.

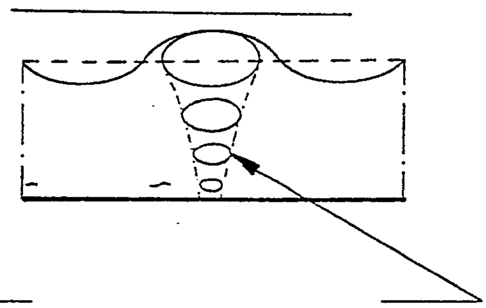
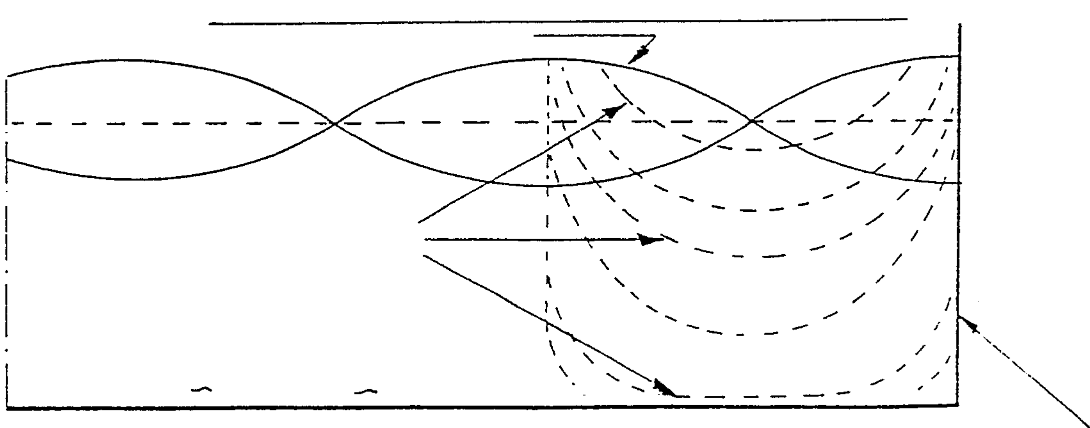


Fig. 9.



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European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 82 40 0160

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	US-A-4 247 962 (HALL) *Column 2, line 1 - column 3, line 12; figures* ---	1,2,8,9	A 47 C 27/00
Y	US-A-4 241 465 (YARIMIE) *Column 1, line 51 - column 3, line 10; figures* ---	1	
Y	US-A-4 152 796 (FOGEL) *Column 2, line 66 - column 4, line 24; figures* ---	1,3,5,8,9	
A	US-A-3 736 604 (CARSON) *Column 2, line 66 - column 3, line 20; figure 11* ---	4,10	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	GB-A-1 288 319 (INNERSPACE) *Page 4, lines 47-57; figure 11* -----	8	A 47 C A 61 G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14-05-1982	VANDEVONDELE J.P.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

T : theory or principle underlying the invention
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document