

Sept. 21, 1971

C. T. DENTON

3,606,704

ELEVATED FLOOR STRUCTURE

Filed May 2, 1969

5 Sheets-Sheet 1

Fig. 1.

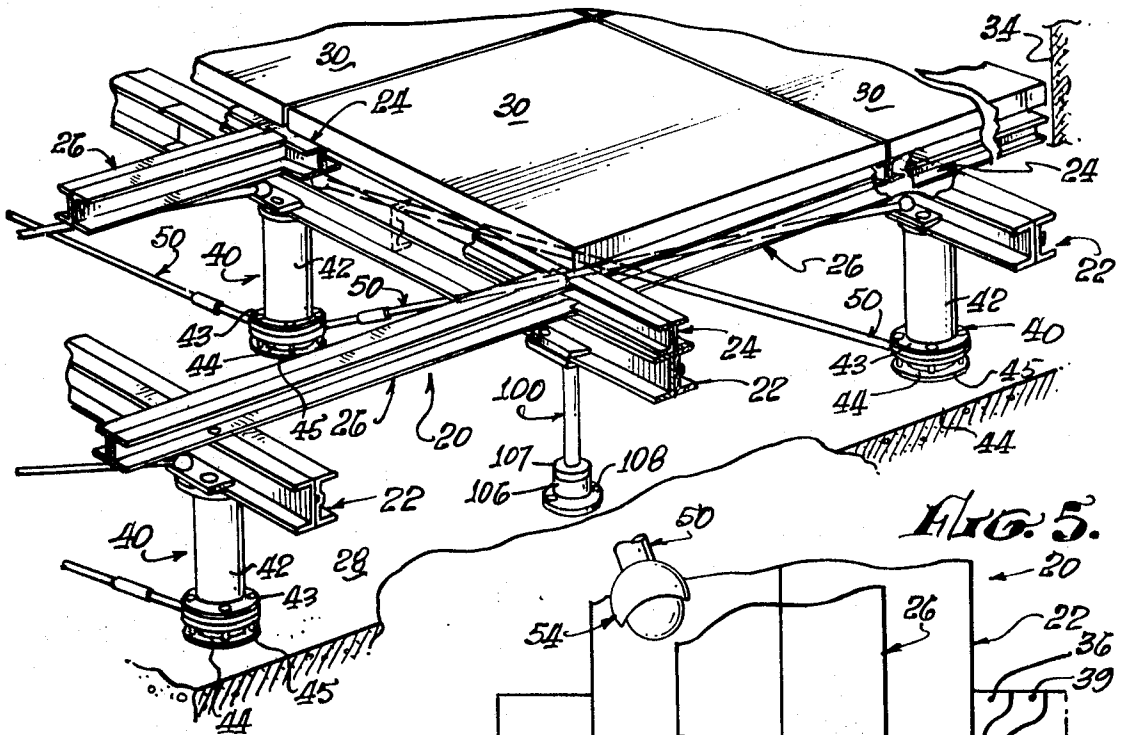


Fig. 5.

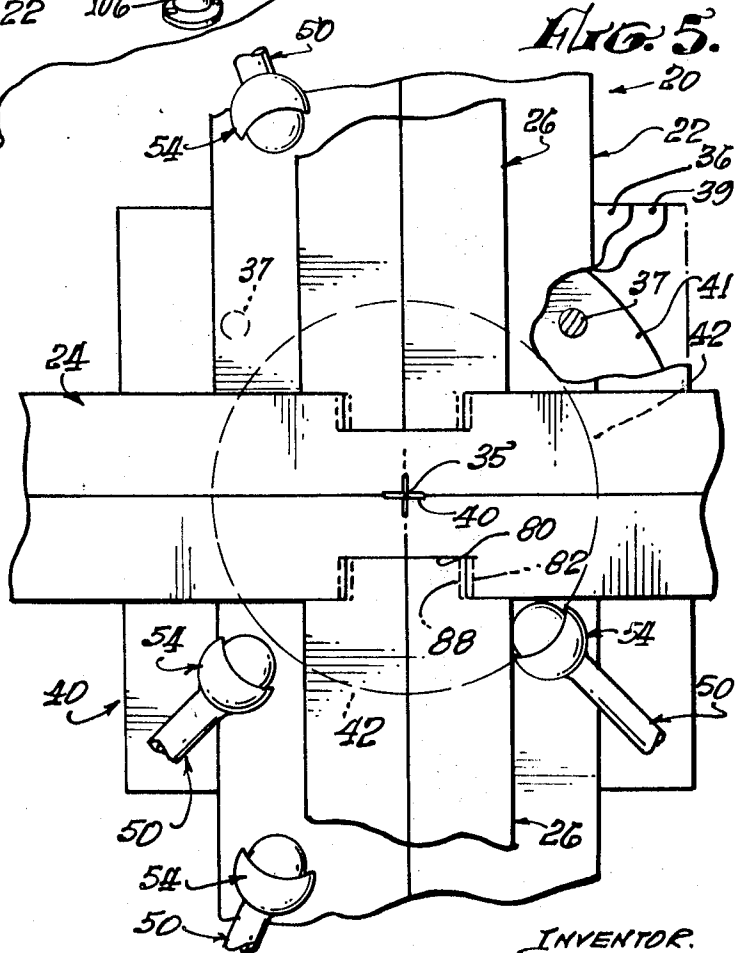
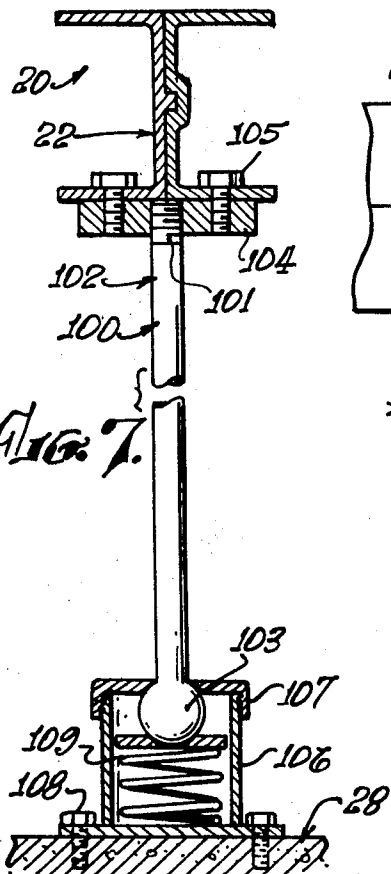


Fig. 7.



CLYDE T. DENTON,

By *Charlton M. Lewis*

Sept. 21, 1971

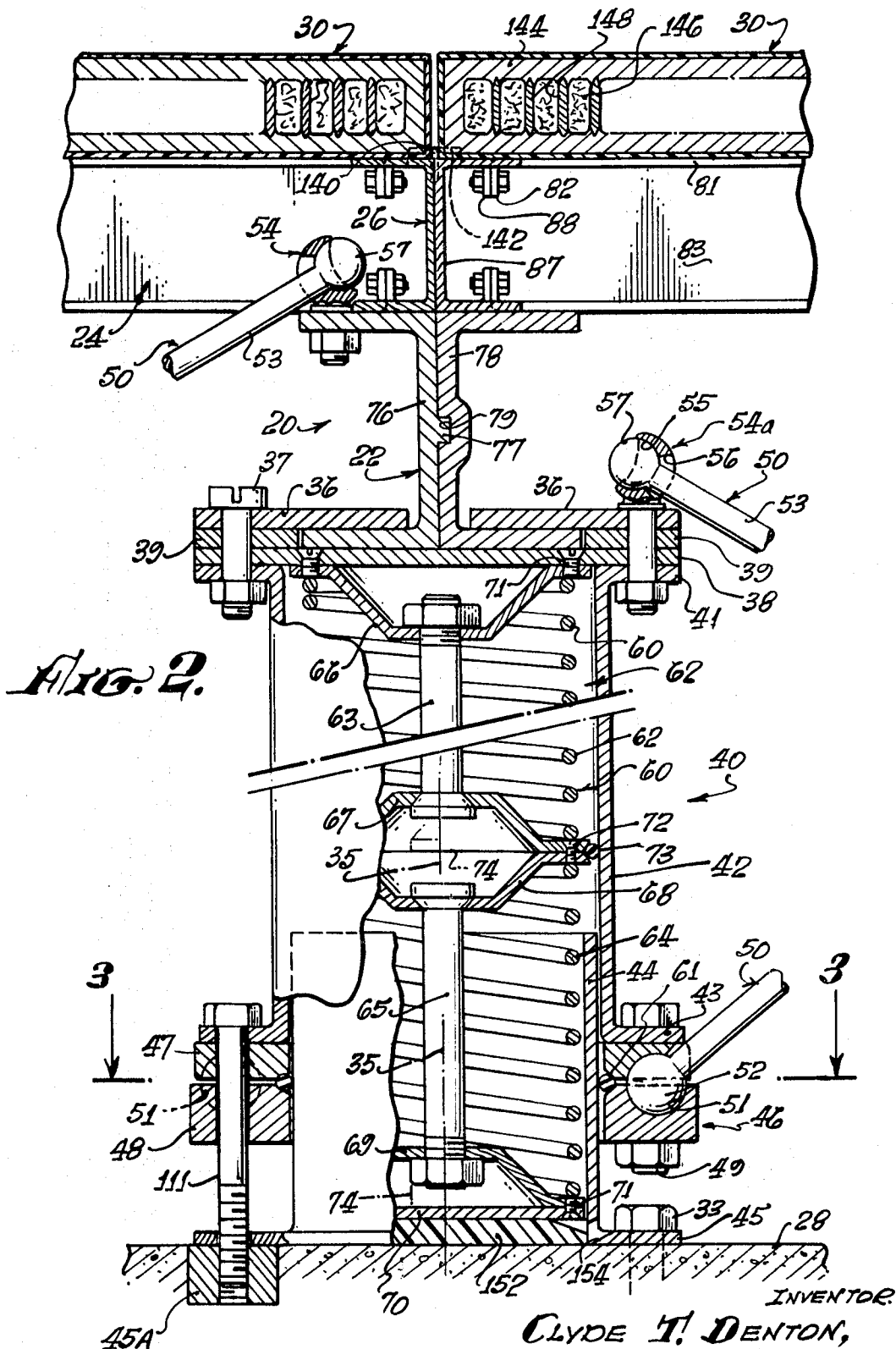
C. T. DENTON

3,606,704

ELEVATED FLOOR STRUCTURE

Filed May 2, 1969

5 Sheets-Sheet 2



Sept. 21, 1971

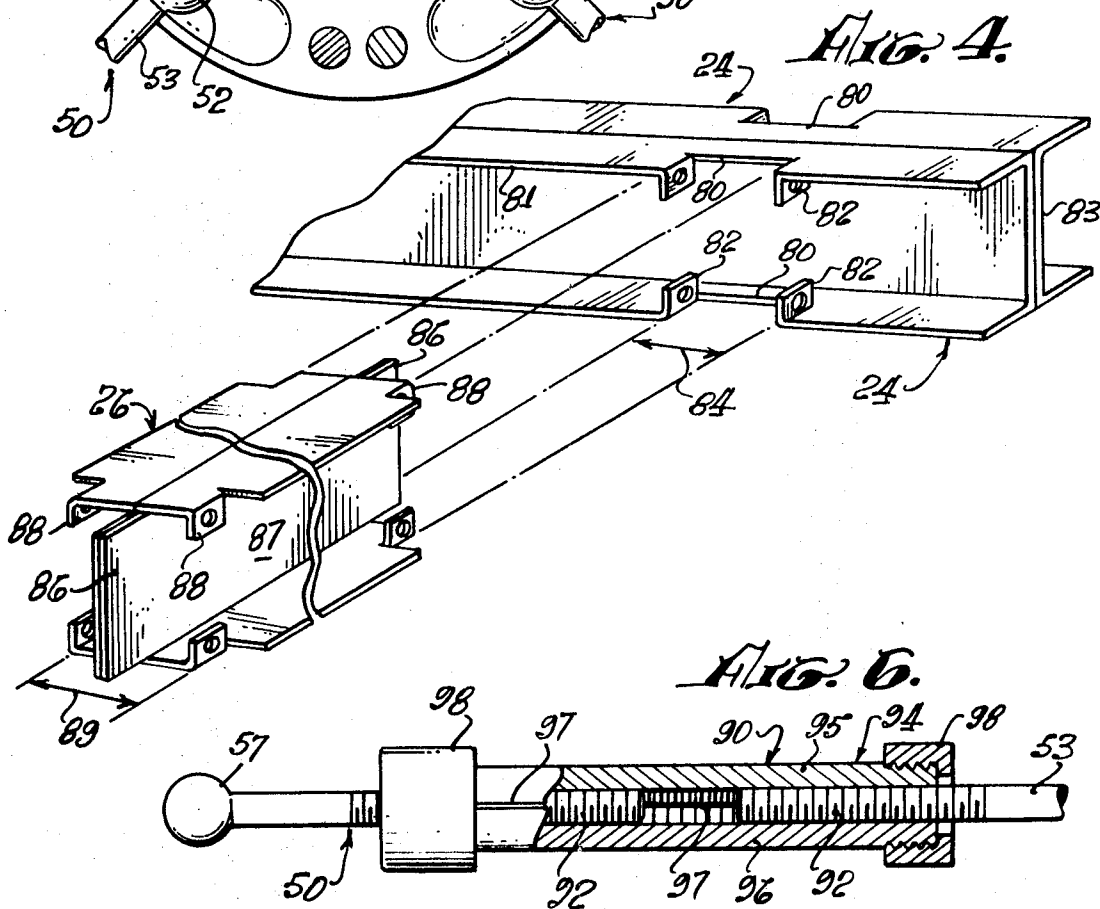
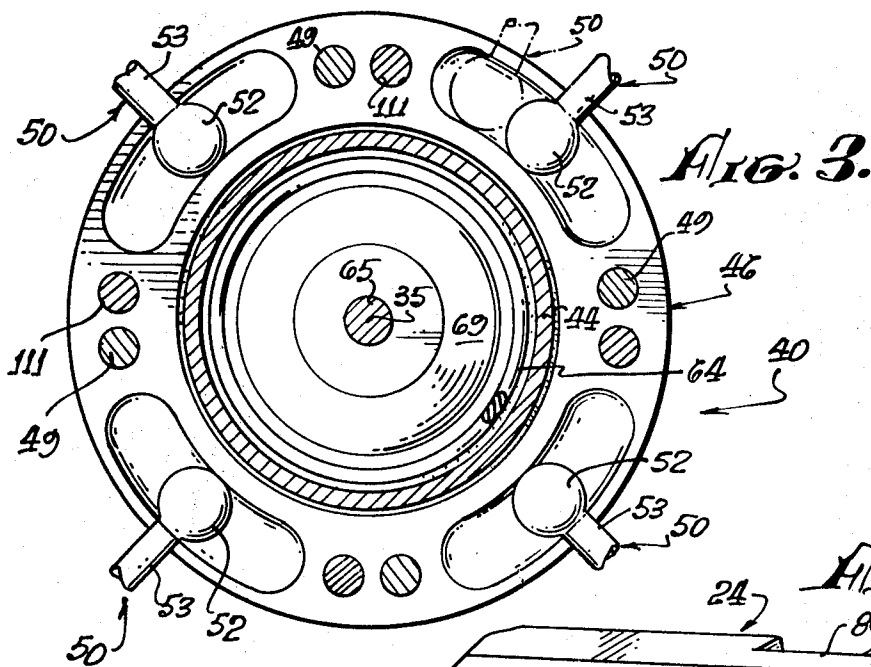
C. T. DENTON

3,606,704

ELEVATED FLOOR STRUCTURE

Filed May 2, 1969

5 Sheets-Sheet 3



INVENTOR.

CLYDE T. DENTON,

By *Charlton L. Lewis*

Sept. 21, 1971

C. T. DENTON

3,606,704

ELEVATED FLOOR STRUCTURE

Filed May 2, 1969

5 Sheets-Sheet 4

FIG. 8.

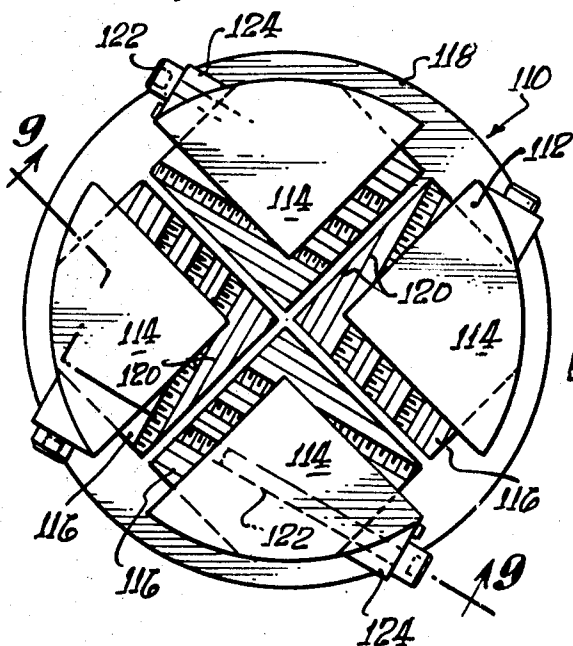


FIG. 10.

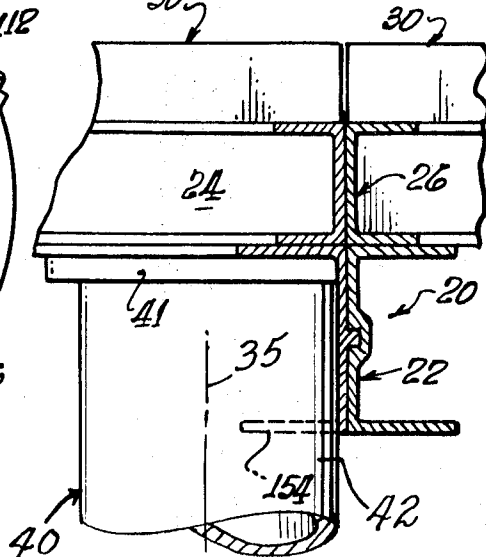
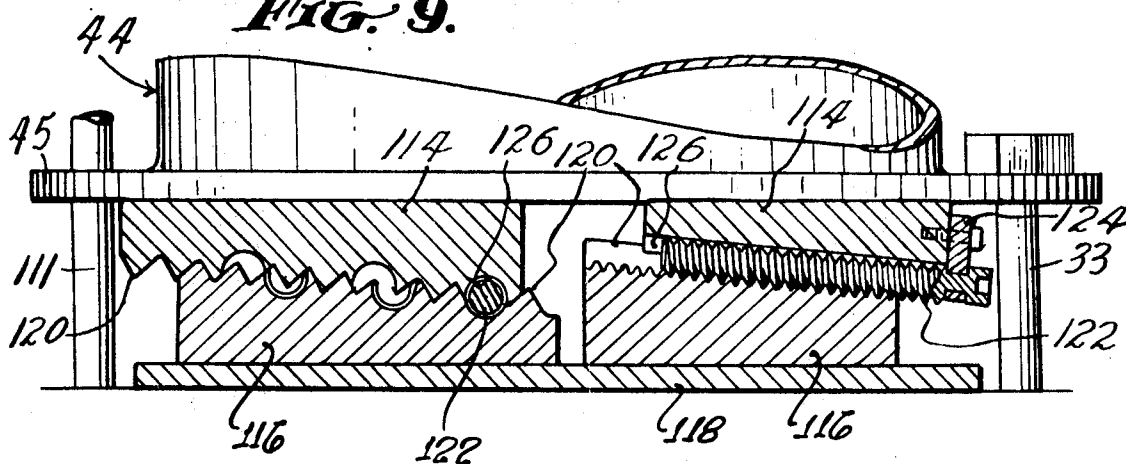


FIG. 9.



INVENTOR

CLYDE T. DENTON,

By *Charles W. Lewis*

Sept. 21, 1971

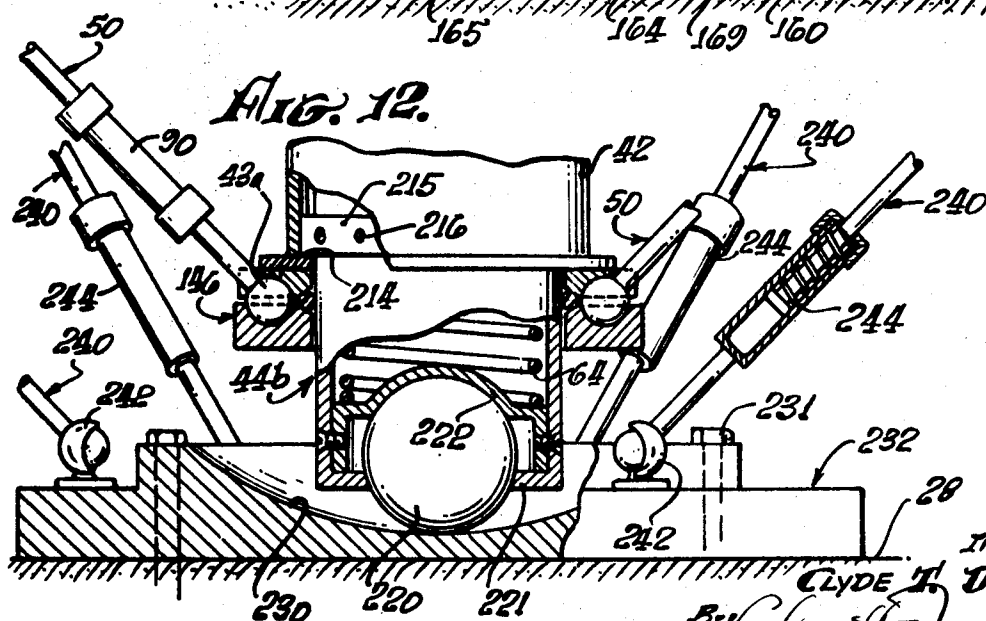
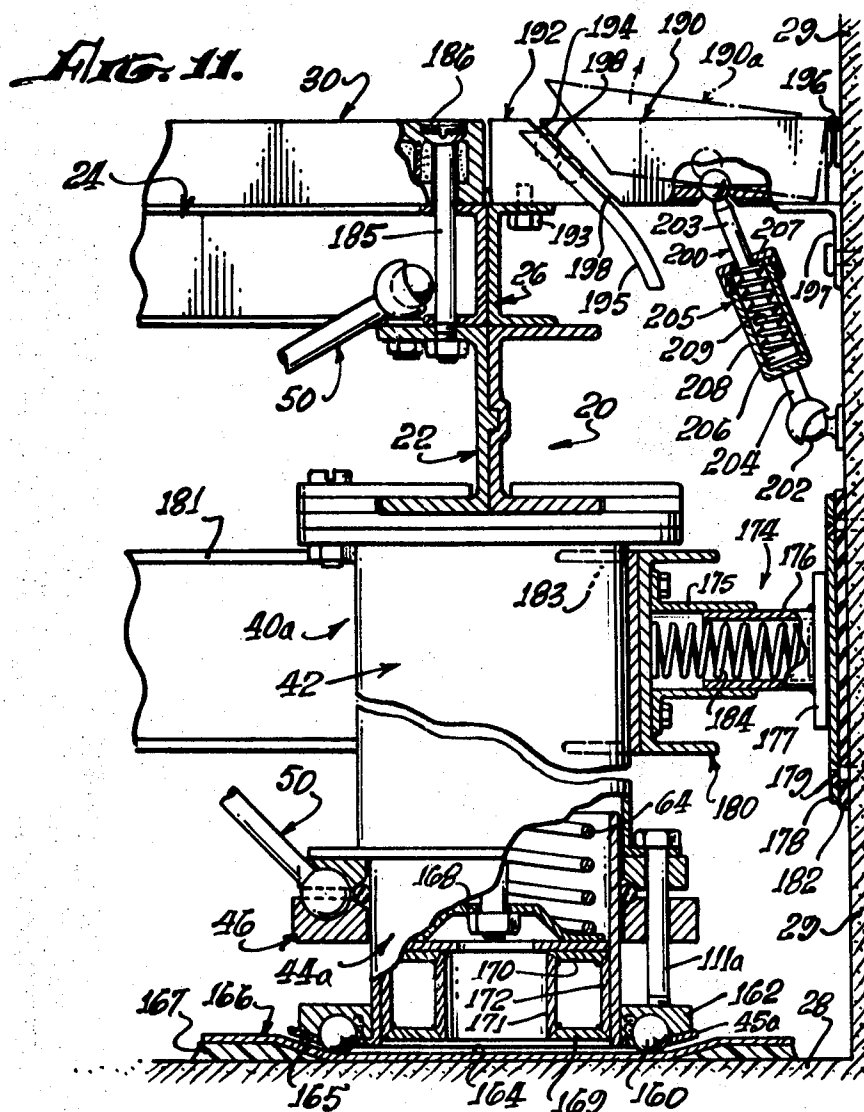
C. T. DENTON

3,606,704

ELEVATED FLOOR STRUCTURE

Filed May 2, 1969

5 Sheets-Sheet 5



INVENTOR

Clyde T. Denton,

By Charles Lewis

1

3,606,704

ELEVATED FLOOR STRUCTURE

Clyde T. Denton, West Covina, Calif., assignor to
Resilient Services Incorporated, Los Angeles, Calif.

Filed May 2, 1969, Ser. No. 821,396

Int. Cl. E04h 1/98; E04h 9/02

U.S. Cl. 52—167

10 Claims

ABSTRACT OF THE DISCLOSURE

This elevated floor structure comprises a rigid frame carrying the floor proper and supported above the subfloor by a plurality of springs that are vertically compressible to accommodate local deformations of the subfloor. Each spring unit is mechanically prevented from expanding beyond a predetermined length, representing prestressing of the spring to a force that is related to the anticipated total load. The floor proper comprises individual cast metal panels coated with seamless, electrically insulating, resilient material. Special tie-rod brackets, resilient tie-down links and adjustable shims, are described. A modified structure, suitable for missile launching installations and the like, accommodates large amplitude vibrations by permitting the entire floor frame to move both horizontally and vertically with respect to the subfloor, with displaceable perimeter panel structures between the floating floor and the building side-walls. The floor frame is yieldably urged toward normal position in response to both gravity and resilient forces.

This invention has to do with elevated floors that are designed to maintain the floor surface accurately and reliably plane and level, as is required for supporting complex machines such as electronic computing equipment, for example.

The floor surface of the present invention is carried by a frame structure that floats resiliently with respect to the conventional subfloor. That floating action isolates the floor frame from local movements of the subfloor, permitting the floor surface to remain true despite sagging, buckling or warping of the subfloor.

The floor frame structure includes post members incorporating prestressed coil springs which carry the weight of the floor and its load and are supported by the subfloor via adjustable structures for compensating non-uniformity of the subfloor. Those springs are further compressible in response to local upward movement of the subfloor, preventing such movement from distorting the carried floor. However, the post structures include mechanisms that limit the spring expansion and thereby accurately define the initial floor level.

The floor frame involves numerous structural features to be described. It includes adjustable control links in the form of tie rods, which are connected to the frame members by special bracket structures and form oblique braces for stiffening the floor frame and maintaining the floor surface accurately plane. Vertical tie-down links between the frame and subfloor prevent the frame from rising above the desired level. The entire frame is electrically grounded as a unit.

The floor proper comprises individual panel members which are metal castings having all surfaces covered by seamless resilient material that provides electrical insulation. The structural members of the floor frame form a rectangular grid, each opening of the grid being filled by a floor panel. Each panel is readily removable, by use of vacuum cup lifters, but when in place forms an air seal with the frame, facilitating control of air flow for cooling and ventilation. A cable screen can be readily installed above the subfloor but below the cross members of the floor frame.

2

A further aspect of the invention relates to the stabilization of resiliently supported floors against large amplitude oscillations such as are encountered, for example, at missile launching installations, where complex and sensitive instruments must be protected both from vibrations due to missile launch and from possible shock due to enemy action. In such installations, floors are typically designed to permit resilient movements as large as seven inches both vertically and horizontally with relation to the building structure. For that purpose, the floor supports are movably mounted on the subfloor, with structure for yieldably urging the supports toward normal position both by resilient action and in response to gravity. Specially hinged perimeter floor panels accommodate lateral movements of the floor structure.

A full understanding of the invention, and of its further objects and advantages, will be had from the following description of illustrative structure for carrying it out, which description is to be read with reference to the accompanying drawings.

In the drawings:

FIG. 1 is a schematic perspective representing a floor installation in accordance with the invention;

FIG. 2 is a fragmentary vertical section on line 2—2 of FIG. 5;

FIG. 3 is a section on line 3—3 of FIG. 2;

FIG. 4 is an exploded perspective, representing preferred beam coupling structure;

FIG. 5 is a fragmentary plan;

FIG. 6 is an elevation, partly broken away, representing preferred turnbuckle structure;

FIG. 7 is an elevation, partly broken away, representing preferred structure for tie-down links;

FIG. 8 is a plan, representing an adjustable shim structure;

FIG. 9 is a section on line 9—9 of FIG. 8 with a supported post in position;

FIG. 10 is a section showing a modification; and

FIGS. 11 and 12 are sections showing further modifications.

In the illustrative form here shown, the floor installation of the invention comprises the floor panels 30, carried on the floor frame 20. That frame comprises the parallel longitudinal sleeper joists or beams 22; the main runners 24, which rest on beams 20 at right angles to them; and the cross runners 26, which extend transversely between adjacent main runners, forming with them a rectangular grid. Each floor panel 30 fills an opening of that grid, with two opposite panel edges supported on main runners 24, and the other two panel edges resting on cross runners 26.

Beams 22 are supported at suitable intervals along their lengths by the post structures 40, shown best in FIG. 2. Each post structure maintains the beam normally at a pre-adjusted distance above the subfloor 28, but is resiliently compressible to permit reduction of that distance in response to abnormal local movement of the subfloor. Oblique tie-rods 50 brace the entire floor frame, forming an essentially rigid unitary truss structure. That frame is preferably spaced slightly from the side walls of the room, indicated at 34 in FIG. 1, isolating the floor from wall vibrations. The tie-down links 100 between beams 22 and subfloor 28 define the floor height despite local shifting of the subfloor.

Post structures 40 comprise the upper and lower sleeve members 42 and 44, lower sleeve 44 being freely telescopically received within upper sleeve 42 on the common axis 35. Lower sleeve 44 carries the support flange 45 at its lower end, adapted to rest on the concrete subfloor either directly or via a suitable shim structure. Bolts 33 may be provided to hold lower sleeve 44 down to the subfloor. Upper sleeve 42 is flanged at 41

3

at its upper end and carries the cap plate 38. Main beams 22 typically rest directly on cap plate 38, to which they may be secured in any convenient manner. As illustrated in FIG. 2, the lower flanges of beam 22 are clamped to the post structure by clamp structure comprising the bolts 39, the clamp plates 36 and the spacers 38.

Within each sleeve assembly 42, 44 is housed a spring structure 60, comprising the upper and lower springs 62 and 64. The ends of each spring are seated on the upper and lower spring caps, 66 and 67 for the upper spring and 68 and 69 for the lower spring. The separation of each pair of spring caps is limited to a definite maximum spacing by the respective bolts 63 and 65. However, the bolt shanks are freely slidable in the axial holes in the caps, permitting the latter to move toward each other from that maximum spacing. The uppermost cap 66 is screwed to cap plate 38 by the screws 71, and the lowermost cap 69 is similarly secured to the base plate 70, which is axially slidable with respect to lower sleeve 44. The two adjacent spring caps 67 and 68 are fastened together by the screws 72, but are slidable as a unit within upper sleeve 42. That movement may be damped and guided by the O-ring 76, mounted in a peripheral groove formed by spring caps 67 and 68. The dish form of the spring caps provides clearance for the bolt heads to move in response to compression of the springs, as indicated at 74 in FIG. 2. Each bolt is designed or adjusted to a length that represents a definite selected degree of pre-stressing of its associated spring. The resulting axial spring force is ordinarily made equal for both springs of any one post structure.

Unless the total weight load on the post structure exceeds that set spring force, both springs 62 and 64 remain extended to the limits set by bolts 63 and 65, holding the upper end lower sleeves 42 and 44 in their normal, relatively extended position, as shown in FIG. 2. The post structure then acts as an essentially rigid support for beam 22 and the floor that it supports. However, if the effective loading on the post becomes greater than the selected value, either due to increased weight load on the floor or due to upward buckling of the subfloor 28, the spring assembly 60 permits resilient compression of the supporting post by relative telescopic movement of the two sleeve members 42 and 44.

Main beams 22 of the elevated floor frame are preferably formed of two channel members which are assembled back to back and maintained in positive alignment with each other by a tongue and groove formation. As shown, male channel 76 carries the flange 77, which is received in the milled groove 79 of female channel 78. The tongue and groove preferably extends the entire length of each member. Beams 22 preferably extend the long dimension of the floor. When the length of the floor is greater than the convenient length of a single beam member, beams 22 may be made up of a plurality of channel members of moderate length. The butt joints between male channel members 76 are then staggered with respect to the joints between female channels 78, so that the beam is effectively continuous for its entire length.

The frame grid formed by main runners 24 and cross runners 26 is rendered true and rigid by special interlocking structure shown best in FIG. 4. Those members are preferably all of identical section. Each is typically formed of two channels arranged back to back and secured together in any suitable manner. However, for convenience of description, they will usually be referred to as a unitary member. Main runners 24 have their flanges 81 notched at 80 wherever a cross runner is to be connected, the material at the ends of the notch being bent inward toward the other flange to form ears 82. The length of the notch between the inner faces of the ears, is indicated in FIG. 4 by the numeral 83.

At the ends of each cross runner 26, the flanges 85 are cut back, permitting the channel webs 87 to project

4

at 86 beyond the flanges. Also, each remaining flange corner is bent inward toward the other flange to form the ears 88. The outer faces of those ears on opposite sides of the runner are spaced apart by a distance indicated in FIG. 4 by the numeral 89. That distance is made equal to, or very slightly less than distance 84. On assembly, assuming suitable dimensions of the described cuts, the projecting web end 86 of the cross runner fits tightly between flanges 81 and butts against web 83 of the main runner, with the edge 87 of each cross runner flange fitting accurately against the base of notch 80. Each pair of ears 88 of the cross runner is fittingly received between a pair of ears 82 of the main runner, positively positioning the members. In particular, the described interlock prevents rotation of the cross runner about its longitudinal axis, thereby resisting warping of the grid structure out of its normal plane. Holds may be formed in suitable complementary positions in the ears of both members, so that each pair of adjacent ears can be conveniently bolted together. The described interlock formations are readily assembled on the job by first assembling all of the cross runners along one side of a main runner. The adjacent main runner can then be advanced laterally toward the projecting cross runners and assembled to their ends. Main beams 22 form a convenient support for carrying out that assembly. After its completion, the grid of runners can be secured to beams 22 in any suitable manner.

The entire floor frame 20 is strengthened and rendered more rigid by the tie rods or links 50, which extend obliquely in a pattern that may be varied according to the particular requirements of each installation. The specific positions of the links shown in the drawings are somewhat schematic and are intended to be illustrative. The lower ends of the links are typically connected to the lower ends of post sleeves 42, which form the upper portion of the spring housings and carry beams 22 at their upper ends. A convenient bracket structure 46 for such connection of a variable number of links 50 comprises the upper and lower rings 47 and 48, which are clamped together by the bolts 49 and are mounted on the lower face of the flange 43, formed on the lower end of sleeve 42. Both rings are grooved on their opposing faces to form the arcuate chambers 51 of generally circular cross section, adapted to receive and clamp the spherical heads 52 of a plurality of tie-rods or links 60. Four such chambers may be provided at uniform angular positions and each extending about 60° with respect to axis 35. That length not only permits installation of several links (FIG. 3), but permits each link to be clamped at an adjusted angular position about axis 35 such that the link force is accurately centered with respect to that axis. Since chambers 51 are similar to portions of a ball bearing race, brackets 46 may be referred to as race brackets. The race bracket is preferably radially defined with respect to lower sleeve 44 of the post structure, as by the O-ring 61, which is received in a groove formed between the bracket members. That O-ring cooperates with O-ring 73 to guide the relative vertical movement of the two post sleeves, while somewhat damping any vibration and preventing noise transmission.

Similar race brackets may be provided at the upper ends of post sleeves 42, bolted to upper sleeve flanges 41, to mount the upper ends of links 50. An alternative type of upper link bracket is shown at 54, comprising a bolt-like structure with a large, generally spherical head 55 and a threaded shank 56. A part-spherical hollow 58 in head 55 is adapted to receive the upper link head 57. The bracket head is slotted at 59 to receive the shank 53 of the link, allowing ample angular adjustment of the link in a vertical plane. Horizontal link adjustment is accommodated by rotation of the entire bracket 54 in its mounting hole. Such pivoting brackets can conveniently be mounted on a flange of one of the frame members. A preferred mounting position is just above the upper hori-

5

zontal flange of main beam 22, as shown at 54 in FIG. 2. That beam is typically wide enough to provide mounting space outward of the cross runner 26. Moreover, bracket 54 can usually be mounted in such position as to bring its link 50 into a plane through post axis 35 without interfering with one of the main runners 24, as shown best in the plan view of FIG. 5. Alternatively, a pivot bracket may be mounted on the lower flange of beam 22, as shown at 54a of FIG. 2. The bolt structure of the bracket may then replace one of the previously described clamping bolts 37.

FIG. 6 illustrates preferred turnbuckle structure 90 for adjusting the tension of the tie rods or links 50. The link ends to be connected are provided with respective right- and left-handed threads, and are received in a correspondingly internally threaded sleeve structure 94, which is rotatable in the usual way to adjust the axial separation of the link ends. However, sleeve 94 is composed of two separable half-sleeves 95 and 96, which meet at an axial plane indicated at 97, and are releasably clamped together to form a rigid sleeve by the threaded end rings 98. The structure is readily assembled on a link 50 by first slipping the rings 98 over respective link ends, then assembling the half-sleeves 95 and 96 on the threaded end portions of the links, with the link threads engaging the internal threads of the sleeve, and finally clamping the sleeve halves together by the end rings. The resulting, essentially unitary sleeve is then rotatable in the usual way to adjust link 50.

FIG. 7 represents preferred structure for tie-down links 100 for holding down the floor frame 20 to prevent the floor from rising above its proper level in case a local region of the subfloor should change its level. Such tie-down links are preferably connected between main beams 22 and the subfloor 28 at selected points of the floor frame, the number of such ties depending upon the size of the floor and other conditions of the installation. Tie-down 100 typically comprises the rod or shank portion 102, having its threaded upper end 101 secured to the underside of beam 22 by means of the mounting plate 104 and the bolts 105. The spherical head 103 at the lower end of shank 102 is caged in the spring housing 106, which is secured to the subfloor 28, as by the bolts 108. The housing cap 107 positively prevents shank head 103 from rising beyond a set level, but the prestressed compression spring 109 permits downward movement of the shank whenever the set spring force is exceeded. Shank 102 may be made adjustable by a turnbuckle structure, preferably of the type shown in FIG. 6. Tie-down links 100 may be supplemented or replaced by connecting equivalent tie-down structure between the two lower flanges 43 and 45 of upper and lower sleeve members 42 and 44 of some or all of the post structures. For example, the bolt 111 in FIG. 2 passes freely through clearance holes in flange 43 and in race bracket rings 47 and 48 and is secured into the subfloor 28. Such a bolt positively prevents upward movement of upper sleeve 42, while permitting free movement downward. No spring corresponding to spring 109 of FIG. 7 is required, since post springs 62 and 64 perform an equivalent function.

FIGS. 8 and 9 illustrate a preferred adjustable shim structure, which may be placed under some or all of the post structures, either temporarily to assist initial adjustment of the floor installation, or as a permanent part of the post structure to facilitate later adjustment, as to compensate for abnormal shifting of the subfloor. Shim structure 110 comprises the base 118 and four identical pad assemblies 112 which are individually adjustable in vertical thickness. Each pad comprises upper and lower pad elements 114 and 116, respectively, provided with complementary mating formations of parallel ridges 120. The ridges lie essentially in a plane, which is inclined to the horizontal in two respects. The plane of the ridges is inclined in the direction transverse of the ridges, as shown best in the lefthand portion of FIG. 9. Also, that

6

plane is inclined longitudinally of the ridges, as shown best in the righthand portion of FIG. 9, the angle of the latter inclination being typically much less than that of the former. Adjustment is accomplished by mutually shifting the elements 114 and 116 either transversely of the ridges, to produce relatively large, discrete changes of level, or by shifting them longitudinally of the ridges, to produce relatively small, continuous changes. Such longitudinal shifting is controlled by rotation of a screw 122, which is rotatably mounted on one of the pad elements, shown as upper element 114, by the mounting ring 124 which also acts as a thrust bearing for the screw. A smooth walled channel 126 is provided in element 114 parallel to ridges 120 to freely receive the upper half of the screw. The lower half of the screw is received in a channel 128 in lower element 116. Channel 128 is threaded, and mates with the threads of screw 122 thereby defining the relative position of the two elements longitudinally of ridges 120.

To facilitate relative shifting of the pad elements transversely of ridges 120, several smooth channels 126 are provided in upper pad 114, and several threaded channels 128 are formed in lower pad 116. Those channels are staggered with respect to each other, as shown somewhat schematically in FIG. 9, so that for every transverse step of the elements at least one set of channels is aligned to receive the screw 120. The screw may be shifted to the desired channel 126 by detaching mounting ring 124 and moving it with the screw to the desired channel. At each transverse adjustment step, the pad elements can be continuously shifted longitudinally for fine adjustment. The dimensions and angles are preferably selected so that such fine adjustments covers the entire range between discrete transverse steps, with ample overlap. The described shim structure can compensate for inclination of a surface on which it is placed by differential adjustment of the several pad assemblies. When no such inclination is present, a single pad assembly may be employed for adjusting the vertical position of any carried structure.

The floor proper may be formed and supported on frame 20 in any suitable manner. The preferred flooring shown comprises individual panels 30, which are preferably all of uniform size and shape except for filling panels required at the edges of the floor. Each panel covers an opening of the grid structure formed by runners 24 and 26, and is thus supported all the way around its periphery. Top and bottom faces of the panels are preferably flat, so that each panel is reversible and the panels are located with respect to the frame by corner spacers 140, which fit in milled slots at the intersections of runners 24 and 26. A sponge rubber gasket 142 is inserted between the panel edge and the runners all the way around, forming an airtight seal so that the space under the panels can be used efficiently as an air duct for ventilation and cooling.

Each panel comprises primarily an aluminum casting 144 of closed box form, surrounding a core 146 of light material such as asbestos. The casting is preferably strengthened by metal cross members or studs 148, which are typically set into the core and cast in place, forming an effectively rigid interconnection between the panel faces. After heat treatment to prevent warping, the casting is milled to size and is then encapsulated in a resilient resinous material of a type which produces a suitable floor surface. That covering is applied by suspending the casting in a mold and injecting the liquid resin, which may be either thermoplastic or polymerizable. The result is a seamless coating that covers top, bottom and sides of the casting. Hence the panels can be inverted in case of damage or wear, and the covering provides reliable electrical insulation of any apparatus carried by the floor, both from the floor panels and from their supporting frame 20.

If the available space above the subfloor is insufficient to accommodate the post structure of FIG. 2, space may be saved by mounting main beams 22 at one side of the upper sleeve member 42, rather than resting on its end. Such a mounting is shown schematically in FIG. 10.

A circular cut-out is made in the lower flange of beam 22 to receive the cylindrical post, and the upper post flange 41 is cut back to clear the beam web. Runners 24 and 26 and panels 30 can be mounted essentially as in FIG. 2. However, main runners 24 may be supported by the tops of the post structures as well as by beams 22.

In installing the elevated floors of the invention, wire guide lines are first set up to establish the desired plane of beams 22. Frame 20 is then assembled, supported on falsework or by post structures 40 at selected points. Adjustable shims of the type described in connection with FIGS. 8 and 9 are preferably used for leveling the frame at the required height above the subfloor. The remaining post structures and links 50 can then be installed. After connection of the upper caps of each post structure to the frame the space between base plate 70 of each spring assembly and the subfloor is filled with a hardenable material to permanently fix the spring assembly's height. For that purpose a suitable caulking compound can be forced in from a gun through the hole 154, provided for that purpose in the wall of sleeve 44 near base flange 45. Weep holes are preferably provided on the other side of the sleeve. After the filling has hardened, the spring assemblies support the floor accurately at the set level. Any temporary supports may then be removed, and the floor panels 30 installed.

Each compression spring is assembled at the factory with its end plates and restraining bolt 63 or 65 to establish the desired degree of preloading of the spring. That preloading is set at a force corresponding to the anticipated total loading of the particular post structure, and typically from about 5 to about 50% more than that loading.

FIGS. 11 and 12 represents illustrative structures in accordance with a further aspect of the invention for accommodating large amplitude oscillations such as may be encountered at missile launching installations. Many of the components of FIGS. 11 and 12 correspond in both structure and function to parts identified by the same numerals in FIG. 2, and require no further description. However, the base of each post 40a is not fixed to subfloor 28, but is permitted essentially free horizontal movement for a limited distance about its normal position. As illustrated in FIG. 11, the balls 160 are rotatably mounted in recesses in the ring 162 and project downward through countersunk holes in base flange 45a of lower post sleeve 44a. Balls 160 roll freely on the base plate 166, which is mounted on subfloor 28 and provides a hardened steel surface capable of resisting the maximum downward force that can be exerted through the balls, which are provided in suitable number and size. The lower end of lower spring 64 rests on a seat structure 168 supported by lower sleeve 44a. As shown, that seat structure rests on the rigidly assembled annular plates 169 and 170 and spacer rings 171 and 172. The resulting ring assembly is welded to sleeve 44a, supporting the spring with the desired degree of prestressing under normal conditions. Upper sleeve 42 of the post structure terminates far enough above the subfloor to allow the desired degree of compression of the spring assembly.

The entire floor frame 20 is normally retained in the proper position on subfloor 28 by the shock absorbing structures 174, which act between the room walls 29 and the frame on all four sides of the latter. Suitable mounting of the shock absorbing structures on frame 20 is obtained by providing additional beams 180, which are typically I-beams formed from two channel sections, and which form a frame that goes around the entire perimeter of the main frame structure 20. Besides providing a suitable mounting for the shock absorbing structures 174, perimeter frame 180 greatly strengthens the floor supporting frame 20, especially near its perimeter where stresses may otherwise build up. Such a perimeter frame may be employed also in the previously described embodiment if desired. Cross members may be provided between perimeter beams 180 wherever desired to add

further strength, as indicated at 181. Beams 180 preferably have their inner flanges coped out to fit the cylindrical upper post sleeves 42 as at 183.

Each shock absorbing structure 174 comprises the fixed sleeve 174, which is rigidly mounted on the web of beam 180, and the telescopically slidable sleeve 176, the outer end of which rigidly carries the bearing plate 177. Bearing plate 177 flatly engages the steel wall plate 178, which is supported on side wall 29 by the screws 179, with the resilient pad 182 interposed to deaden transmission of vibration and sound between the wall and the floor frame. Vertical movement of the floor frame is accommodated by sliding of bearing plate 177 on wall plate 178. Sleeves 175 and 176 enclose and guide the spring 184, which is prestressed sufficiently to maintain bearing plate 177 firmly pressed against wall plate 178 in all lateral positions that the floor frame may assume. Springs 184 tend strongly to center the floor under normal conditions. The friction between sleeves 175 and 176 normally provides sufficient damping, but additional damping may be provided if desired.

Base plate 166 may be formed with a depressed central area 164, separated by the smooth and relatively narrow annular ramp area 165 from the flat outer portion of the plate. Ramp 165 closely surrounds balls 160 in normal position of the floor frame and accurately defines that position.

In the present embodiment, floor panels 30 are rigidly secured to the grid frame formed by runners 24 and 26, as by the bolts 185, which preferably also connect the grid frame rigidly to main beams 22 and electrically ground each panel casting to frame 20. The bolt heads are covered by threaded cap plugs 186 of insulating material. Such fastenings may be employed also in the previously described modification.

FIG. 11 also shows perimeter floor structure for accommodating the relatively large horizontal movements of the floor frame that are anticipated in the described types of service. The floor area between the outermost runner 24 or 26 and the adjacent room wall 29 is filled by the special perimeter panels 190 and the cam panels 192. Cam panels 192 are rigidly mounted on the edge runner, as by the bolts 193, and have an outer edge that is beveled to form the cam face 194 with the downward extension 195. Perimeter panels 190 are hinged to the wall at 196 at their upper edge for upward swinging movement, as indicated in phantom lines at 190a. In normal position of the perimeter panel, shown in solid lines, the main weight is taken by the support joist 197, rigidly mounted on wall 29. The inner edge of perimeter panel 190 is beveled to form a cam face 198 that is complementary to cam face 194 of the cam panel. Ball bearing structures 198 may be mounted on one or other of the panels to facilitate sliding of one of those cam faces over the other.

In normal position of the floor frame, perimeter panels 190 are held by the cam faces 194, 198 at such level that their upper surface forms a smooth continuation of the main floor. If the entire floor frame should move toward the wall, the perimeter panels are cammed upward, as at 190a, and return to normal position without exerting undue stress on any of the structure. Extension 195 prevents the edge of perimeter panel 190 from becoming caught below cam panel 192 even during violent vibrational movements. A spring link 200 is preferably provided to apply tension between each perimeter panel and a bracket 202, which may be secured to a part of the floor frame, or to wall 29 as shown. Link 200 comprises the upper and lower rods 203 and 204, connected by the spring device 205. The compression spring 209 is seated at one end on the head 206 of upper rod 203 and at the other end on the internal flange 207 of the spring housing 208, which is fixedly mounted on lower rod 204. Link 200 resiliently urges the perimeter panel toward normal position, insuring proper alignment of the floor surface.

A modified foot structure is shown illustratively in FIG. 12. Upper post sleeve 42 may be essentially as previously described. As shown, however, lower flange 43a extends inward to form a shoulder 214. Lower post sleeve 44b is provided with an outer stop flange 215, rigidly mounted as by the screws 216, which engages shoulder 214 to limit the sleeve extension. Sleeve 44b may be guided at its upper end within the upper sleeve by a flange similar to 215. The ball 220 is rotatably mounted at the lower end of lower sleeve 44b, being retained between the sleeve flange 221 and the rigidly mounted spring seat 222. Spring 64 acts between that seat and an upper spring seat through which upper sleeve 42 is supported, either directly or via an upper spring as in the first described embodiment. Spring 64 is sufficiently prestressed to carry the entire load of upper sleeve 42 and the frame it supports and to maintain lower sleeve 44b normally extended as far as stop flange 215 permits.

Ball 220 rests on the spherically curved surface 230 of the base block or bowl 232, which is secured to subfloor 28 by the bolts 231. The area of surface 230 is such that it will contain ball 220 even under the most extreme lateral movements anticipated, and its curvature is designed to lift ball 220 in response to such lateral movement through an appreciable distance, typically several inches. That upward movement of ball 220 tends to compress spring 64, exerting additional upward force on the floor frame, and may raise the floating floor a corresponding distance. In any case, the downward force of spring 64 on ball 220 produces a horizontal component force tending to center the ball in surface 230 and thereby return the entire floor structure to its normal position. Thus the structure of FIG. 12 provides a centering force derived primarily from gravity, which may supplement the centering action of shock absorbing structures 174 of FIG. 11.

Additional centering mechanism is preferably provided, as shown schematically in FIG. 12. The centering links 240 are mounted at their lower ends via the brackets 242 on base bowls 232, or otherwise secured to the subfloor. The upper ends of links 240 are connected via similar brackets to any suitable rigid portion of the floor supporting frame 20 (FIG. 11). Each link 240 includes upper and lower link sections joined by a spring device 244 tending to shorten the link resiliently. Spring devices 244 may be similar in structure, as in function, to the spring devices 205 shown in FIG. 11, but are provided with very much stronger springs. Links 240 typically extend obliquely between frame 20 and base bowls 232, and therefore exert downward stabilizing forces on the frame as well as tending to center it horizontally.

The foot structure of FIG. 12 may replace that of FIG. 11 for all post structures of an installation. Alternatively, the post structures of FIG. 11 may be employed at crossing points of the floor supporting frame 20, in the general manner of FIG. 1, and supplementary post structures with foot arrangements of the type shown in FIG. 12 may be provided at selected intermediate points of the frame. With the latter system, it is preferred to design the supplementary post structures with springs prestressed to carry a greater load than the regular post structures. In presence of severe horizontal vibrations that cause balls 220 to become uncentered, the supplementary post structures then tend to take over much or all of the load normally carried by the spring mechanisms of the regular post structures. The additional load strengthens the centering action at spherical surfaces 230, while base plates 166 provide final accuracy.

When any of the floor structures that have been described are to carry equipment requiring extensive wiring it is desirable to mount a cable screen immediately below the floating, floor carrying frame 20 and spaced above the subfloor. An electrical grounding connection may be made to the floor frame at any convenient point, and will then effectively ground the entire frame.

I claim:

1. Floor structure for carrying precision apparatus above a subfloor that is surrounded by building sidewalls, comprising in combination

a horizontally extending, substantially rigid frame, structure carried on the upper side of the frame and forming a floor surface,

a plurality of vertically compressed spring mechanisms supported on the subfloor and engaging respective, horizontally spaced points of the frame for supporting the same with respect to the subfloor,

base structures interposed between the respective spring mechanisms and the subfloor and comprising anti-friction means for facilitating horizontal movement of the spring mechanisms relative to the subfloor, and

a series of peripheral floor panels hinged at one edge to a building sidewall and having an inclined cam face at the opposite edge,

said floor surface structure including peripheral cam formations engaging the cam faces of the panels, in complementary supporting relation.

2. Floor structure for carrying precision apparatus above a subfloor, comprising in combination

a horizontally extending, substantially rigid frame, structure carried on the upper side of the frame and forming a floor surface,

a plurality of vertically compressed spring mechanisms supported on the subfloor and engaging respective, horizontally spaced points of the frame for supporting the same with respect to the subfloor, the frame including means for individually guiding the spring mechanisms to maintain them mutually parallel,

a base structure interposed between each of the spring mechanisms and the subfloor for facilitating horizontal movement of the frame relative to its normal position with respect to the subfloor and for returning the frame to such normal position,

said base structures comprising balls rotatably mounted in supporting relation to the respective spring mechanisms, and base elements fixed to the subfloor and having upper surfaces supportingly engaging the balls,

said surfaces having depressed areas with points of maximum depression at the normal positions of the respective balls and curving smoothly upward away from such normal positions, said surfaces acting in response to frame displacement from normal position to exert on the respective balls progressively increasing horizontal component forces tending to return the frame to normal position.

3. Floor structure for carrying precision apparatus above a subfloor, comprising in combination

a horizontally extending, substantially rigid frame, including a plurality of horizontally spaced, generally vertical, hollow post structures, a plurality of mutually parallel horizontally spaced beams supported on said post structures, and a plurality of links obliquely interconnecting the lower ends of said post structures with said beams,

bracket structures for connecting the links to the post structures comprising two axially adjacent rings coaxially mounted at the lower end of each post structure and forming between them arcuate chambers opening radially outward, and means for releasably clamping the ring together,

said links having at their lower ends generally spherical heads that are clamped in said chambers, structure carried on the upperside of the frame and forming a floor surface,

sleeve members telescopically related to the respective post structures and forming therewith chambers of variable vertical length,

vertically compressed coil springs mounted in the respective chambers,

11

upper and lower spring seats for each spring, the upper spring seat engaging the post structure for supporting the frame, and
 a base structure for supporting the lower spring seat with respect to the subfloor.

4. Floor structure for carrying precision apparatus above a subfloor, comprising in combination
 a horizontally extending, substantially rigid frame including a plurality of horizontally spaced, generally vertical, post structures having respective axes, and mechanism rigidly interconnecting the post structures and the frame to form an essentially rigid truss structure,
 structure carried on the upper side of the frame and forming a floor surface, and
 base structures for resiliently and individually supporting the respective post structures with respect to the subfloor,
 said interconnecting mechanism including links extending obliquely between the post structures and the frame and means for tensioning said links, each tensioning means comprising
 a sleeve structure internally threaded with right and left handed threads at its respective ends and divided at an axial plane to form two mutually separable sleeve halves, and
 means for releasably locking the sleeve halves together in coaxial relation to form an essentially rigid sleeve, each link comprising two portions having adjacent ends that are threaded to engage the threads at the respective ends of the sleeve.

5. A floor structure for carrying precision apparatus above a subfloor, comprising in combination
 a horizontally extending, substantially rigid frame forming a rectangular grid with a flat upper surface,
 a plurality of vertically compressed spring mechanisms supported on the subfloor and engaging respective, horizontally spaced points of the frame for supporting the same with respect to the subfloor,
 a plurality of flat rectangular panels supported on the flat surface of the frame in closely juxtaposed relation in a common plane and forming a floor surface, each panel comprising an effectively rigid metal casting of closed box form enclosing a light core of asbestos fibers and having opposite plane parallel faces of equal size and side edges generally perpendicular to the faces, the entire exterior surface of each casting being covered with a seamless layer of electrically insulative resilient resinous material adapted to form a floor surface and forming a continuous electrically insulating coating both panel faces and on all panel edges, and
 flat spacing members rigidly mounted on the frame and projecting above the grid surface between the panels for positively positioning the panels on the frame, each panel being invertable to utilize either panel face as the floor surface.

6. Floor structure for carrying precision apparatus above a subfloor, comprising in combination
 a horizontally extending, substantially rigid frame, structure carried on the upper side of the frame and forming a floor surface,
 a plurality of vertically compressed spring mechanisms supported on the subfloor and engaging respective, horizontally spaced points of the frame for supporting the same with respect to the subfloor, and
 structure for adjustably mounting each spring mechanism with respect to the subfloor, comprising
 upper and lower blocks having mutually opposing working surfaces, complementary, mutually parallel grooves in the working surfaces interengageable in a plurality of laterally spaced block positions for defining relative sliding movement of the blocks parallel to the grooves,
 mounting structure on the lower block for supporting

12

the same on the subfloor with the working surface inclined to the horizontal at a first acute angle and with the grooves inclined to the horizontal at an acute angle smaller than said first angle,
 screwthreaded means for adjustably driving said sliding movement of the blocks, and
 means on the upper block for supporting a spring mechanism.

7. Structure as defined in claim 6, and in which said screwthreaded means comprise
 complementary semicylindrical channels in said working faces parallel to said grooves, the channel in one of the blocks having internal threads,
 a threaded shaft rotatably mounted in the channels and engaging said threads, and
 thrust means defining the relative axial position of the shaft with respect to the other block.

8. Structure as defined in claim 6, and in which said screwthreaded means comprise
 respective pluralities of semicylindrical channels in said working faces parallel to each other and to said grooves, the channels in the respective blocks being so spaced that in each said lateral position of the blocks at least one channel in one block is complementary to a channel in the other block and forms therewith a cylindrical passage, the channels of one block having internal threads,
 a threaded shaft rotatably mountable in any one of said passages in engagement with the threads therein, and
 thrust means defining the relative axial position of the mounted shaft with respect to the other block.

9. Floor structure for carrying precision apparatus above a subfloor, comprising in combination
 a horizontally extending, substantially rigid frame including a rectangular grid of joists and cross runners both extending continuously the entire horizontal dimensions of the floor structure, a plurality of horizontally spaced, generally vertical, hollow post structures having respective axes and having their upper ends rigidly joined to the frame grid, and oblique tensioned links interconnecting the post structures and the grid frame for maintaining the axes mutually parallel and at fixed mutual spacings and forming an essentially rigid truss structure,
 structure carried on the upper side of the frame and forming a floor surface,
 sleeve members telescopically related to the respective post structures for mutual axial movement and forming therewith chambers of variable axial length,
 coil springs mounted in the respective chambers for urging the sleeve members downward with respect to the post structures, and
 independent base structures for individually supporting the respective sleeve members with respect to the subfloor, each base structure comprising an anti-friction ball rotatably mounted in fixed position with respect to the sleeve member and an upwardly facing spherically concave surface mounted on the subfloor and supportingly engaging the ball,
 the base structures defining a normal position of the frame with all balls at the lowest points of the respective concave supporting surfaces and facilitating horizontal oscillatory movement of the frame about that normal position.

10. Floor structure as defined in claim 9, and in which each chamber contains at least two coil compression springs mounted in series end to end with upper and lower seat structures for each spring, and an axial link interconnecting each pair of seat structures for positively defining the maximum value of the seat separation, and a lost motion mechanism for each link for permitting free relative movement of the seat structures at separations less than that maximum value.

13

References Cited

UNITED STATES PATENTS			
344,918	6/1886	Miller	287—87
1,702,675	2/1929	Ventura	188—102
1,948,600	2/1934	Templeton	52—126
2,053,226	9/1936	Rage	52—167
2,055,000	9/1936	Bacigalapo	52—167
2,741,910	4/1956	Thornley	52—122
3,025,934	3/1962	Spiselman	52—126
3,364,639	1/1968	Davenport	52—407
3,404,501	10/1968	Von Wedel	52—122
3,426,489	2/1969	Lambert	52—484
2,819,037	1/1958	Wilkin	254—104
2,451,777	10/1948	Salas	52—296
2,616,284	11/1952	Leontovich	52—303
2,736,581	2/1956	Ricics	287—60
2,977,863	4/1961	Jenne	94—3

14

FOREIGN PATENTS

1,023,875	1958	Germany	52—122
23,953	11/1902	Great Britain	52—167
825,059	1959	Great Britain	52—167
6710164	1968	Netherlands	52—126
639,666	1962	Italy	248—20
170,528	1934	Switzerland	52—167
675,982	12/1963	Canada	52—402

10 FRANK L. ABBOTT, Primary Examiner
H. C. SUTHERLAND, Assistant Examiner

U.S. Cl. X.R.

15 52—126, 615; 287—60; 254—104; 248—20, 23