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SHOCK ISOLATING MEANS FOR IMPACT MACHINE

Filed July 3, 1963

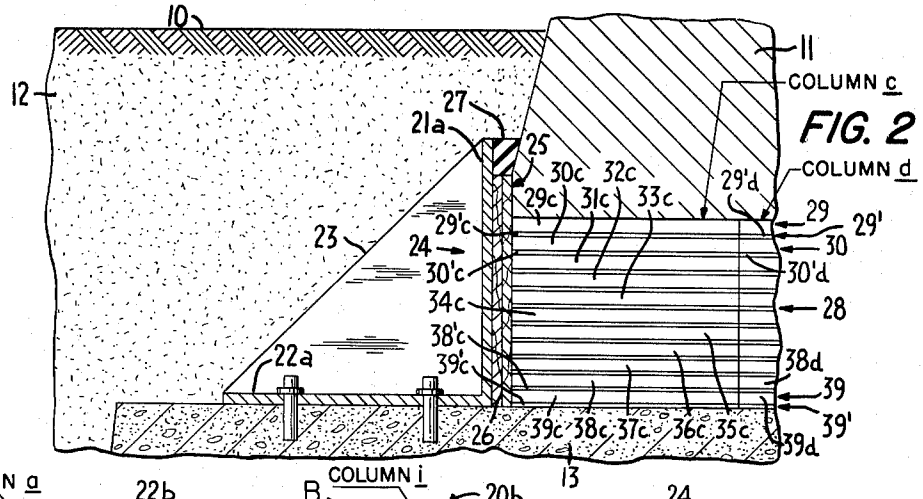


FIG. 2

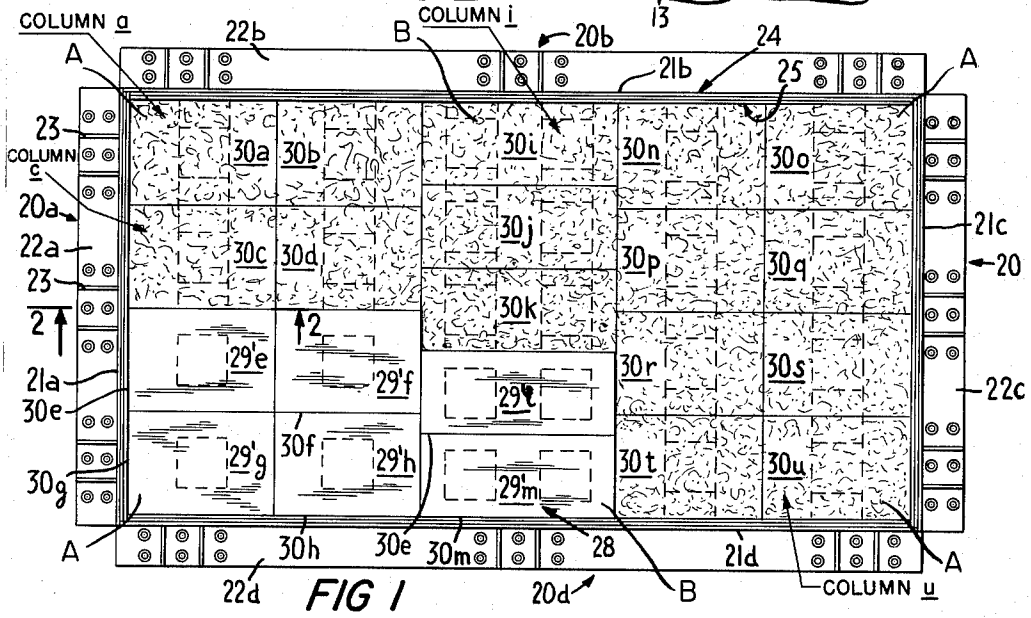


FIG 1

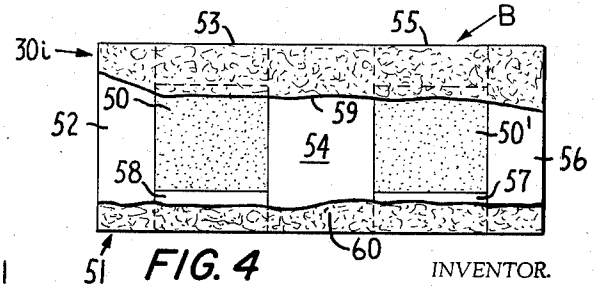


FIG. 4

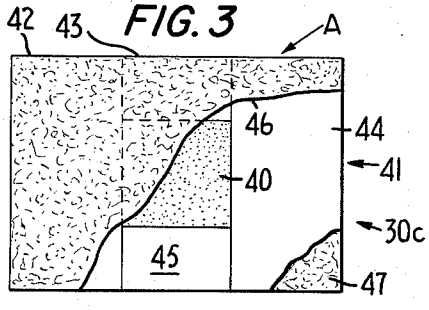


FIG. 3

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SHOCK ISOLATING MEANS FOR IMPACT MACHINE

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This invention relates to shock-isolating structures for impact machines as, for example, drop hammers, forging hammers, heavy capacity presses and the like. More particularly, this invention relates to structures of such sort which provide greatly improved attenuation of the impact shock, noise, mechanical vibration and other mechanical disturbances normally accompanying the operation of an impact machine.

Drop hammers an other impact machines now commonly have shock-isolating foundations constructed of layers of machined oak timbers and/or layers of resilient pads coextensive in expanse with the area of the entire foundation. Those foundations are, however, relatively ineffectual to isolate the impact shock of the machine from the underlying soil or rock substrate. As a result, the operation of the machine develops earth tremors of sufficient strength to be annoying at some distance away from the shop in which the machine is located. Also, workers tending the machine or in its vicinity become fatigued by the high amplitude impact shock and the vibration transmitted from the machine through its foundation to the surrounding area. Other disadvantages of those prior art foundations are that they are of short useful life, expensive to maintain, and of a construction which does not lend itself well to pre-fabrication.

It is accordingly an object of this invention to provide shock-isolating foundation structures for impact machines which are more efficient attenuators of impact shock or other mechanical disturbances than previous foundations used for that purpose.

A further object of this invention is to provide shock-isolating structures of such sort in which the structure is entirely or mostly formed of pre-fabricated components.

A still further object of the invention is to provide such components individually or in combination.

These and other objects are realized according to the invention by providing a foundation structure comprised of a two-dimensional array of vertical support means of which each is comprised of a plurality of vertically superposed elastically compressible pads in horizontally spaced relation from the pads of the adjacent support means. A preferred material for such pads is an elastomeric material such as cotton duck impregnated with rubber which may either be natural rubber or neoprene. Other materials may, however, also be used as, say, slabs of natural or synthetic rubber or other elastomeric synthetic resin materials or pads of canvass or a like tough fabric impregnated with one of the aforementioned elastomeric materials.

An elastomeric pad has little or no volumetric compressibility when squeezed by a load. Therefore, in order for the pad to yield, the pad must bulge outwardly at its peripheral edge. When, according to conventional practice, the foundation is constructed wholly or in part of plural horizontal layers of resilient pads individually coextensive in area with the foundation itself, each such pad has a ratio of peripheral edge length to area which is relatively small. Accordingly, a foundation incorporating such pads has a stiff reaction to loading to thereby have a relatively high frequency of response to an impact shock. Because of such high response frequency, the foundation is relatively inefficient as an attenuator of the shock. Moreover, when the frequency of response of the foundation is high, that frequency often

approaches close to or equals the natural frequency of response of the underlying earth formations such that the foundation and the formations provide together a resonant system which has an amplifying effect upon the shock transmitted from the machine.

I have discovered that the problems just mentioned can be minimized by eliminating the stiffly-reacting single-pad layers (and/or the even more stiffly-reacting oak timber layers) of conventional foundations and by replacing them with the described two-dimensional array of vertical support means individually comprised of vertically superposed elastomeric pads. In such an array, the static and dynamic loading of the impact machine is distributed in the horizontal plane over a number of mutually spaced pads of relatively small area as opposed to a single pad of large area or a continuous layer of timber. Because such elastomeric pads have a ratio of peripheral edge length to area which is relatively high, and because such pads are spaced from each other to permit outward horizontal expansion of each pad individually when subjected to a downward load, the separate pads yield easily, i.e., have a high elastic compliance in the presence of such load. Therefore, the frequency of response of a foundation comprised, as described, of such elastomeric pads is relatively low to thereby cause the foundation to be a good attenuator of impact shock and to have little or no tendency to resonate with the underlying earth.

Preferably, the elastomeric pads of the present invention form components of a plurality of horizontally-spaced support cores extending vertically through a matrix which is also a part of the foundation, but which bears a lesser fraction of the total load then does the array of cores. The matrix is preferably formed of an elastically compressible material which acts as a spacing and horizontal-support medium between the pads of the separate cores. Natural suberose materials such as cork are very satisfactory for this purpose. The matrix may, however, be constituted of other materials as, say, packed fibrous or comminuted material which is somewhat springy, natural or synthetic rubber having a greater compliance under load than does the elastomeric material of the pads, or, alternatively, synthetic suberose-like materials such as foam polyethylene.

The foundation may be constructed of a number of damping plates of which each comprises one or more pads of elastomeric material and, also, a frame constituted of said elastically compressible material and disposed around such pad or pads. Preferably, the plates are arranged to form separate vertical support columns of which the plates in each are in non-overlapping relation with the plates of adjacent columns to thereby permit each column to respond individually to an applied load.

It is also preferable that each column be so shaped and dimensioned in relation to adjacent columns that the various columns fit side to side in close relation to each other to fill up substantially all the space occupied by the foundation. This close fitting together of the separate columns is fully realized only by prismatic columns, i.e., columns of uniform horizontal cross section which are, say, of triangular, hexagonal or rectangular (square or oblong) shape in that cross section. When, as is generally the case, the foundation site is rectangular, prismatic columns of rectangular shape are preferred.

As an aid to construction and to provide better side support of each column by the others, it is desirable for the plates in the separate columns to be vertically positioned relative to each other so as to form in the structure a plurality of vertically superposed horizontal layers of plates, the plates in each layer being at the same level and being disposed side to side in close fitting relation to provide mutual horizontal support.

As an aspect of the invention, each column may contain a plurality of rigid plates constituted of, say, steel, iron, or some other strong rigid material, the rigid plates being disposed in interleaved relation with the damping plates of the column. The functions performed by such rigid plates will be later described.

For a better understanding of the invention, reference is made to the following description of a representative embodiment thereof, and to the accompanying drawings wherein:

FIG. 1 is a plan view of a partly completed recessed foundation according to the invention, the sub-floor material in which the foundation is recessed being absent from the view in order to provide a better showing of the whole foundation proper;

FIG. 2 is a front elevation view, partly in cross section and taken as indicated by the arrows 2—2 in FIG. 1, of a portion of the foundation of FIG. 1 and of a portion of the sub-floor material surrounding and overlying such foundation;

FIG. 3 is a plan view of one type of damping plate employed in the shock-isolating structure of FIG. 1 and designated herein as type "A," the damping plate being partly broken away to provide a showing of each of the constituent elements thereof; and

FIG. 4 is a plan view of another type of damping plate employed in the shock-isolating structure of FIG. 1 and designated herein as type "B," the last named damping plate being likewise broken away to provide a showing of the constituent elements thereof.

Referring now to FIGS. 1 and 2, the reference numeral **10** designates the floor of a shop in which is located a steam drop hammer having an anvil **11** (FIG. 2). The floor **10** is underlaid by a thickness of ordinary foundation material **12** (e.g., earth, concrete) overlying and surrounding a massive reinforced concrete block **13** sunk into to the ground below anvil **11**. Block **13** supports four steel L-angle sections **20***a*–**20***d* (FIG. 1) having respective vertical flange plates **21***a*–**21***d* and horidontal flanges plates **22***a*–**22***d*, the latter flange plates being bolted to the block. Each of the L-angles has triangular stiffening webs **23** extending between the horizontal and vertical flange plates thereof.

As shown, the four L-angles are arranged so that their vertical flange plates form an outer rectangular retaining frame **24** enclosing a space about 9 ft. wide and 16 ft. long. Within the retaining frame **24** is an inner rectangular "side-isolation" frame **25** formed by four vertical timber walls **26** (FIG. 2) disposed inside and against the vertical flange plates of the four L-angles. The inner frame **25** in turn encloses the lower part of anvil **11** and a shock-isolating foundation structure **28** interposed between anvil **11** and the block **13**. It is the structure **28** which is the primary subject of this application. As indicated by FIG. 2, the inner frame **25** extends upwards from the block for a lesser distance than does outer frame **24** to form a trough above frame **25** and extending inside frame **24** around the periphery of anvil **11** at a level at which the sides of the anvil taper convergently in the upward direction. This trough is filled with a layer **27** of a sealer material such as mastic.

The shock-attenuating structure **28** is comprised of eleven vertically superposed layers of damping plates of which the uppermost layer and the next-to uppermost layer are designated as **29** and **30**, respectively, and the lowermost layer is designated as **39**. Interleaved with those layers of damping plates are eleven layers of rigid steel plates of which the uppermost layer is designated **29′** and the lowermost layer is designated **39′**. As illustrated, each of the damping plate layers and each of the steel plate layers is only one plate thick, whereby single damping plates and single steel plates alternate with each other in the vertical direction. If desired, however, either type layer may have a thickness constituted of two or more plates.

The damping plate layer **30**, is for the most part, shown in FIG. 1. Some of this layer is, however, overlaid in the FIG. 1 view by steel plates belonging to the layer **29′**. For convenience of reference, in both the damping plate layers and the steel plate layers, the plates of each layer are designated by the same number as the layer itself but are differentiated in designation from the layer and from each other by letter suffixes which are different for the reference numbers of the different plates.

As indicated by FIG. 1, the layer **30** is constituted of three groups of damping plates, namely, a left-hand group **30***a*–**30***h* of type "A" plates (**30***e*–**30***h* being overlaid by plates **29′***e*–**29′***h* of steel plate layer **29′**), a central group **30***i*–**30***m* of type "B" plates (**30***e* and **30***m* being overlaid by plates **29′***e* and **28***m* of steel plate layer **29′**) and a right-hand group **30***n*–**30***u* of type "A" plates. As will be noted, all of the plates of layer **30** are prismatic in that they are rectangular. Further, those plates are so related in size and shape to each other that each plate is disposed side to side and in close fitting relation with each of the plates adjacent thereto, such close fitting relation being implemented by the prismatic shape of the plates. In practice, any two adjacent plates in layer **30** are desirably in actual contact but may be separated by a crack. The actual or near contact of adjacent plates in the layer maintains each plate in its proper horizontal position even though the plate is otherwised unsecured and is otherwise held in place only by the friction force produced by the weight of the overlying plates.

The other damping plate layers of the structure **28** are duplicates of layer **30** in respect to the damping plates therein and in the manner in which those plates are arranged. Moreover, the steel plates in each layer thereof are substantial duplicates of the damping plates of layer **30** in respect to size, shape, manner of arrangement and the actual or near mutual contact which maintains the plates properly positioned. Accordingly, the damping plates and the steel plate structure **28** form a plurality of separate vertical support columns of which each is coextensive at any horizontal plate level with only a single plate, and of which each is comprised in the vertical direction of a stack of alternate damping plates and steel plates.

These columns are designated herein as columns *a* to *u*, inclusive, the letter used to designate each column being the same as the common letter suffix in the respective designations for all the plates in that column. Column *c* is exemplary of the others. As shown in FIG. 2, column *c* is comprised of the damping plates **29***c*–**39***c*, the steel plates **29′***c*, **30′***c*, **38′***c*, **39′***c* and other steel plates not designated by number in the figure.

Each of columns *a*–*u* is prismatic in the sense that it is of uniform polygonal horizontal cross section. It follows that there is no overlapping of a plate or plates of any given column with a plate or plates of the columns adjacent thereto. Hence, each column is individually loadable in the sense that it may be compressed downwardly without the downward load on that column being transmitted to the columns adjacent thereto.

The columns *a*–*h* and *n*–*u* employ type "A" damping plates of which the plate **30***c* is exemplary and is shown in detail in FIG. 3. At its center, the plate **30***c* has an elastomeric pad means provided by a single 12″ x 12″ square pad **40** of 1″ thick rubber-impregnated cotton duck. The pad **40** has a peripheral edge constituted of the four individual straight-line edges thereof.

Disposed around pad **40** is a frame means **41** of equal thickness. Such frame means is comprised of four 1″ thick cork slabs **42**–**45** arranged as shown and of a size and shape to impart to plate **30***c* an exterior width of 26½″ and an exterior length of 36″. Each of the slabs **42**–**45** contacts a respective one of the four straight-line edges of pad **40**. Thus, the pad **40** is horizontally supported around its entire peripheral edge by the frame **41**. While, in each of the slabs, the grain runs parallel to the

pad edge contacted by that slab, the cork material of the frame is substantially homogeneous and elastically compressible in all directions.

The pad **40** and the cork slabs **42–45** are joined together to form a structurally unitary plate by an upper asphalt-felt sheet **46** and by a lower asphalt-felt sheet **47**. Each of those sheets is bonded to the pad and to each of the cork slabs by suitable elastic adhesive (not shown).

The support columns *i–m* of structure **28** each employs a type "B" damping plate of which plate **30***i* is exemplary and is shown in detail by FIG. 4. In the plate **30***i*, the pad means thereof is comprised of two 12" x 12" pads of 1" thick rubber-impregnated cotton duck. The frame means **51** of plate **30***i* is comprised of the cork slabs **52–58** arranged as shown so that the central portion of slab **54** acts as a spacing means between the pads **50** and **50'**. As in the case of plate **30***c*, the pads and the cork slabs of plate **30***i* are joined together to form a structural unit by upper and lower asphalt-felt sheets **59** and **60** of which each is bonded to each of the pads and cork slabs of plate **30***i* by suitable elastic adhesive (not shown). The exterior dimensions of plate **30***i* are 21 3/16" x 48", and the spacing between pads **50** and **50'** is 12". Otherwise, the plate **30***i* is similar to the earlier described plate **30***c*.

The steel plates of the foundation structure are each 1/8" thick and each has the same width and length dimensions as the damping plates of the column incorporating that steel plate. Thus, the steel plates in, say, column *c* each measures 26 1/2" x 36" (the same as plate **30***c*), and the steel plates in, say, column *i*, measure 21 3/16" x 48" (the same as plate **30***i*).

As will be apparent from the foregoing description, the elastomeric pads of the structure **28** are arranged in vertically superposed sets of which the pads in each set are components of a vertical support core. Column *c*, for example, contains one such core, whreas column *i* contains two such cores. The plurality of vertical support cores which are so formed are surrounded by an elastically compressible matrix provided by the cork frames of the various damping plates.

The shock-isolating structure **28** is constructed while anvil **11** is removed from the foundation site but after the outer and inner frames **24** and **25** are in place. The construction proceeds by first laying in steel plates side by side on top of block **13** to form the lowermost steel plate layer **39'** (FIG. 2). Next, damping plates are placed side by side on top of layer **39'** with the same arrangement as that illustrated in FIG. 1 for layer **30** to thereby form on top of the steel plate layer **39'** the lowermost damping plate layer **39** (FIG. 2). The remaining steel plate and damping plate layers are laid down in like manner. Finally, the anvil **11** is placed on top of the structure, and the anvil is sealed in place by the forming around it of the mastic layer **27**.

A shock isolating structure of the sort described is installable at new foundation sites for impact machines. It is also installable at existing sites (i.e., those already having a support block such as **13** and retaining frames such as **24** and **25**), without requiring any special revision to the ancillary construction other than perhaps the addition of more concrete to the top of the support block. Such additional concrete may be needed because a shock-isolating of the sort shown in FIG. 1 occupies considerably less vertical space than conventional foundations (i.e., ones formed of plural layers of timber and/or large area resilient pads) and, accordingly, may have to be elevated in order to maintain the anvil at the same level as before.

Further constructional advantages of the presently described structure are that it costs about the same or less than a conventional shock-isolating foundation while, at the same time, it is easier to install because of being built up entirely of components which can be fabricated ahead of time. Once in place, the present structure has a much longer useful life and requires much less maintenance than the conventional structure. The number of the layers and the size and construction of the damping and steel plates employed in the present structure may readily be engineered for each specific installation. If desired, however, the structure may be constructed in a modular manner by providing a stock of plates which vary in a standardized manner among themselves in respect to width and length, and be selecting from the stock the particular combination of plates which can be arranged into layers best fitting the dimensions of the foundation site. Any minor discrepancy between the dimensions of such layers and the dimensions of the outer frame **24** can, of course, be compensated for by varying the horizontal thickness of the various wall sections of the inner side-isolation frame **25** of timber.

The primary purpose of the frames **24** and **25** is to prevent the hammer anvil from walking off the pads of the shock-isolating structure. For such purpose, those frames need not extend around the entire perimeter of the foundation, and, in fact, any stop arrangement that prevents the anvil from shifting is satisfactory.

The shock-isolating structure **28** responds as follows to a load. Under static conditions, the load caused by anvil **11** is distributed with substantially uniform loading among the separate columns *a–u* of the structure. Because those prismatic columns fit closely together as to leave no large voids between them, the total support area provided by the columns is maximized (i.e., approximates the area in the horizontal plane occupied by the whole foundation structure). Accordingly, over each column the loading per unit area is minimized.

Consider now the individual effect of the downward load on the damping plate **30***c* (FIG. 3). If the pad **40** and the cork frame **41** of that plate were to be separated from each other, and if each were to then be compressed by the same downward load (i.e., force) to produce on each a uniformly distributed loading per unit area (i.e., load valve divided by total face area subjected to the load) the cork frame **41** would compress more in the vertical direction per unit inch of vertical thickness than would the pad **40**. That is, the overall structure of the cork frame **41** of plate **30***c* has a greater compliance to a downward load than does tht overall structure of the pad **40**. This follows from the fact that the compliance per unit vertical thickness per unit horizontal area of the frame's cork material is substantially greater than that of the pad's elastomeric material.

In the shock isolating structure **28**, the damping plate **30***c* is overlain by a coextensive steel plate **29'***c* which transmits to that damping plate the downward load impressed on column *c* from the anvil **11**. The rigidity of such steel plate causes that downward load to compress damping plate **30***c* in a manner whereby the pad **40** and the cork frame **41** are equally compressed. In those circumstances, because the material of the frame **41** has much greater compliance per unit area than does the material of the pad **40**, the major part of the downward load is carried by the pad **40** (i.e., only a minor part of that load is carried by the cork frame **41**) despite the fact that the frame has a greater total face area than the pad.

Since the material of pad **40** has little or no volumetric compressibility, the pad must expand outwardly in the horizontal direction in order to be squeezed (i.e., compressively decreased in thickness) in the vertical direction by the downward load. Thus, the pad **40** responds to such load by developing at its peripheral edge an outward pressure which is exerted against the inner margin of the cork frame **41**. The material of that frame is, however, elastically compressible in an isotropic manner. Moreover, for a given loading per unit vertical area over such margin, the frame material has a greater compliance per unit horizontal thickness than does the material of the pad. Therefore, the cork material of the frame elastically yields to the outward pressure exerted

by the pad so as to allow the pad to expand outwardly to thereby permit the pad to be vertically compressed by the downward load.

The yielding of the frame 41 to the loaded pad 40 is aided by the fact that the horizontal thickness of the frame is greater than the horizontal thickness of the pad from its edge to its center. A relatively large horizontal thickness for the frame increases, of course, its total compliance per unit vertical area to outward pressure from the pad because such total compliance in compression is equal to the produuct of the frame thickness in the horizontal direction and the frame's compliance per unit vertical area per unit horizontal thickness.

The other type "A" damping plates respond like plate 30*c* to a static downward load as do the type "B" plates (e.g., plate 30*i*) excepting that the latter type plates have two expanding pads instead of one. Therefore, the static load of the anvil 11 is distributed over the shock-isolating structure 28 in such maner that the major part of the anvil load is carried by the vertically superposed sets of elastomeric pads (i.e., the array of support cores) and the minor part of the load is carried by the cork frames around the pads (i.e., the matrix of the structure). Under the static load, the cork frames in each layer of damping plates tend to expand slightly to make pressure contact with each other and to thereby close any clearances existing between adjacent columns under unloaded conditions. That pressure contact is not, however, great enough to permit transmission by shear of any substantial amount of the load on one column to the columns adjacent thereto. An advantage of the pressure contact is that, when the columns are so in side to side contact, each column is horizontally supported by its adjacent columns against being laterally deflected by the downward load.

Impact shocks received by the anvil 11 are distributed over the shock-insulating structure 28 in the same manner as the static load to produce effects in and on that structure which are generally alike to those which would be produced in accordance with the foregoing description if the static load were first to be increased and then reduced back to its initial value. In addition, certain transient effects are obtained. Specifically, because each of the elastomeric pads in the structure has a relatively high value for the ratio of its peripheral edge length to its area, and because the cork frame around each pad has both high compliance to a downward load thereon and high compliance to outward pressure exterted by the pad as it seeks to expand under the downward load, each layer of damping plates has much greater compliance to an impact load than would a layer of equal area and thickness constituted of a single pad of elastomeric material (or of timber). Therefore, in accordance with well known principles of mechanics, the shock-isolating structure 28 has a much lower frequency of response to a sudden impact shock than would a conventional structure comprised of plural layers of single elastomeric pads and/or plural layers of timbers. Also, because the cork material of the present structure has an excellent damping characteristic (i.e., has high internal friction and a slow recovery from compression), any mechanical oscillations induced in the structure 28 by the impact shock are much more rapidly damped out than in a conventional structure. Because of the considerations just mentioned, the structure 28 has the advantages over conventional shock isolating structures of providing a much higher percentage of attenuation of the shock transmitted thereto while, at the same time, suppressing any excessive rebound or continual oscillation that might affect the operating efficiency of the hammer. Moreover, because of the low frequency of response of the structure 28, it has little tendency to resonate with the underlying earth formations (which usually have a much higher resonant frequency), wherefore the structure and the earth formations do not act together to amplify the vibrations produced by the impact shock.

In the damping plates of the FIG. 1 structure, there is is little or no shear transmission of force from the pad or pads of the plate to the surrounding cork frame. Hence, if each column of the structure were to be constituted wholly of damping plates, there would be no interaction between the major part of the load which is carried by the pads forming the inner core (or cores) of the column and the minor part of the load carried by the cork frame which forms an outer vertical casing around that inner core (or cores). In other words, the one or more pad-formed cores of the column and the frame-formed casing of the column would act as separate support elements having entirely independent responses to the applied load. In those circumstances, however, there may be a variation from plate to plate in the column with respect to the amount by which each plate is loaded, the amount of bulging of the central pad or pads thereof, and the amount of compression (decrease of thickness) under load of the frame of each plate as compared to its pad or pads.

When, however, steel plates are interleaved in the manner shown with the damping plates of each column, the steel plates preclude such variations from arising. This is so because the steel plates are rigid and transmit force in shear to thereby replicate for each damping plate below the top one of the loading of the top plate by the contacting rigid member provided by the anvil 11. Under such conditions where the mode of loading of the top plate is, in effect, reconstituted by each steel plate for the damping which lies beneath it, all of the plates of the column are uniformly loaded, the pads thereof bulge uniformly, all the plates undergo a uniform amount of compression (decrease of vertical thickness), and, in each plate, there is no differential between the amount of compression of the pad or pads and the amount of compression of the surrounding cork frame. By so avoiding any peaking of the loading or bulging of the pads in the plates of a column, internal stresses due to bulge effect are minimized. Further, the steel plates plus the individual pads help dissipate heat so as to reduce the heat built up during operation. Still further, the arrangement of the steel plates in horizontal layers in which they fit closely, side to side, does much to increase the horizontal stability of the columns. That is, if a given column exerts a lateral force on adjacent columns, while the cork material in the damping plates of the adjacent columns might yield somewhat to that force, the steel plates of the adjacent columns would not do so and would, therefore, preclude lateral bowing of the given column by that force.

To give a practical example of the improvement afforded by the present invention, a 35,000 lb. steam drop hammer had previously used for shock-isolating purposes a structure comprised of two 12" layers of timbers plus three layers of ⅝" thick cotton duck impregnated with neoprene. Such hammer weighed over 1,120,000 lbs. including a 39,000 lb. ram and a 30,000 lb. upper die, the hammer comprising a 69,000 lb. falling weight actuated through 68" by 135 p.s.i. steam pressure in a 38" diameter cylinder. The vibration transmitted from such hammer through such prior art structure to the earth was within the limits considered acceptable by the prior art. Nonetheless, the impact from the hammer shook the whole neighborhood and caused fatigue and lowered efficiency of the workers in the hammer shop.

The described timber and fabric structure was replaced by a shock-isolating structure similar to that shown in FIG. 1 hereof. An extra layer of concrete was added to the underlying support block in order compensate for the difference in height between the old structure and the new one. Before installation, it was calculated that the new structure would reduce the earth-transmitted shock and vibration by 75% from its previous level. After installation, it was established by tests that the new structure had the effect of reducing the average value of

the acceleration (a measure of earth-transmitted shock) by a ratio of 6:1 or 83% with a maximum reduction by a ratio of 12:1, well in excess of 90%. The actual value of shock reduction obtained by the new structure exceeded that theoretically calculated for the probable reason (not taken into account in the calculation) that the lower frequency of response of the new structure cured a resonant condition which had existed between the old structure and the underlying earth.

The above described embodiment being exemplary only, it will be understood that additions thereto, modifications thereof and omissions therefrom can be made without reparting from the spirit of the invention, and that the invention comprehends embodiments differing in form and/or detail from that specifically disclosed. Accordingly, the invention is not to be considered as limited save as is consonant with the recitals of the following calims.

In the claims:

1. A foundation structure comprising, a two-dimensional horizontal array of vertical support cores each comprised of vertically supreposed elastomeric pads, the pads of each core being in spaced relation from the pads of adjacent cores, and a matrix compressible material disposed around said cores and having a greater compliance than said array of cores to a downward load applied to said structure, said matrix being yieldable to outward pressure exerted by said pads under said load to permit outward expansion of said pads.

2. A foundation structure comprising, a two-dimensional horizontal array of vertical support columns each comprised of vertically superposed horizontal damping plates of which each is comprised of central elastomeric pad means and of elastically compressible frame means disposed around such pad means and having greater compliance than said pad means to a downward load applied to the plate, the frame means of each plate being yieldable to outward pressure exerted by the pad means thereof when under said load to permit outward expansion of such pad means.

3. A foundation as in claim 2 in which a plurality of rigid plate means are interleaved in each column with the vertically superposed damping plates thereof.

4. A foundation structure as in claim 2 in which said columns are disposed side to side in close fitting relation to each other in said dimensions of said array, said columns being prismatic to provide such close mutual fit.

5. A foundation structure as in claim 2 in which the respective damping plates of said columns form in said structure a plurality of horizontal layers of plates, and in which the plates in each layer are disposed side to side in close fitting relation with each other, said last named plates being prismatic to provide said close fitting relation.

6. A foundation structure comprising, a two-dimensional horizontal array of vertical prismatic support columns each comprised of a plurality of vertically superposed prismatic damping paltes of which each is comprised of elastomeric pad means and of elastically compressible frame means around such pad means, the respective plates of said columns forming in said structure a plurality of horizontal layers of plates, and the plates in each layer being disposed side to side in close relation with each other, said close fitting relation being provided by the prismatic shape of said plates.

7. A foundation structure as in claim 6 in which the frame means of each plate has greater compliance to a downward load than the pad means thereof, and in which such frame means is yieldable to outward pressure exerted by such pad means under such load to permit outward expansion of such pad means.

8. A foundation structure comprising, a two-dimensional horizontal array of vertical prismatic support columns each comprised of a plurality of vertically superposed prismatic damping plates and a plurality of prismatic rigid plates interleaved in such column with the damping plates thereof, each of said damping plates being comprised of central elastomeric pad means and of elastically compressible frame means around said pad means and having a greater compliance to a downward load than such pad means, and such frame means being yieldable under outward pressure exerted by such pad means when under said load to permit outward expansion of such pad means, the respective damping plates and rigid plates of said columns forming in said structure a plurality of vertically superposed horizontal layers of damping plates interleaved with a plurality of horizontal layers of rigid plates and the plates in each such layer being disposed side to side in close fitting relation with each other, said close fitting relation being provided by the prismatic shape of such plates.

9. A foundation structure comprising, a two dimensional array of individually loadable columns each comprised of a plurality of vertically superposed elastically compressible plates and of a plurality of rigid plates interleaved with said elastically compressible plates, the plates in each column being unsecured in horizontal position in the absence of the other columns, the respective plates of said columns forming in said structure a plurality of horizontal layers of plates, each layer being in one continuous plane over the horizontal area of said array, and each plate in each such layer being in at least proximate contact with adjacent plates to render each plate in that layer constrained in horizontal position by said adjacent plates.

References Cited by the Examiner

UNITED STATES PATENTS

1,666,311	4/1928	Rosenzweig	248—22 X
2,184,482	12/1939	Austin	161—113
2,255,571	9/1941	Rosenzweig	248—22
2,447,712	8/1948	Nathan	248—22
2,724,670	11/1955	Mason	248—22 X
2,775,998	1/1957	Osborn	267—1
2,982,536	5/1961	Kordes	267—1

FOREIGN PATENTS

1,241,030	8/1960	France.
398,657	9/1933	Great Britain.
404,895	1/1934	Great Britain.
890,942	3/1962	Great Britain.

CLAUDE A. LE ROY, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,218,008 November 16, 1965

Jack Harris

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 39, for "horidontal" read -- horizontal --; column 5, line 37, for "whreas" read -- whereas --; column 6, line 39, for "valve" read -- value --; line 44, for "tht" read -- the --; column 7, line 36, for "shock-insulating" read -- shock-isolating --; column 8, line 26, strike out "of", first occurrence; line 69, after "order" insert -- to --; column 9, line 18, for "calims" read -- claims --; line 22, for "supreposed" read -- superposed --; column 9, line 24, after "matrix" insert -- of --; line 58, for "paltes" read -- plates --.

Signed and sealed this 6th day of September 1966.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

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