June 3, 1930. F. D. CUMMINGS 1,761,660

BUILDING CONSTRUCTION (QUAKEPROOF BUILDING)

Filed Oct. 16, 1928 2 Sheets-Sheet 1

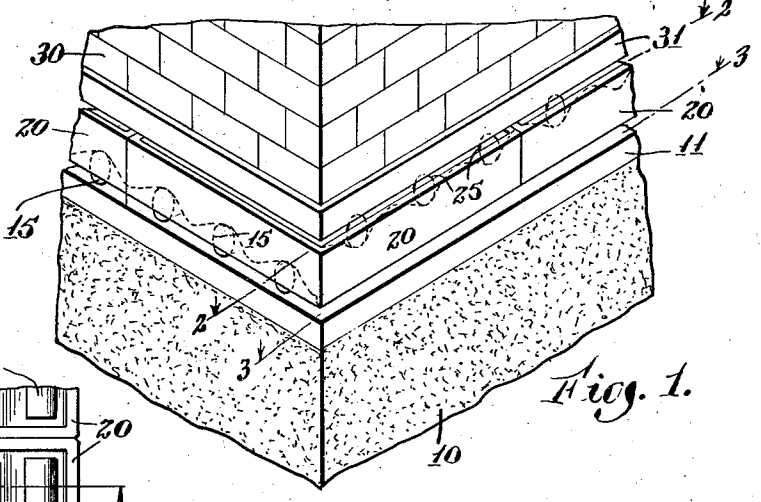


Fig. 1.

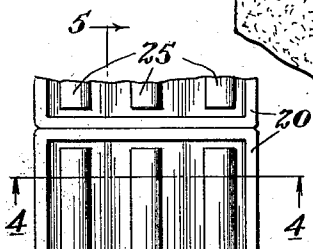
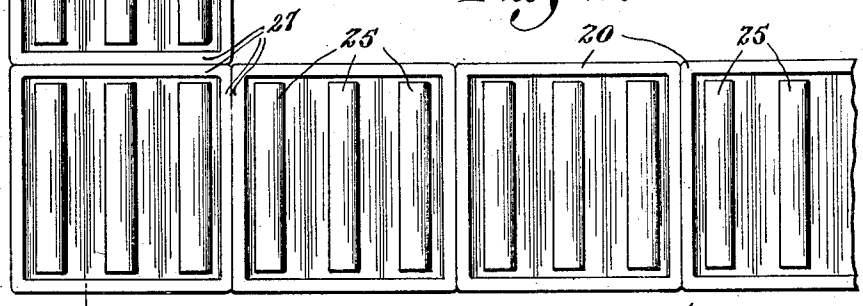


Fig. 2.



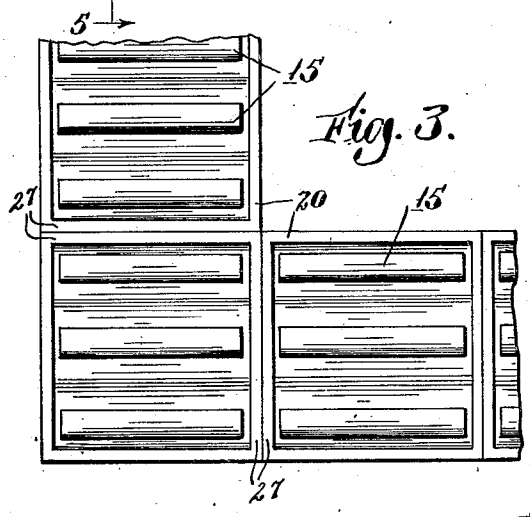
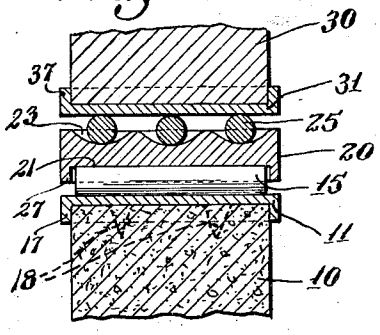


Fig. 3.

Fig. 4.



Inventor
Frank D. Cummings
by Mitchell, Chadwick & Kent
Attorneys

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Fig. 5.

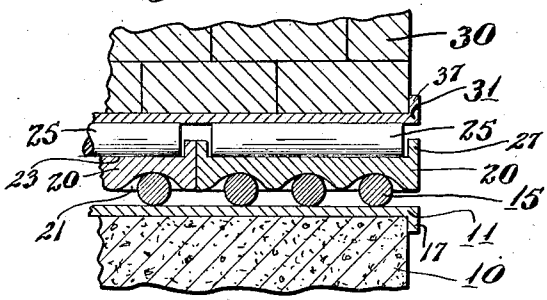
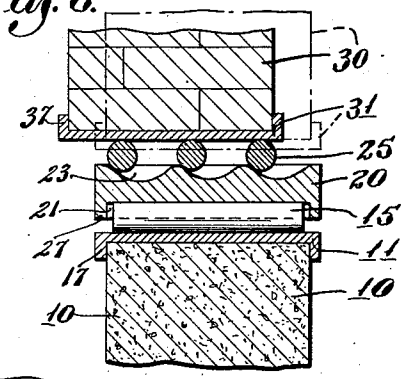


Fig. 6.



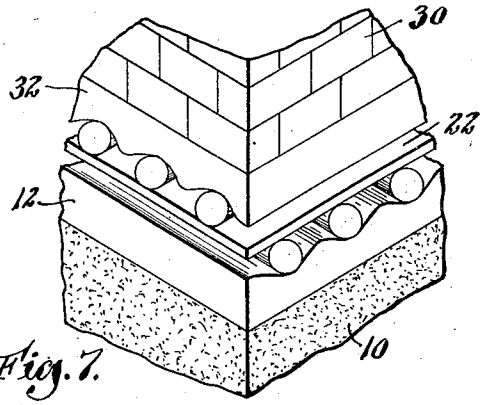


Fig. 7.

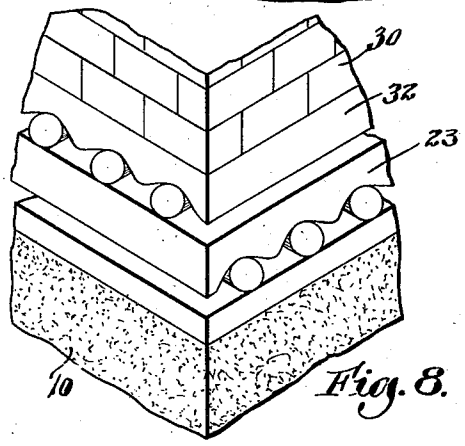


Fig. 8.

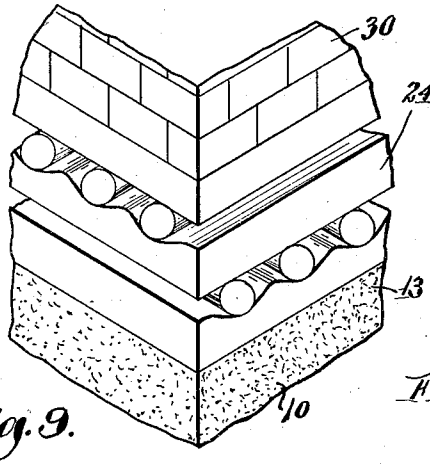


Fig. 9.

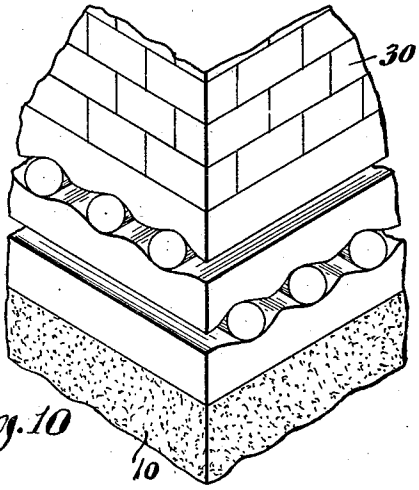


Fig. 10

Inventor
Frank D. Cummings
by Mitchell, Chadwick & Kent
Attorneys

Patented June 3, 1930 1,761,660

UNITED STATES PATENT OFFICE

FRANK D. CUMMINGS, OF LOS ANGELES, CALIFORNIA

BUILDING CONSTRUCTION (QUAKEPROOF BUILDING)

Application filed October 16, 1928. Serial No. 312,849.

This invention relates to improvements in building construction, (quake proof building).

More especially it provides for the embodiment of improved quake-absorbing elements, for reducing materially the dislocating effects of earthquakes and the like upon buildings and other structures, with resulting damage to persons and property.

In my co-pending application for patent Serial No. 247,607, I have disclosed and claimed means to this end, which, by a sort of flexible earth-connection to a large degree prevents the oscillations of the earth from being communicated to the structure and its contents. The present invention embodies improvements in the quake-absorbing elements, and the disclosure herein is of a species different from the species claimed in the said application.

The invention relates in general to the mounting of the superstructure of the building, or of the other engineering work which is to be protected, as for instance an aqueduct or a bridge, on a foundation cleavage containing a multiplicity of rollers. The lines of contact between rollers and structure afford a total supporting area which is vastly greater than where the rolling elements are balls, as heretofore proposed, and, as compared with ball supports, this correspondingly reduces the intensity of the crushing forces to which the rolling elements are subject, when in action, and when at rest. This in turn reduces the deformation of each rolling element, resulting from its compression, and increases the facility with which all of them start into action when occasion arises. These distinctions become of especial importance where buildings of substantial weights and heights are to be protected. In the said co-pending application the species illustrated and claimed includes two cleavages, the one having rollers extending at right angles to the rollers in the other; and with the embodying of a cam in each rolling element, so that, with lateral amplitude of quake, the cam introduces a lifting of the structure, and gravity tends to return the structure to original position.

In the species herein set forth the rollers may be cylindrical. A cam is embodied in one or both of the surfaces against which a roller contacts. Practical problems of building such a shiftable combination into a wall accurately and economically are met by providing for bearing plates which can be easily laid by those skilled in the construction of masonry or concrete, and which become respectively rigid with the foundation or the superstructure, and which provide the desired cam lifting effect by co-acting with the rollers when an earthquake occurs. Several ways are illustrated herein. The bearing plates may have, on their backs, lugs or projections for more rigid inbuilding with the foundation or with the superstructure. Their respective faces, which constitute walls of the cleavages containing the rollers, may be corrugated in valleys whose rising slopes constitute the cams. Varieties of these are described herein with their advantages. It is intended that the patent shall cover by suitable expression in the appended claims whatever of patentable novelty is found in the invention disclosed.

The accompanying drawing illustrates several embodiments, differing slightly, which are illustrative applications of the invention.

In the drawings:

Figure 1 is a perspective of a lower fragment of a building embodying features of the invention;

Figure 2 is a plan of the fragment seen in Figure 1, in section on the upper cleavage plane, indicated at 2—2;

Figure 3 is a similar plan, in section on the lower cleavage plane, indicated at 3—3;

Figure 4 is an elevation, in section on 4—4 of Figure 2;

Figure 5 is an elevation, in section on 5—5 of Figure 2;

Figure 6 is a diagrammatic showing of positions which may be assumed by rollers and their engaging elements when a shock occurs; and

Figures 7–10 are perspective of alternative arrangements of the cam surfaces.

Referring to the drawings, and especially to the form of the invention illustrated in Figures 1–5, the building foundation 10 and its superstructure 30 are represented as being held apart by rollers 15 and 25, with median plate 20 between the rollers. The rollers 25 are arranged in a cleavage which extends under the superstructure at the level 2—2, above the median plate 20; and the rollers 15 are in another cleavage at the level 3—3, below the median plate 20. These cleavages are horizontal and parallel. As represented, the whole of each cleavage is in a single horizontal zone, but the whole extent of a cleavage is not necessarily so. The median plate 20, which is separated by the cleavages from both foundation and superstructure, rests on the tops of the rollers 15 of the lower set, and supports the rollers 25 of the higher set. The cam surfaces are arranged so that each roller bears against at least one cam surface, which may be below it or above it; and there may be such surfaces bearing upon it both below and above, as in Figure 10. These cam surfaces are in the nature of shallow valleys with intervening rounded ridges, Figures 4, 9. In the middle of each of these valleys a roller rests; or the valleys may be inverted over the rollers, Figures 5, 8. Preferably the median plate 20 will be of metal, and usually made of sections, of convenient length, (short, like building blocks; or long, like stringers) arranged in succession along the foundation. It will have its surfaces, either both plane; or both furrowed with valleys; or one surface plane and one surface furrowed; as may be elected by the designer. The furrows in the same cleavage are all parallel to each other; and these all run at right angles to those in the other cleavage. Preferably the rolling surface is made without any sharp peak at its highest point. Then if an earth movement is of such amplitude as makes the rollers run over the crest, the smoothness of the curve will facilitate the rollers being brought back to their original position by the return oscillation of the earth.

With the form of plate 20 seen in Figures 1–5 the roller-engaging surfaces of both foundation plate 11 and superstructure plate 31 may be plane. This simplifies the construction of the foundation and superstructure. All of the cam surfaces will then be provided on the median plate 20, being seen at 21 on its under surface and at 23 on its upper surface. The cams can thus be prepared in advance with as great precision as may be desired, by the making of this one plate, which can be made by casting, forging, machining, or whatever desired method of manufacture and of finish, may be most easy, good and economical. And the top face of the foundation 10 may be a steel plate 11 comprising a standard steel shape which needs only to be laid truly horizontal by the mason or other craftsman. Then, if the rollers and plates 15, 20, 25 and 31 have been accurately made, it is only necessary to lay them loosely in their proper places and then to proceed with the superstructure. Standard steel shapes can also be utilized for the under plate 31 of the superstructure 30.

But, as seen in Figure 7, if it be desired, the roller-engaging under surface of the superstructure may be a plate 32 having the cams; and similarly the roller-contacting face of the foundation may be a plate 12 having the cams, in which case the median plate 22 might be plane both on upper and lower faces as in Figure 7. Or, if desired, the cam valleys may all be inverted as in Figure 8, being formed in a median plate 23 and in a superstructure plate 32; or both may be concave upward, as in Figure 9, in the plates 24 and 13; or the cam valleys may be duplicated for each roller, one with hollow up and the other inverted with hollow down, as in Figure 10. In this last case the rise of the cam need be only one half as great, on each member, for the getting of a desired lift. Where both are concave downward there is less of a pocket underneath for the gathering of dirt or foreign matter that might obstruct the operation.

The respective plates 11, 20 and 31 may either be in long lengths, as beams, or be composite, in short lengths, comparable to building blocks, of masonry or other sort, it being a matter of choice whether to lay the plates 11 and 20 and 31 in long units or in short units. These may have flanges to house the rollers endwise, examples being seen at 27. They may have flanges to grasp securely the top of foundation and bottom of superstructure, as at 17 and 37. And, especially if the plate be in small units, there may be projections 18 (Fig. 4) from the plate into the adjacent concrete or masonry, of foundation or of superstructure, in order the more firmly to lock the surface plate in rigid relation with the foundation or superstructure of which it is a portion. The plate 31 may constitute a sill for the superstructure, if this plate be a long unit; and masonry blocks may be laid on it as in Figures 1 and 4. Or, if it be in short sections, a long sill may be laid over the sections, in which case the part 39 in Figure 4 might represent a cross section of such a sill of wood, upon which construction could proceed.

The drawing represents in Figure 1 a foundation 10 of poured concrete, and a superstructure 30 of concrete blocks, laid as masonry on a long steel flanged plate 31 which constitutes the sill. The plates 11 and 20, on the contrary, are represented as

being made up of separate square sections, each holding three rollers. By this device a single model of plate-section can be used all around the wall, whether the valleys therein be set lengthwise or crosswise of the particular portion of wall where the section is located. For the structure shown in Figure 4 the sections of plate 20 have one shape and the sections of plate 11 have another; but for the structure shown in Figure 9 the sections of foundation plate 13 and of median plate 24 may be identical in shape; and if square may be laid in succession all around the structure, regardless of corners and changes in direction of the course of the wall. In any case it is well to have a roller positioned close to each edge of the wall of the building as those at right and left sides in Figure 4; and to have one or more between them. This makes a broad bearing base for supporting whatever is above.

A structure thus embodying the invention is largely unresponsive to horizontal forces whose natural tendency would be to dislocate or demolish it. The foundation can yield to and fro horizontally in any direction, moving upon each set of rollers simultaneously whatever distance is needed so that, by the combination of both, the foundation moves away from the superstructure in any direction with the quaking of the earth, while the superstructure will be lifted and lowered slightly as the rollers 14 ride up and down their respective cams; and if the quake leaves the foundation permanently displaced laterally from its original location, the superstructure automatically will move to where the foundation is, by gravity, with the rollers running back to the depths of the valleys.

As each of the cam surfaces is in the nature of a groove, or valley, the rigidly parallel walls thereof maintain the parallelism of all the rollers in a particular cleavage. If the rollers are cylindrical, all will come to rest in the middles of the valleys with their tops at uniform height. Thus the rollers will tend to arrange themselves in proper operative positions, and will be retained in such positions; and normally gravity will hold them at rest, ever ready to provide for the desired yielding of foundation in any direction at time of earthquake hazard.

The ability of the device to respond to oscillations in any horizontal direction is due to the angular relation between the two directions in which rolling movements can occur and can combine to produce the desired resultant movement. This resultant is attained most easily and simply when the said relation is rectangular, which is the arrangement likely to be most used in practice. Hence rectangularity is the relation between valleys and between rolling movements in the different zones indicated in the claims; but it will be understood that this is only an approximate term.

I claim as my invention:

1. A device for protecting a structure against earthquakes, comprising the provision of two horizontal foundation cleavages in the structure; rolling elements in each of said cleavages for supporting the load imposed by the superstructure, the elements in one cleavage having contacts with the corresponding cleavage surfaces extending perpendicularly to like contacts in the other cleavage, whereby all together permit a resultant rolling movement between sub-structure and superstructure with horizontal component in any direction; and cams in said cleavages co-acting with said rolling elements to provide a relatively slight vertical component of movement of the superstructure simultaneously with its said rolling.

2. A structure having earthquake protection comprising two horizontal foundation cleavages; plates lining the cleavage surfaces, one of said plates being provided with parallel valleys, constituting cam surfaces, extending perpendicularly to like valleys in another plate; and bearing rollers in the valleys for lifting the superstructure upon movement of the foundation in any horizontal direction, said rollers having line contacts with said plates and serving at all times to support the load imposed by the superstructure.

3. An earthquake protection for a structure, comprising two sets of cylindrical load-supporting rollers arranged in different horizontal zones at the foundation of the structure; and a plate, located between the two sets of cylindrical rollers, forming part of the structure and having its upper and under surfaces respectively in contact with the rollers of the two sets; and cam surfaces for engaging the rollers in line contact.

4. The combination, with a structure, of earthquake protection comprising two load-supporting layers of elongated rollers, there being elongated shallow valleys occupied by the individual rollers between the earth and the superstructure which is to be protected.

5. An earthquake protection for a structure, comprising two sets of cylindrical load-supporting rollers in different horizontal zones, and shallow valleys formed in the structure, wherein the rollers lie, those in one set being perpendicular to those in the other set.

6. An earthquake protection for a structure, comprising two sets of cylindrical load-supporting rollers in different horizontal zones and a plate there between having shallow valleys formed in its upper surface and similar valleys, inverted and running at right angles thereto in the lower surface, in

which valleys said load-supporting rollers are received.

7. An earthquake protection for a structure having walls, comprising two sets of cylindrical load-supporting rollers in said walls in different horizontal zones, and, associated therewith, and plates, having cam valleys which the rollers occupy said plates being made up of a succession of unit-sections which individually have length approximately equalling the width of wall.

8. An earthquake protection for a structure having walls, comprising two sets of cylindrical load-supporting rollers in said walls in different horizontal zones, and, associated therewith, and plates having cam valleys which the rollers occupy, said plates being made up of unit-sections each of which individually is approximately as long and as wide as the width of the wall and each of which has valleys positioned in it near its opposite edges, those on one side of the plate-section being perpendicular to those on the other.

9. A structure having two horizontal foundation cleavages with load-supporting rollers at each cleavage, all rollers in the same cleavage being parallel and being at a substantial angle to those in the other cleavage.

10. A structure having two horizontal foundation cleavages with load-supporting rollers at each cleavage, all rollers in the same cleavage being parallel and being at a substantial angle to those in the other cleavage, said rollers having cam surfaces associated therewith whereby the superstructure is raised by their rolling.

11. A structure having cleavage space extending horizontally between its foundation and superstructure, and, associated with said cleavage space, load-supporting rollers carrying the weight of the superstructure and arranged in two superimposed zones, the rollers in one zone being arranged to roll in one horizontal direction and those in the other zone to roll in a different horizontal direction.

12. A structure having a plurality of horizontal cleavages between foundation and superstructure, and, at each cleavage, load-supporting elements arranged for horizontal movement of the superstructure thereon, each said load-supporting element having line contact with the surfaces of its cleavage and extending angularly with respect to the load-supporting elements of an adjacent cleavage.

Signed at Los Angeles, Calif., this ninth day of October, 1928.

FRANK D. CUMMINGS.

CERTIFICATE OF CORRECTION.

Patent No. 1,761,660. Granted June 3, 1930, to

FRANK D. CUMMINGS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, line 104, claim 3, and page 4, lines 7 and 16, claims 7 and 8, respectively, strike out the word "and"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of July, A. D. 1930.

Wm. A. Kinnan,
Acting Commissioner of Patents.

(Seal)