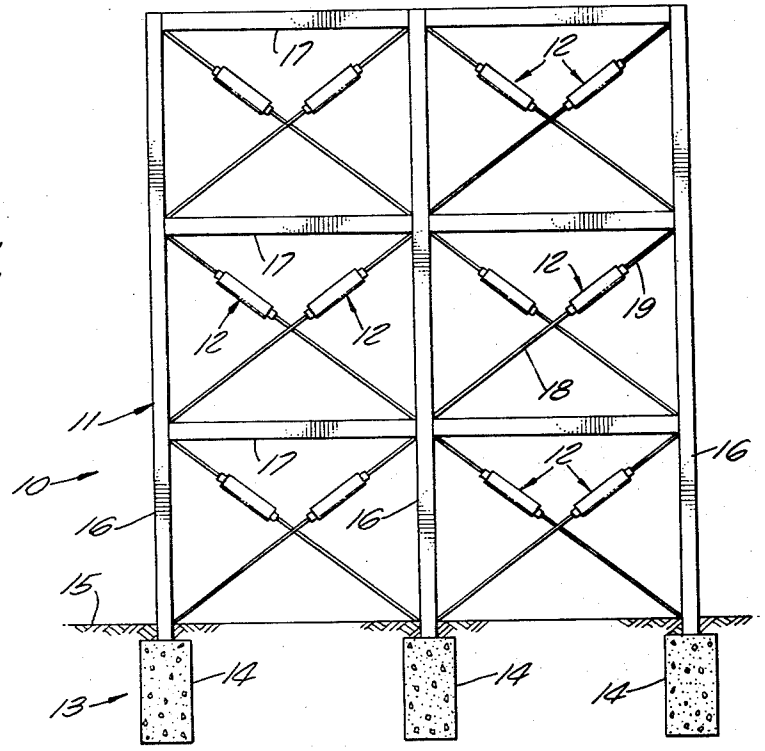
Dec. 31, 1968 B. CARDAN 3,418,768

BUILDING CONSTRUCTION

Filed July 21, 1966

FIG. 1.



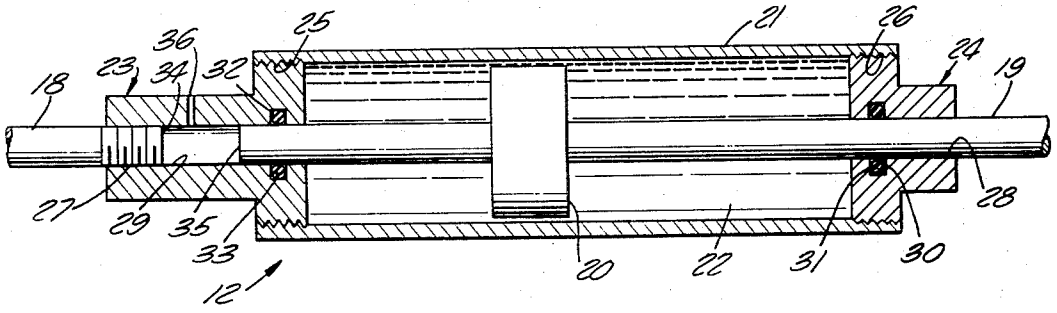


FIG. 2.

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BUILDING CONSTRUCTION

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ABSTRACT OF THE DISCLOSURE

The basic housing structure is a generally rectangular load-bearing unit consisting of a pair of spaced vertical supports secured together by a pair of spaced horizontal supports. The diagonally opposite corners at which the horizontal and vertical supports adjoin are interconnected via respective non-load-bearing structures each including a dashpot. When the construction is subjected to a relatively high velocity motion, such as motion induced by an earthquake, relative horizontal movement of the horizontal and vertical supports cause movement in the dashpot, resulting in conversion of kinetic energy into heat.

This invention relates to the construction of apartment buildings, office buildings or any other structure having a foundation on the earth, and more particularly to an arrangement for economically increasing the ability of a building in withstanding earthquakes or other similar types of loads.

In the past dashpot type protective devices have been employed in building constructions. These are disclosed in resilient type foundation applications in Rubenstein U.S. Patent No. 2,950,576. Dashpots are also disclosed for a superstructure in Ruge U.S. Patent No. 2,053,226. However, the Ruge devices are spring biased, main or load bearing members. Ruge explains that each spring is normally placed under initial stresses sufficient to make it substantially rigid under ordinary conditions. A spring thus, for example, gives when an extraordinary earthquake load is imposed on the structure.

Unfortunately, the spring biased devices of Ruge do nothing for a building to absorb stresses imposed by moderate earthquakes and the major part of a severe one. Also, the initial stress under which a spring is placed makes the building resist motion jerkily when finally the spring begins to give and on the way back stops at the original length. However, most important is the fact that the springs are installed in a rigid truss system rather than a flexible moment resisting frame system, thereby increasing the magnitude of the seismic force rather than decrease it.

In accordance with the construction of the present invention, the above-described and other disadvantages of the prior art are overcome by providing an arrangement having dashpots to damp the vibration thereof. However, in accordance with the present invention, the dashpots are not spring biased. They are not load bearing members but act as redundant members. Moreover, even the static friction they develop is wholly insignificant in comparison to the dynamic friction they develop. Thus, as distinguished from the initial stress imposed on the Ruge springs, the devices of the present invention offer substantially zero resistance to building sway at zero velocity. Further, there is no resilience added to the building. Thus, pure vibration damping actually limits the maximum sway of a building and increases its ultimate strength. As the other side of the same coin, the device of the present invention has the advantage of reducing the cost of a comparative building of the prior art because it is not necessary to use building materials and component parts which are as large or as strong as those required in the prior art.

From the foregoing, it will be appreciated that conventional buildings that are now standing may be made more earthquake resistant by simply adding the device of the present invention.

It is a feature of the present invention that the device thereof on a building forces a fluid through a constriction as the building sways. A further feature of the invention resides in the use of an incompressible fluid. By using such a fluid the spring-like characteristic of a compressible fluid like a gas is thereby avoided.

The above-described and other advantages of the present invention will be better understood from the following description when considered in connection with the accompanying drawings.

In the drawings which are to be regarded as merely illustrative:

FIG. 1 is a side elevational view of a building construction made in accordance with one embodiment of the present invention; and

FIG. 2 is an enlarged longitudinal sectional view of damping means employed in the structure of FIG. 1.

The building construction of the present invention is indicated at **10** in FIG. 1. Construction **10** includes a frame **11** of a building with damping means **12** mounted therein. Except for damping means **12** building **11** may be entirely conventional. Building **11** has a foundation **13** including concrete footings **14** in the ground **15**. Building **11** also includes vertical steel load supporting columns **16** and horizontal steel supporting beams **17**. Building **11** may be any size, as desired. Building **11** is symmetrical. All the vertical and horizontal members are identical and all of them are not shown because they are identical. Building **11** is square. It has a width and length identical to the width shown in FIG. 1. It has a uniform and flat roof. Building **11** is a three story building.

Vertical and horizontal members **16** and **17** are riveted, bolted or welded together, as is conventional. Damping means **12** are pinned at its ends, not shown, to the intersection of members **16** and **17**. One of the means **12** is shown in FIG. 2. Means **12** includes a hollow cylinder **21** into which plugs **23** and **24** are threaded at **25** and **26**, respectively. The fit of plugs **23** and **24** in cylinder **21** provides a fluid-tight seal thereat to eliminate leakage of a fluid **22** inside cylinder **21** out of the ends of cylinder **21** between plugs **23** and **24** and cylinder **21** at the threads **25** and **26**.

A rod **18** is fixed to plug **23** at a thread **27**. A rod **19** is movable inside plugs **23** and **24**, and inside cylinder **21**. Rod **19** has a piston **20** fixed thereto inside cylinder **21**. Rod **19** extends through a bore **28** in plug **24** and into a bore **29** in plug **23**. Plug **24** has an internal groove **30** therein which carries an O-ring seal **31**. Similarly, plug **23** has an internal groove **32** therein which carries an O-ring seal **32**. The ends of rods **18** and **19** are spaced from one another at **34** and **35** inside plug **23**. Plug **23** has an air vent **36** which extends radially through the wall thereof from the exterior to the interior of bore **29** between rod ends **34** and **35**.

Piston **20** has an outside diameter somewhat smaller than the inside diameter of cylinder **21**. Movement of piston **20** relative to cylinder **21** thus causes a flow of fluid **22** to one side of piston **20** to the other side thereof. Fluid **22** may be conventional hydraulic fluid. Fluid **22** fills the entire space inside cylinder **21** between plugs **23** and **24** around rod **19** and piston **20**.

Due to the fact that plugs **23** and **24** are sealed to cylinder **21** and due to the fact that O-rings **31** and **32** also act as hydraulic seals, fluid **22** is trapped inside cylinder **21**. O-rings **31** and **32** bear against and thus fit tightly between rod **19** in plugs **24** and **23**, respectively.

In the operation of the damping means **12**, if building **11** is subjected to an earthquake load, swaying of building

11 will cause piston 20 to move relative to cylinder 21 throughout all of the damping means 12 shown in FIG. 1. This will cause fluid 22 to flow from one side of piston 20 to the other side thereof and back again. The flow of fluid 22 in the small space between piston 20 and the internal surface of cylinder 21 will then generate heat, part of the energy imparted to building 11 as it sways back and forth due to an earthquake will be absorbed in damping means 12.

As stated previously, damping means 12 takes several forms, and any one of a number of alternative embodiments conventional or otherwise may be usefully employed in lieu of the damping means 12 disclosed herein. For example, the fit of the piston 20 inside cylinder 21 may be very close, and the principle flow of fluid 22 therein controlled by the ports extending completely through piston 20. Further, this construction or any other construction for damping means 12 may be employed in different combinations of alternative constructions.

Damping means 12 may also take the form of an external passage from one end of cylinder 20 to the other. If substantial heat is generated in such an external passage, heat transfer fins might be provided on the external passage.

If desired, damping means 12 shown in FIG. 2 may be provided with an external spring biased piston to maintain the pressure inside cylinder 21 somewhat above atmospheric, even though the available volume inside cylinder 21 stays constant or changes with the relative position of rod 19 therein.

The cylindrical surface of piston 20 may be smooth. On the other hand, this external surface may be grooved axially or spirally, if desired. A circumferential groove may be provided in this surface, if desired.

Note will be taken that it is an outstanding feature of the present invention that the sway of building 11 is absorbed in some friction producing device. Thus, the construction 10 of the present invention is not limited to the damping means 12, but is limited only to friction means for producing heat through the forcing of a liquid through some kind of constriction.

The word "fluid" is hereby defined for use in this description and in the claims to follow as any fluid which is liquid or in a semi-solid or amorphous state, such as is heavy grease.

The word "rectangle" as used in this description or in the claims to follow is hereby defined, as it is usually defined in mathematics, to include a square which is a special case of a rectangle with four equal sides.

In accordance with the present invention, the damping means 12 employed therein may be dashpots which, if desired, may be adjustable. Thus, optimum damping may be achieved if an external passage providing a constriction is employed wherein the orifice thereof can be adjusted from a smaller to a larger size, or vice versa.

Note will be taken, it is an outstanding feature of the mode of operation of the present invention that if the velocity of piston 20 approaches zero, movement of piston 20 inside cylinder 21 is not substantially resisted. That is, the dynamic friction created by damping means 12 is far greater than the static friction that exists between plugs 23 and 24, seals 31 and 32, and rod 19. If it is not already abundantly clear, building 11 is provided with nine footings 14 because it is square. It also has nine vertical beams 16.

As distinguished from the damping means disclosed in the said Ruge patent, note will be taken that damping means 12 are not load bearing members. They are redundant. Only members 16 and 17 are main or load supporting members.

Note will be taken that none of the damping means 12 employ a spring. Thus, the disadvantages of the spring-biased devices of the prior art are avoided. Thus, as distinguished from the initial stress imposed upon the springs of the prior art devices, the damping means of the present invention offer a resistance to building sway which approaches zero as building sway velocity approaches zero. Note will be taken that prestressed springs will offer a resistance to building sway at any velocity. Further, the damping means 12 of the present invention add no appreciable resilience to the building 11. Thus, the vibration damping afforded thereby actually reduces the maximum sway of a building and therefore increases its ultimate strength. It is therefore possible to build a stronger building or to build a useful building with fewer and lighter component structures at less cost.

It will also be appreciated that damping means 12 may be mounted in conventional buildings to make them stronger.

It is an outstanding feature of the present invention that fluid 22 is incompressible. Thus, in this case, damping means 12 has no spring-like characteristic as a compressible fluid like gas has.

In a building any number of devices 12 may be used in any or all of the frames and in any or all of the floor levels.

The device 12 may be inserted in a member 18 and 19 that is able to resist tension only, compression only or both.

Although only one specific embodiment of the present invention has been described and illustrated herein, many changes and modifications will of course suggest themselves to those skilled in the art. This single embodiment has been selected for this disclosure for the purpose of illustration only. The present invention should therefore not be limited to the embodiment so selected, the true scope of the invention being defined only in the appended claims.

What is claimed is:

1. An earthquake proof high-rise building comprising: a foundation; a plurality of main, load bearing column members connected to said foundation; a plurality of main, load bearing beam members fixed between adjacent pairs of said column members; a dashpot-like device having a cylindrical rod connected from each end to two corresponding ones of said members, said device being a non-load bearing, redundant member, longitudinal movement of one of said rods in either direction relative to the other one thereof being wholly resisted only by non-resilient resistance means in said device, said means having negligible static friction compared to its dynamic friction; said device including a hollow cylinder, having a closure at each end thereof; one of said rods extending completely through said cylinder and through both of said closures thereof, a piston inside said cylinder fixed to said one rod in a position concentric with said cylinder; and a fluid inside said cylinder, said cylinder being fluid tight, said device being constructed to permit a restricted flow of said fluid from a position inside said cylinder on one side of said piston to a position inside said cylinder on the other side of said piston, said closures being sealed to said cylinder, each of said closures including a plug having an O-ring groove therein and an O-ring seal in each said groove compressed against said one rod, said plugs having bores therein to receive said one rod, one of said plugs being connected to the other of said rods, said other rod being threaded into the end of said bore therein, the mutually adjacent ends of said rods being located in spaced relation inside the bore in said one plug, said one plug having a vent hole thereinto extending from the exterior thereof into the interior of the bore thereof at a position between said rod ends in the space inside said one plug bore between said rod ends, the outside diameter of said piston being slightly smaller than the inside diameter of said cylinder, all of the space inside said cylinder between said plugs and around said piston and said one rod being completely filled with said fluid, said fluid being an incompressible liquid.

2. An earthquake proof high-rise building compris-

ing: a foundation; a plurality of main, load bearing column members connected to said foundation; a plurality of main, load bearing beam members fixed between adjacent pairs of said column members; a dashpot-like device having a cylindrical rod connected from each end to two corresponding ones of said members, said device being a non-load bearing, redundant member, longitudinal movement of one of said rods in either direction relative to the other one thereof being wholly resisted only by non-resilient resistance means in said device, said means having negligible static friction compared to its dynamic friction; said device including a hollow cylinder, having a closure at each end thereof; one of said rods extending completely through said cylinder and through both of said closures thereof, a piston inside said cylinder fixed to said one rod in a position concentric with said cylinder; and a fluid inside said cylinder, said cylinder being fluid tight, said

device being constructed to permit a restricted flow of said fluid from a position inside said cylinder on one side of said piston to position inside said cylinder on the other side of said piston.

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