L. KOHL.
DEVICE FOR PROTECTING BUILDINGS AGAINST EARTHQUAKES.
APPLICATION FILED JULY 3, 1914.

1,158,932. Patented Nov. 2, 1915.

Fig 1

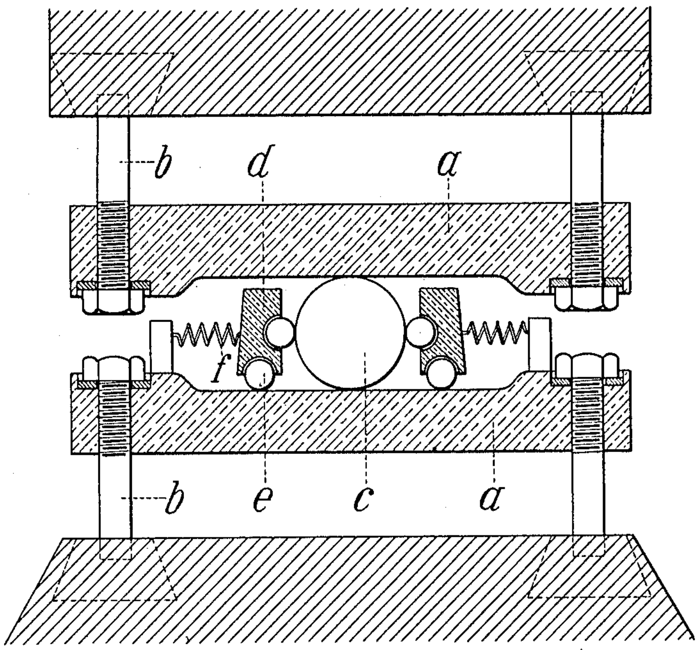
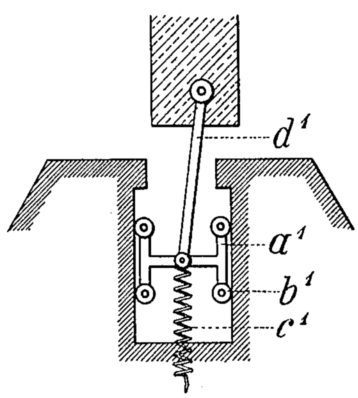


Fig 2



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LUDWIG KOHL, OF FRANKFORT-ON-THE-MAIN, GERMANY.

DEVICE FOR PROTECTING BUILDINGS AGAINST EARTHQUAKES.

1,158,932. Specification of Letters Patent. Patented Nov. 2, 1915.

Application filed July 3, 1914. Serial No. 848,989.

To all whom it may concern:

Be it known that I, Ludwig Kohl, a subject of the German Emperor, and resident of Frankfort-on-the-Main, Germany, have invented certain new and useful Improvements in Devices for Protecting Buildings Against Earthquakes, of which the following is a specification.

The hitherto known devices for protecting buildings against earthquakes, consisting of ball-bearings between basement and building, have so serious drawbacks that their practical employment is impossible, because: 1, the connection between building and basement was unsatisfactory; 2, they do not decrease the vehemency of the horizontal shocks to the minimum extent required; 3, they do not allow an exact static calculation of the building previously and independently from the strength of the shocks; and 4, they do not take up the vertical shocks.

The present invention proposes to overcome all these drawbacks detrimental to the security of the buildings in earthquake regions, by allowing to effectively protect the buildings against horizontal and vertical shocks within wide limits.

The accompanying drawing illustrates how the invention is put into practice.

Figure 1 is a vertical section through the ball-bearing, Fig. 2 shows the vertical anchorage.

The main principle of the invention is as follows:—Between foundation or basement and the building proper, an appropriate ball-bearing is inserted, whereby the building can move within the required limits as resistanceless as possible toward the basement, without compensating thereby the necessary connection in vertical direction between basement and building. For this purpose, in the gap between building and basement, the two ball-bearings *a* are arranged, the upper one being connected with the building and the lower one with the basement. The bearings *a* are turnable for a small degree by means of strong screw-bolts *b* movably arranged in the basement and building respectively, so that the bearings are allowed to tilt somewhat toward the horizontal plane or to return from the tilted position into the horizontal position. Both movements are essential, particularly the latter one. For, in order to obtain a smallest possible resistance against a movement of the building toward the basement in horizontal direction, it is essential that the bearing planes of all balls lie practically in the same horizontal plane. The screw-bolts *b* serve thus chiefly for making all ball-bearing planes, as far as possible, parallel to one another. This exact parallel position is an essential requirement for the proper working or operation of the device, because with non-parallel bearing-planes the balls, with large movements of the basement, would roll out between the bearing-planes, which is impossible with parallel bearing planes.

The material of the ball-bearings *a* is steel or the like hard metal, whereby the balls, which are under high pressure between the bearing planes, are prevented from being impressed in the latter whereby they could not move in lateral directions. The bearing planes of the ball-bearings *a* are perfectly smooth and lubricated, for attaining a smallest possible resistance against lateral movements of the balls. This minimum of resistance must be attained, because this resisting power is the impact, which acts as horizontal power on the building and which forms the outer load of the building by action of horizontal earthquake shocks, from which load the static calculations must be started. The smaller the resisting power, the lesser is also the strain on the building. Besides, the essential advantage for solving the question of earthquakes results therefrom that the impact acting on the building becomes in wide limits independent from the strength and extent of the earthquake shocks; the impact becoming exclusively a function of the pressure (G) on the ball, that is $=0+G$, 0 being the friction coefficient of the rolling ball. With well-lubricated smooth ball-bearings and for large loads, generally present in the art of building, $0=0.002$, so that generally the impact$=0.002$ G, that is proportionate to the pressure of the ball-bearing.

Between the two ball-bearings, the above-mentioned balls *c* are located, which are also made of hard material. Each ball is surrounded by a separate cage or ring *d*, which has the purpose to prevent the ball, upon a non-parallel position of the two ball-bearings happening eventually, from rolling out of its seat between the bearing planes, without a perceptible resistance being opposed to lateral movements of the basement. For this purpose, the ring runs on separate small balls e and is thus movable in all directions, while separate springs f, which are in balance in the initial position, that is before the horizontal stroke, prevent the ring d itself from rolling out between the ball-bearings a. For reducing friction between the balls c and ring d, small antifriction rollers are inserted between ring d and ball c.

The operation of this safety-device or cage is simple: By the action of horizontal earthquake shocks, the basement moves suddenly sideward, while the building remains practically at standstill owing to its power of inertia, the friction powers in the ball-bearings producing a small displacement of the building only in the direction of the movement of the basement. This lateral displacement will be the lesser, the smaller are the friction powers. At the same time, the latter act as impacts on the building. These impacts represent the outer load of the building by action of horizontal earthquake shocks. It is mentioned above that the impacts within wide limits attain the amount of 0.002 G (G=ball pressure) with well-lubricated ball-bearings. The same movement is repeated for the following sudden movements of the basement, alternately in one and the other direction, until finally after gradual decrease of the movement of the ground the standstill is again attained. In the position of rest, each ball must, unless a permanent displacement of the basement has happened, again assume its initial position. The ring d does not act, as long as the ball-bearings a are or remain parallel, it being only moved, each time for half of the movement of the basement, alternately out of and into its initial position owing to the lateral movement of the ball c by action of a horizontal earthquake. Its function proper begins, however, as soon as the ball does not more receive a vertical pressure owing to the non-parallel position of the two ball-bearings a, whereupon the ring arrests the ball in its seat so that it cannot roll out between the ball-bearing planes.

The vertical anchorage consists of a slide a^1, which runs on small rollers b^1 or the like, a spring c^1 attached to the slide and made fast in the basement, and the anchor proper d^1. The latter is pivotally connected at the top and bottom end with the building and slide respectively in such a way that it can tilt in all directions of the horizontal plane. The slide a^1 runs compulsorily in a corresponding cavity of the basement, the spring c^1 controlling the position of the slide.

Upon the basement being pushed aside by action of horizontal earthquake shocks, the slide moves upward and the spring c^1 is tensioned, owing to the upper building remaining in its position. Thereby, a horizontal power is produced in the anchor d^1, which serves to return the upper building again to its initial position with reference to the basement, as soon as a permanent displacement of the basement has happened. At the same time, this horizontal power limits the movement of the upper building in lateral direction, as soon as for any reason the upper building would tend to run off from its basement.

The main advantages of the safety-device are that horizontal and vertical shocks are effectively neutralized, and that the horizontal shocks are reduced to the minimum to be attained at all in the art of building, so that the buildings are protected, as far as possible, against the devastating effects of earthquakes. Besides, the device allows to indicate, within wide limits, the minimum to be attained, previously and independently from the earthquake shocks, so that the building can be erected according to exact static calculations, whereby the security is still considerably increased. Finally, the device maintains the absolutely required connection in vertical direction between basement and building.

What I claim, is:

In a ball-bearing for buildings exposed to earthquakes with a coöperative vertical anchorage between basement and building proper, the combination of a freely movable, automatically adjustable ball cage—consisting of a ring, race-balls for the ring, and springs to secure the ring in position,—a ball located in said cage, an upper and a lower ball-bearing plane to inclose said ball, screw-bolts to adjust said ball-bearing planes, a vertically movable, spring-controlled slide in the basement, and an anchor to pivotally intervene between said slide and the building proper and adapted to move in any direction of the horizontal plane, substantially as and for the purpose set forth.

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Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."