

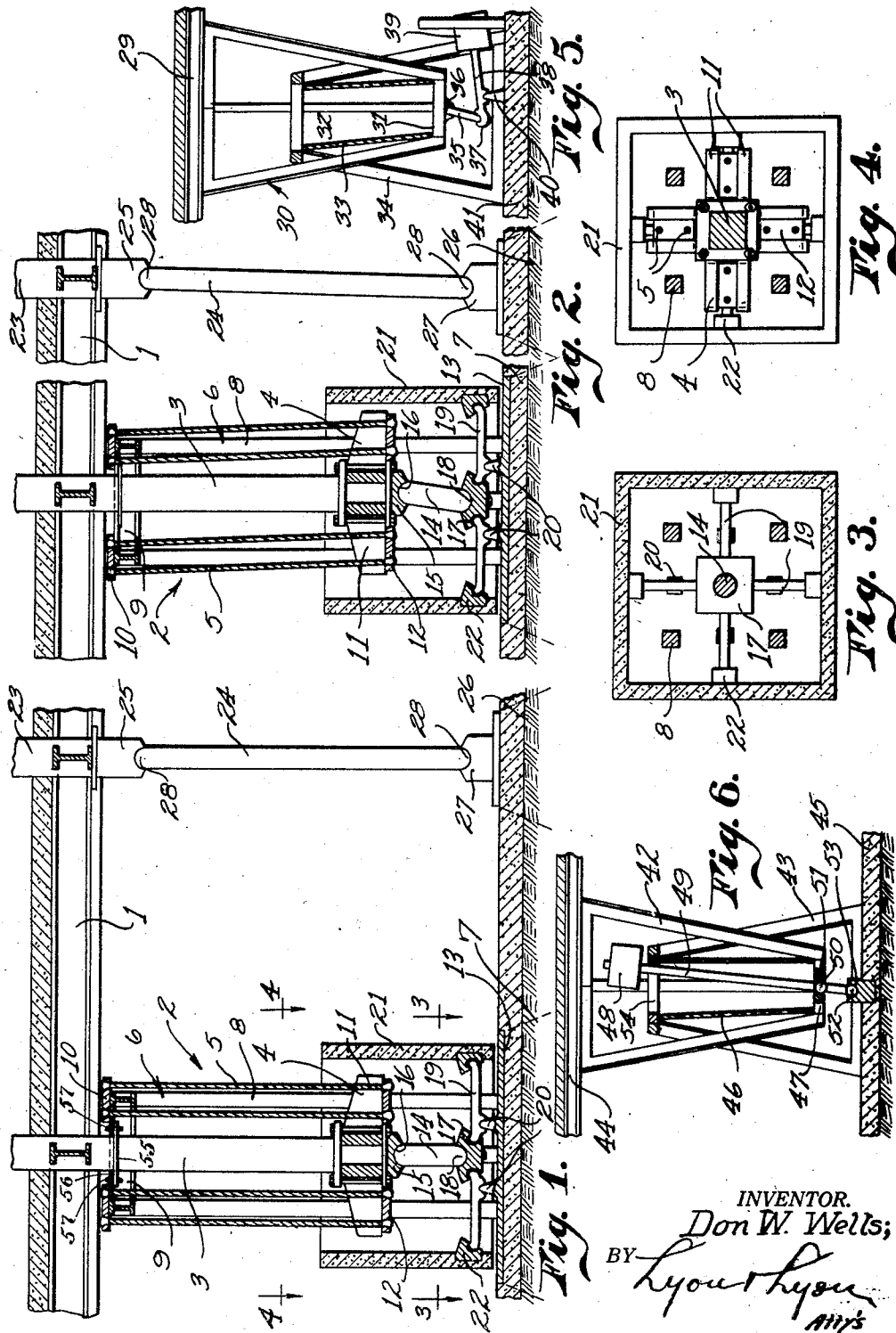
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FOUNDATION CONSTRUCTION

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UNITED STATES PATENT OFFICE

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FOUNDATION CONSTRUCTION

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This invention relates to a foundation construction, the purpose of which is to absorb earthquake shocks or other earth movements so as to prevent injury to supported structure; the invention is adaptable for supporting rigid structures of any kind, for example, buildings, bridges or any other rigid structures. The general object of the invention is to provide a construction which will largely neutralize the earth movement and prevent imparting the full force of the shock to the supported structure; also to provide means for resisting the equilibrating movement which would naturally take place as a consequence of the displacement of the ground beneath the supported structure.

A further object of the invention is to provide means for preventing wind pressure on the side of the supported structure from causing undue movements in it.

In the embodiment of the invention disclosed in the present specification, the invention includes a cradle or sling supported on the ground and operating as a support for the supported structure; when the earth movement occurs this sling prevents imparting of the full force to the supported structure, but the use of a sling entails an equilibrating movement of the sling with the earth movement; one of the objects of this invention is to provide means for resisting or "damping" this equilibrating movement of the sling so as to minimize the effects of the ground shock or movement upon the supported structure.

The invention consists in the novel parts and combination of parts to be described hereinafter, all of which contribute to produce an efficient foundation construction.

A preferred embodiment of the invention is described in the following specification while the broad scope of the invention is pointed out in the appended claims.

In the drawing:

Figure 1 is a vertical section taken at the

foundation of a building and illustrating an embodiment of the invention; this view shows the parts in the normal position.

Figure 2 is a view similar to Figure 1 but broken away, and this view illustrates the parts in a displaced position such as they would have when a ground movement such as an earthquake occurs.

Figure 3 is a horizontal cross section taken on the line 3—3 of Figure 1.

Figure 4 is a horizontal cross section taken on the line 4—4 of Figure 1.

Figs. 5 and 6 are vertical sections illustrating modified embodiments of the invention.

In practicing the invention I provide a construction which operates to absorb a force developed by a lateral ground movement, for example, an earthquake, and in doing so I employ a cradle or sling for supporting a rigid structure. This cradle is supported on a base and includes flexible members which prevent imparting of the full force of a shock directly through the sling to the supported structure. However, the displacement of the ground supports entails a slight equilibrating movement of the sling, and means is provided for resisting this equilibrating movement.

Although the invention may be applied in a foundation for any rigid structure, I shall now describe the invention as applied to the foundation of an ordinary steel frame building.

Referring more particularly to Figs. 1 to 4 inclusive, 1 represents the rigid frame of a building. According to my invention I support the frame of this building or rigid structure at a plurality of points on slings 2, each sling or cradle operating to support a portion of the weight of the building. In the case of a steel frame building this is preferably accomplished by extending downwardly columns such as the column 3, and supporting each column on a floating cross head 4 which forms the lower part of the cradle 2,

the cross head being supported on flexible members 5 preferably in the form of steel cables. At their upper ends these steel cables are supported upon a base 6 which may be of any suitable construction and resting upon a foundation 7. In the present instance this base may consist of four short columns or posts 8 surmounted by a cap ring 9 of square form, and this "ring" may be of I-beam cross section. The flexible members or cables 5 may be supported on saddle plates 10 extending over and resting on the cap ring.

The cables preferably are arranged in pairs corresponding to each saddle plate.

The cross head 4 is secured in any suitable manner to the lower end of the column 3, and this cross head preferably comprises bifurcated arms 11 so that a space is formed between the forks of each arm through which the cables pass, the lower ends of the cables being anchored in saddle plates 12 which straddle the under sides of the arms.

The lower ends of the columns or posts rest upon the foundation plate 13 supported on the foundation 7.

In a foundation having the features described above, it will be evident that if a lateral ground movement occurs a lateral displacement of the cap ring 9 will result. However, this will impart no direct force to the supported structure 1 by reason of the presence of the sling. In this way a large part of the effect of the shock to such a supported structure will be eliminated, enabling the building to experience such a shock without injury. I prefer, however, to provide means for resisting the equilibrating movement of the structure which must take place as a consequence to the lateral displacement of the cap ring or base which supports the sling. In order to accomplish this I prefer to provide means for exerting "damping" force directly upon the building, or supported structure; if desired, I provide means also for exerting a damping force directly upon the cross head.

The means for resisting the equilibrating movement at the cross head preferably includes a strut member 14 which is disposed between the cross head 4 and the foundation plate 13. This strut member is normally in a vertical position, but when the ground movement occurs it will assume an inclined position, the effect of which is to exert a thrust force against the cross head in a direction to oppose the equilibrating movement.

The manner in which this strut member will develop this opposing force will be evident from an inspection of Fig. 2 which represents the parts in the position which they would have during an earth shock; this view shows the parts in the relation they would have if the foundation had been displaced suddenly by a ground movement toward the earth.

When so displaced it will be evident that the sling will tend by gravity to swing toward the left, in its equilibrating movement. But this equilibrating movement will be resisted by the horizontal component of the inclined thrust force which will be exerted by the strut member 14 against the under side of the cross head 4.

The strut member 14 preferably has a flexible connection with the under side of the cross head which may consist of a socket 15 receiving the rounded nose 16 on the upper end of the strut member.

According to my invention I support the lower end of the strut member on a floating support including a weighted lever or levers. In the embodiment of the invention shown in Fig. 1 the lower end of the strut member is received in a socket member 17, the lower end of the strut member having a rounded nose 18 which cooperates with the socket member to form a flexible connection at the lower end of the strut member.

The floating socket 17 is supported on a plurality of levers 19, the short arms of which engage recesses in the sides of the socket member. These levers are supported on abutments 20 forming fulcrums. If desired, individual weights can be provided for the levers 19, but I prefer to provide a common weight 21 for them, consisting of a sleeve of heavy material. This sleeve may consist of a casting, if desired, but may be formed, if desired, of concrete with cast socket members 22 on its inner face to provide sockets for the outer ends of the long arms of the levers 19.

In the preferred embodiment of the invention, at points remote from the sling 2 I provide means between the ground and the structure 1 for imparting a thrust force to the structure to dampen the equilibrating movement of the structure which would naturally occur with the equilibrating movement of the cross head.

This means, in the case of a building, is preferably located under intermediate columns such as the column 23 of the building, which might be assumed to take less load than the column 3. In applying the invention to ordinary steel buildings I would usually support the outside columns of the building on a cradle such as the sling 2, and provide for exerting the damping force under interior columns, which may be called equilibrating columns.

In practice, any combination of equilibrating columns and sling columns can be employed which will give proper support and equilibrium to the building, and which will enable sufficient equilibrating force to be developed to damp the equilibrating movements of the building. In the present instance, under the column 23 I provide a strut member or strut column 24 in the form of a

rigid post having a flexible connection at its upper end with a socket 25 under the column 23, and having a flexible connection at its lower end supported on the foundation 26. The flexible connection at the lower end includes a base socket 27, and the ends of the column 24 have rounded noses 28 received in the socket members.

The effect of the strut column 24 will be evident from an examination of Fig. 2. Due to the inertia of the structure any movement of the ground will displace the sling 2 at the top, and strut column 24 at the bottom, the angles of displacement of sling 2 and strut column 24 being opposed to each other. The equilibrating movement of the cross head 1 and sling 2 will therefore be damped by the horizontal component of the thrust force in strut column 24 acting in the opposite direction to the ground movement. The building 1 tends to move toward the left with the cross head 4 in the equilibrating movement of the sling. This movement, however, will be resisted by the horizontal component of the thrust force developed in the strut column 24.

Of course it is understood that the strut column 24 is normally disposed in a vertical position like the other strut member 14.

It will also be evident from an inspection of Fig. 2 that the weight 21 acting through levers 19 and strut 14 will exert a horizontal force resisting the equilibrating movement of the cross head 11. The embodiment of the invention disclosed in Figs. 1 to 4 is especially adapted for heavy buildings with steel frames.

Other embodiments of the invention may be employed especially adapted for supporting lighter constructions such as frame or brick dwellings or the like, such constructions as illustrated in Fig. 5 in which 29 represents the sill of the building. On the under side of this sill I provide a frame 30, the lower end 31 of which constitutes a cross head forming part of the sling 32 including flexible members or cables 33, the upper ends of which are supported in a frame 34 which may be of similar construction to the frame 30. Between the cross head 31 and the ground I provide a strut member 35 the ends of which are received in sockets. In the present instance, these sockets include a socket 36 on the under side of the cross head and a socket 37 formed on the short arm of a lever 38 carrying a weight 39 on its long arm and supported on a fulcrum 40 on the building foundation 41. In Fig. 5 the parts are illustrated with the foundation displaced toward the left as by an earth movement coming from the right. This displacement throws the strut member 35 in its normal vertical position and places it in a position to exert a thrust force toward the right in a direction to oppose the left swing or equilibrating movement of the sling 32.

Another embodiment of the invention suitable for light buildings is illustrated in Fig. 6. In this embodiment of the invention I provide frames 42 and 43 which are similar in construction to the frames 30 and 34. The frame 42 is attached to the floor sill 44 of the building, and the frame 43 constitutes a base supported on the foundation 45 and forming a sling by means of cables 46, the lower ends of which are attached to the cross head 47 formed at the lower end of the frame 42. The weight 48 to assist in damping the equilibrating movement is carried on the end of a bar 49 having a flexible connection in the form of a ball 50 formed in the bar near its lower end and received in a socket 51 formed in the cross head. The lower end of the bar 49 is formed with a ball 52 received in a socket 53 in the foundation 45. The upper end of the frame 43 is formed by a cross head with a large opening 54 through which the bar 49 extends upwardly. This opening 54 permits lateral swinging movement of the bar 49. With this construction it should be understood that the bar 49 is normally disposed in a vertical position. If a ground movement occurs moving the foundation 45 toward the left the bar 49 will swing toward the right and by reason of the position of the weight 48, resistance will be offered to the equilibrating movement of the cross head 47 which would be toward the left.

In connection with the weights, it should be understood that these weights assist the damping of the equilibrating movement largely by reason of their inertia.

In order to prevent pressure developed by the wind on the side of the supported structure from swaying the structure unduly on its foundation, I provide frangible means which is sufficiently strong to resist the forces, but which will be sheered by the forces developed by an earthquake. For this purpose I provide a substantially horizontal plate 55 mounted to move with the supported structure. As indicated in Fig. 1 this plate is attached to the column 3. The edges of this plate extend under flanges 56 which project outwardly from the saddle plates 10. These plates 55 and 56 have their faces substantially against each other and are provided with registering openings to receive a frangible pin 57. This pin may be of porcelain or some composition which will shear under a great stress, but it will be sufficiently strong to resist the forces developed in the building by the wind.

If desired the struts 14 may be omitted and the struts 24 may be used to develop all the equilibrating force necessary.

It is preferable to use flexible cables 5 as compared with flexible suspending rods for the reason that the cables absorb torsional movements and prevent their being imparted to the base of the column 3. They also are more readily put in place and permit more

Another embodiment of the invention suitable for light buildings is illustrated in Fig. 6. In this embodiment of the invention I provide frames 42 and 43 which are similar in construction to the frames 30 and 34. The frame 42 is attached to the floor sill 44 of the building, and the frame 43 constitutes a base supported on the foundation 45 and forming a sling by means of cables 46, the lower ends of which are attached to the cross head 47 formed at the lower end of the frame 42. The weight 48 to assist in damping the equilibrating movement is carried on the end of a bar 49 having a flexible connection in the form of a ball 50 formed in the bar near its lower end and received in a socket 51 formed in the cross head. The lower end of the bar 49 is formed with a ball 52 received in a socket 53 in the foundation 45. The upper end of the frame 43 is formed by a cross head with a large opening 54 through which the bar 49 extends upwardly. This opening 54 permits lateral swinging movement of the bar 49. With this construction it should be understood that the bar 49 is normally disposed in a vertical position. If a ground movement occurs moving the foundation 45 toward the left the bar 49 will swing toward the right and by reason of the position of the weight 48, resistance will be offered to the equilibrating movement of the cross head 47 which would be toward the left.

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If desired the struts 14 may be omitted and the struts 24 may be used to develop all the equilibrating force necessary.

It is preferable to use flexible cables 5 as compared with flexible suspending rods for the reason that the cables absorb torsional movements and prevent their being imparted to the base of the column 3. They also are more readily put in place and permit more

freedom of movement in the cradle, permitting the cradle to maintain itself in a horizontal position without developing the same character of strains that would be developed at the connection points of the lower ends of suspending rods.

It is understood that the embodiment of the invention described herein is only one of many embodiments this invention may take, and I do not wish to be limited in the practice of the invention nor in the claims, to the particular embodiment set forth.

What I claim is:

1. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a cradle supporting the said structure, a base having means for suspending the cradle, and means for resisting the equilibrating movement of the structure consequent to the displacement of the base when said ground movement occurs.

2. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a cradle having flexible supporting members with a cross head supported thereby, a base on the ground having means for supporting the flexible members toward their upper ends, and means for resisting equilibrating movement of the cradle consequent to the displacement of the base when said ground movement occurs.

3. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a cradle supporting the said structure, a base having means for supporting the cradle, and a strut member operating to develop a force in a direction to oppose the equilibrating movement of the cradle consequent to the displacement of the base when said ground movement occurs.

4. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a cradle supporting the said structure, a base on the ground having means for supporting the cradle and a strut member normally disposed in a substantially vertical position and mounted so as to be displaced into an inclined position when the ground movement occurs, and operating to exert a thrust force in a direction to oppose the equilibrating movement of the cradle consequent to the displacement of the base.

5. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a base supported on the ground, a cross head, a load-carrying member supported on the cross head, flexible means for suspending the cross head on the base to permit a swinging movement of the cross head when the ground movement occurs, and means for resisting the equilibrating movement of the cross head

consequent to the said movement of the base.

6. In a foundation for a rigid structure, to absorb a force developed by a lateral ground movement, the combination of a cradle supporting the said structure, a base having means located at a point removed laterally from the cradle for exerting a force upon the said structure to resist the equilibrating movement of the cradle consequent to the displacement of the base when said ground movement occurs.

7. In a foundation for a rigid structure, to absorb a force developed by a lateral ground movement, the combination of a cradle supporting the said structure, a base having means for supporting the cradle, and a strut member located at a point removed laterally from the cradle supported at its lower end on the ground and operating to exert a thrust force upon the structure in a direction to resist the equilibrating movement of the cradle consequent to the displacement of the base when said ground movement occurs.

8. In a foundation for a rigid structure, to absorb a force developed by a lateral ground movement, the combination of a cradle supporting the said structure, a base having means for supporting the cradle, a substantially vertical strut member removed laterally from the said cradle, having a flexible joint supporting the same on the ground, and a flexible joint at its upper end for supporting the structure, said strut member operating to develop a thrust force against the said rigid structure to resist the equilibrating movement of the cradle consequent to the displacement of the base when said ground movement occurs.

9. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a cradle, means for supporting the cradle at its upper portion from the ground, said cradle having a cross head at its lower head to receive the weight of the rigid structure, and a thrust member cooperating with the said cross head to develop a thrust force in a direction to resist the equilibrating movement of the cradle consequent to the displacement of the base when said ground movement occurs.

10. In a foundation for a rigid structure, to absorb a force developed by a lateral ground movement, the combination of a sling having flexible members and a cross head at their lower ends, a base having means for supporting the upper ends of the flexible members, said cross head operating to support said rigid structure, and a strut member located under the cross head having a flexible connection therewith, and normally disposed in a substantially vertical position, said strut member operating to exert a thrust force against the cross head to resist the equilibrating movement of the cross head

consequent to the displacement of the base when said ground movement occurs.

11. In a foundation for a rigid structure, to absorb a force developed by a lateral ground movement, the combination of a sling having flexible members and a cross head at their lower ends, a base having means for supporting the upper ends of the flexible members, said cross head operating to support said rigid structure, a strut member engaging the cross head, normally disposed in a substantially vertical position, means for supporting said strut member carrying a weight, said strut member operating to exert a thrust force against the cross head in a direction to resist the equilibrating movement of the sling consequent to the displacement of the base when said ground movement occurs.

12. In a foundation for a rigid structure, to absorb a force developed by a lateral ground movement, the combination of a cross head supporting the rigid structure, a base supported on the ground, flexible members for supporting the cross head from the base, a weight and means connecting the same with the cross head operating to exert a force upon the cross head in a direction to resist the equilibrating movement of the cross head consequent to the displacement of the base when said ground movement occurs.

13. In a foundation for a rigid structure, to absorb a force developed by a lateral ground movement, the combination of a sling having a cross head and flexible members supporting the same, a base on the ground supporting the flexible members at their upper ends, a strut member normally in a substantially vertical position under the cross head, means including a lever with a short arm supporting the said strut member and having a long arm carrying a weight, said strut member operating to exert a thrust force against the cross head to resist the equilibrating movement of the sling consequent to the displacement of the base when said ground movement occurs.

14. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a cradle for supporting the said structure, a base having means for supporting the cradle, and frangible means for connecting the base and the structure operating to resist stress developed by the wind on the structure but operating to fail under the action of an earthquake.

15. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a cross head supporting the said structure, a base supported on the ground, and cables supporting the cross head from the base.

16. In a foundation for a structure, to absorb a force developed by a lateral ground movement, the combination of a cradle sup-

porting the said structure in a normal upright position, a base having means for supporting the cradle and operating when moved by the earth movement, to permit the structure to assume a condition of unstable equilibrium and thereby cause an equilibrating movement in the structure under the action of gravity, returning the structure to said normal upright position, and means for resisting the said equilibrating movement of the structure.

Signed at Los Angeles, California this 29th day of March, 1928.

DON W. WELLS.

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