May 29, 1945. J. H. THORNLEY 2,377,055

PILE CAP

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Fig. 1.

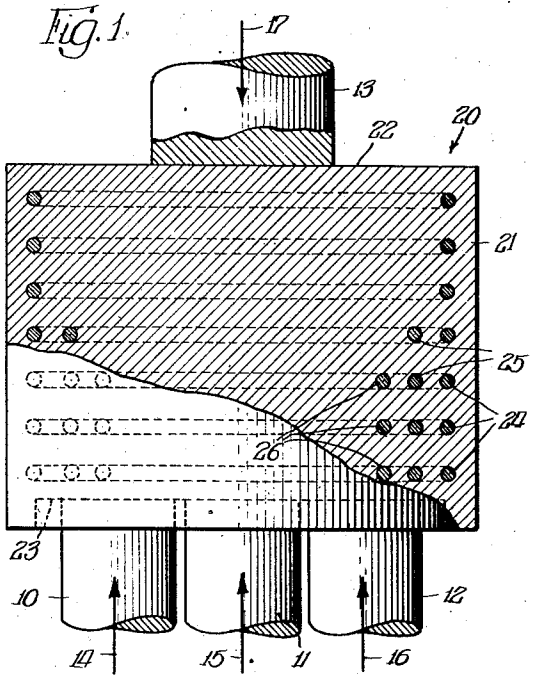
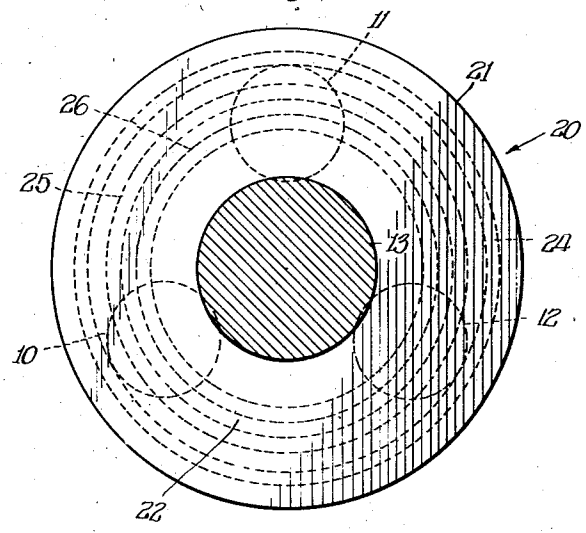


Fig. 2.



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PILE CAP

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Fig. 3.

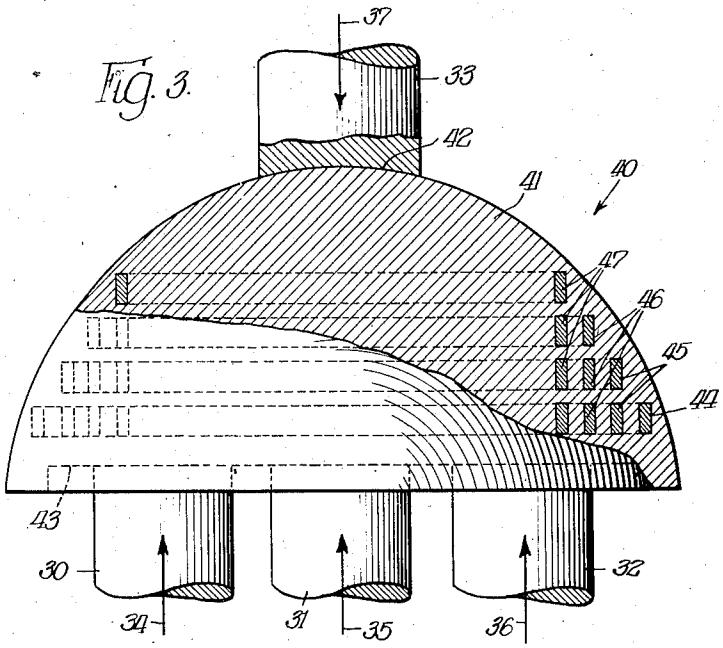
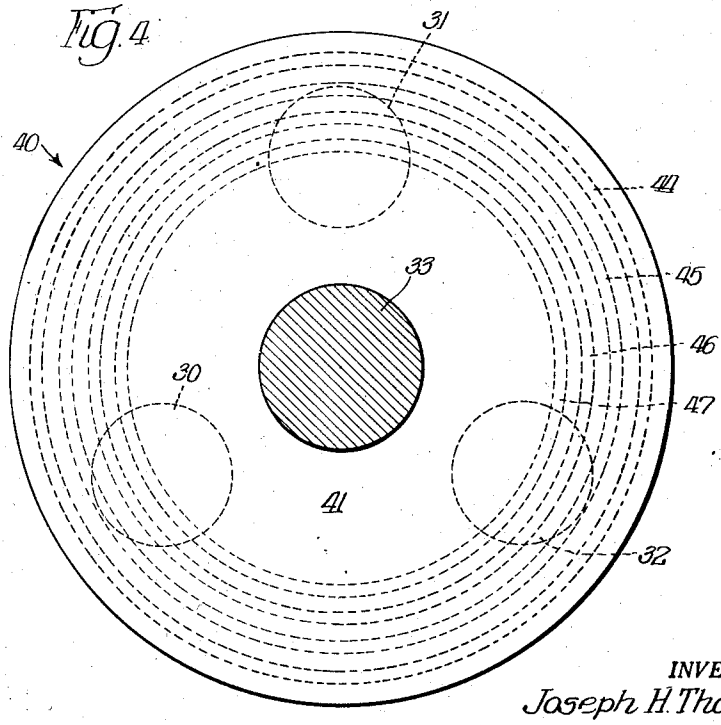


Fig. 4.



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UNITED STATES PATENT OFFICE

2,377,055

PILE CAP

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Application May 31, 1944, Serial No. 538,120

5 Claims. (Cl. 61—77)

My invention relates generally to building foundations or building structures, and it has particular relation to means for distributing the load imposed by a column among a plurality of supporting columns or piles, or to other load supporting means.

The invention is not limited to use as a pile cap. It is applicable to any situation where a heavy concentrated load, such as is carried in a column, is imposed upon a supporting body of concrete or the like, which is required to receive and distribute the concentrated load.

The principal object of my invention is to provide a structure for distributing the load from a column through a body of concrete or the like to spaced apart load supporting means, which may be separate from or integral with the body and wherein circular or hooplike reenforcement is disposed in said body in such manner as to secure a high degree of strength and stability.

Other objects of my invention will, in part, be obvious, and in part appear hereinafter.

In transferring a single concentrated load to two or more eccentric supports, the art heretofore has employed a cap or block on the theory that it is to serve as a beam or plate supported at the ends and loaded at the middle, and that flexure is to be resisted. I conceived that if material strong in compression were to be employed economically, it should embody the theory of the arch instead of that of a beam. Experimental investigation of the failure of caps or blocks of various structures and shapes confirmed my theory that the most advantageous use of material such as concrete could be made by stressing the concrete as an arch and restraining the tendency of the limbs thereof to separate or spread by a reenforcing metal tie. When the load is to be carried on two or more spaced areas of support, or is distributed over an area of support greater than the loading area, a body of circular section, i. e., having a surface of revolution, and preferably a body which is an arch in any vertical axial section, is a simple and highly effective form, since in that form annular reenforcing rings having maximum strength toward the supporting side can provide the tension strength with a minimum of material.

The body of concrete preferably shaped like a sugar loaf or hemisphere, and without reenforcement or restraint when subjected to compressive stress, tends to crush by shearing an inverted cone of material down through the center of the body, splitting the base in all directions. By providing the body with hoop strength increasing progressively downward, I secure a base or cap of the desired load carrying ability with substantially a minimum of material.

This discovery applies not only to the transfer occurring between a concentrated load as from a column and eccentrically disposed supporting piles, but to any situation where the load is to be spread from the center to two or more points offset from the axis of the projected area of the column or concentrated load. In fact, it applies equally well to the spread of the concentrated column load to a supporting surface which comprises all of the bottom surface of the cap, as might be the case where the load of the column is to be spread at reduced unit pressure to all or a large part of the bottom area of the cap. The invention thereby provides a novel utility in spreading laterally, with or without decrease in unit pressure, a concentrated imposed load, and is particularly useful as a pile cap, because in that situation the supporting areas provided by the pile ends have no other tie between them to keep them from spreading apart.

While the preferred external form is the hemispherical or sugar loaf form, this is not the essential feature, but only a highly advantageous feature. The essential feature is concerned with the method of containing the bursting stresses developed in a block when the area or areas of support is or are not coincident in area and in line with the area of load imposition. Which is load and which is support is of no moment for that is merely a way of looking at the structure. The bursting stresses are best contained by circular hooplike rings near or at the outer surface of the cap. Any lateral pressure which tends at any point in the included area of the hoop to increase the material inside the hoop (i. e., put it into compression) tends to expand the radius of the area in the hoop, and that force is therefore resisted by the tension strength of the hoop. The hoop therefore is effective for all conditions of load support of the central concentrated load. The hoop may be a distributive hoop, i. e., consist of a plurality of rings graduated in size and/or number to give the desired disposition of strength. Also, instead of an integral metallic ring, it may consist of spiral or helical coils of rodlike stock suitably disposed and distributed as will be understood by those skilled in the art.

It is to be observed that the reenforcing ring or rings surround or embrace within their confines the free area or cross sectional area, whichever is the construction through which the load is applied, and likewise the area or areas of support.

In brief, the compression stress falls inside the ring, and is therein converted into a generally radial force which is contained by the ring.

The ring above mentioned may be a concentrated or a distributive reenforcement. When it is distributive as herein illustrated, graduation of the amount of reenforcement (i. e., cross sectional value) at various locations is facilitated.

For a more complete understanding of the nature and scope of my invention reference can be had to the following detailed description taken in connection with the accompanying drawings in which:

Figure 1 is a view, partly in side elevation, and partly in section, illustrating one embodiment of my invention;

Figure 2 is a top plan view of the construction shown in Figure 1;

Figure 3 is a view, partly in side elevation and partly in section, illustrating another embodiment of my invention; and

Figure 4 is a top plan view of the construction shown in Figure 3.

Referring now particularly to Figures 1 and 2 of the drawings, it will be noted that the reference characters 10, 11 and 12 designate columns or piles in a building construction or foundation which are arranged to support a column 13 that is adapted to carry a portion of the building load. The arrows 14, 15 and 16 indicate, respectively, the direction of the reaction of the columns or piles 10, 11 and 12 to the load applied through the column 13 as indicated by the arrow 17.

With a view to distributing the load indicated by the arrow 17 among the columns or piles 10, 11 and 12, a cap, shown generally at 20, is provided. It will be readily understood that the cap 20 is subject not only to compressive stress resulting from application of the load indicated by the arrow 17, but also it is subjected to tension stress at a maximum near the lower portion or base because of the positions of the axes of the columns or piles 10, 11 and 12 spaced from the axis of the column 13, as is more clearly shown in Figure 2 of the drawings. It is desirable that a minimum weight and amount of material be employed in making up the cap 20 for obvious reasons. However, it is necessary to take into consideration the compressive and tension stresses and their distribution in the cap 20 and to make the same sufficiently strong to resist them.

Preferably the cap 20 is largely formed of a material which is relatively strong in compression and relatively weak in tension. For example, concrete is well suited for this purpose.

In the particular embodiment shown in Figures 1 and 2 of the drawings, the concrete is preformed as a solid of revolution, for example, a cylinder 21 with its longitudinal axis vertically disposed substantially coaxially with the longitudinal axis of the column 13. It will be noted that the column 13 rests upon the upper surface 22 of the cylinder 21 and that the columns or piles 10, 11 and 12 bear against the under recessed surface 23 of the cylinder 21.

As indicated, the tension stress is at a maximum at the base of the cylinder 21. The material, such as concrete, of which the cylinder 21 is largely made, is relatively weak in tension. With a view to resisting this tension stress a series of concentric rings 24, 25 and 26 of circular or other cross-section, are embedded in the cylinder 21 substantially coaxially with the direction of application of the load, as indicated by the arrow 17. If desired, more or less than three concentric rings can be used, and they are preferably of steel or other high tensile strength material.

Since the tension stress in the cylinder 21 decreases upwardly from the base thereof, the number of concentric rings is reduced, as shown, until at the top only a single ring is employed in each layer. It will be understood that a single ringlike tension member can be employed which decreases in cross section from a maximum at the base to a minimum at the top, or the graduation of reenforcement to stress distribution secured by various modifications of the hoop or ring structure. However, it is preferred to use a plurality of ringlike tension members of different diameter as shown embedded in the concrete.

It will be understood that the proportions of the cylinder 21 and of the rings 24, 25 and 26 can be varied, and that the compositions thereof can be chosen in accordance with the character and magnitude of the imposed load, the dimensions of the column 13 and piles 10, 11 and 12. It is important to so proportion the various elements entering into the design of the cap 20 that a proper balanced relation is maintained between the load carrying capabilities thereof and the distribution of the compression and tension characteristics thereof.

In Figures 3 and 4 of the drawings, the prepared embodiment of my invention is illustrated. The construction there shown takes advantage of the load carrying ability of an arched configuration, as will be presently set forth.

Similarly to the arrangement previously described, columns or piles 30, 31 and 32 are disposed to support a column 33, the forces exerted thereby being indicated by the arrows 34, 35 and 36, respectively. The downward load or force exerted through the column is indicated by the arrow 37.

A cap, shown generally at 40, is provided for distributing the load represented by the arrow 37 among the columns or piles 30, 31 and 32. The cap 40 is generally dome shaped and, as shown, has an arched cross section in any vertical axial section. This permits substantially maximum use to be made of the material 41, such as concrete, in distributing uniformly the compression stress throughout the entire upper and outer portion of the cap 40. At the same time there is no unstressed portion, as is the case in the upper and outer portion of the cap 20 shown in Figure 1.

It will be noted that the column 33 bears against the upper surface 42 of the cap 40. A recessed under surface 43 is provided for receiving the upper ends of the columns or piles 30, 31 and 32.

With a view to resisting the tension stress developed in the base of the cap 40, concentric tension rings 44, 45, 46 and 47, preferably but not necessarily of rectangular cross section, and preferably of high tensile strength steel or the like circumscribe the indicated portions of the base. Since the tension stress decreases upwardly from the base, the number of the concentric rings in each layer is reduced in accordance with the stress distribution.

The load transferring member of my invention optionally may be integral with one or more of the load imposing or load supporting elements or it may be a detached piece.

Now the external form is not the criterion of my invention. The criterion is the controlled disposition of reenforcing hoops or rings or their

equivalent in the body which receives the concentrated load and distributes the same. The body which I have shown as a separate cap may be formed as a part of a mat or slab, and hence may not appear externally to conform to the structures herein illustrated as typical embodiments.

Also, it is to be noted that the structure illustrated in Figures 3 and 4 as formed externally in the shape of a dome is an idealized form. In practice, such a form is difficult to shape, and without any departure from the broad aspects of my invention, the cap may be cylindrical, as in Figure 1, or rectangular, or pyramidal in external form, and yet include the structure and gain the advantages of my invention. Similarly, the part or column need not be circular in section, although that is the preferred form.

In both embodiments illustrated the distributed reenforcement rings overlie the areas of support of the piles in a transverse direction, whereby increased strength in shear is provided against failure by shear of the cap about the areas of support of said piles. This is not a feature of primary importance and is optional.

The preferred disposition of the rings or hoops is as illustrated in Figures 1 and 2, with the rings disposed coaxially on successive levels and with the maximum number of concentric rings on one or more of the lower levels thereby to accomplish the desired increase of aggregate cross section of the reenforcement.

Since other modifications of the constructions shown and described hereinbefore can be made without departing from the spirit and scope of the present invention, it is intended that all matter shown in the accompanying drawings and described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In combination a central loaded column, a plurality of substantially symmetrically spaced apart supporting piles for receiving the load of the column and a pile cap comprising a body of concrete interposed between said column and said piles and having annular metallic reenforcement symmetrically disposed therein increasing in aggregate cross section from top toward the bottom, the axis of said annular reenforcement substantially coinciding with the vertical axis of said column.

2. A load distributing pile cap comprising a solid block of concrete having a vertical axis of symmetry in line of which load is adapted to be imposed, and a substantially planar bottom face upon symmetrically disposed restricted areas of which support is adapted to be applied, said block comprising a series of annular metallic reenforcement members with their axes disposed in substantially the axis of the block effective as hoops embedded in the block, said reenforcing members being of aggregate cross section increasing from top toward the bottom of the body of the cap.

3. A load distributing pile cap comprising a solid body of concrete of a form providing substantially a hemisphere in any vertical section, said cap having a vertical axis for a centrally applied load, and having a base adapted to rest upon a plurality of substantially symmetrically disposed supporting piles, and hooplike reenforcing rings embedded in said body of concrete with their axes disposed substantially in line with the axis of the cap and being of increasing aggregate cross section from top toward the bottom of the body.

4. A load distributing pile cap comprising a solid body of concrete having a central area of loading on a vertical axis on the top side thereof and having separate areas of support on parallel vertical axes on the bottom side, and having reenforcing rings of graduated aggregate cross section increasing from top toward bottom of the body, said rings embracing the projected area of the applied load and the lowermost rings extending across the projected areas of support.

5. A load distributing pile cap comprising a solid body of concrete having a top central area of loading on a vertical axis and having separate restricted bottom areas of support on parallel vertical axes and embodying reenforcing rings graduated in aggregate cross section to increase from top toward bottom of said body, said rings being disposed on successive levels with a greater number of rings on the lower level than on the top level.

JOSEPH H. THORNLEY.