Sept. 2, 1952 H. P. BURRELL 2,608,830

FOUNDATION STRUCTURE

Original Filed June 13, 1946 2 SHEETS—SHEET 1

Fig. 1.

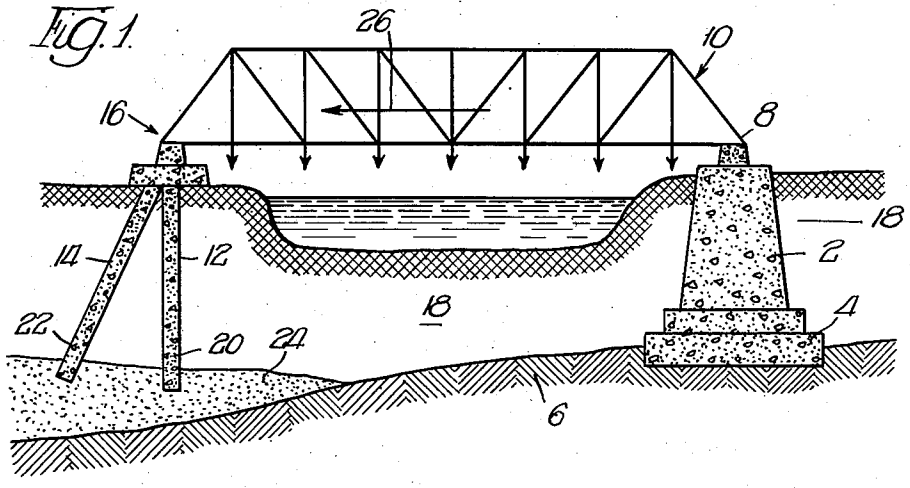
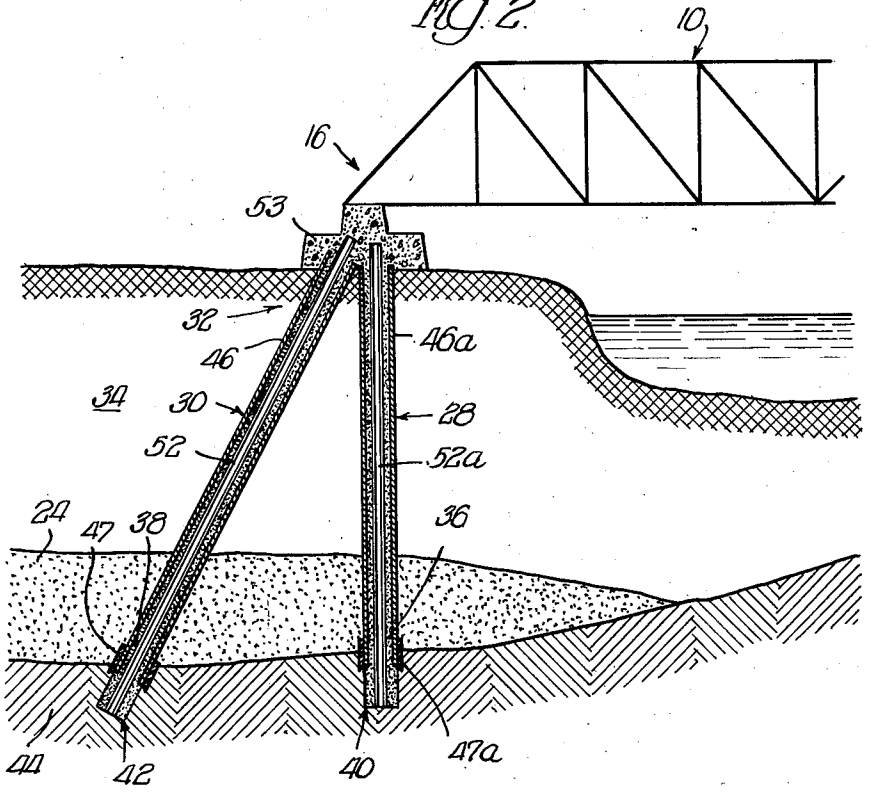


Fig. 2.



INVENTOR.
Harold P. Burrell,
BY
Brown Jackson Boettcher & Dienner
Attys

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Fig. 3

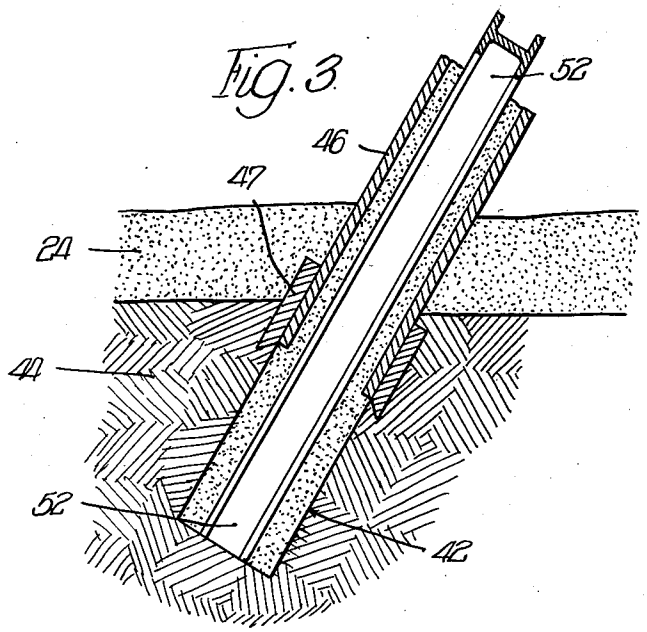


Fig. 4

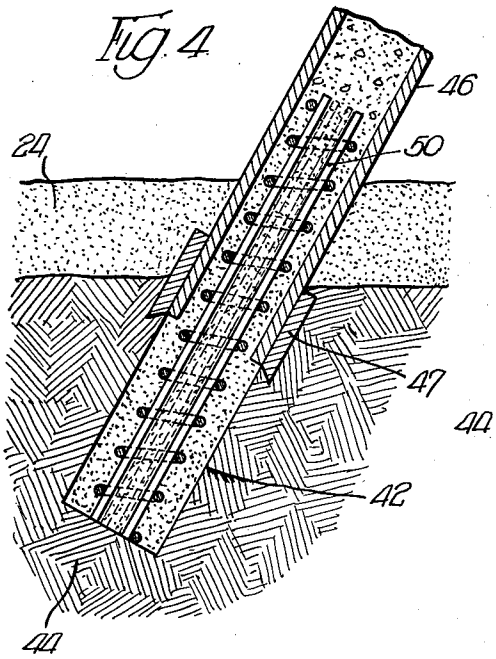
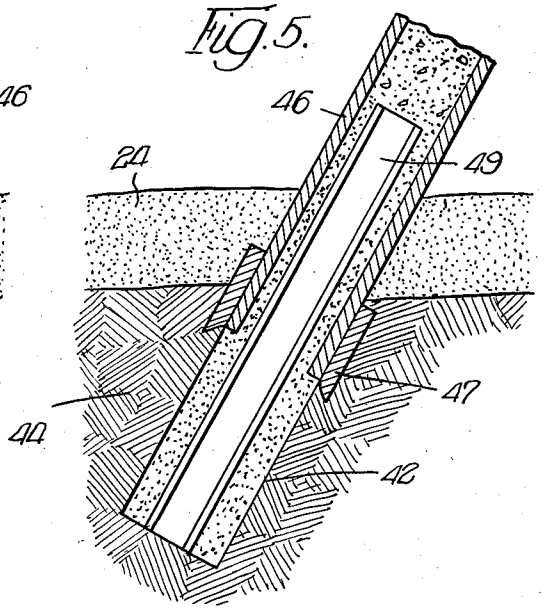


Fig. 5.



INVENTOR.
Harold P. Burrell,
BY
Brown Jackson Boettcher Dennis
Attys.

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UNITED STATES PATENT OFFICE

2,608,830

FOUNDATION STRUCTURE

Harold P. Burrell, Noroton, Conn., assignor to Western Foundation Corporation, New York, N. Y., a corporation of Delaware

Original application June 13, 1946, Serial No. 676,482, now Patent No. 2,593,532, dated April 22, 1952. Divided and this application October 20, 1948, Serial No. 55,540

9 Claims. (Cl. 61—52)

1

This invention relates to foundations for buildings, bridges and other structures.

An object of the invention is to provide a new and improved type of foundation structure comprising foundation columns angularly disposed relative to each other, with their upper ends connected together and having their lower ends securely engaging the rock formation therebelow, thereby forming a triangular foundation frame in which the base of the triangle is the rock formation itself.

Another object of the invention is to provide a foundation of the class known as a deep foundation, in which the members composing it are disposed to form a closed system, in which the forces acting in the members are axial, and amenable to exact analysis, and are not subject to substantial bending.

A further object of the invention is to provide a foundation comprising a plurality of caissons at least one of which is inclined from the vertical, and in which the upper ends of the caissons are interconnected and the lower ends are securely set into sockets formed in the rock formation therebelow.

A further object of the invention is to provide a foundation structure comprising drilled-in caissons angularly disposed relatively to each other with their upper ends connected together and having their lower ends set into and bonded to rock sockets in bed rock thereby forming a triangular foundation frame in which the base of the triangle is bed rock.

Another object of the invention is to provide a new and improved type of foundation which is simple in construction, and which has a high load bearing strength, the value of which can be computed with exactitude.

Other objects and advantages of my invention will become apparent from the following description of a preferred embodiment thereof as illustrated in the accompanying drawings and in which,

Fig. 1 is a diagrammatic representation of a bridge structure supported on foundations as heretofore used;

Fig. 2 is a fragmentary representation of a bridge structure as supported on a foundation according to my invention;

Fig. 3 is an enlarged sectional view of a portion of the structure shown in Fig. 2; and

Figs. 4 and 5 are enlarged sectional views of modified forms of the lower end of a foundation member.

This application is a divisional of my co-pending application, Serial No. 676,482, filed June 13, 1946, now Patent No. 2,593,532 issued April 22, 1952, for Foundation Structure and Apparatus for Constructing the Same.

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Certain types of structures, such as bridges, quay walls, crane runways, dams and so forth, may be subjected to vertical and horizontal forces, the latter resulting, for example, from the braking action of a train, earth or water pressure, wind, and similarly acting forces. These structures are frequently located where sound foundation strata lie at great depths, while the material above is very soft. In such cases, the forces acting on the structure must be carried through the soft material and delivered to the underlying sound strata, such as bed rock.

In the present state of the art, two main designs are used, one of these being large piers 2 shown on the right hand side of Fig. 1, the base or footing 4 of the pier 2 resting on bed rock 6 wherever it is accessible, the pier thus supporting one end 8 of a bridge structure 10. Due to their relative large size and weight, these large piers are seldom stressed to the safe limit of the material even when bending stress is added to the vertical forces present.

The other of the two main designs presently used is typified by the vertical and batter piles illustrated on the left hand side of Fig. 1. As shown, the vertical forces are carried by relatively slender vertical piers or piles 12, while inclined or "batter" piles 14 take care of the horizontal forces. The piles 12 and 14 are generally assumed to act as members of a frame and thus to be subject to axial forces only. As shown, the vertical and inclined piles 12 and 14 are pinned together or otherwise connected at their upper ends to furnish support for the end 16 of the bridge 10. The soft earth 18 is excavated to receive the massive pier 2 shown on the right of the view, but the piles 12 and 14 are normally driven down through the earth 18 until their lower ends 20 and 22 respectively, lie in a stratum of relatively firm material 24.

It is thus apparent that the above mentioned assumption that the piles 12 and 14 act as members of a frame and are subject to axial forces only, is not correct, because, although the upper ends of the piles 12 and 14 are rigidly connected, their lower ends are not. A pile is generally driven into the ground by the blows of a pile hammer, the point sinking deeper under each blow. Even when the point is driven to firm material, it is not rigidly fixed in its position because of the yielding nature of the soil which was

soft enough to allow the pile to be driven into it. The ground itself not being rigid, cannot provide a rigid connection between the two lower ends of the piles.

Thus, it must be observed that there are only two members to the frame, namely piles 12 and 14, whose lower ends are not rigidly interconnected. The horizontal forces acting longitudinally of the bridge structure in the direction of the arrow 26, will cause tension in pile 12 and compression in pile 14. Under these axial loads pile 14 will sink to the left while pile 12 will tend to lift, causing the top of the pile 12 to move to the left of the view and the lower end or tip to move to the right. Thus pile 12 will be subject to bending, and, since it is normally designed to support vertical loads only, the increased stress due to bending must be taken care of by enlarging the diameter of the pile or adding vertical piles. The movements of the piles may be relatively small, but they do exist and cannot be accurately determined.

An important feature of my invention is to provide a novel type of construction of a deep foundation to overcome this difficulty, and this is done by so disposing the supporting members as to form a closed frame, this is, one in which there can be no lateral movement of the lower ends of the foundation columns relative to each other as described above.

For this purpose I propose to use two piers or foundation columns inclined to each other and rigidly connected at their tops while their lower ends or points reach far enough into bedrock or similar firm material as to form a rigid connection therewith. The third member of the frame is thus the bed rock or similar rigid substance. The foundation columns, according to my invention, may individually be vertical or inclined to any degree, so long as they are inclined to each other. As shown in Fig. 2, there are two members, 28 and 30, connected together at their upper ends, and extending downward through earth or other material 34.

Their lower ends 36 and 38 respectively, are set into sockets 40 and 42 drilled into the bedrock 44. As a result, it is obvious that the foundation frame now comprises a triangle having its two legs 28 and 30 interconnected at the apex 32, and having their lower ends 36 and 38 substantially rigidly connected to the bed rock 44 which thus forms the base of the triangle of the frame. Since all the members of the triangular frame are thus rigidly interconnected, there cannot be any relative movement of any of the members, and a solid foundation is thus formed. It will be understood of course, that for a bridge of any size, it will be necessary to use more than one foundation frame.

For purposes of illustration I have shown and described foundation columns anchored into rock, of the type known commercially as "drilled-in caissons." These members would be grouped in pairs, either one vertical and one inclined, or two members inclined in different positions or directions. The two members are connected at their upper ends, and have their lower ends anchored into sockets drilled in the rock, which thus forms the third member needed to close the triangle.

A drilled-in caisson is made by driving a pipe such as the casing 46 of the batter caisson 30 through the soil indicated by the layers 34 and 24 until it rests on bed rock. The lower end of the pipe is provided with a tool steel cutting shoe 47 in the form of a collar attached to the pipe by welding. The soil is removed from the inside of the pipe 46 by suitable means, and a socket 42 (see Figures 2 and 3) of substantially the inside diameter of the pipe 46 is drilled into the rock 44. The pipe 46 with the cutting shoe 47 thereon is then driven into this socket 42 far enough to form a tight fit with the upper end of the socket to keep mud, sand and clay from entering the socket. If the loads are not too high, the socket 42 and pipe 46 are filled with concrete which completes the caisson 30, except that a structural steel member 49 as shown in Figure 5, or a steel reenforcing cage 50, as shown in Figure 4, may be placed in the socket 42 and extended into the pipe 46 to provide better anchorage between the caisson 30 and the rock 44. A full length structural steel unit, preferably an H-beam 52, shown in Figures 2 and 3, may be added in the axis of the caisson shaft and bonded into the socket 42 at its lower end and to the cap 53 at its upper end, as shown in Figure 2, to provide a greater load bearing capacity if required. The column 28 is constructed in like manner as a drilled-in caisson with the same kind of anchorage at its lower and its upper ends in the rock socket 40 and in the cap 53, respectively. The concrete cap 53 embeds and bonds together the upper ends of the cores 52 and 52*a* of the two caissons 30 and 28, and the upper ends of the pipes 46 and 46*a* to provide a rigid connection between the said upper ends of the cores and of the pipes.

Where, as in Figures 4 and 5, the metal reenforcement is extended from the socket only a relatively short distance into the pipe, the lateral bond provides the load transferring medium, particularly in the case of tension axially of the column. In the latter case, that is, when the column constructed as shown in Figures 4 and 5 is subjected to tension, the metallic wall of the pipe provides the necessary strength in tension. Where, as in Figures 2 and 3, the full length structural steel unit 52 is employed, it may provide the major part of the load carrying capacity in compression or in tension as the design requires.

The horizontal load component of the load imposed by the bridge frame 10 upon the foundation frame shown in Figure 2 tends to place the column 30 in compression and the column 28 in tension axially of said columns. These forces are transferred to bed rock 44 by virtue of the rigid anchorage of the lower ends of the columns in the rock sockets 42 and 40, respectively. The vertical load component of the load imposed by the bridge frame 10 tends to place the columns in compression.

The foundation frame of my invention is capable of sustaining vertical load components either up or down and within the plane of the columns 30 and 28 horizontal load components either to the right or to the left in Figure 2 entirely by stresses axially of the said columns.

Although I have described embodiments of my invention in specific terms, it is to be understood that various changes may be made in size, shape, materials and arrangement without departing from the spirit and scope of the invention as claimed.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. A foundation structure of skeletal triangular form comprising a cap member comprising a body of concrete, a plurality of rock socketed

caissons comprising tubular casings, steel cores and a filling of concrete extending from the cap member to bedrock through the intervening soil, the cores and casings being anchored at their upper ends by the cap member, the casings extending into engagement with the rock, and the cores and the concrete filling extending into sockets cut into the rock below the casings, the concrete filling in the sockets bonding the cores to the walls of the rock sockets to sustain either tension or compression said caissons being rigidly connected together only at top and bottom and constituting the sole rigid connection between the cap member and bedrock.

2. A foundation extending from bedrock upwardly through overlying non-rigid earth strata consisting essentially of a load receiving member disposed a substantial distance above bedrock and a plurality of steel reenforced concrete caissons one of which has batter relative to another, said caissons converging upwardly and at their upper ends being coupled together by said load receiving member, said caissons diverging downwardly, and at their lower ends being bonded into sockets in said bedrock whereby they are connected together by said bedrock, said caissons being bound together only at the top and at the bottom, by the load receiving member and by said bedrock respectively as aforesaid, and constituting the principal load transmitting means between the load receiving member and bedrock.

3. A foundation structure comprising a concrete cap member, a pair of rock socketed caissons one of which is disposed on a batter relative to another, each caisson comprising a tubular casing disposed in engagement with bed rock at its lower end and connected to the cap member at the upper end, a steel core in each casing extending throughout the length of the casing and having its upper end bonded into the body of the cap and having its lower end extending into a rock socket formed in the bed rock below the end of the casing, and a body of concrete filling the space between the casing and the core and bonding the lower end of the core to the side walls of the rock socket, said caissons having rigid connection with each other only at the top and bottom as aforesaid and comprising the only rigid load transmitting means between said cap and bed rock.

4. In a foundation, the combination of a load receiving member disposed adjacent the free earth surface at the site and lying at a substantially distance above bedrock underlying said site, a plurality of drilled-in steel reenforced concrete caissons having their lower ends bonded in sockets in said underlying bed rock and having the upper ends coupled to each other and to said load receiving member, one of said caissons being disposed at a batter relative to another whereby to develop a horizontal reaction in the mass of bedrock between said two caissons upon the exertion of a horizontal force component against said load receiving member in the plane of said two caissons, said caissons being connected together only at their upper ends and at their lower ends and constituting the sole rigid connection between said load receiving member and supporting rock.

5. A foundation extending from bed rock upwardly through intervening strata comprising a load receiving member disposed a substantial distance above bed rock and a plurality of caissons at least one of which is inclined to the vertical and has its upper end convergent with respect to the upper end of another of said caissons, the bed rock having sockets cut thereinto axially in line with said caissons, each of said caissons including metallic reenforcement which at its lower end extends into the corresponding socket and is bonded to the side walls thereof and at its upper end is coupled to said load receiving member whereby a load in tension may be sustained axially of the caisson, said caissons being connected rigidly only at their upper and at their lower ends as aforesaid, and constituting the principal load transmitting means between the load receiving member and bed rock.

6. Foundation adapted to support a load including a substantial horizontal load component comprising a load applying member disposed above bed rock, a rock socketed caisson extending from said load applying member to bed rock, there being a socket cut into said bed rock at the lower end of said caisson, said caisson containing a steel core which at its upper end is connected to said load applying member and which at its lower end extends into said socket, the walls of the socket and the included end of the core being bonded together by cement to provide a connection capable of sustaining a tension load in said core, a compression sustaining member comprising a column, said caisson and said column being disposed at an angle to each other in substantially a common vertical plane, the upper end of said core and the upper end of said column converging into proximity to each other and being closely connected to each other and to said load applying member, the lower end of said column bearing upon bed rock to deliver thereto the compression load in the column, said load applying member having means to sustain a load having a substantial horizontal load component in said common vertical plane.

7. Foundation for anchoring to bed rock a horizontal load component comprising a plurality of steel columns having their upper ends disposed at a substantial distance above bed rock and being connected together at said upper ends, said columns extending down from said connection through intervening strata to bed rock, at least one of said columns being divergent relative to at least another and being adapted to sustain tension longitudinally thereof, and to deliver said tension load to bed rock and another of said columns being adapted to sustain compression longitudinally thereof and to deliver said compression load to bed rock, there being a socket in the bed rock into which socket the lower end of said one column extends, the side walls of the socket and the lower end of the said one column being bonded by cement to provide a connection capable of sustaining the tension load in said one column, and load imposing means connected to the upper convergent ends of said columns for delivering load having a horizontal load component in a direction tending to impose tension upon the said one column and compression upon said other column.

8. In a foundation adapted to anchor a horizontal load component at one level, to bed rock at a substantially lower level, the combination of a load applying member disposed a substantial distance above bed rock, a caisson extending from the member through intervening earth strata to bed rock, said caisson having a steel core, there being a socket in the rock, the lower end of the steel core extending into the socket and being bonded thereinto by cement to provide a connection for sustaining tension upon the

caisson, a column connected at its upper end to said load applying member and extending down into the earth to a load supporting stratum to develop support for a downwardly acting compression longitudinally of the column, the upper end of the caisson and the upper end of the column converging and said upper ends being connected together and to said load applying member, the lower end of said column being disposed a substantial distance horizontally from said rock socket by downward divergence of said caisson and said column.

9. Foundation for anchoring to bed rock a horizontal load component of a structure to be supported, comprising a plurality of steel columns connected together at their upper ends, at least one of said columns extending from said connection down through intervening strata to a firm load bearing stratum adapted to support a load in compression longitudinally of the column, at least another of said columns extending from said connection divergently relative to said first named column down through intervening strata to bed rock, and being adapted to support a load in tension longitudinally of the column, there being a socket in the bed rock into which socket

the lower end of said last named column extends, the side walls of the socket and the lower end of said last named column being bonded by cement to provide a connection capable of sustaining the tension load in said last named column, and load imposing means connected to the upper ends of said columns for delivering load having a horizontal load component in a direction tending to impose compression upon said first named column and tension upon said last named column.

HAROLD P. BURRELL.

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