

Feb. 7, 1928.

1,658,633

J. R. FREEMAN

SUPPORTING PIER

Filed Aug. 24, 1921

3 Sheets-Sheet 1

Fig. 1.

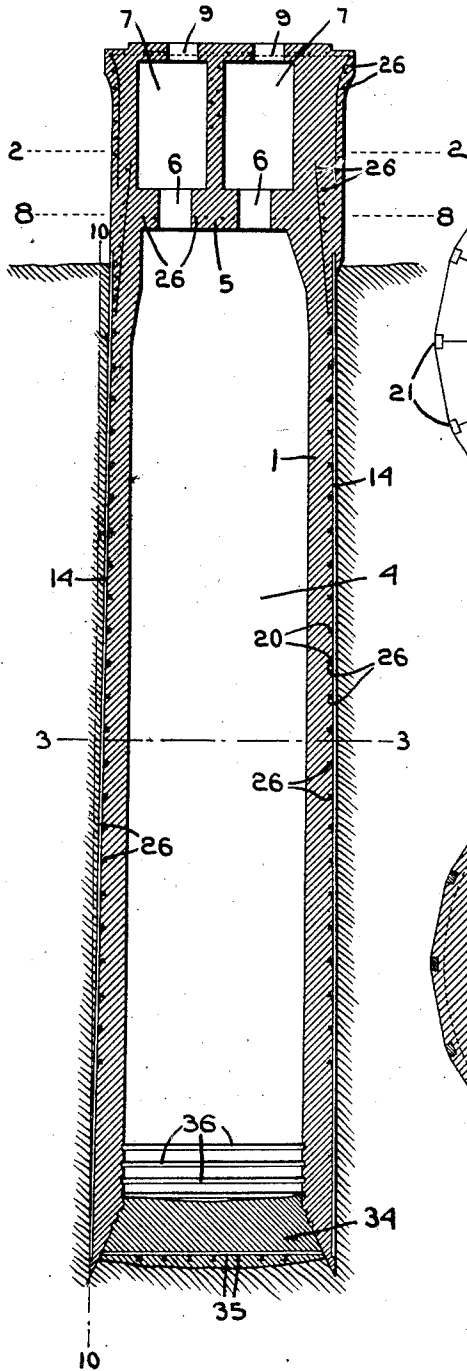


Fig. 2.

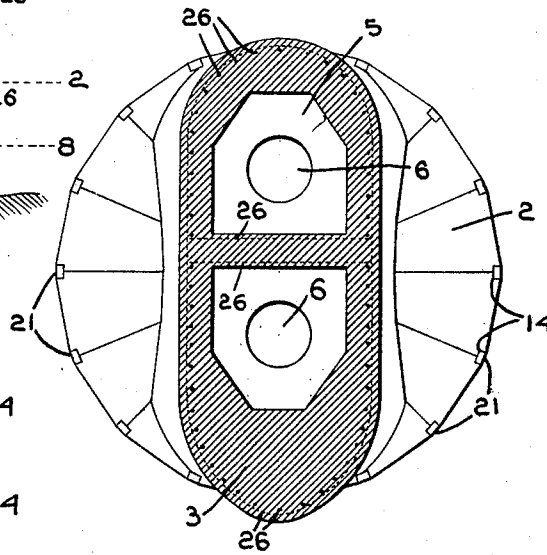
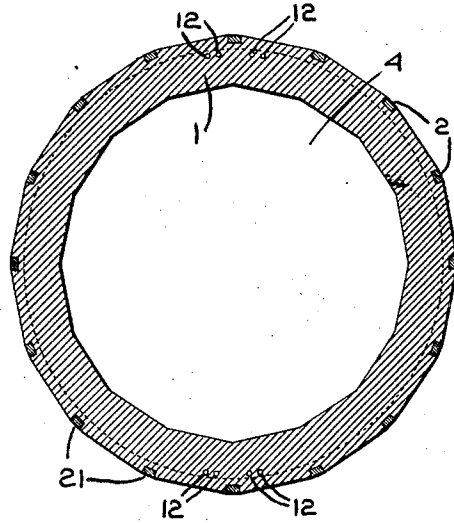


Fig. 3.



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Fig. 4.

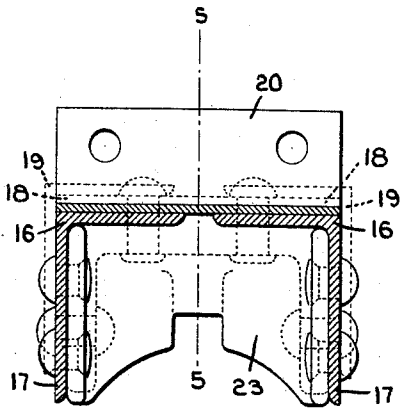


Fig. 6.

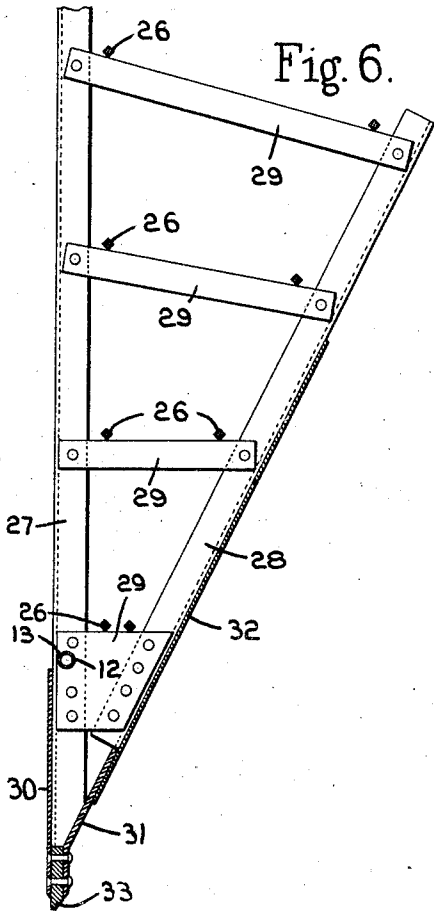
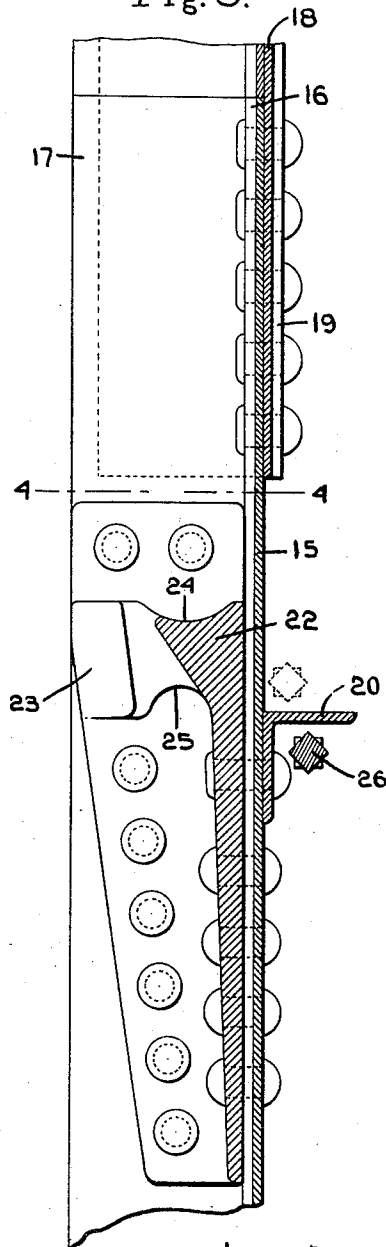


Fig. 5.



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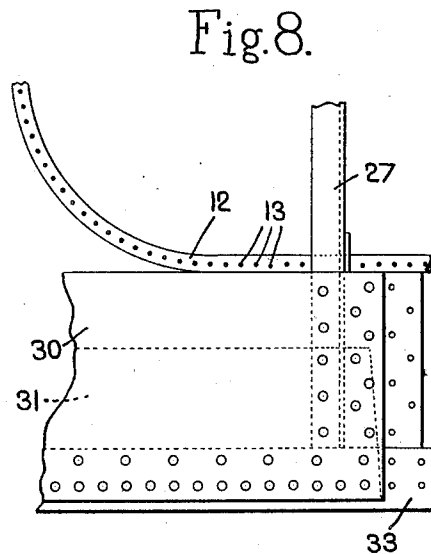
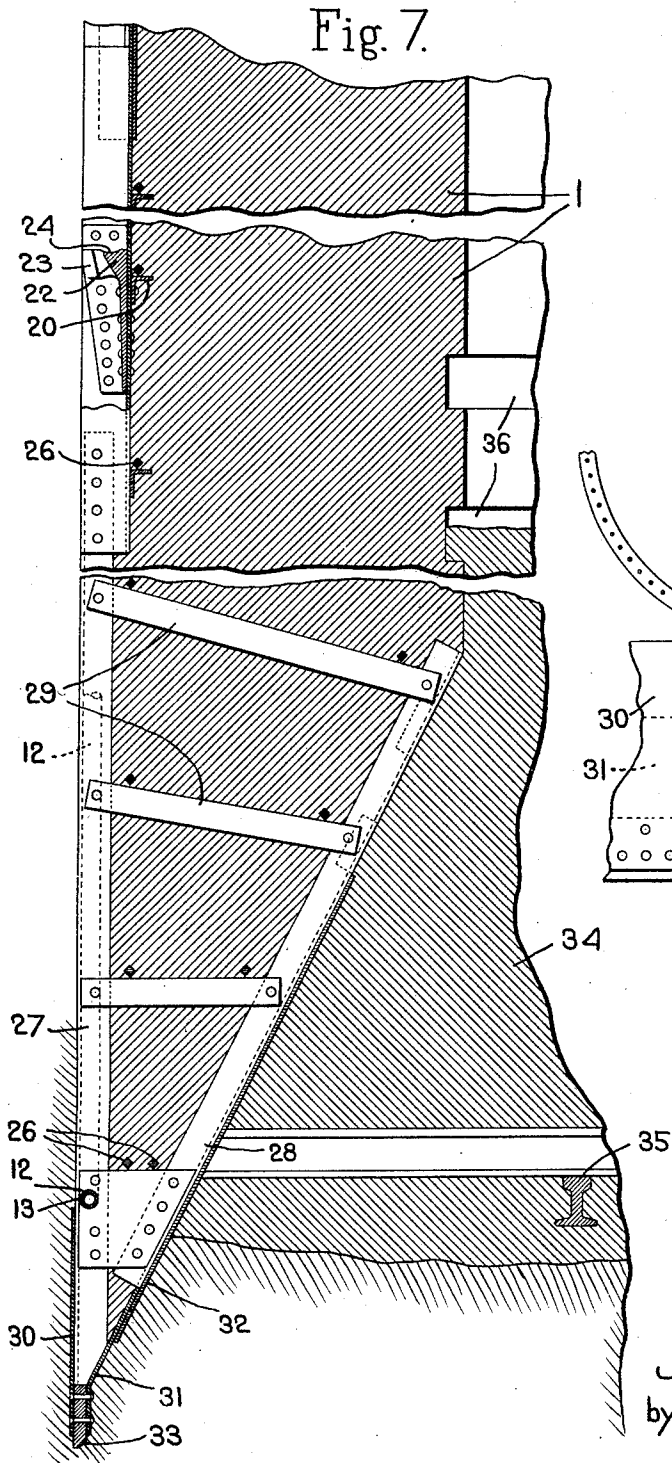
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE.

JOHN R. FREEMAN, OF PROVIDENCE, RHODE ISLAND.

SUPPORTING PIER.

Application filed August 24, 1921. Serial No. 494,945.

This invention relates to the construction of a supporting pier particularly designed to be sunk in and rest upon soft earth, such as a deep bed of unstable soft river silt, and to support a structure such as a bridge.

One feature of the invention consists in such a pier provided with one or more cavities closed at the bottom and sides by the material of the pier and filled with substance, such as air or water, of less specific gravity than that of the earth supporting the pier, so that the specific gravity of the mass of the pier, considered as a whole, is reduced and a minimum amount of pressure at the base of the pier is exerted upon the earth.

The feature of the invention is thus to give a certain degree of buoyancy to the entire pier relatively to the surrounding soft earth, such as sand, clay, or silt, in which it is embedded and upon which it rests by means of a cavity within the pier partially or entirely filled with air or water or substance of less specific gravity than that of the earth.

The feature of the invention is to provide such a pier in which the size of the cavity and the amount and specific gravity of the filling substance have a proportional relation to the weight of the pier and its load and the area of the base and the character of the supporting earth such as to produce a pressure on the supporting earth at the base of the pier materially less than that which can be safely borne thereby and not detrimentally greater than the normal pressure imposed by the surrounding earth at the level of the base of the pier.

Other features of the invention reside in the means employed for reinforcing the pier when made of concrete, for providing permanent rigid vertical columns in its exterior periphery to take forces of thrust and draft and transmit them to the material of the pier during the sinking operation and to the exterior configuration of the pier, by means of which, when it is sunk, the pressure of the surrounding earth is relieved without inviting any extensive inward movement of the earth.

These and other objects and features of the invention will appear more fully from the accompanying description and drawings and will be particularly pointed out in the claims.

The drawings represent a supporting pier construction embodying a preferred form of the invention and particularly designed as a bridge pier to be formed of concrete and sunk in and supported by soft earth, such as alluvial soil or silt, often forming to a great depth the bed of a river at its delta.

In the drawings:

Fig. 1 is a transverse vertical section of the completed pier in position.

Fig. 2 is a view on a larger scale taken on the line 2—2, indicating the high water level in Fig. 1.

Fig. 3 is a view on the same scale as Fig. 2 in transverse cross section taken on the line 3—3 of Fig. 1.

Fig. 4 is an enlarged detail of one of the rigid vertical columns in transverse cross section taken on the line 4—4 of Fig. 5.

Fig. 5 is a view in vertical cross section of one of the columns taken on the line 5—5 of Fig. 4.

Fig. 6 is a view in side elevation in partial vertical cross section, showing the metal reinforcement and cutting shoe at the bottom of the pier.

Fig. 7 is a view in vertical cross section partially broken away of the pier showing the relation of the reinforcing elements to the remainder of the structure.

Fig. 8 is a front elevation of a portion of the structure shown in Fig. 6.

The pier embodying the invention is particularly designed as a monolithic shell of reinforced concrete having a large interior cavity, so that its body portion presents a caisson with a sharp lower peripheral cutting edge. The pier is designed to be poured in successive layers prior to its sinking into the earth foundation and to be gradually sunk as a caisson. When it has been sunk to the required depth, the bottom of the shell is filled with a reinforced plug of concrete, which forms the base of the pier and which is interlocked with the shell of the pier.

A preferred apparatus and method for constructing and sinking such a pier or caisson is made the subject of Patent 1,630,337 granted May 31, 1927.

The body portion or shell of the pier which is embedded in the earth, such as the river bed, may take any desired form, but is preferably as shown in Fig. 3 of a generally circular or polygonal shape. This

form presents the maximum resistance to the pressure of the surrounding earth with the minimum amount of material and is readily formed by the use of flat rectangular forms when the concrete is poured. The shape of the pier structure above the river bed may also vary as desired. In the construction illustrated the annular shell 1 is exteriorly tapered upwardly, as shown at 2 in Fig. 2, and above the tapered portion is given a shape such as to give less obstruction to the current as shown at 3 in cross section in Fig. 2.

The large cavity 4 in the body or shell of the pier is preferably closed at the top by a transverse wall or partition 5, in which manholes 6 are provided, and the section of the pier above this wall 5 is provided with suitable chambers 7 to reduce the weight of the pier. The partition 5 closes the cavity 4 below the low water level indicated at 8—8 in Fig. 1, so that no frost strains can develop within the shell; and if necessary in cold climates the water in the cavity 4 may be kept even lower than this level. But the water may be allowed to rise and stand in the manholes at a higher level, because even in cold climates the thickness of the walls outside these manholes is so great that there is little danger from frost strains. Access is had to the chamber 7 by manholes 9 in the top surface of the pier, so that sand, stone, or other ballast can be deposited in the cavity 4, if under any particular conditions it should be found desirable to increase the theoretic stability of the pier by lowering its center of gravity.

The pier also embodies in its permanent construction a small upward and inward exterior taper on the shell or body. This taper, which is of about one percent where the river bed is of silt or other similar formation, is for the purpose of reducing the skin friction of the surrounding earth when the pier is being sunk and is barely large enough to relieve the pressure of the surrounding earth, and admit the circulation of a thin film of water while sinking, but is not sufficiently large enough to invite any extensive inward movement of the earth while it is being sunk. This taper is indicated in Fig. 1 by the vertical line 10—10.

The pier also embodies in its permanent construction a plurality of vertical water pipes 12, bent laterally at the bottom and provided with holes 13 at the exterior of the shell, through which water may be forced and discharged to provide a lubricating film when sinking with the pier. These pipes in the permanent construction of the pier provide a part of the vertical reinforcing means.

The main vertical reinforcement of the pier is provided by a plurality of rigid vertical metal columns 14, preferably extend-

ing throughout the length of the shell of the pier. The number of these will vary according to the dimensions of the pier and the particular conditions. In the form illustrated there are sixteen, one at each of the angles of the exterior polygonal surface. A preferred form of these columns is illustrated in detail in Figs. 4 and 5. Therein each column is shown as of channel form, being made up of a vertical back plate 15 with two angle-irons 16 bolted thereto, and presenting outwardly extending flanges 17 forming the channel. Each column may be made in vertical sections, as shown, and the abutting sections spliced together by the plate 18 and the angle-irons 19 bolted thereto. At frequent vertical intervals angle-irons 20 are bolted to the rear of the column with their flanges projecting inwardly. The entire column with the inwardly projecting flanges of the angle-irons 20 is built into the concrete of the shell as it is poured and thus firmly embedded therein.

These rigid vertical columns thus present strong reinforcements to the material of the pier and serve to unite together into one mass the successive layers or sections of concrete. When the pier is completed the channels of these columns are filled with concrete 21, put in place as the shell is sunk into the earth.

These columns not only serve as permanent reinforcements of the pier but they are also utilizable in transmitting forces of thrust and draft, preferably used in the sinking of the pier as it is constructed. For this purpose each column is provided with a plurality of vertically separated steps, which form a permanent part of the pier. Each step, as illustrated, comprises a heavy iron bracket 22 bolted in place in the channel, as illustrated in Figs. 4 and 5. This bracket comprises a heavy outwardly projecting step 23. These steps are designed to take on the top surface at 24 the thrust from powerful jacks and on the bottom surface at 25 the pull or draft exerted by extensible suspending means, such as heavy cable chains, all designed to assist in the speedy, accurate, and even sinking of the pier during its construction, and made the subject of the hereinbefore mentioned patent. Thus these forces of thrust and draft are transmitted through vertical columns to the lower sections of hard set concrete as the pier is sunk, and all danger of the shell of the pier being broken or cracked during its sinking is prevented.

The pier is also suitably reinforced longitudinally and transversely wherever desirable under the particular conditions by familiar means, such as twisted iron rods 26 embedded in the concrete at suitable points. A large number of these reinforcing rods are employed in circular transverse

position in the shell of the pier and serve to reinforce the shell of the pier against any transverse or arch thrust.

The lower peripheral edge of the pier is heavily reinforced, particularly for the purpose of supporting the sharp cutting metal shoe used in sinking, but this structure forms a permanent part of the pier and is shown in detail in Fig. 6. This reinforcement comprises a plurality of generally triangular frames. These frames are arranged radially of the shell of the pier and embedded in the lowermost section. Each is preferably bolted to and forms a continuation of one of the main vertical columns 14. One of the frames is shown in Fig. 6. It comprises a vertical angle-iron 27 and an inclined angle-iron 28, secured together by the transverse plates 29. These frames are faced at the lower exterior with a metal plate 30 and at the lower interior with metal plates 31 and 32. A heavy annular steel cutting shoe 33 is bolted between the plates 30 and 31. The plates 30, 31, and 32 form a continuous annular reinforcement and surface for the extreme lower edge of the pier, as well as supporting the cutting shoe.

The pier is sunk by dredging out the earth from the interior of the pier or caisson and utilizing the forces and means hereinbefore referred to. When the pier reaches the desired depth, it is closed at the bottom by a plug 34 of concrete, placed in position by a tremie or open-bottom bucket and this forms the base of the pier. This plug is preferably reinforced by transversely arranged layers of separated bars 35 of railroad rails or other material, and it is interlocked with the shell of the pier by means of the grooves 36 formed in the interior periphery of the shell.

When the pier is completed and in position, the cavity 4 is filled to any desired height, depending upon the particular conditions, with a suitable filling substance, such as air or water, or a ballast of sand or earth at the bottom in combination with air or water, so as to give the desired buoyancy to the pier. By varying the diameter and proportional size of the cavity and of the shell of the pier with relation to the area of the base and the particular character of the supporting and surrounding earth and the amount and specific gravity of the filling substance and the total weight of the pier and its load, it is thus possible to cause the pressure produced by the pier and its load at the base on the foundation earth to be well within that which can be safely borne by the earth at this point, even when of a soft and unstable nature. In fact, this pressure is readily designed by this invention so as to be not detrimentally greater than the pressure produced at the level of the base of the pier by the

surrounding earth itself. And when the skin friction of the surrounding earth on the exterior periphery of the pier is considered, no difficulty is experienced in bringing the pressure at the base of the pier well within and below that which can be safely borne by the earth at this point. This means for producing a buoyancy of the pier and its load with respect to the surrounding earth so as to enable it readily to be supported in soft earth, such as the silt or sand of a river bed, is the important feature of the invention.

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

1. A supporting pier embedded in and supported upon soft earth and provided with a cavity closed at the bottom and sides by the material of the pier and filled with water to a plane below low water level, whereby the pressure upon the supporting earth at the base of the pier may be brought within impossible limits and deleterious freezing of the water prevented.

2. A hollow supporting pier embedded in and supported upon soft earth and provided with a cavity closed at the bottom and sides by the material of the pier and means for varying the pressure imposed upon the supporting earth by the pier and its load which consists in a filling substance placed within the cavity, in an amount and of a specific gravity sufficient to secure the required stability and to make the pressure on the supporting earth at the base of the pier less than that which can be safely borne by the supporting earth.

3. A hollow concrete supporting pier embodying a plurality of rigid vertical columns built into its exterior periphery and steps located at vertical intervals on the exterior of said columns utilizable to receive a vertical thrust or draft applied thereto and to transmit the same through the columns to the lower hard set concrete.

4. A hollow concrete supporting pier to be sunk in soft earth having an exterior upward and inward taper of approximately one per cent acting to relieve the inward pressure, and insufficient to invite the extensive inward movement, of the earth in which it is to be sunk.

5. A hollow concrete supporting pier embodying a plurality of rigid vertical columns built into its exterior periphery, a triangular metal frame secured to the bottom of each column and extending radially of the pier and embedded therein, and an annular metal cutting shoe secured to the lower points of said frames.

6. A hollow concrete supporting pier embodying a plurality of rigid vertical channel metal columns having secured to their rear plates horizontal vertically spaced pro-

jections, the said columns built into the exterior periphery of the pier with the channel faces outward and acting vertically to reinforce and unite the concrete of the pier into a continuous mass.

5 7. A hollow concrete supporting pier having the construction defined in claim 6, together with a concrete filling in the channel faces of said columns.

8. A hollow concrete supporting pier having the construction defined in claim 6, together with metal steps secured at vertical intervals to said columns within the channel faces thereof. 10

In testimony whereof, I have signed my name to this specification. 15

JOHN R. FREEMAN.

CERTIFICATE OF CORRECTION.

Patent No. 1,658,633.

Granted February 7, 1928, to

JOHN R. FREEMAN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 23, for the misspelled word "filted" read "filled"; page 3, line 89, claim 1, for the word "impossible" read "imposable"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of March, A. D. 1928.

Seal.

**M. J. Moore,
Acting Commissioner of Patents.**