(No Model.) 2 Sheets—Sheet 1.

W. D'H. WASHINGTON.

METHOD OF AND APPARATUS FOR SINKING CAISSONS FOR PIER FOUNDATIONS, &c.

No. 563,106. Patented June 30, 1896.

Fig. 1.

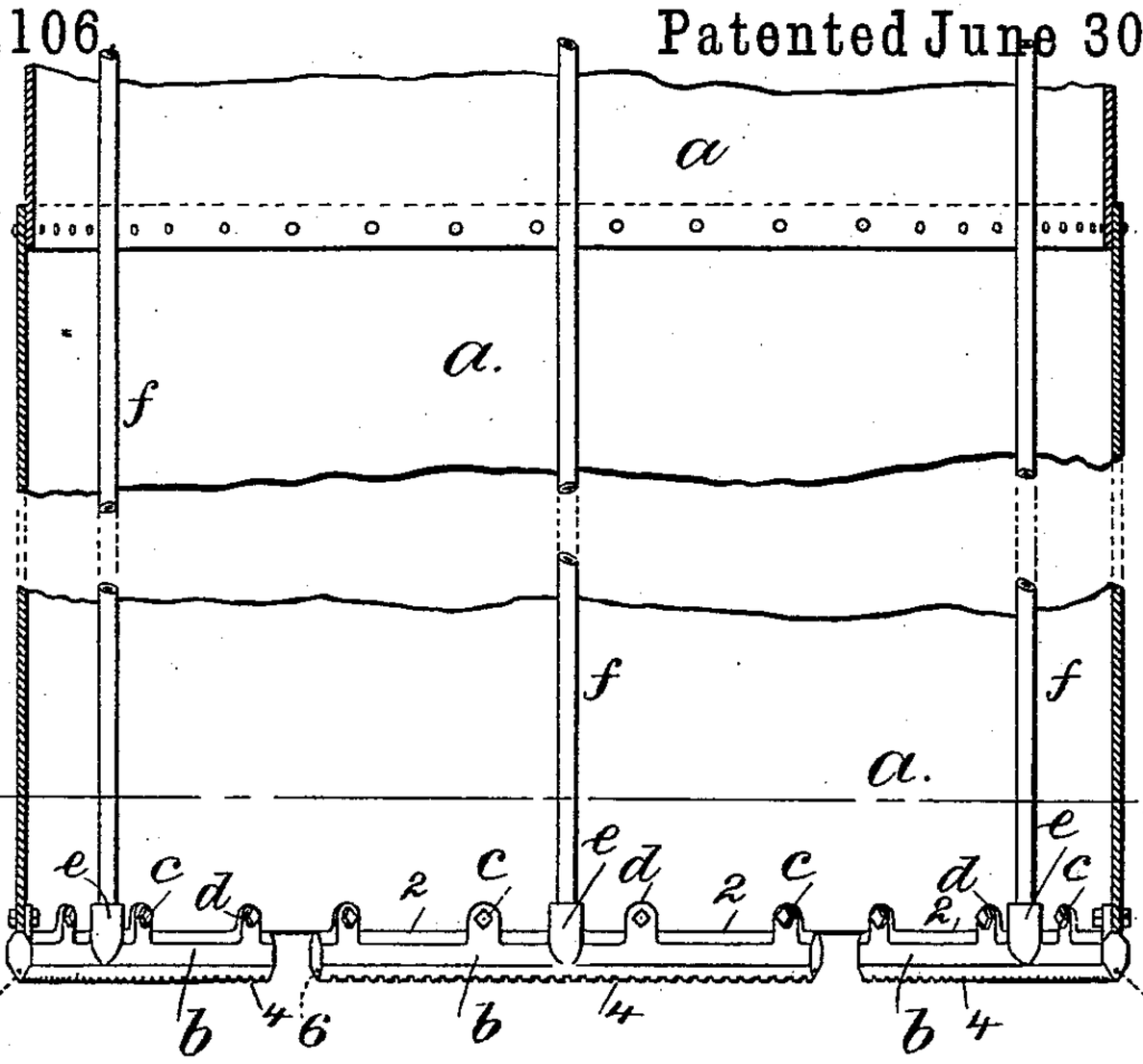


Fig. 5.

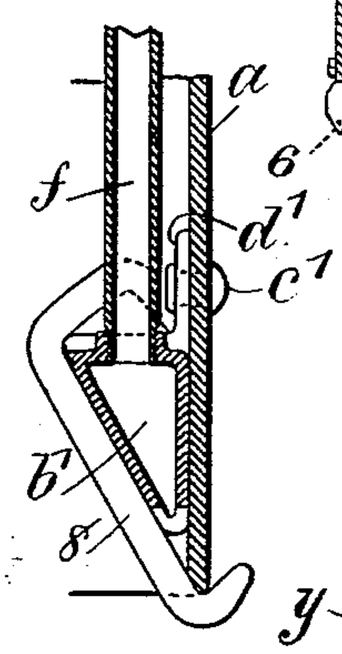


Fig. 2.

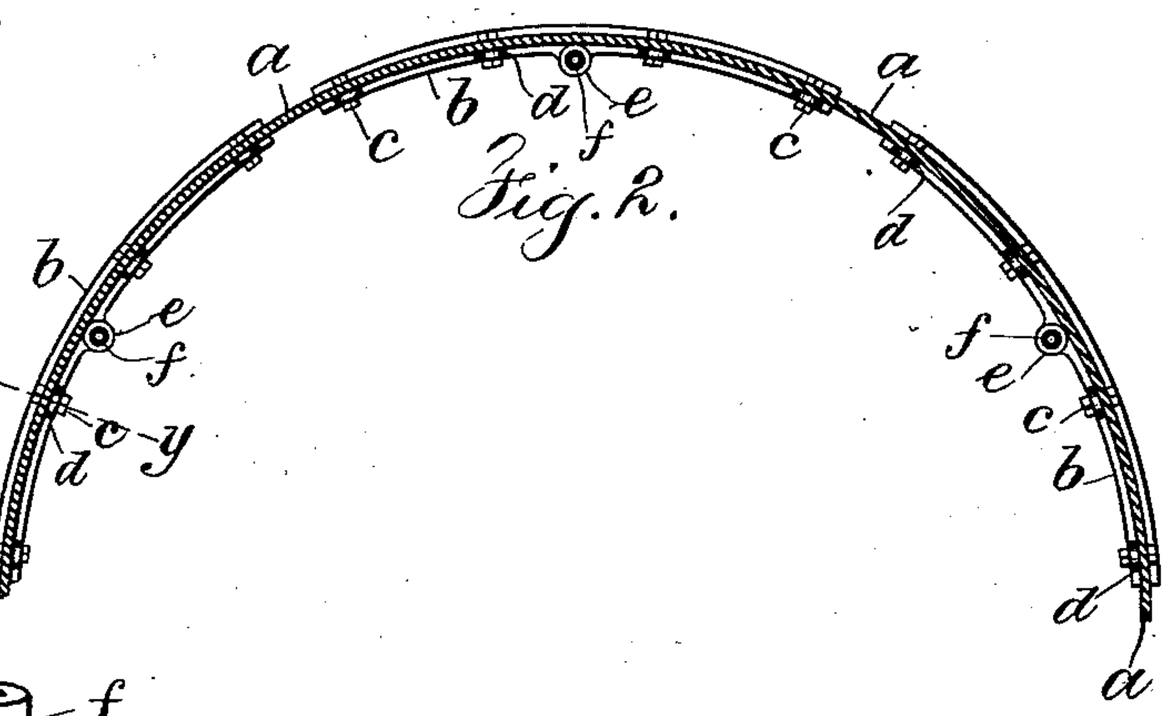


Fig. 4.

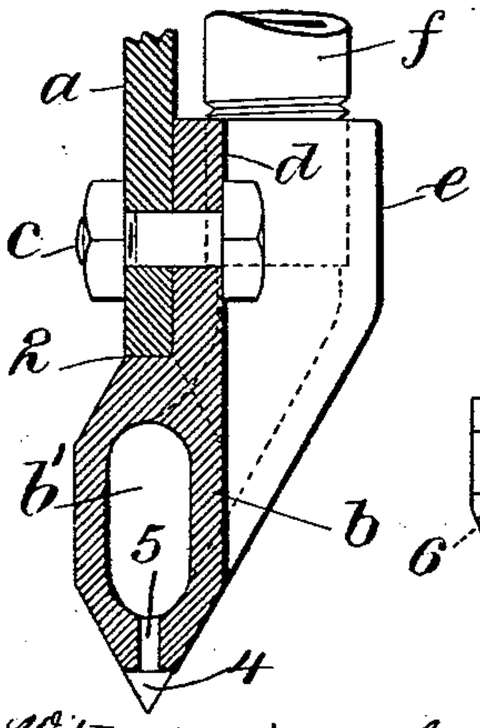
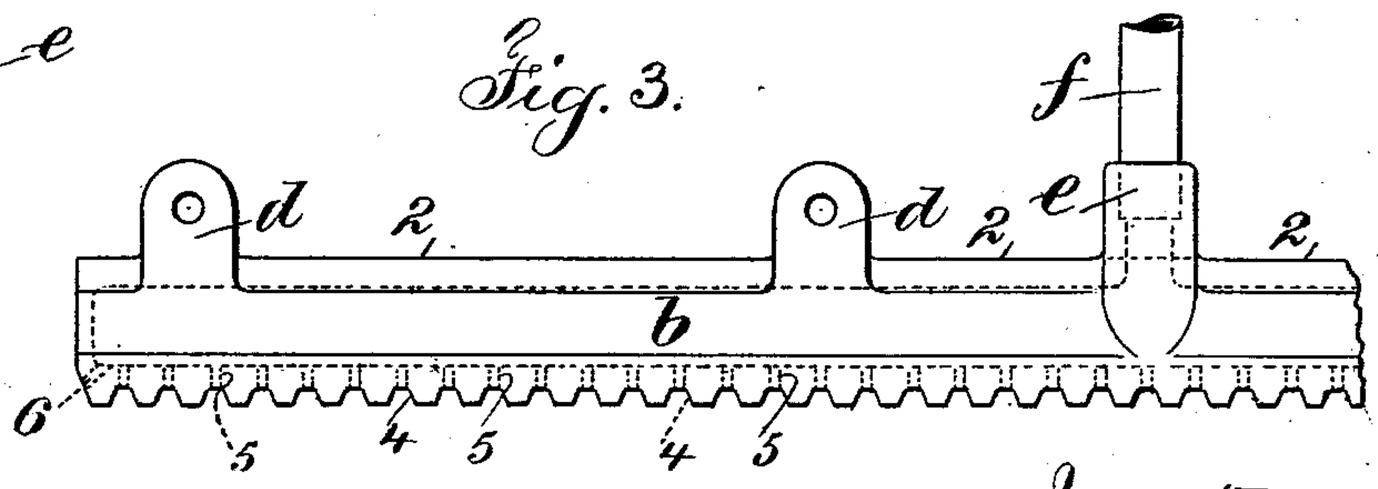


Fig. 3.



Witnesses
O. F. Barthel.
P. W. Hulbert

Inventor
W. D'H. Washington
per Thos. G. Sprague & Son
Attys.

(No Model.)

2 Sheets—Sheet 2.

W. D'H. WASHINGTON.

METHOD OF AND APPARATUS FOR SINKING CAISSONS FOR PIER FOUNDATIONS, &c.

No. 563,106. Patented June 30, 1896.

Fig. 7.

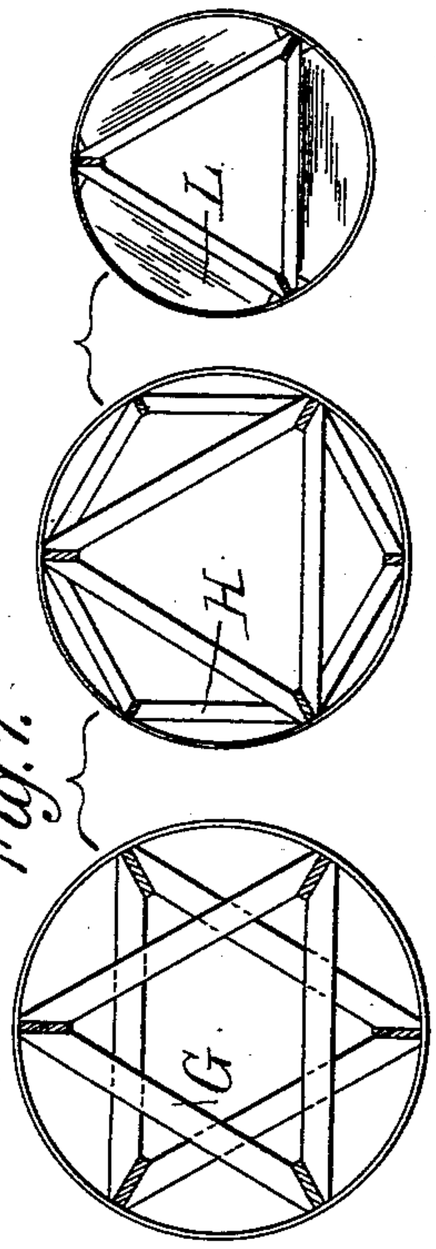


Fig. 6.

Witnesses:
O. F. Barthel,
P. M. Hulbert

Inventor:
W. D'H. Washington,
By Munn & Sprague & Co
Attorneys.

ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.

UNITED STATES PATENT OFFICE.

WILLIAM D'H. WASHINGTON, OF NEW YORK, N. Y.

METHOD OF AND APPARATUS FOR SINKING CAISSONS FOR PIER-FOUNDATIONS, &c.

SPECIFICATION forming part of Letters Patent No. 563,106, dated June 30, 1896.

Application filed October 14, 1895. Serial No. 565,639. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM D'H. WASHINGTON, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Sinking Caissons for Pier-Foundations, &c., of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates particularly to the construction of pier-foundations of masonry, which in the art of building heavy structures are generally resorted to where piling cannot be used to advantage, as in localities where solid bed-rock is reached at some depth below the surface.

In the present state of the art the building of pier-foundations is generally carried out by sinking strong iron cylinders, casings, or so-called "caissons" vertically by digging away the soil from below them and utilizing the cylinder as the well-curb until the bed-rock is reached, after which the masonry pier is built inside from the foundation up. This method is aggravatingly slow and costly and to this end I have devised the hereinafter-described improvement, which is based on the hydraulic plan of cutting away the soil below the caissons by means of water-jets, and which has resulted in making the construction of pier-foundations much more expeditious and less expensive, all as more fully hereinafter described in connection with the drawings, in which—

Figure 1 is a vertical section through a caisson particularly devised to carry out my improvement. Fig. 2 is a horizontal section of Fig. 1 on line *x x*. Fig. 3 is a detached elevation of one of the sections of the cutting-shoe with which the lower end of the caisson is provided. Fig. 4 is an enlarged section on line *y y* of Fig. 2. Fig. 5 is a similar view as Fig. 4 of a modified form of construction. Fig. 6 is a vertical sectional view illustrating my method of sinking a caisson. Fig. 7 shows different forms of interior bracing applied to the caisson.

The caissons shown in the drawings are lap-joint steel cylinders built up in telescopic sections, as shown in Fig. 1. The diameters of these caissons are proportioned to the amount of load calculated to be carried by the piers they contain, and as they are intended simply to exclude the earth and water during excavation and filling they are built of thin steel plates with single rows of rivets, and the seams may be left uncalked.

Each caisson is shod with a special cutting edge or shoe made of segments *b* of hollow castings, provided with lugs *d*, by means of which they are secured by bolts *c* to the lower edge of the caisson which bears on the shoulder 2, formed on top of the casting.

Each section of the casting forms a tapering serrated cutting edge 4 and in the indentations of the serrations are placed the small water-jet orifices 5, which communicate with the closed interior space *b'* of the cutting edge and through a suitable branch *e* with the water-supply pipe *f*, which extends along the interior wall of the caisson to the top thereof.

In Fig. 5 I show a somewhat modified construction of the cutting edge, in which the castings are made of a form to fit against the interior wall of the caisson and are detachably secured thereto by means of suitable clamping-hooks 8, which in connection with suitable angle-plates *d'*, secured by bolts *c'* to the inside of the caisson, are adapted to firmly hold the sections of the cutting edge detachably in place. These castings *b*, constructed and arranged as described, form a complete shoe around the lower edge of the caisson, which when supplied with water under pressure is adapted to produce an annular series of small water-jets directly below the lower edge of the caisson. To close up any possible interval between the sections, the ends of the segments may be provided with inclined jet-apertures 6. To sink such a caisson, a pit is preferably dug by hand to the level of the ground-water and the caisson is placed in it by a steam-derrick. A steam-pump A is set near the caisson which is adapted to deliver water at a pressure of from fifty to one hundred pounds into branches B, which connect the pump with the vertical supply-pipes *f* in the caisson. Each of the branches consists of flexible tubing connected with the vertical pipes *f* through goosenecks *f'* over the top of the caisson and each is independently controlled by a valve C. The caisson is heavily weighted down, as

by piling pig-iron upon a platform P on top, and differential hoists H′ are applied, preferably at four equidistant points, hung from the timber-frame across the top and hooked at the bottom to an anchor-platform D, which is also provided with a load of pig-iron E. Now if water is admitted into the cutting edge the jets of water pouring out at a great pressure will loosen and scour away the surrounding earth and create an annular well into which the caisson will sink under the extra weight applied to the caisson. By the proper arrangement and working of the hoists in connection with the manipulation of the valves which control the access of water to the separate sections of the cutting edge the verticality of the caisson can be readily maintained throughout the whole operation of sinking. The jets are maintained until the caisson reaches the solid foundation. The downward progress of the caisson is ordinarily so rapid that it may be followed by the eye, and the time consumed to sink the caisson to a moderate depth, say about thirty feet, will be fewer hours than it took days heretofore in the old way. The water which is used for jetting out the well in which the caisson sinks is allowed to rise around the sides of the caisson to the surface of the ground, and in order to save water where it would be expensive to waste it a pulsometer or other suitable pump E′ is arranged to collect it and pump it back into a settling-tank F, for which purpose a previously-sunk caisson or a number of them may be used, and which can be easily converted into a settling-tank by inclosing it, if necessary, with a protecting sheet-piling after the bottom is sealed tight with a layer of concrete.

The caissons may be delivered in sections, and after one section is sunk the next one may be riveted on top, and so on until the whole caisson is completed while sinking it. This permits of building pier-foundations where there is not enough overhead room available to sink the whole caisson in one piece, as would be the case, for instance, in erecting pier-foundations in the cellar of an existing building which is designed to receive additional stories.

The core of soil which remains in the interior of the caisson may not be removed from the interior of the cylinder until the caisson reaches the solid foundation upon which the pier is to be built.

Where the caissons are buried in solid stiff clay, which often covers a rock surface, the cutting edge will become effectually sealed, so that the interior can be excavated and the masonry built dry by the aid of moderate pumping, if necessary, or after excavating a reasonable distance an air-lock may be put in and the excavation completed that way.

With an irregular surface of rock other means may be resorted to, such as sheet-piling, but the simplest way which my method enables me to use is to seal up the edges and bottom by pumping thin grout into the cutting edge and injecting it through the jet-holes into the cavities scoured out by the water. When excavating begins, the sides of the caisson are braced to resist exterior pressure and deformation by the assistance of triangular frames wedged tight. In smaller cylinders three bevel-ended struts G, with interposed oak wedges, make a suitable frame, which is put as low down as practicable. Then the men dig out under it as far as possible and set another frame a few feet below it, and so on, always passing the excavated ground up in buckets hoisted through the center of the caisson by the derrick. Instead of excavating by hand, however, the sand pump or dredge might be used. For larger caissons two sets of triangular braces may be used, or auxiliary braces H, or solid plank segments L may be provided in the exterior space on each side of the triangular main frame, all as shown in Fig. 7.

Except where loose sand is encountered the core remaining in the caisson after sinking is but little affected, and where quicksand is present the difficulty heretofore encountered in the old method by the constant inflow of the sand is entirely avoided, as the tendency of the quicksand to flow is so slow that by the rapid work of my method the bottom can be reached, the rock cleaned, dressed a little, if necessary, and closed up by concrete before it penetrates the interior. Moreover, as the material inside and outside the caisson maintain each other, there can be but little tendency of the quicksand to flow.

When the excavation is completed, the rock bottom is cleaned and the bed of cement concrete a few feet in thickness is placed thereon by building up in layers, as in the usual manner. Upon this concrete the pier is built the full size of the caisson up to the top thereof, either solid or hollow.

It will be seen that in my method the caissons are intended to act simply as shields and their function is accomplished as soon as the masonry inside them is completed, and their endurance therefore is immaterial. Therefore they may be built less strong and consequently cheaper than heretofore, as they are not needed to resist any unbalanced exterior forces until the excavation is begun and this is then practically resisted by the interior cross-bracing, and no reliance need be placed therefore on the cylindrical walls themselves to resist these strains.

By exercising proper care the sinking of a caisson is accomplished in a practically continuous manner, if during the sinking the perpendicular position of the caisson is carefully watched and the proper means are immediately applied to keep it from swerving to any one side. If the character of the soil should offer greater resistance at one point than at another, of course the jetting out would advance more rapidly at the point of less resistance and consequently cause the

caisson to swerve. By shutting off the water from such segment or segments which are in advance and by hauling up the weight D (by means of the hauling-rope H′) on the side where increased action is needed, the action of the jets is temporarily localized upon the spot which has the greater resistance until the caisson straightens itself up again. Ordinary obstructions, such as roots or stones, are easily cut through by the cutting edge, or are pushed aside by it, and where such obstructions are liable to be encountered it is always advisable to use a shoe provided with a suitable cutting edge, and it is obvious that the less lateral dimension is given to the shoe the easier it will penetrate into the ground, and by means of the serrations at the cutting edge a free outflow of the water from the jet-holes is preserved.

From the foregoing description it will be readily seen that my method of sinking the caissons and building the foundation-piers is much more flexible and adapted to different contingencies than the old method, its progress is much more rapid and satisfactory, and it is adapted to be carried out before the old building above the site is removed.

Where circumstances admit, the modified construction of the shoe shown in Fig. 5 may be used and after completion of the sinking of the caisson it may be removed and used again. Although I have described my invention as applied for building pier-foundations, I have done so merely for the purpose of illustrating it, as its scope is much broader, and those skilled in the art will readily perceive its application to solve other engineering problems, as in constructing coffer-dams, light-houses, bridges, air-shafts, tunnels, and the like, or for constructing cisterns, storage-tanks, deep wells, &c., and the engineer will at once see that it solves the problem of how to overcome "skin-friction" in sinking caissons and the like in a most perfect way, and thus opens the way to sink caissons to much greater depth than has been practicable heretofore, as in my method the skin-friction of the caisson, that is, its frictional contact with the ground, is done away with, as the water is directed upwardly both inside and outside and quasi forms a lubricant between the ground and the walls of the caisson.

In sinking to such great depth where the upflow of water might be liable to become obstructed, or if on account of loose soil it might find other outlets, supplementary jets could be readily attached around the walls of the caisson, inside or outside or both, at suitable intervals in sinking. Thus after sinking about fifty feet a shoe of the character shown in Fig. 5 can be fastened to the inside and a similar one (beveled reversely) to the outside and the sinking proceeded with by the additional use of the supplementary jets required.

My method may be used in sinking caissons in water, as well as on dry land, and hydraulic force or the sand-pump may be used to clean out the soil within the caisson either during the process of sinking or after it is completed, and by using concrete as the material for filling its exterior the bracing of the caisson would not be at all required.

The caissons of course may be cylindrical, rectangular, or of any other desired cross-section, and may be built of wood, cast-iron, steel, or any other available material, and provided with a shoe adapted to it or formed integrally with it, and the strength of the caisson may be made such as to support the load directly upon it without recourse to an inside pier.

Among all the modifications to which my invention will necessarily be subjected in carrying it out to meet practical requirements the use of compressed air or steam as an available substitute for water for jetting out the soil obviously suggests itself.

I use the phrase "digging an annular well" in the claims to signify that a comparatively narrow channel is formed, of the shape of the caisson-shell, (whether round or polygonal,) leaving within the caisson a core of earth, which is not removed by the jet action, and the outer face of which forms, when the caisson is sunk, a substantially similar earth wall within the caisson to the earth wall around the outside of the caisson.

What I claim as my invention is—

1. The herein-described method of sinking hollow caissons, which consists in digging an annular well by water-jets at the lower edge of the caisson and simultaneously lowering the caisson into such well.

2. The herein-described method of sinking hollow caissons, which consists in digging an annular well by fluid-jets at the lower edge of the caisson, simultaneously forcing the caisson into such well, and carrying the debris out through the well by the escaping fluid.

3. The herein-described method of sinking hollow caissons which consists in digging an annular well by water-jets at the lower edge of the caisson, simultaneously forcing the caisson into such well, and directing its downward movement by localizing the action of the water.

4. The herein-described method of sinking hollow caissons, which consists in forming an annular well by jetting water at the lower end of the caisson, applying downward pressure thereon simultaneously and directing the movement by applying the jets and pressure proportionately to the resistance at various points in the well, during the progress of sinking.

5. In the art of building pier-foundations the herein-described method of sinking a hollow caisson, which consists in first sinking the caisson into an annular well formed by

jetting out the soil with water discharged from the lower edge of the caisson, then sealing it by the use of fluid cement in lieu of water and then excavating the interior core, substantially as described.

6. In an apparatus for sinking casings, the combination with a casing, of a hollow shoe at the lower edge thereof which is provided with imperforate sides and with jet-holes from the interior hollow space downward in line with the walls of the casing, and water-supply connections extending up the wall to the top of the casing, substantially as described.

7. In an apparatus for sinking a tubular caisson, the combination with the caisson of a hollow shoe attached to the lower edge thereof and composed of independent segments, each provided with a perforated cutting edge, and a vertical supply pipe connecting each section with a source of water-supply, substantially as described.

8. In apparatus for sinking tubular caissons, a shoe composed of hollow segments *b* each provided with a serrated cutting edge, means for attaching each segment to the lower edge of the caisson, and the branch *e* for connecting each segment independently to a source of water supply, substantially as described.

9. In an apparatus for sinking tubular caissons, the combination of a caisson provided with a hollow shoe having jet-apertures directed only downward to dig an annular well, of a series of weights suspended by hoists from the top of the caisson at different parts of the circumference, substantially as and for the purpose described.

10. In an apparatus for sinking caissons, a shoe provided with means for attaching it to the lower edge of the caisson having an interior chamber, connections therewith from a supply of fluid under pressure, said shoe being provided with an independent lower cutting edge and jets in the indentations and away from the cutting edge.

11. In an apparatus for sinking caissons, the combination with a caisson of a shoe attached to the lower edge thereof provided with a cutting edge and having an interior chamber, connections between said chamber and the fluid supply under pressure, such shoe having imperforate side walls, and perforations adapted to jet the water directly below the shoe, substantially as described.

12. In an apparatus for sinking caissons, the combination with a tubular caisson, of a hollow shoe at the lower edge thereof, connections between the interior of the shoe and a fluid supply under pressure, the shoe being provided with jet-apertures directed only downward to dig an annular well in which the caisson may sink or be forced, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

WILLIAM D'H. WASHINGTON.

Witnesses:

BASSETT W. INGLE,

J. J. MAGUIRE.