No. 673,443.

Patented May 7, 1901.

G. L. MOUCHEL.

PILE.

(Application filed May 15, 1900.)

(No Model.)

3 Sheets—Sheet 1.

Fig. 1.

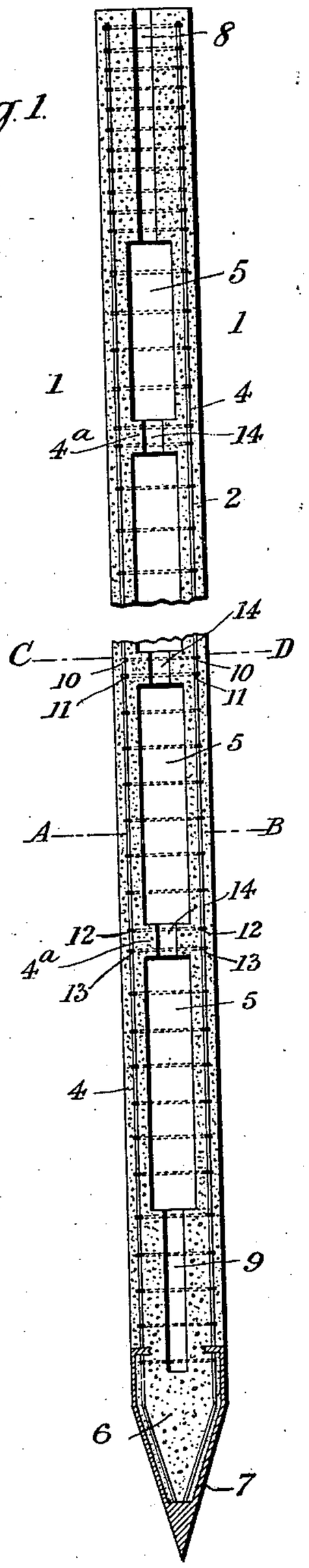


Fig. 2.

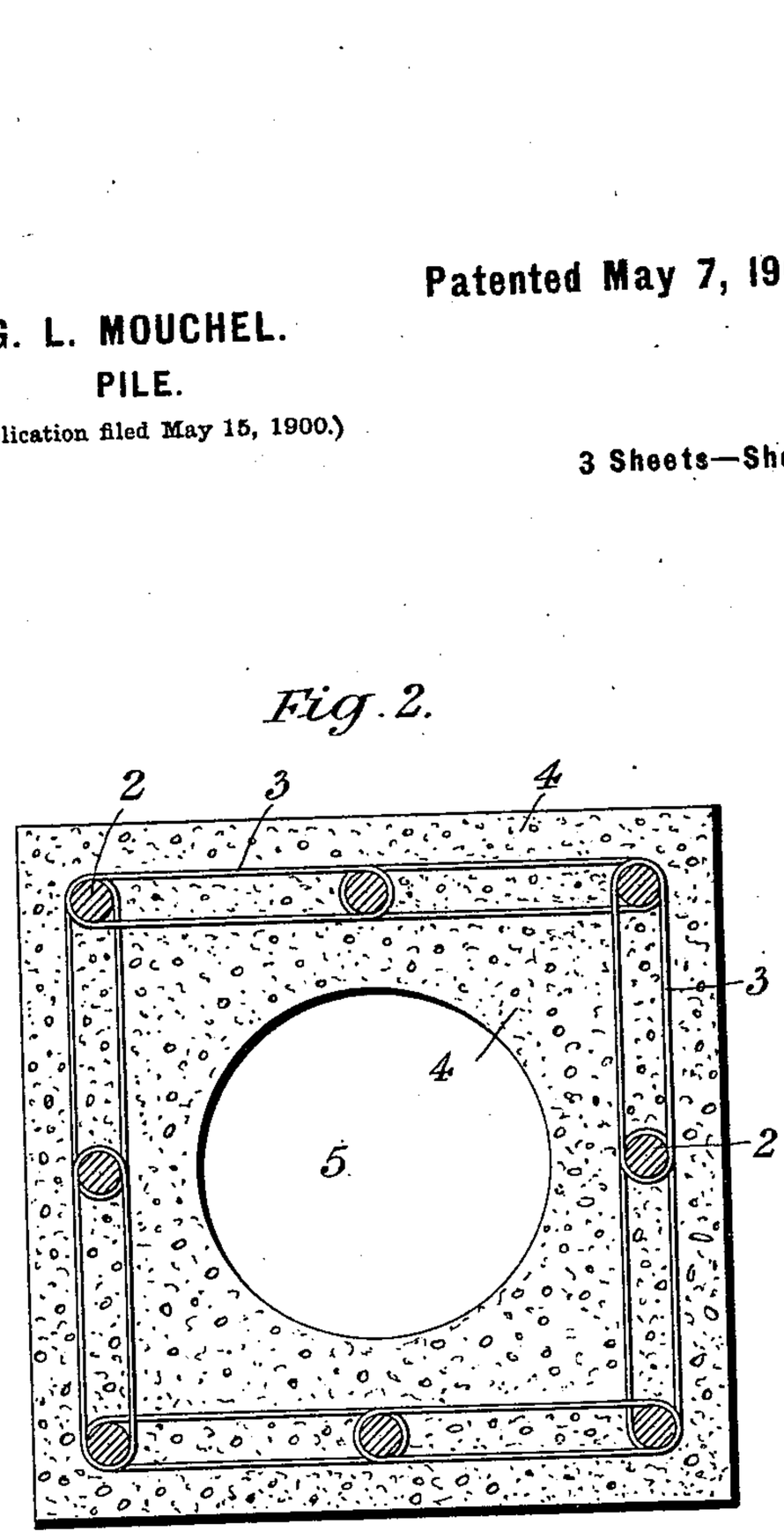
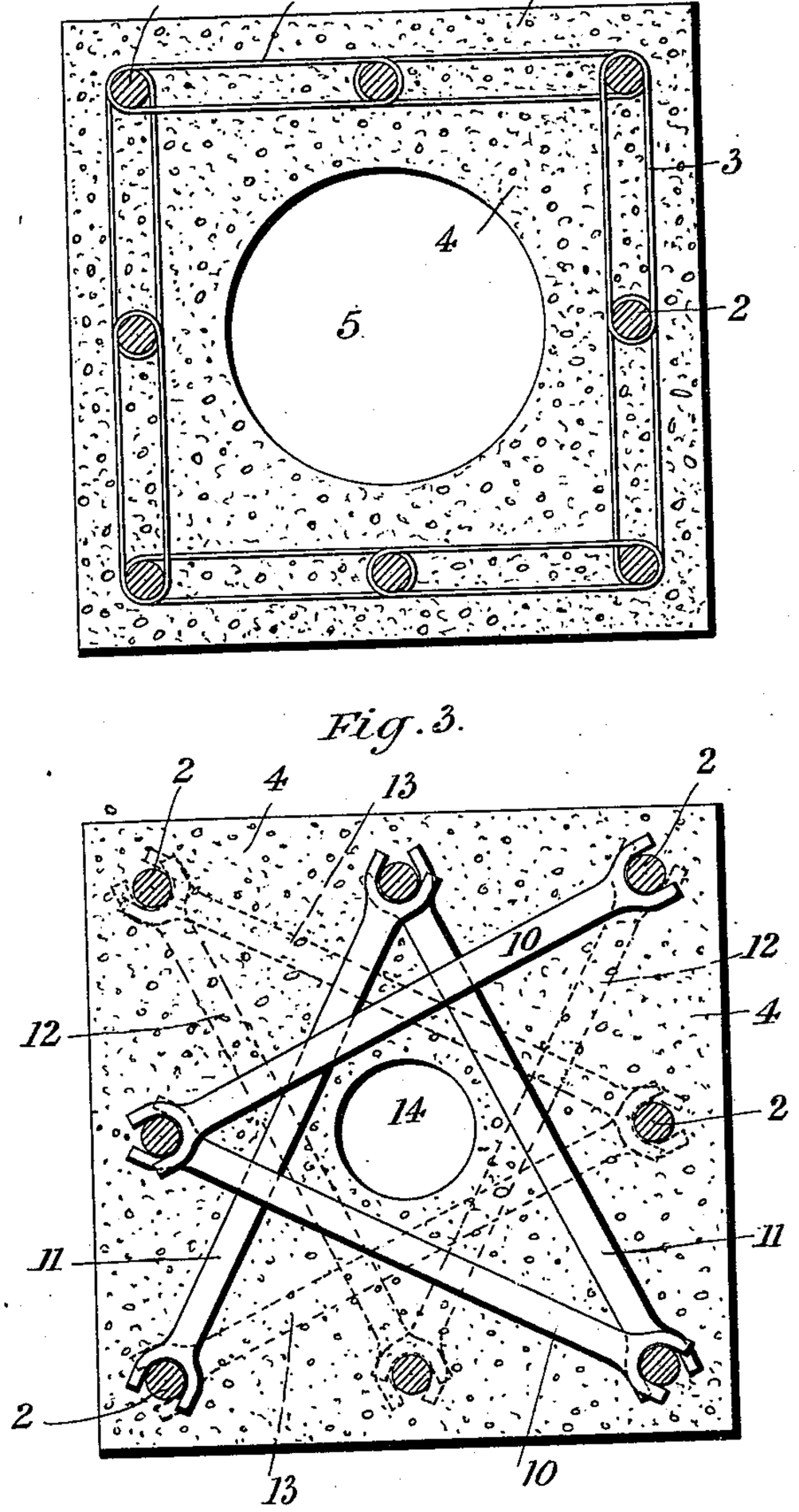


Fig. 3.



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(No Model.) 3 Sheets—Sheet 2.

Fig. 4.

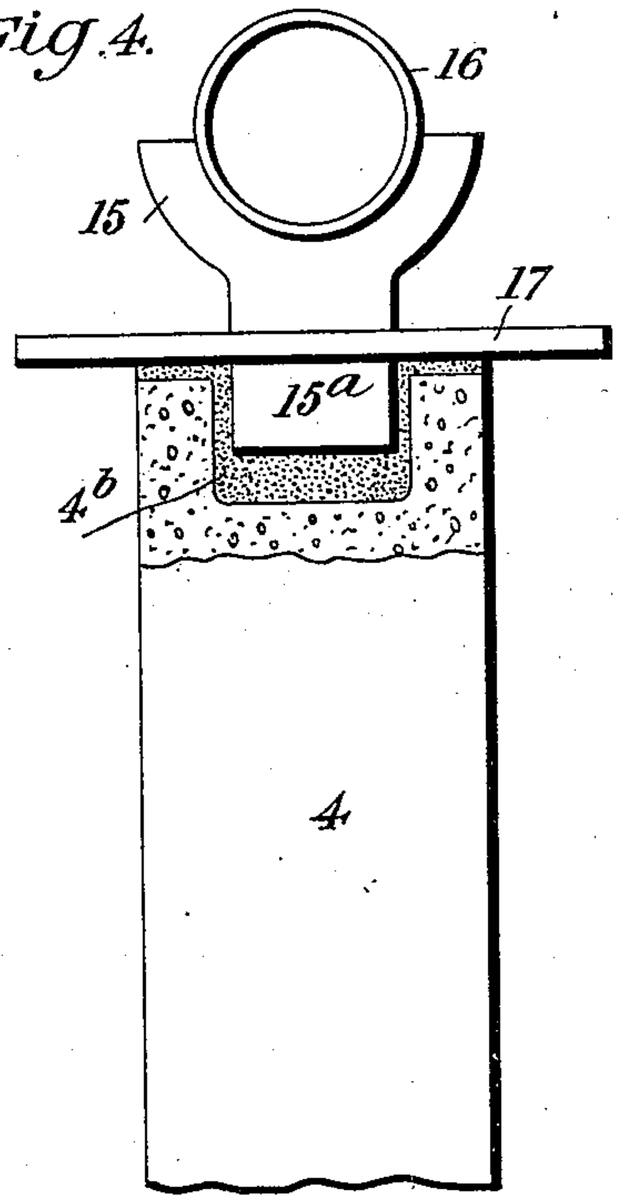


Fig. 5.

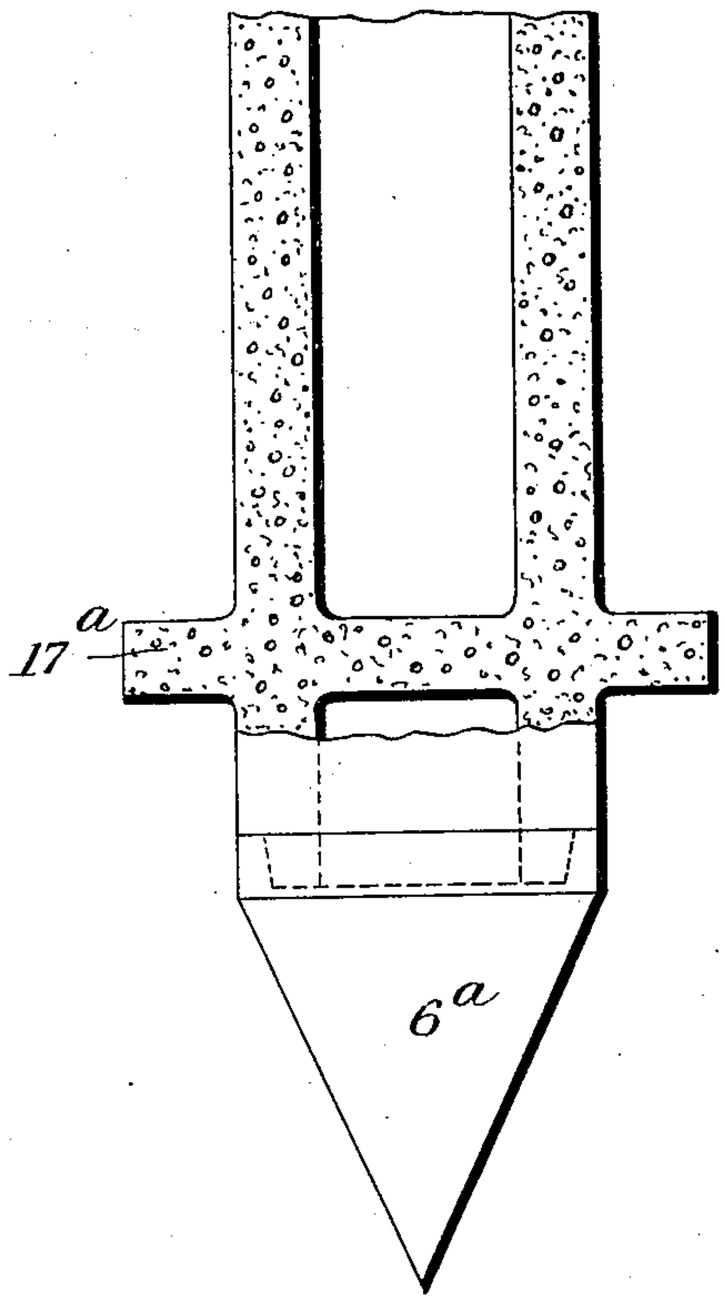


Fig. 6.

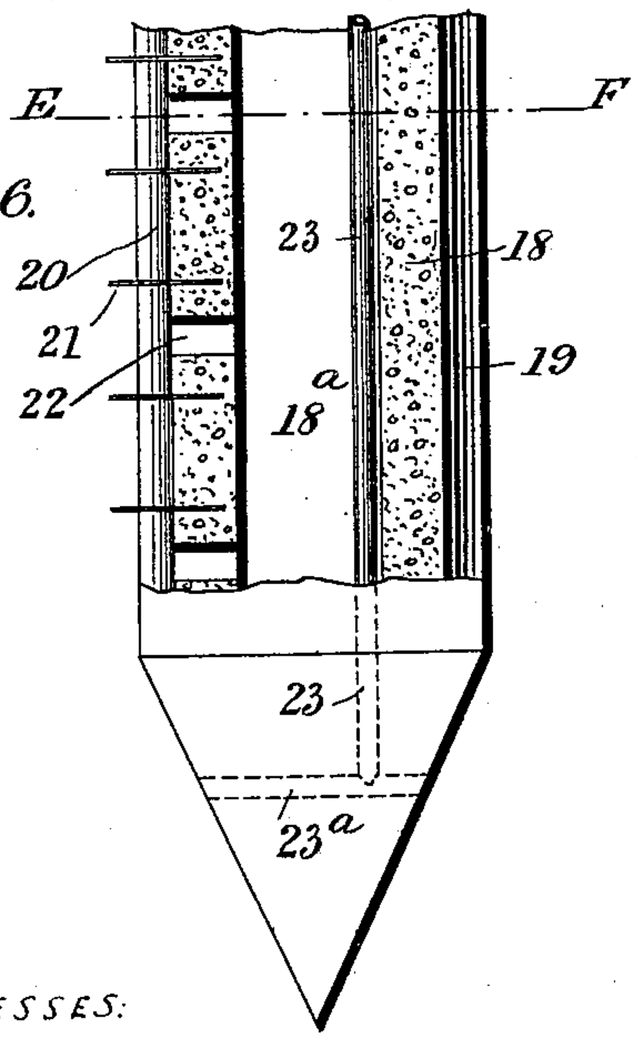
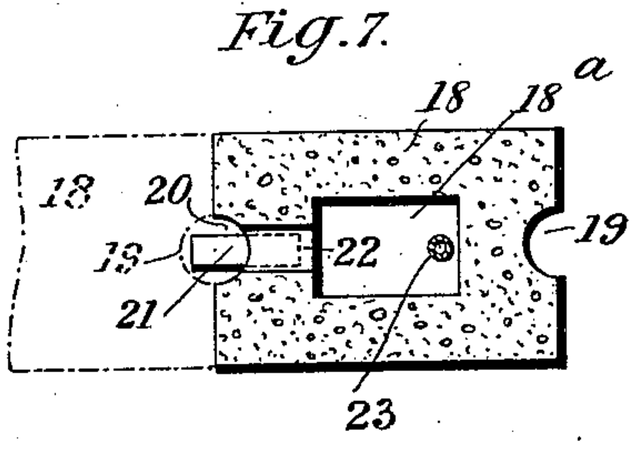


Fig. 7.



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(No Model.)

3 Sheets—Sheet 3.

Fig. 8.

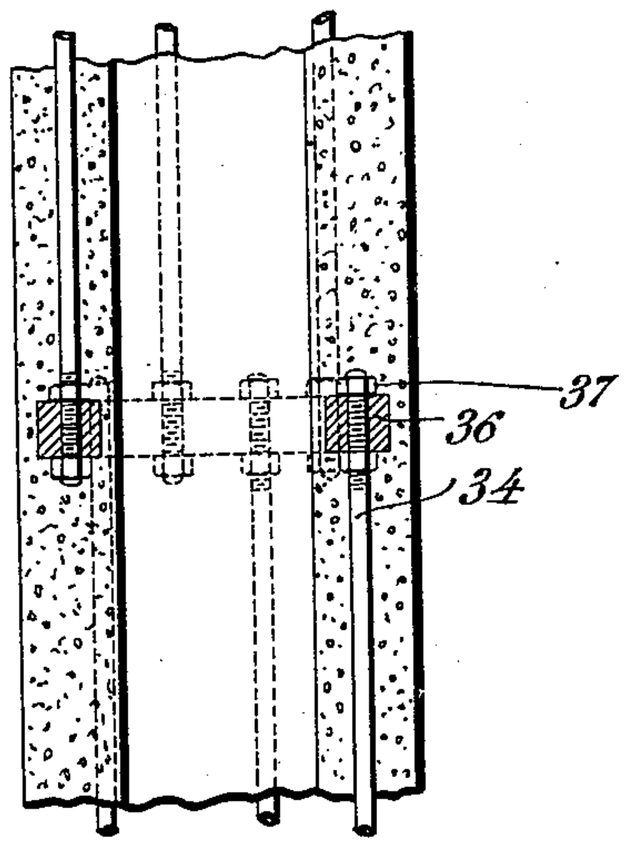


Fig. 9.

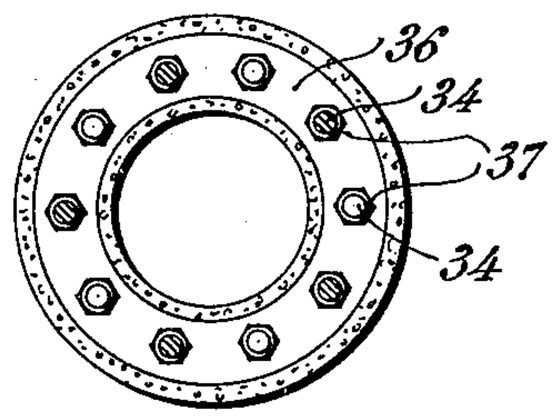
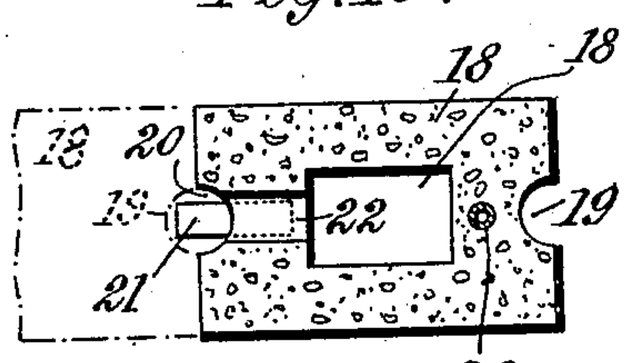


Fig. 10.



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UNITED STATES PATENT OFFICE.

GUSTAVE LOUIS MOUCHEL, OF LONDON, ENGLAND.

PILE.

SPECIFICATION forming part of Letters Patent No. 673,443, dated May 7, 1901.

Application filed May 16, 1900. Serial No. 16,725. (No model.)

To all whom it may concern:

Be it known that I, GUSTAVE LOUIS MOUCHEL, engineer, of 124 Holborn, London, England, have invented certain new and useful Improvements in Piles and Pile-Like Structures, of which the following is a specification.

This invention has for its object to provide an improved and cheap construction of pile as a substitute for the wooden piles and iron piles at present used, which are extremely expensive in the great lengths and cross-sectional dimensions required for marine works and which are comparatively short-lived, because wooden piles are liable to wet and dry rot and also to the attacks of worms and other boring marine animals, while iron piles quickly rust away.

It has therefore been proposed to use piles made of concrete, which is not liable to rot or to destruction by marine animals or by rust; but the concrete piles hitherto employed or proposed have been solid, so that they have the following great disadvantages: Their great weight entails almost prohibitive expense in removing them from their molds, carrying them to store, and transporting them to the place of use and then handling them in erecting and driving them, more especially in those cases in which the piles have to be sent by sea to distant places where there is no skilled labor and suitable materials are very expensive, so that the piles cannot be made on the site of the work to be erected.

In order to reduce the number of piles in foundations, and consequently also the cost, there is a tendency to use fewer piles, but of much greater diameter. As the weight increases in the same ratio as the diameter, these heavier piles necessitate very special and costly plant—such as much more powerful cranes, hoisting-tackle, and pile-drivers—than are generally used in this class of work, so that at last a stage is soon reached where almost the whole energy of the blows of the pile-driver is absorbed and neutralized by the great mass of the pile, which merely constitutes an anvil for the blows of the pile-driver, that acts solely to crush the concrete pile without causing it to penetrate farther into the ground. For instance, in very weak ground, where one cannot rely upon meeting any solid strata and where one can only rely upon the skin friction of the pile, one has great advantage in making, say, three large hollow piles with the same quantity of materials that would go into two solid ones.

Owing to the great weight of solid concrete piles they cannot carry as great a safe load as a lighter pile, because both theory and practice show that the safe load on a pile after having been driven into the ground diminishes with an increase in the weight of the pile.

This invention relates to improvements in the construction of piles and pile-like structures composed of concrete rammed or molded and strengthened by means of a metal skeleton or framework which shall not be liable to corrosion.

According to this invention I make the piles and pile-like structures hollow or cellular, with the object of reducing their weight, and thereby increasing their carrying capacity.

In the accompanying drawings, Figure 1 is a longitudinal section of a single pile constructed in accordance with my invention. Fig. 2 is a cross-section on the line A B of Fig. 1. Fig. 3 is a cross-section on the line C D of Fig. 1. Fig. 4 is an elevation, partly in vertical section, of part of a pile for supporting a sewage-outfall pipe. Fig. 5 is a vertical section, partly in elevation, of part of a pile suitable for use in sand. Fig. 6 is a vertical section, partly in elevation, of a sheet-pile. Fig. 7 is a cross-section on the line E F of Fig. 6. Figs. 8 and 9 are a vertical and a horizontal section, respectively, of the joint between two adjacent lengths of a pile; and Fig. 10 is a modification.

Figs. 2 and 3 are drawn to a larger scale than Fig. 1.

Referring to Figs. 1, 2, and 3, 1 is a rigid strengthening metal skeleton or framework composed of a number of upright bars of iron connected firmly together at suitable intervals along the length of the pile. In the embodiment of my invention shown I use eight such bars 2, arranged, preferably, in the form of a square and connected by means of fastenings or ties in the form of endless straps or loops 3, of iron, each of which embraces and fastens together two adjacent upright bars, the alternate straps being situated in the

same horizontal plane, as shown in Fig. 2. One or more of these upright bars 2 may be made tubular or in the form of pipes or tubes. Concrete 4 is rammed or molded in between the members of the skeleton 1 and around the skeleton to form the body of the pile of any desired external contour (square in the figures) in cross-section. The concrete is also rammed or molded around the inner side of the skeleton, so as to completely envelop the latter and prevent it from being affected by corrosion, due to external influences. At the time of ramming or molding the concrete 4 to form the body of the pile a central cavity 5, of circular shape in cross-section, extending throughout the pile for the greater part of its length, is formed by introducing in the central space inclosed by the skeleton a core or mandrel of suitable shape, which will allow concrete to be rammed or molded to form the walls 4 of the pile without filling the central cavity with concrete. This core or mandrel is removed after the operation of molding. The foot 6 of the pile is made solid and is inclosed in a pointed metal shoe 7. The head and the lower portion of the pile, which are most affected by the strains set up in driving the pile, are provided with central longitudinal cavities 8 and 9, respectively, of equal size in cross-section, but considerably smaller than the cavity 5 in the body of the pile.

At suitable intervals along the length of the body of the pile the upright bars 2 are stayed together by means of a double set of struts, formed with forked ends to embrace the upright bars. The upper set, situated at every alternate interval, consists of two iron bars 10 10, arranged so as to form two sides of a triangle and acting to stay two corner upright bars 2 on the same side with the central upright bar 2 on the opposite side. The lower set consists of two bars 11 11, arranged at a small distance below the upper set and serving to stay another central upright bar with a corner upright bar already stayed by a bar 10 and an upright bar in the diagonally opposite corner.

At every other interval the double set of struts consists of stay-bars 12 and 13, arranged, as shown in dotted lines in Fig. 3, to take in and support the upright bars 2 that are not already stayed by the sets of bars 10 and 11. Each double set of struts is rammed up with concrete in the form of a diaphragm 4^a, which completely surrounds the said struts and extends partly across the central cavity of the pile, leaving only a small central opening 14 which is not filled with concrete. These diaphragms 4^a, with their metal framework of struts, act as distance-pieces to stiffen the walls of the pile and to prevent the said walls from caving in under the blows of the pile-driver and the pressure of the surrounding ground.

Fig. 4 shows a pile which is intended to support large pipes, such as are employed for sewage outfalls into the sea, waterworks, gas and electric mains, and similar works. It is made with a forked or crescent-shaped head 15, having a concave bearing-surface to receive the pipe 16. 17 is a bearing slab or plate or collar, which is intended to rest on the surface of the ground when the pile has been driven and to aid in supporting the pile in soft or loose ground. The head 15 and slab 17 are molded together, but separate from the body 4 of the pile, the upper end of which is formed with a recess 4^b, into which the head and slab are afterward fixed and securely grouted in after the pile has been driven. By this means any inaccuracy in the position of the pile can be remedied within wide limits after driving the pile. 15^a is a projecting portion, molded on the under side of the slab 17 for the purpose of affording a good hold in the grouting.

Fig. 5 shows a pile with the bearing slab or plate 17^a formed on the lower portion of the pile just above the foot or shoe. This form of pile is intended for use in cases where there is a firm stratum underneath a considerable depth of loose or soft ground. The foot 6^a of the pile enters the firm stratum, upon the top of which the slab 17^a rests and aids in supporting the top load.

In all cases where the piles are to be driven by the blows of a pile-driver care must be taken in the molding that the tops of the upright bars of the metal skeleton are covered with a layer of concrete at least three to four inches thick. For the purpose of driving the pile I then place around the head of the pile or sheet-pile a metal helmet or open tube or cylinder of suitable shape and section. I fill the cylinder with a suitable mixture of cork or india-rubber waste or other suitable elastic substance and sand, sawdust, ashes, or fine coke-breeze or any other suitable pulverulent substance. The admixture of an elastic substance to the pulverulent substance has for its object to prevent the hardening of the latter under the blows of the pile-driver. I may, however, use the elastic substance by itself in some cases. I have found that old bagging or sacking properly fixed on the head of the pile and between the latter and the cylinder referred to above is the best means of preventing the layer or cushion of pulverulent matter from escaping. On top of the filling I place a rigid plate of metal of about the same shape in section as the internal cavity of the cylinder, and on top of this plate I rest the lower part of a wooden dolly of suitable shape and construction, which is intended to receive the blows of the pile-driver, or I may simply interpose between the head of the pile and the foot of the dolly a cushion of any substance likely to soften the jar of the blow, such as old rags, paper, timber, lead, or the like.

I may employ the usual forms of shoes with my improved piles; but in the case of piles which are hollow throughout or which have an open hollow foot or point I preferably em-

ploy cast-iron or cast-steel shoes having open ends or points, with their inner or outer sides tapering to a sharp or chisel edge.

All that precedes concerning single piles applies equally to sheet-piling.

Figs. 6 and 7 show a sheet-pile 18, of rectangular form in cross-section, with a longitudinal central cavity 18^a, also of rectangular form in cross-section. In one of the two sides of the pile which are intended to abut against the corresponding sides of the adjacent piles there is formed a semicircular groove 19, extending from the top to the foot of the pile. In the other or opposite side there is formed a similar groove 20. 21 represents pieces or strips of metal embedded in the pile at intervals of its length on the side of the groove 20 and projecting from the said groove 20 to some distance inside the groove 19 in the adjacent pile, (shown in dotted lines in Fig. 7,) but not coming in contact with said adjacent pile. 22 represents holes formed in the wall of the pile between every two strips 21 and affording communication between the central cavity 18^a and the groove 20. 23 is a pipe leading from the head of the pile down along the inside of the cavity 18^a. It is provided at its lower end with two oppositely-directed horizontal branches 23^a, opening out on the outside of the pile-foot. Through this pipe 23 water under high pressure can be forced out at the pile-foot while the pile is being driven, with the object of reducing the friction by opening up the ground and facilitating the sinking of the pile where such aid is required. Either pressure-water alone or the simultaneous application of pressure-water and of the pile-driver may be used for this purpose. When the pile has been driven home, the pipe 23 may be used for the purpose of forcing pure cement grout into the soil around the shoe. This grout forms a mortar, which solidifies around the shoe and forms a kind of bed-plate or foundation, which greatly increases the bearing capacity of the pile.

The horizontal direction of the branches 23^a prevents their being choked with soil during the driving. When the piles have been driven to form the sheet-piling, poor concrete or sand may be run through the cavity 18^a into the lower portions of the sheet-piles until the ground-level is reached. Then rich grout is forced into the cavity 18^a in the upper portions, whence it exudes and finds its way through the lateral holes 22, fills up the cavities formed by the grooves 19 20 between the sheet-piles, and surrounds the metal strips 21, thus making a perfect joint, which when hardened by reason of the metal strips affords absolute rigidity and strength of connection between every two adjacent sheet-piles and by reason of the grout gives a perfect monolithic character to the wall of sheet-piles. The pipe 23 may also be molded in or embedded in the wall or cement of the pile at the time of molding. Fig. 10 shows such a pile. Pipes, such as 23, with branches 23^a, may also be provided in the single piles hereinbefore described.

In piles of great length the metal skeleton is made in sections joined together by means of a joint constructed as shown in Figs. 8 and 9, in which 36 is a metal joint piece or ring with as many perforations as are required to allow the vertical bars 34 at the ends of two abutting pile-sections to pass through in staggered order. There are therefore twice as many holes in the joint as there are vertical bars to be connected. The vertical bars are screw-threaded at their ends for a length a little greater than the height of the joint-piece 36, with the additional length required to receive two nuts 37, one on the upper and one on the lower side of the joint-piece, after the vertical bars have been threaded through. When the two sections of the skeleton have been joined and screwed together, the whole joint between the concrete portions of the pile-sections is then surrounded with quick-setting cement or concrete, so as to enable the driving of the pile to be restarted without any great loss of time. By providing a joint connecting together two sections of pile I am enabled to sink or drive short lengths at a time.

In general by making concrete piles with a strengthening-skeleton of metal and with a longitudinal central cavity the weight of such piles is considerably reduced and their load-carrying capacity is thereby increased. As a result of the considerable reduction in their weight such piles may be made under economical conditions at any spot convenient for obtaining the raw materials and may then be carried, either whole or in sections, at a low cost for freight to the place of use and with considerable economy in time and cost of handling and driving or erecting the same. An additional advantage consists in that such hollow piles require less rich concrete and metal than if they were made solid. Once delivered at the place of use and driven home, the central cavity may be filled up with poor cement, sand, or the like, if desired. The piles as well as the upright bars may be made of any suitable shape in cross-section—square, round, oval, ovoidal, rectangular—and with a smooth grooved or fluted contour. The bars will be arranged in a shape or figure corresponding to that of the section of the pile.

The stiffening-diaphragms may be made with or without a strengthening-skeleton of metal, and they may be made solid or with apertures to allow grout or sand or other material to be introduced into the cavities of the pile.

In all the modifications hereinbefore described one or more of the vertical or other members of the rigid strengthening metal skeleton may be made tubular or in the form of pipes or tubes.

What I claim, and desire to secure by Letters Patent, is—

1. In a pile, the combination of a pile-body composed of concrete and having a central longitudinal cavity, a rigid strengthening longitudinal metal skeleton embedded in the concrete, and stiffening-diaphragms of concrete molded with the body and extending across the central longitudinal cavity, substantially as set forth.

2. In a pile, the combination of a pile-body composed of concrete and having a central longitudinal cavity, a rigid strengthening longitudinal metal skeleton embedded in the concrete, stiffening-diaphragms of concrete molded with the body and extending across the central cavity, and strengthening metal skeletons embedded in the said concrete diaphragms, substantially as set forth.

3. In a pile, the combination of a pile-body composed of concrete and having a central longitudinal cavity, a rigid strengthening longitudinal metal skeleton embedded in the concrete, stiffening-diaphragms of concrete molded with the body and extending across said central longitudinal cavity, and formed with apertures affording communication between the overlying and underlying portions of the central longitudinal cavity, and strengthening metal skeletons stayed to opposite portions of the longitudinal metal skeleton and embedded in the concrete diaphragms, substantially as set forth.

4. In a pile, the combination of a pile-body composed of concrete and formed with a cavity in its top, a loose pile-head of concrete formed with a concave bearing-surface in its top, and with a lower portion adapted to enter and be fixed by grouting in the cavity in the top of the pile-body, and a bearing slab or plate molded with the pile-head below the concave bearing-surface thereof, substantially as set forth.

5. In a pile, the combination of a pile-body composed of concrete, and a bearing slab or collar molded in one piece with the pile-body at an intermediate point of the length of the pile-body, substantially as set forth.

6. In a pile, the combination of a pile-body composed of concrete and a bearing slab or collar molded with the pile-body near the lower end of said pile-body, substantially as set forth.

7. In a pile, the combination of a pile-body composed of concrete and formed with a central longitudinal cavity, a longitudinal groove molded in one side of the pile-body, a longitudinal groove molded in the opposite side of the pile-body, pieces of metal embedded in the concrete body at intervals along its length and projecting into and beyond the last-mentioned groove, and apertures formed in the pile-body on the side of the said last-mentioned groove in between the said pieces of metal, and affording communication between the central longitudinal cavity of the pile-body and the said last-mentioned groove, substantially as set forth.

8. In a pile, the combination of a pile-body composed of concrete and formed with a central longitudinal cavity, a rigid strengthening longitudinal metal skeleton embedded in the concrete, a pile-shoe connected to said pile-body, a pipe leading down inside the pile to the shoe, and branch pipes connecting said pipe with orifices formed in the sides of the pile-shoe, whereby water or grout under pressure can be forced out around the pile-shoe, substantially as set forth.

9. In a pile, the combination of a pile-body composed of concrete and formed with a central longitudinal cavity, a rigid strengthening longitudinal metal skeleton embedded in the concrete, a pile-shoe connected to said pile-body, a pipe embedded in the concrete of the pile-body, and branch pipes leading from the said pipe to orifices formed in the sides of the pile-shoe, whereby water or grout under pressure can be forced out around the pile-shoe, substantially as set forth.

10. In a pile, the combination of a pile-body of concrete molded in lengths, vertical longitudinal metal bars embedded in each pile length and formed with screw-threaded ends projecting at the ends of each pile length, a metal screw-piece formed with holes to receive the screw-threaded ends of the vertical bars of two adjacent lengths of the pile-body, nuts screwing on said screw-threaded ends against the upper and lower faces of said metal piece, and a cement joint filling up the space between the concrete of the two adjacent pile lengths and surrounding the metal parts in said space, whereby two adjacent lengths of the pile-body are securely jointed together, substantially as set forth.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

GUSTAVE LOUIS MOUCHEL.

Witnesses:
GEORGE BELOE ELLIS,
GEORGE C. BACON.