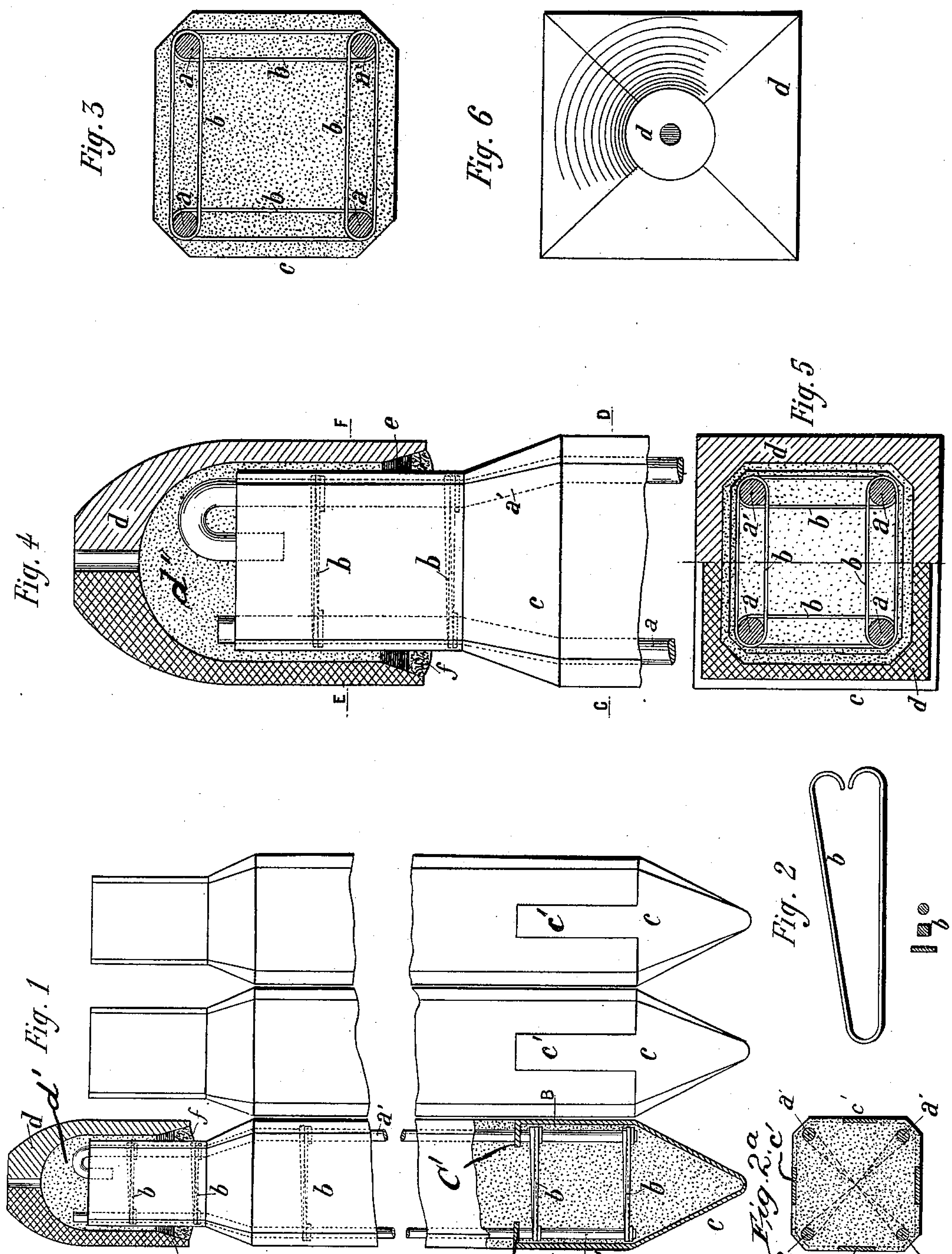
No. 611,909. Patented Oct. 4, 1898.

F. HENNEBIQUE.

PILE.

(Application filed Dec. 29, 1897.)

(No Model.) 2 Sheets—Sheet I.



Witnesses:
E. N. Bolton
[illegible]

Inventor:
François Hennebique
By [illegible]
his Attorneys.

No. 611,909. Patented Oct. 4, 1898.

F. HENNEBIQUE.

PILE.

(Application filed Dec. 29, 1897.)

(No Model.) 2 Sheets—Sheet 2.

Fig. 11

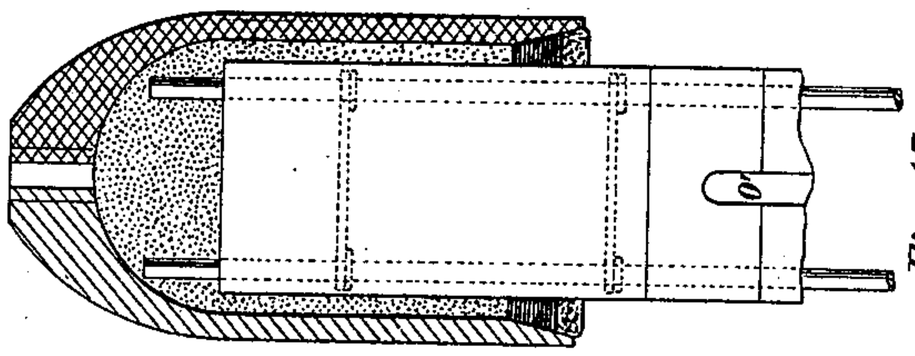


Fig. 13

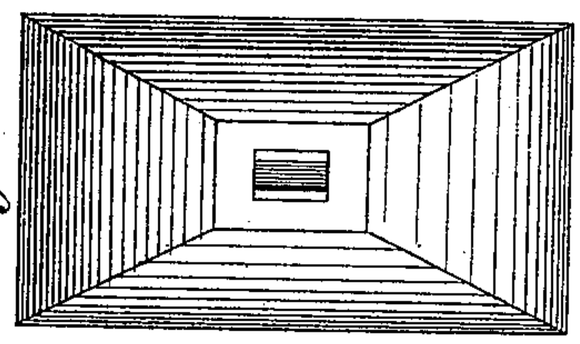


Fig. 10

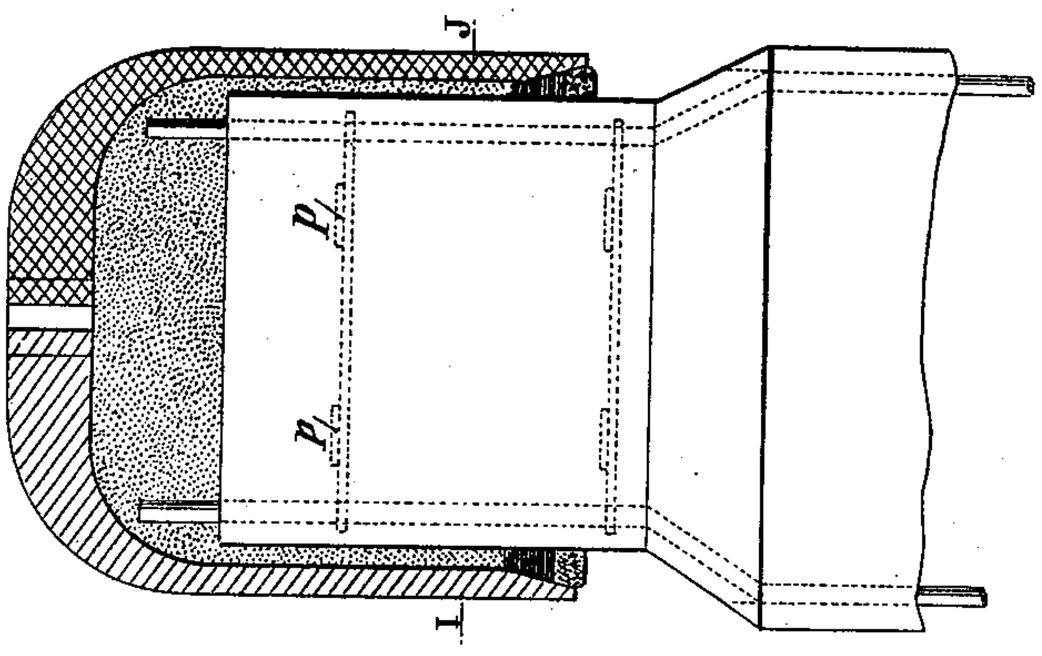


Fig. 12

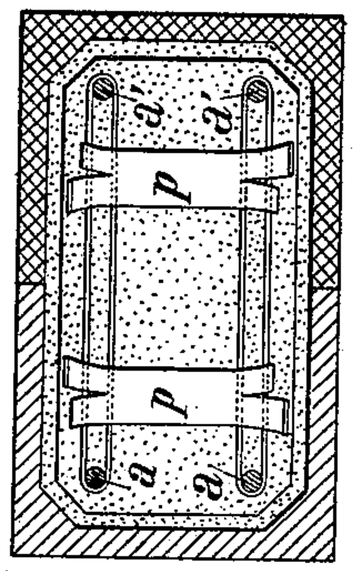


Fig. 9

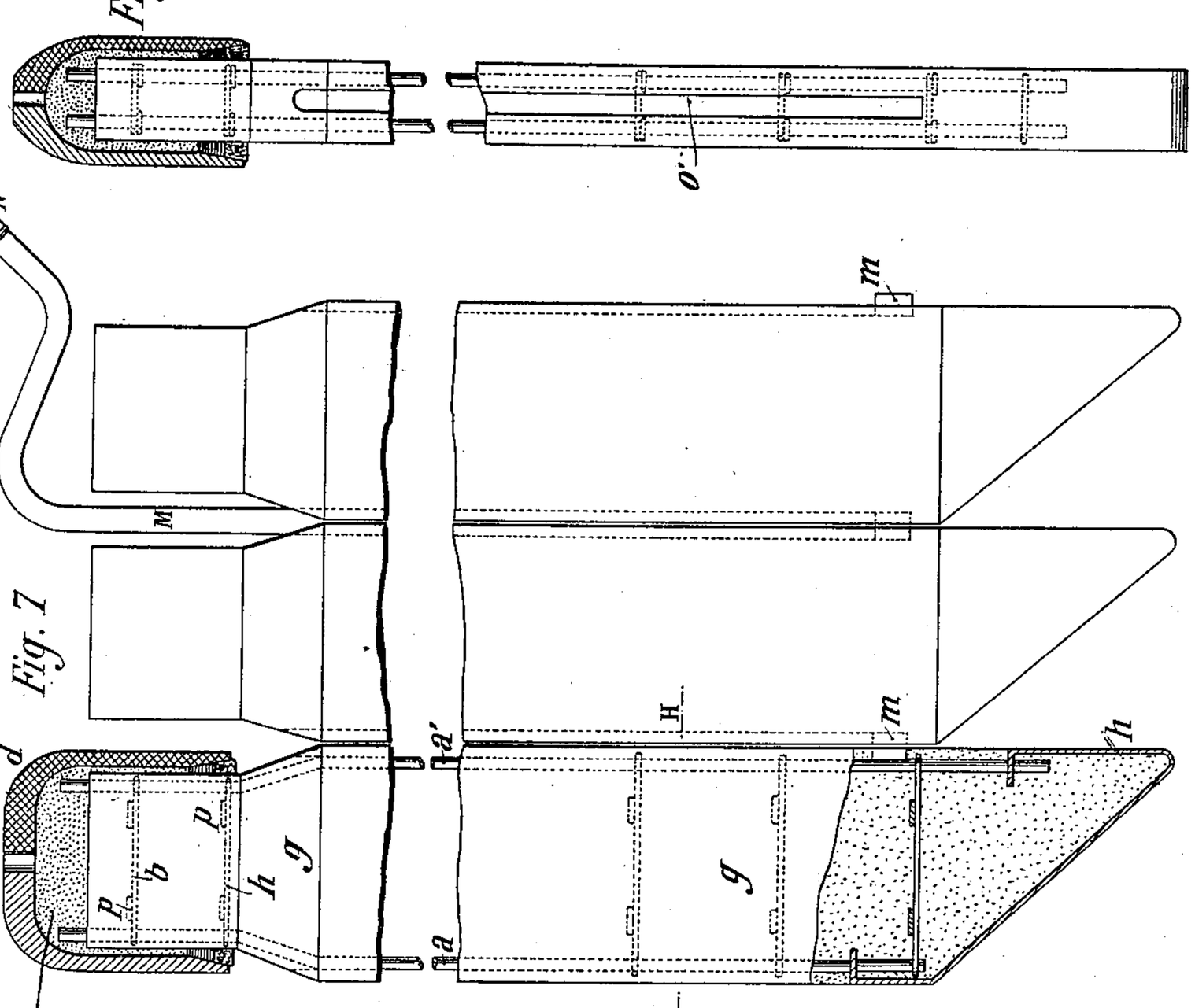
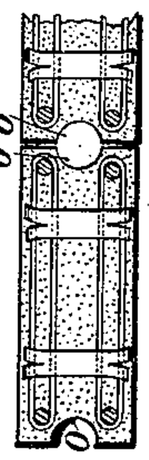


Fig. 8a

Fig. 8



Witnesses:
C. B. Bolton
Otto Munn

Inventor:
François Hennebique
By Renwick & Co
his Attorneys

UNITED STATES PATENT OFFICE.

FRANÇOIS HENNEBIQUE, OF PARIS, FRANCE.

PILE.

SPECIFICATION forming part of Letters Patent No. 611,909, dated October 4, 1898.

Application filed December 29, 1897. Serial No. 664,331. (No model.) Patented in Belgium September 29, 1896, No. 127,663; in Italy March 29, 1897, No. 44,255; in England April 23, 1897, No. 10,203, and in Austria April 24, 1897, No. 23,853.

To all whom it may concern:

Be it known that I, FRANÇOIS HENNEBIQUE, a citizen of the French Republic, and a resident of Paris, France, have invented certain new and useful Improvements in Piles, Posts, and the Like, of which the following is a specification, this invention having been patented in Belgium, No. 127,663, dated September 29, 1896; in Italy, No. 44,255, dated March 29, 1897; in Austria, No. 23,853, dated April 24, 1897, and in Great Britain, No. 10,203, dated April 23, 1897.

Concrete strengthened with iron or steel has already been employed in building construction in various ways. Thus, more particularly in the formation of girders and beams of strengthened beton, there are obtained many advantages particularly shown by the use of a rational mixture of iron or steel and cement, the former being extremely suitable for resisting the effects of traction or tension and the latter offering a considerable resistance to stress or compression. A capital point for the construction of a practical girder or beam is to connect the bars of metal forming the chord of tension with the chord of compression by means of suitable stirrup-pieces, and in a former application of mine I indicated a certain number of improvements which I introduced in these stirrups or cross-pieces, which in this girder, made of strengthened beton, play the part of the suspension-rods of the lattice-work of metallic girders and insure a perfect resistance of the girders to the severing action under a bending strain. I have applied these principles to the construction of piles, posts, sheet-piles, and solid uprights or standards, which, corresponding to the special conditions of their arrangement or employment, may, according to the strains, the loads, and the pressures to which they are subjected, be assimilated to girders whether placed on two or more supports or embedded at one end, &c.

The construction of these piles and sheet-piles, their combination, and the method of placing them in position, as well as the applications of which these separate and combined elements are capable, form the object of the present invention and are shown in the accompanying drawings.

In the drawings, Figure 1 is a side elevation of three piles, one pile being shown partly in section and the driving-cap removed from the other two. Fig. 2 is a detail of tie band or wire. Fig. 2ª is a cross-section of the tie shown in Fig. 1. Fig. 3 is a section on line C D, Fig. 4. Fig. 4 is an enlarged elevation of the upper portion of a pile of slightly-modified form. Fig. 5 is a section on line E F of Fig. 4. Fig. 6 is a plan view of the cap. Fig. 7 is a view, similar to Fig. 1, of a further modification. Fig. 8 is a section on line G H of Fig. 7. Fig. 8ª is a detail of the tie-wire. Fig. 9 is an edge view. Fig. 10 is an enlarged view of the pile-head in side elevation with the cap in section. Fig. 11 is an edge view. Fig. 12 is a section on line I J of Fig. 10. Fig. 13 is a plan view of the cap.

Fig. 1, Sheet 1, shows in elevation a row of piles. These piles are formed in a mold after the manner of girders of concrete strengthened by metallic rods *a a'* of suitable dimensions and section (generally of round iron of fifteen to thirty millimeters) connected from place to place by stirrups, clasps, or cross-pieces *b*. (Shown in detail in Fig. 2.) These cross-pieces, which may be of any suitable section—such, for instance, as rectangular, square, or circular—are placed as required during the filling of the mold and form veritable clasps or clamps. They may be arranged in plan, as shown in Fig. 3, which is a section on the line C D of Fig. 4, this latter representing on an enlarged scale the head of a pile covered with a cap for the ramming. At its lower end the pile is armed with a shoe *c*, Fig. 1, in the form of a point in order to facilitate its being driven into the ground. This shoe *c* has an approximately conical point, above which are parallel sides or tongues *c'*, embracing the sides of the pile and having inwardly-turned flanges, which securely lock the shoe in place. The head of the pile is of less width than the body, which allows of an interval between the heads of two adjacent piles. The piles are inserted, according to the nature of the ground, either by dropping or by means of ramming. In order to insure uniformly-distributed blows on the pile and to prevent the blows of the ram injuring it, I crown the pile with a cap

d, of steel or cast metal, (shown in longitudinal section in Figs. 1 and 4, in horizontal section in Fig. 5, and in plan view in Fig. 6,) said cap being closed at its lower part by a clay stopper *e*, held by a plug *f*, of hemp or spun yarn. This cap is filled internally with previously-dried sand *d'*. A very regular cushion is thus formed on the head of the pile and all around the said head, which cushion distributes the pressure in an absolutely equal manner. By surrounding the lateral faces of the head I avoid in a certain manner any crushing of the cement. This special arrangement for the ramming enables the irons *a a'*, Fig. 4, to project beyond the head of the pile in order in case of need to allow of their being connected with other parts of the structure. These irons may in this case run in a vertical direction or be bent in the form of hooks.

The sheet-piles, which are in fact a variety of piles, are shown in detail in Sheet 11. Like the piles shown on Sheet 1 these sheetings may be of variable dimensions, according to the resistance and the special conditions of the work to be constructed and the nature of the ground.

Fig. 7 shows in longitudinal elevation a row of sheet-piles connected together, as hereinafter described. They are formed of irons *a a'* of suitable dimensions embedded in concrete and fastened together with clamps *b*. These clamps *b* are themselves cross-tied by flat irons *p*, which are bent at their extremities or which are split at their extremities in order that the two halves may be bent back in such a way as to form a clamp. The sheet-piles thus formed are quite suitable for supporting the weight of an upper structure or any suitable horizontal pressures.

At its lower end the sheet-pile is cut to a point and inserted in a shoe *h*. At the point side at a short distance—say from ten to fifteen centimeters—above the point a spur or projection *m*, Fig. 7, is formed on the narrow side of the pile. In the remainder of its height the pile is notched or grooved on its two narrow faces in such a way as to form two longitudinal semicylindrical grooves *o o'*, Figs. 8 and 9. The stud or projection *m* of one of the sheet-piles will slip into the groove *o* of the next adjacent sheet-pile during the ramming. The head of the sheet-piles for the ramming is provided with a cast-iron or steel cap similar to that hereinbefore described and which is shown in Figs. 10, 11, 12, and 13. A special arrangement (indicated on Fig. 7) allows of the direction being insured perfectly. An iron pipe M, which fits the groove *o* of the one sheet-pile and the groove *o'* of the sheet-pile which is being rammed, is connected by means of a pipe N with a force-pump or with a reservoir. The beak M of the pipe thus serves as a guide. The water under pressure forces out the sand, which might choke the grooves, and thus facilitates the driving in of the piles. Once the sheet-piles are driven to the desired depths cement is run into the free space between the groove *o* of the one pile and the groove *o'* of the next pile, thus establishing a perfect joint between the various sheet-piles and the whole forming an absolutely-tight wall. If desired, connection might be formed between the sheet-piles similar to the joint between match-boarding in wood—that is to say, by tongues and grooves.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is—

1. In combination with a pile of strengthened concrete, a metallic cap of inverted-cup shape adapted to fit over the upper end of said pile, and a filling of loose material interposed between said cap and the end of the pile, substantially as described.

2. A pile of strengthened concrete having oppositely-located grooves in its opposite faces, and a projection on one of said faces at the base of said groove, substantially as described.

In witness whereof I have hereunto set my hand in presence of two witnesses.

FRANÇOIS HENNEBIQUE.

Witnesses:

EMILE BEST, Jr.,

ANDRÉ MORTIERBE.