No. 791,927. PATENTED JUNE 6, 1905.

F. J. M. MONNIER-DUCASTEL.

METHOD OF MAKING FOUNDATIONS IN WATER LOGGED GROUND.

APPLICATION FILED MAY 13, 1904.

3 SHEETS—SHEET 1.

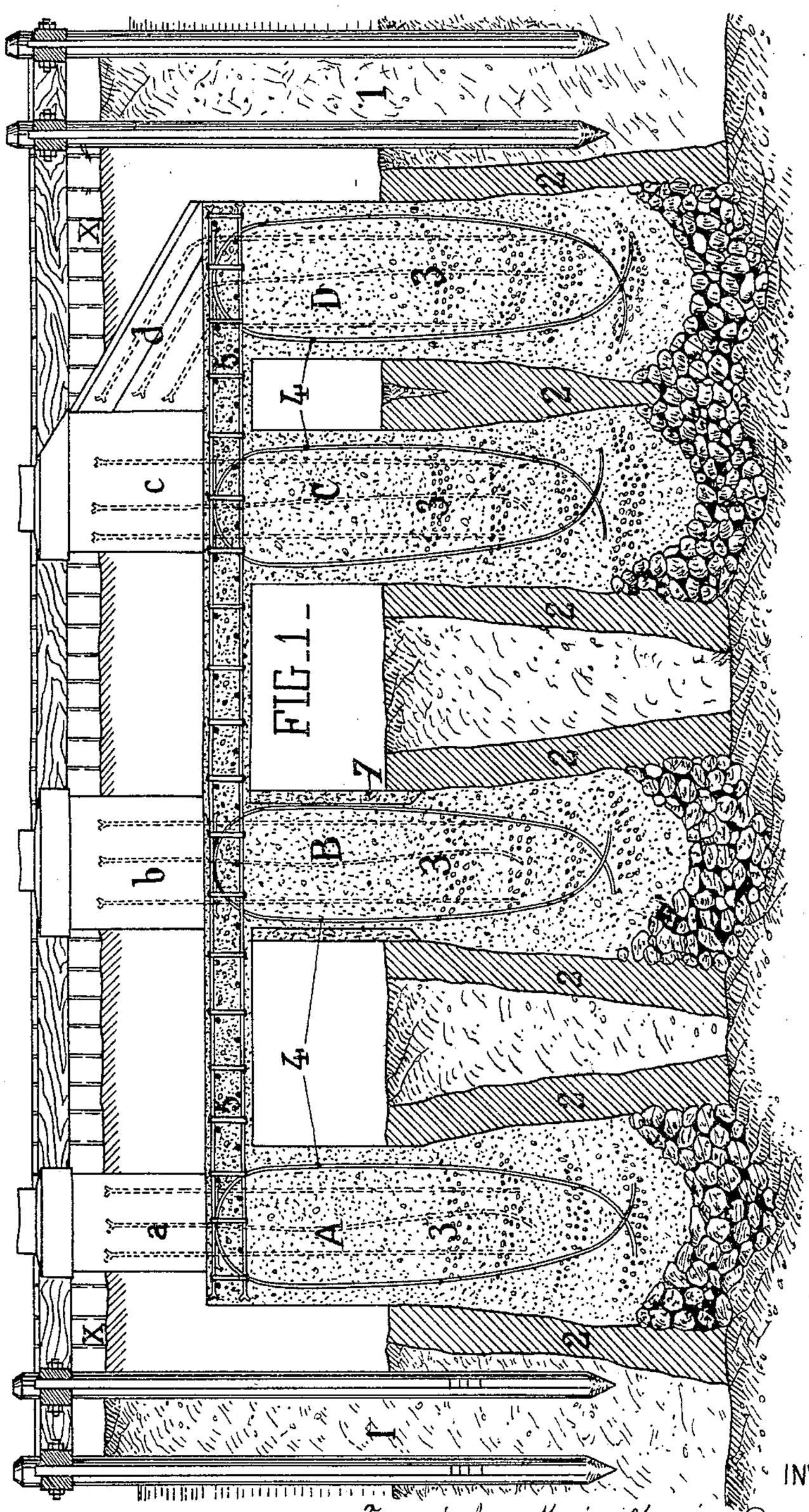

FIG. 1.

WITNESSES

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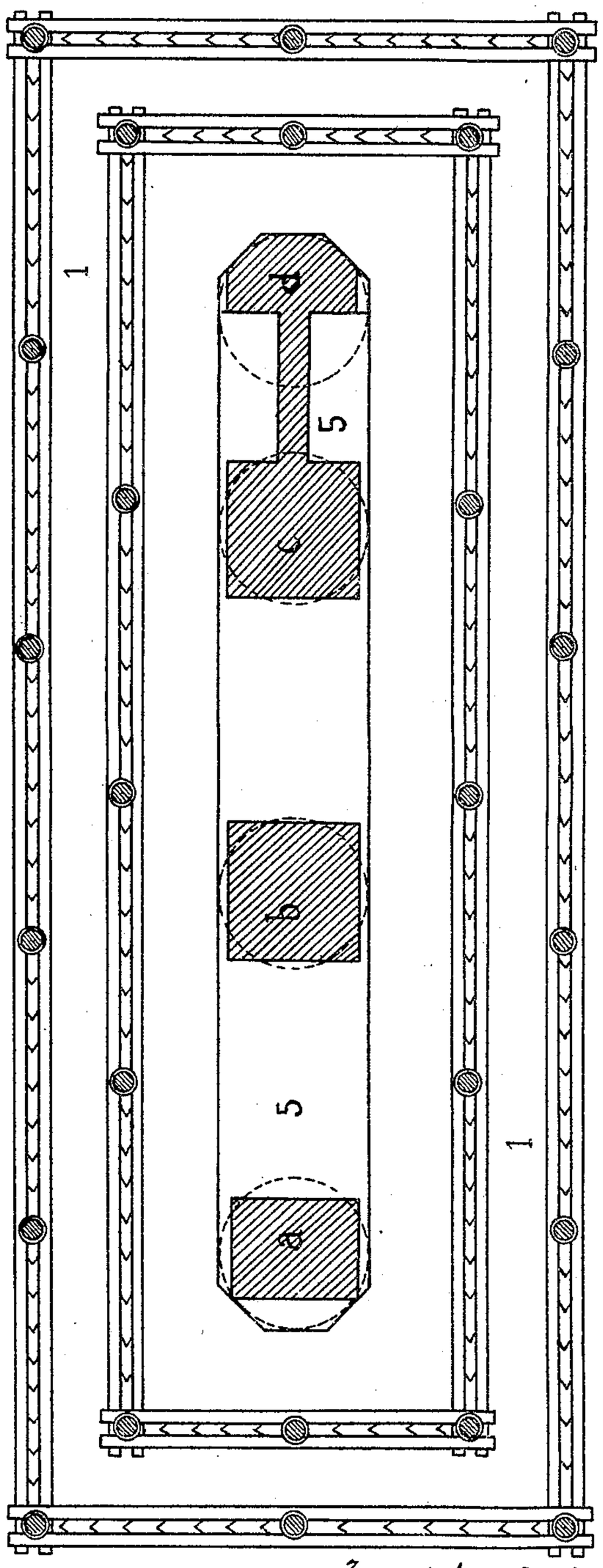

FIG. 2.

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3 SHEETS—SHEET 3.

FIG. 3.

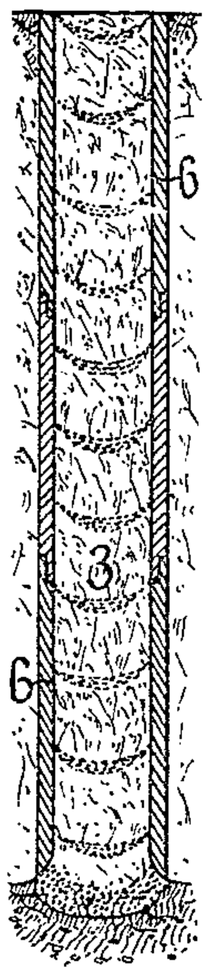


FIG. 4.

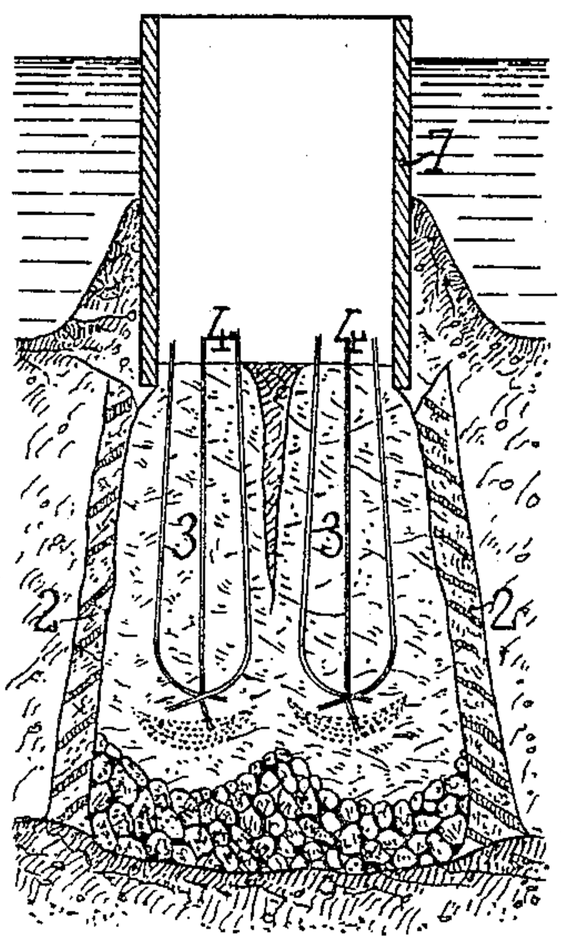


FIG. 5.

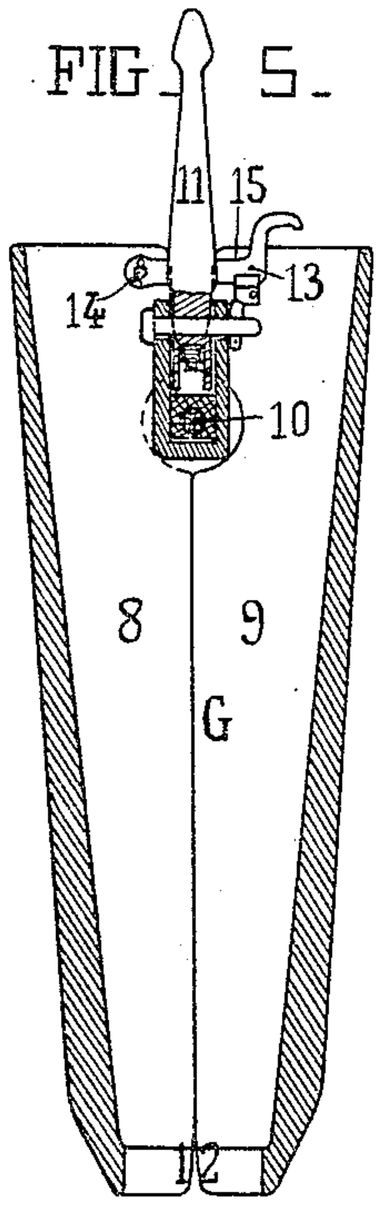


FIG. 7.

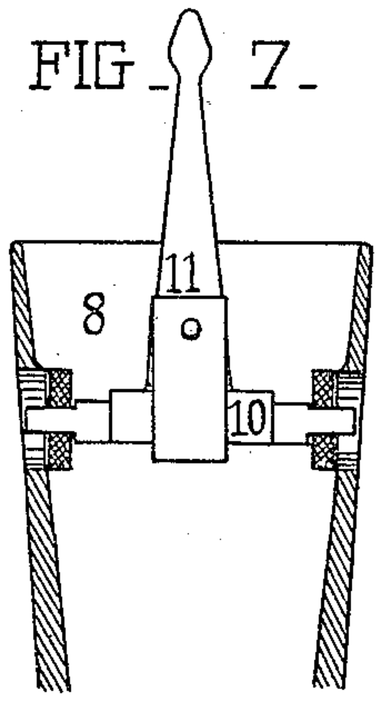
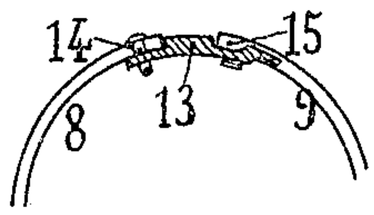


FIG. 6.



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No. 791,927. Patented June 6, 1905.

UNITED STATES PATENT OFFICE.

FRANCOIS JEAN MARIE MONNIER-DUCASTEL, OF PARIS, FRANCE.

METHOD OF MAKING FOUNDATIONS IN WATER-LOGGED GROUND.

SPECIFICATION forming part of Letters Patent No. 791,927, dated June 6, 1905.

Application filed May 13, 1904. Serial No. 207,814

To all whom it may concern:

Be it known that I, FRANCOIS JEAN MARIE MONNIER-DUCASTEL, engineer, a citizen of the Republic of France, and a resident of Paris, France, have invented an Improved Method of Making Foundations in Compressible, Loose, or Water-Logged Ground, of which the following is a specification.

The object of this invention is to improve the method of forming foundations for bridges and the like where the foundations are in submerged, marshy, or wet ground and to do away with the necessity of caisson-work by forming shafts the walls of which are rendered impervious to moisture as said shaft is sunk.

In carrying out this invention I use a ram or pile which I drop repeatedly in the line of the shaft to be formed, said ram being so formed as to compress the soft earth downwardly and laterally. When a certain depth of shaft has been formed, I supply the wall of that depth with an impervious sheath. There are two ways in which this may be done, one by letting into the shaft a pipe of ferroconcrete and another (the preferred manner) by placing within the shaft from time to time clay which as it is compressed laterally will be incorporated with the already-compressed walls and form an impervious sheath. When such a shaft has been sunk to solid ground, it is filled with beton, cement, or other suitable foundation material.

In the following description of the method applied to the two cases mentioned reference will be made to the accompanying drawings, in which—

Figure 1 is a longitudinal section of the foundations of a river-bridge pier or pile; Fig. 2, a corresponding horizontal projection; Fig. 3, a vertical section of a foundation in a ground which is exposed at low water and which constitutes a modification of the system; Fig. 4, a similar view of another modification in course of erection; Fig. 5, a vertical section of the special perforating-ram employed for this kind of work, and Figs. 6 and 7 are partial details of this appliance.

In order to make foundations in rivers, a light coffer-dam 1 is placed, first of all, round the point where these foundations are to be made, Figs. 1 and 2, which coffer-dam need not be made water-tight, seeing that the interior inclosure is then filled up with mold or ordinary earth, excluding sand, gravel, or shingle, up to a sufficient height *x x*. (See Fig. 1.) By operating thus the water is expelled from the said inclosure and an actual platform or island of solid earth is created, on which platform the perforating and ramming rams are conveyed, as well as a pile-driving mechanism, which apparatus may be compared with similar apparatus hitherto employed for converting compressible ground into resistant ground. The machine being brought into the desired position, the perforating-ram is allowed to drop with a free fall from a suitable height above the ground, and then when it has penetrated to from 1.50 meters to two meters the excavation which it has made is filled with clay. This clay is then rammed downward and laterally by the ramming-ram, which is also allowed to drop with a free fall. The excavation produced by the ramming is filled once or twice more, and each time the clay which penetrates into the surrounding soil is vigorously compressed, and it forms a lining for the walls of the excavation obtained over a considerable surface. The perforating-ram is then again operated, which is allowed to drop in order to deepen the said excavation from 1.50 meters to two meters, and clay is again thrown into the bottom of the bore-hole or well, so as to fill up the hollow obtained. It is again rammed with the ramming-ram and clay is again thrown in one or more times, as was hereinbefore mentioned, and the operation is continued, always increasing gradually the depth of the well or hole. By operating thus by successive borings of 1.50 meters to two meters and by each time forming a lining or tight sheath 2, due to the ramming of the clay, solid ground is obtained. Naturally the further we descend the force of the ramming is progressively increased, so as to render the protecting-sheath 2 more resistant as the pressure of water increases. This increase in the force of the ramming is obtained by increasing the height of the fall and increasing the quantity of clay rammed in each time. When solid ground

has been reached, an excavation is made therein by some blows of the perforating-ram, and a small quantity of cement or hard material mixed with mortar is placed at the bottom of the hole formed and then the ramming-ram is again allowed to drop. This latter by its impetus at the moment of the shock forces the materials into the surrounding ground both downwardly as well as laterally. A fresh charge of materials is then introduced, which is followed by a series of two, three, or four blows with the ramming-ram, and thus in succession until the ground-level is reached. According as the ramming is more or less intense—that is to say, according as the series of blows is composed of one or a larger number—the materials are expelled with greater or less force in all directions, forcing in front of them the clay as well as the ground itself.

When the wet ground in which the foundations are to be made is accessible dry-shod, it is evident that it is absolutely needless to construct a coffer-dam as hereinbefore specified. An excavation is produced by means of a perforating-ram and is filled with clay. It is then rammed, deepened, and the operation recommenced in the manner hereinbefore indicated. In both cases the system of foundations considered allows of masonry columns or pillars 3 being obtained, which, bearing largely on solid ground and being anchored therein at the same time, have a diameter proportionate to the ramming. It is therefore possible to graduate at will, according to the loads and constructions to be supported, the section of pressure and resistance of the pillars.

If the construction extends according to a given drawing or even according to a fixed foundation or projection, it suffices to judiciously arrange a certain number of pillars, thus forming a series of columns which directly transmit the pressure to the solid ground. Fig. 1 of the accompanying drawings represents four pillars or piles A B C D, obtained by repeating four times the operations hereinbefore indicated. Although they represent the foundations of a bridge-pile for a river, they would be exactly the same if they were arranged in accessible ground—that is to say, not under water. Evidently, if thought well, the pillars might be combined with metallic strengtheners or binders 4, which would allow the points of support of a whole series of foundations to be interconnected, and even such foundations to be connected with a bridge or other construction, if ferroconcrete be employed, so as to constitute a sort of monolith.

It will be noticed that the binders or strengthening-pieces 4 are arranged in a loop with a view to allowing the passage of the rams. The materials forced down by the ramming-ram are thus automatically and practically caused to force the said armature or strengthening-pieces 4 toward the center part of the pillar or pier.

In Fig. 1 of the drawings it may be seen that a pile or framing apron 5, of ferroconcrete, connects the foundations of the bridge-pier in the manner hereinbefore mentioned and that in addition the armatures or strengthening-pieces 4 of each pillar or pier are prolonged into the columns *a b c* of the bridge and into the buttress or ice-breaker *d*, which is also of ferroconcrete, in order to form an indivisible whole.

Fig. 3 of the drawings shows a modification of the system of foundations. In this arrangement the protecting-sheath 1 is replaced by a cylinder 6, of ferroconcrete, formed of several parts fitting one in the other and starting from the ground-level. In order to employ this modification, one or more of the pipes are gradually engaged in the ground by lowering them some centimeters after a certain number of strokes of the perforating-ram, which bores first a hole in advance. When resistant or firm ground is reached, the hole is widened a little, so as to form a dish for receiving the end of the pipe, the hollow of which is then filled up with beton or more economically even with sand. Pipes of ferroconcrete may be constructed to resist all internal pressures produced by the compression of the materials under the load.

Another modification of the system consists in the combination of the two arrangements previously mentioned. This second modification is shown in the pile or pillar B, Fig. 1 of the drawings. The lower part of the foundation is surrounded with a protective sheath 2, of clay; but from a certain height the materials constituting the pillar are compressed in a cylinder 7 of ferroconcrete. In the case of a bridge this pipe is preferably arranged opposite the part of the foundation which is in contact with the water; but it may be prolonged beneath the ground and occupy any suitable place, as would be done, for that matter, for a foundation in an accessible ground. This second modification will allow the coffer-dam 1, hereinbefore mentioned, to be entirely dispensed with in certain cases. In fact, for foundations in a river cylinders 7 (see Fig. 4) of ferroconcrete or of unstrengthened concrete, which are embedded in the bed of the river to a certain depth, would be of sufficient height to emerge above the water-level and of sufficient diameter to allow one, two, three, or a larger number of pillars or piles to be bored and rammed in the interior of same. After having filled up the support-base and removed the water contained in the cylinder clay is applied internally to its base, which, forming a joint, insures tightness between the pipe and the bed of the river. The perforation of the soil and the ramming down of one or more piles is then operated, and then the interior of the pipe 7 is in its turn filled up and rammed down. In this case of course the bell will be mounted

on a pontoon or a temporary bridge suitably arranged.

Hitherto only conical perforating-rams and ovoid ramming-rams have been employed for the mechanical compression of the ground. The perforating-ram at present employed, which is solid, has great drawbacks when it is necessary to employ it in incompressible and wet ground, in which case, in fact, the operation is a long one, and it is only possible to displace the incompressible layer by a series of repeated falls or drops. In order to obviate these drawbacks, a perforating-ram of special construction is employed for this improved system of foundations which considerably accelerates the work. Figs. 5 to 7 represent this improved perforating-ram. This appliance is constituted by a hollow conical trunk in two parts 8 and 9 of the form indicated in the drawings, joined together along a diametral plane and adapted to pivot easily on a strong uniting-shaft 10, which serves at the same time for the attachment to the suspension-rod 11. 12 is a notch utilized for opening the perforator. 13 is a catch movable on an axis 14, which, engaging under a projection 15, holds the parts 8 and 9 together. When in use, the ram is lifted by the pile-driving machine and the pawl disengages it in order to allow it to drop with a free fall. On reaching the ground the pile-driver or ram by its cutting edge 16 cuts off a piece of the soil, like a hollow punch, which it brings up with it. Brought to the surface the ram is opened after the catch 13 has been released by inserting a wedge in the notch 12 and causing the parts 8 and 9 to pivot on their axis 10. The earth is removed and the operation recommenced. It will, however, be noticed that the conical external form of the ram always enables it to compress the ground laterally in its fall, and consequently to act in a similar manner to the solid rammer at present employed.

I claim as my invention—

1. The herein-described method of forming foundations in wet or marshy ground, consisting in sinking a shaft by repeated blows of a ram, compressing the displaced material downwardly and laterally by said blows, providing an impervious sheath for the shaft formed, from time to time as its formation progresses, and then filling in the shaft with foundation material.

2. The herein-described method of forming foundations in wet or marshy ground, consisting in sinking a shaft by repeated blows of a ram, filling in the opening made with clay, compressing said clay to form an impervious wall to said shaft and repeating said operation until a shaft of the desired length is secured, and then filling in with foundation material.

3. The herein-described method of forming foundations, consisting in forming a shaft of the required depth of greater area at the base than at the top, forming an impervious clay wall by filling said shaft from time to time during its construction with clay and expanding said clay laterally and then filling said shaft with foundation material.

4. The herein-described method of forming foundations, consisting in placing a pipe of sufficient dimension over the space in which the foundation is to be, forming a shaft below said pipe with repeated blows of a ram adapted to force the material downwardly and laterally and from time to time inserting clay in the path of the ram, that said clay will be forced laterally to form an impervious sheath for the shaft and then filling the shaft with foundation material.

5. The herein-described method of forming foundations in wet or marshy ground, consisting in sinking a shaft by repeated blows of a ram, filling in the opening made with clay, compressing said clay to form an impervious wall to said shaft, cutting through non-compressible strata encountered by the ram with the ram itself, and repeating said ramming and cutting operations until a shaft of the desired length is secured, and then filling in with foundation material.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FRANCOIS JEAN MARIE MONNIER-DUCASTEL.

Witnesses:

ANTONIUS MONTEILHETZ,

HANSON C. COXE.