S. L. RAVIER.

SHEETING PILE OF REINFORCED CONCRETE.

APPLICATION FILED SEPT. 15, 1909.

962,784.

Patented June 28, 1910.

2 SHEETS—SHEET 1.

Fig. 1

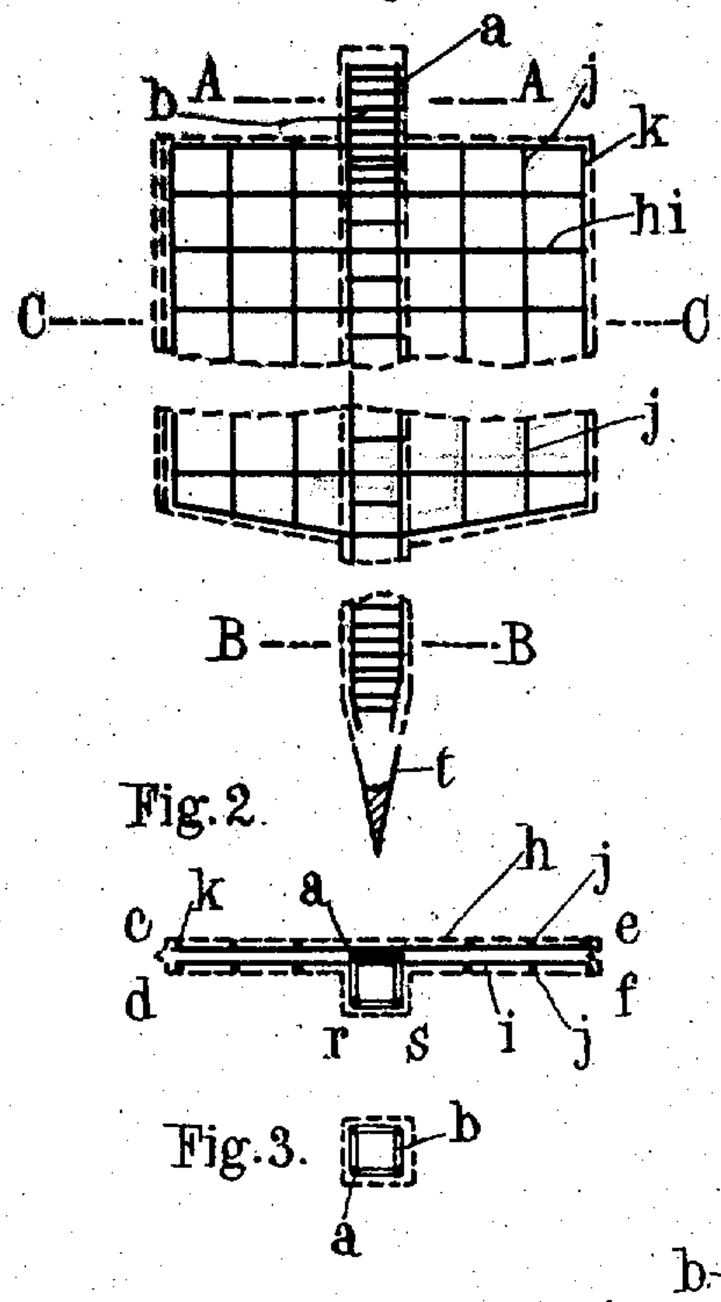

Fig. 2.

Fig. 3.

Fig. 4.

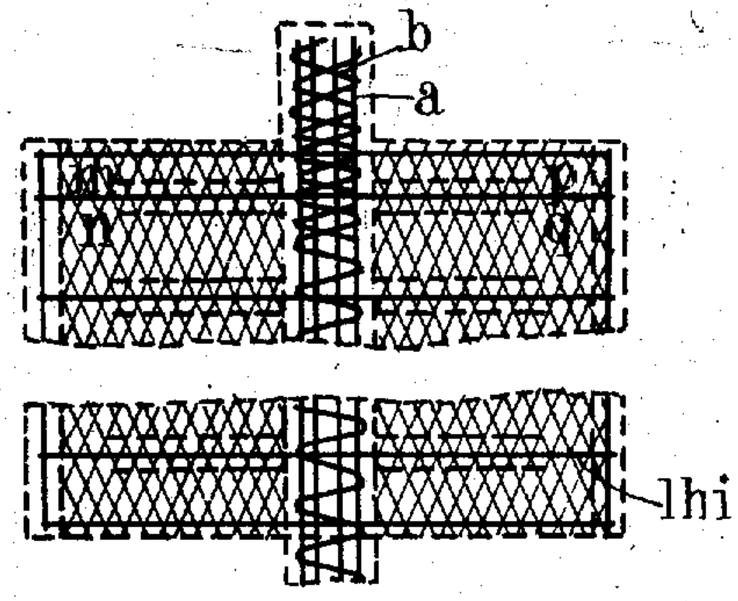

Fig. 5.

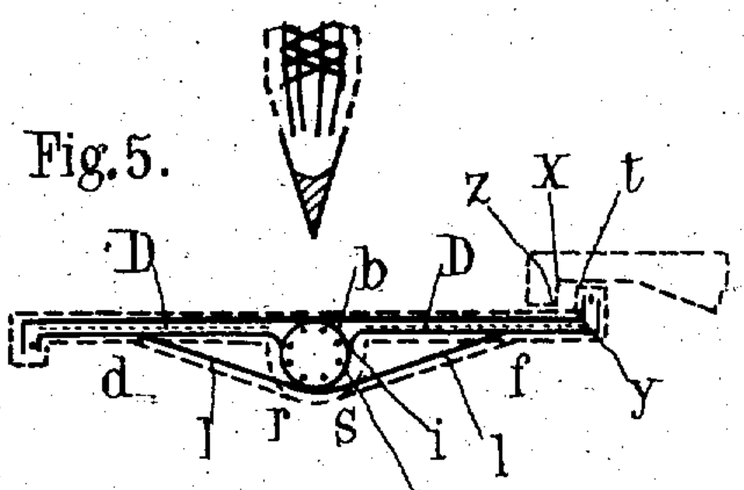

Fig. 6.

Fig. 7.

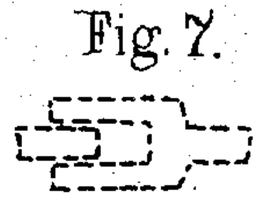

Fig. 8.

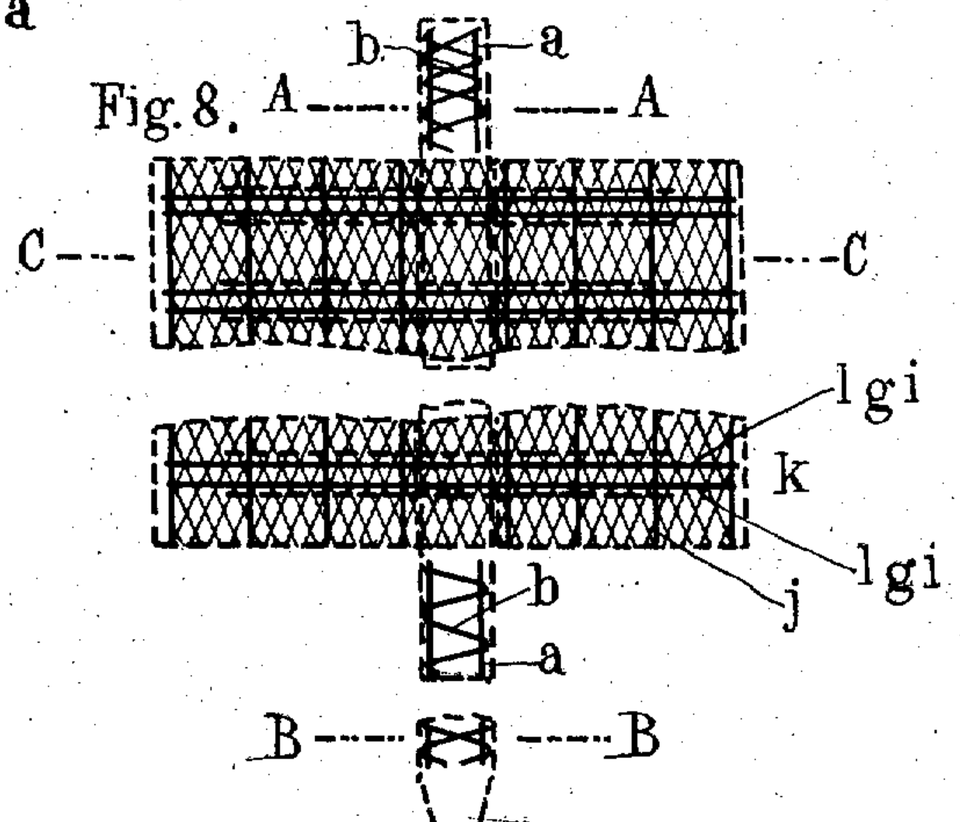

Fig. 9.

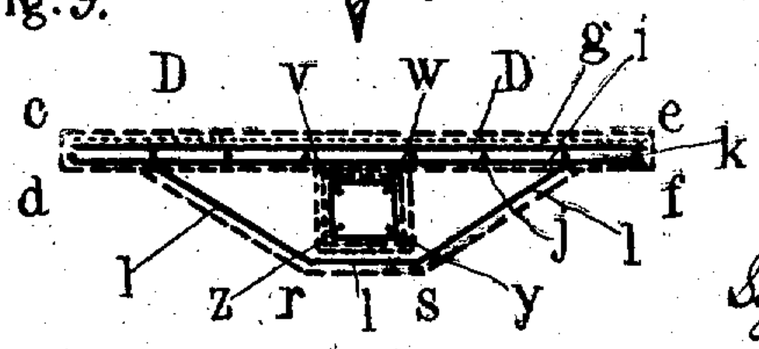

Fig. 10.

WITNESSES

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2 SHEETS—SHEET 2.

Fig. 11.

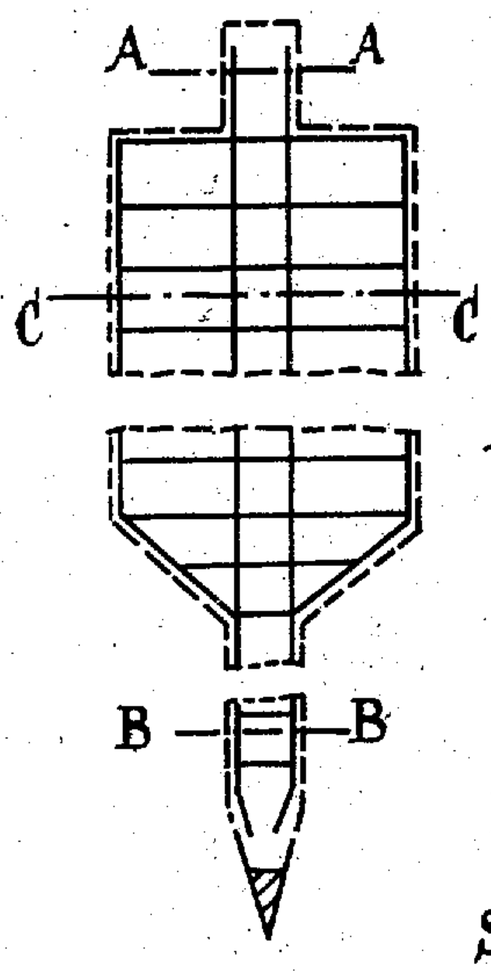


Fig. 12.

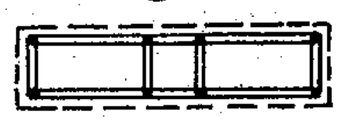


Fig. 13.

Fig. 16.

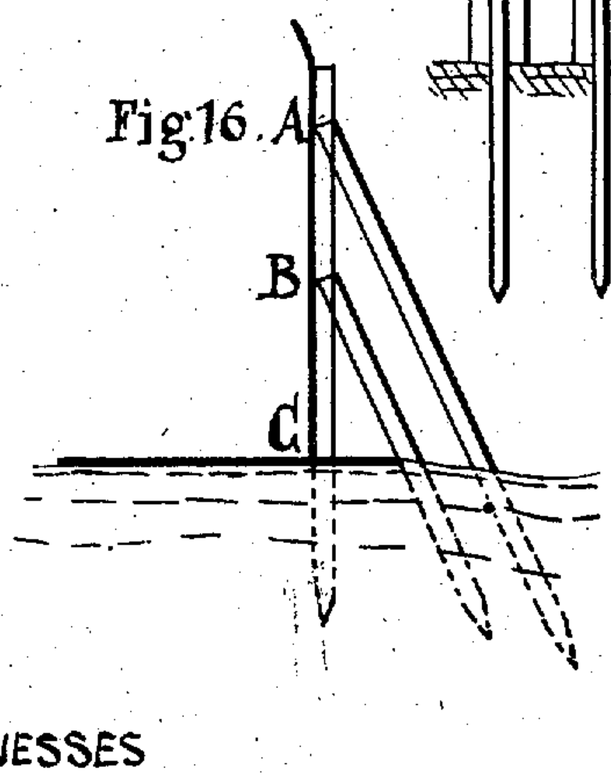


Fig. 14.

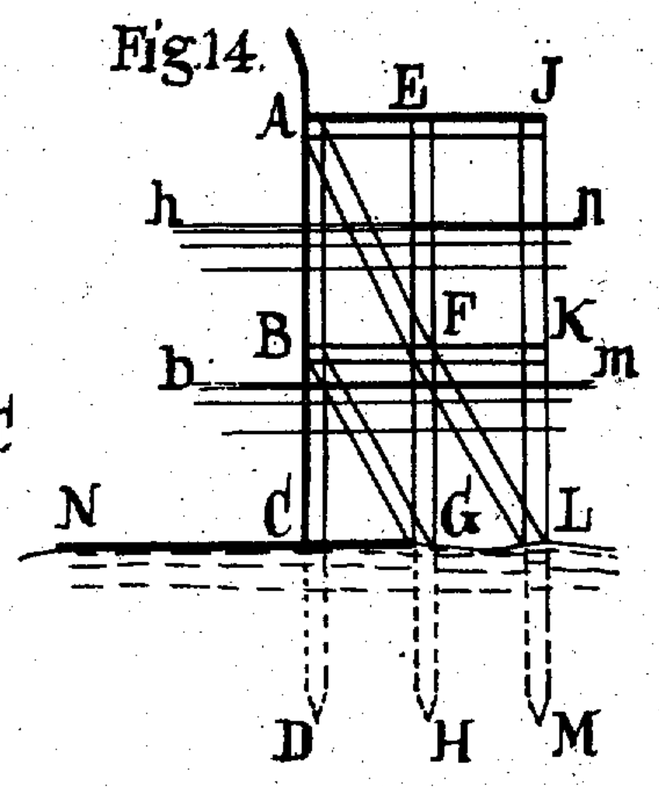


Fig. 15.

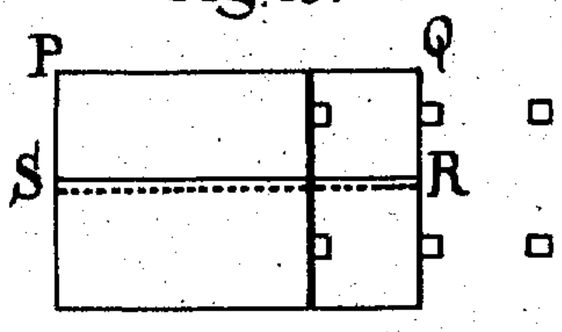


Fig. 17.

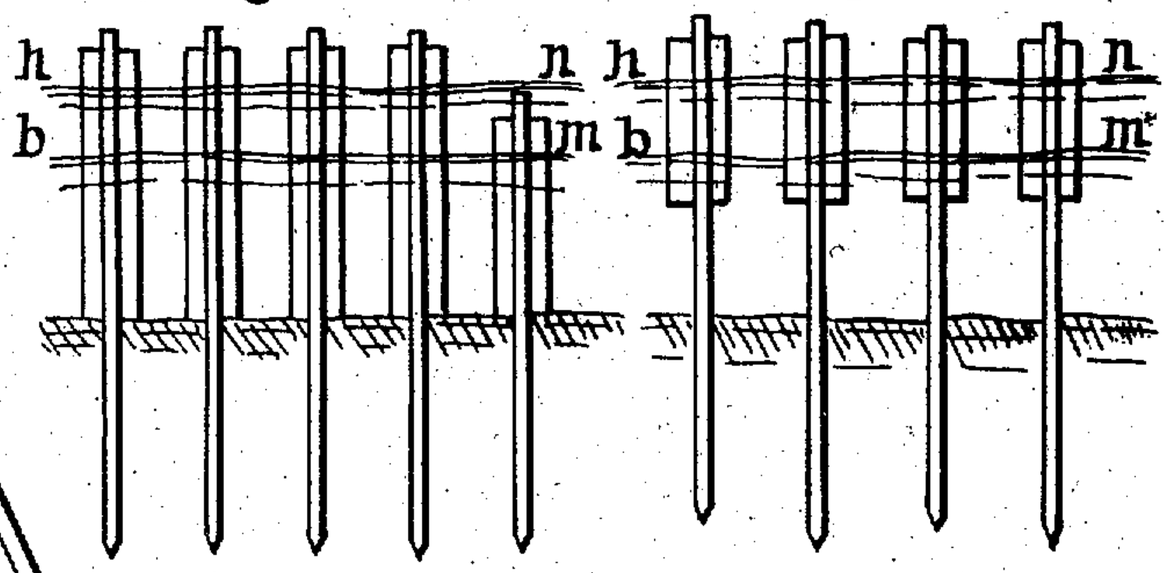


Fig. 21.

Fig. 20.

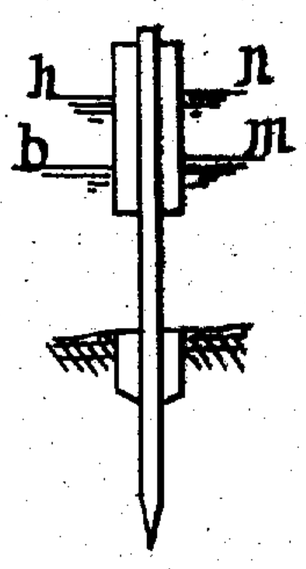


Fig. 22.

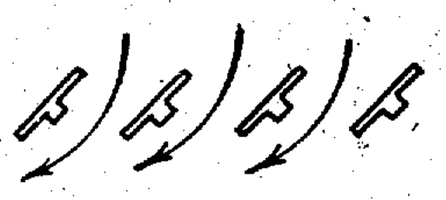
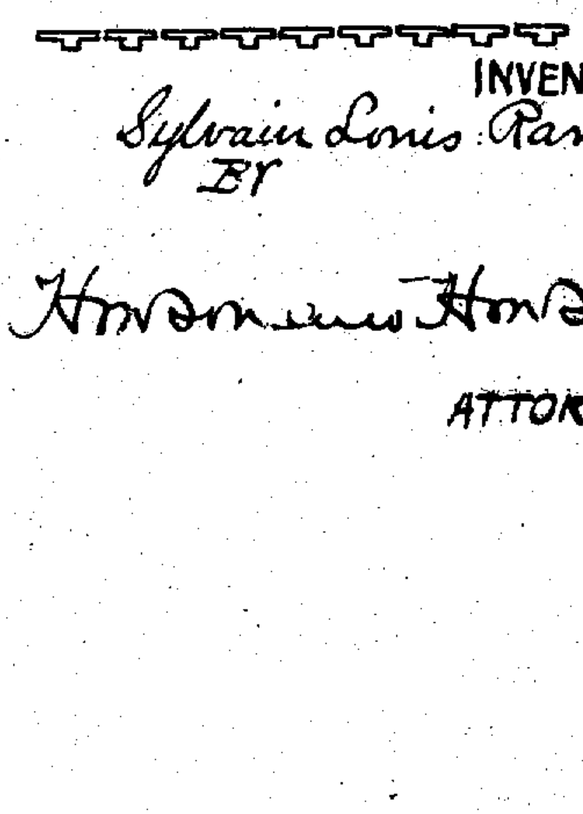


Fig. 18.

Fig. 19.



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SYLVAIN LOUIS RAVIER, OF PARIS, FRANCE.

SHEETING-PILE OF REINFORCED CONCRETE.

962,784. Specification of Letters Patent. Patented June 28, 1910.

Application filed September 15, 1909. Serial No. 517,810.

To all whom it may concern:

Be it known that I, SYLVAIN LOUIS RAVIER, a citizen of the Republic of France, and a resident of Paris, France, have invented a Sheeting-Pile of Reinforced Concrete, of which the following is a specification.

The employment of piles of reinforced or hooped cement concrete rammed like wooden piles has become very general, moreover, sheeting piles of the same kind likewise rammed are also made.

The subject of the present invention is a pile which is of normal form for a portion of its length (preferably the lower portion) combined with sheeting formed in one therewith or independently and mounted thereon and extending over a portion of the length of the pile, (preferably the upper portion) so that the pile is adapted to be driven in as readily as the usual plain pile while at the desired point it has the width of sheeting and is thus adapted for use in forming quays, dams, embankments, jetties and dikes, for preventing the undermining of the foot of quays, etc.

At its upper extremity the pile is preferably formed of normal cross section to facilitate ramming. For many applications the part forming the pile will be driven in while the part forming the sheeting will rest above the ground. In other cases the enlarged part will also enter the ground to a greater or less extent.

The improved sheeting pile may in accordance with the present invention be constructed in various ways. The body formed of concrete may have embedded therein steel bars which are suitably arranged in any suitable manner in accordance with ordinary principles obtaining in reinforced concrete structures. Generally it would appear to be advantageous to so construct the pile that a core in substantially the form of the normal straight pile is maintained throughout its length, the sheeting being added to the desired fraction of the height.

In the accompanying diagrammatic drawings—Figure 1 is a broken elevation of a pile in which my invention is embodied in one form; Fig. 2 is a section of the same on the line C—C, Fig. 1; Fig. 3 is a section on the line A—A or B—B, Fig. 1; Fig. 4 is a broken elevation of a modified form of pile; Fig. 5 is a plan thereof, illustrating also the method of interlock between adjacent piles; Fig. 6 is a cross section of the body of the pile above or below the sheeting; Fig. 7 is a plan of a modified form of interlock between the edges of adjacent piles; Fig. 8 is a broken elevation of another form of pile; Fig. 9 is a section thereof on the line C—C, Fig. 8; Fig. 10 is a section on the line A—A or B—B, Fig. 8; Fig. 11 is a broken elevation of a further modified form of pile; Fig. 12 is a section thereof on the line C—C, Fig. 11; Fig. 13 is a section thereof on the line A—A or B—B, Fig. 11; Fig. 14 is a side elevation of a structure showing my pile employed in connection with anchor plates therefor; Fig. 15 is a plan of the same showing the anchor plates; Fig. 16 is a side elevation of another form of structure in which my improved pile and anchor plate are employed; Figs. 17 and 18 are side elevations of structures in which my improved pile is employed in different forms for different purposes; Fig. 19 is a plan view of a suggested arrangement of the piles for a breakwater; Fig. 20 is a side elevation of modified form of pile with the sheeting in two portions; Fig. 21 is a cross section of the lower portion of a pile having sheeting adapted to be driven into the ground; and Fig. 22 is a plan of another suggested arrangement of the piles for a breakwater.

In the various figures the concrete body of the pile and its sheeting is shown in dotted lines, and the reinforcing bars in full lines, and the size of the sheeting is reduced in proportion to the size of the pile proper or core. The pile proper is of square section as shown in Fig. 3 and is reinforced by longitudinal bars *a* with transverse connections *b*, the latter being spaced closer together at the top of the pile to strengthen the same and enable it to withstand injury during ramming. The sheeting, the section of which is indicated in Fig. 2, at *c—d—f—e* is reinforced by transverse bars *h* and *i* and longitudinal bars *j* and *k*, the number of which varies according to circumstances. The bars are of course appropriately connected one with the other at their points of intersection in accordance with the usual practice in concrete structures. At its lower extremity the pile may be fitted with a sheet metal cap *t* the end of which is filled with cast iron and capped at its head for raming in accordance with one of the processes used for reinforced concrete piles. Instead

of being of a constant width for special purposes the sheeting may be of variable width and present a more or less complicated or irregular contour.

In Figs. 4, 5 and 6 the pile core is hooped while the reinforcing of the sheeting is a plate of expanded metal D. The edges of the sheeting are offset to afford a convenient joint with the edge of the adjacent pile, to which it may be united by pouring cement or other filling material into the space *x*, *y*, *z*, *t*. Instead of a joint like that illustrated in Fig. 5 that shown in Fig. 7 may be substituted or any other of suitable construction may be adopted. In Figs. 4 and 5, the sheeting is strengthened by buttresses the form of which is indicated at *m*, *n*, *p*, *q*, in Fig. 4 and *d*, *r*, *s*, *f* in Fig. 5, these buttresses being themselves reinforced by bars *l* as shown in Fig. 5. Vertical reinforcing ribs might likewise be provided in certain cases, in the manner indicated in Figs. 14, 17 and 18. Instead of a single reinforcing bar *l*, two bars may be provided at each pier or counterfort as shown in Figs. 8 and 9.

Figs. 8, 9 and 10 represent a modification in which the sheeting is not integral with the pile but is merely fitted on it. This arrangement is specially intended for cases where the irregularity of the driving of the piles is troublesome and for sea works where the sheeting would constitute an impediment during the ramming owing to the action exerted upon it by the waves. The piles are first rammed and then the sheetings are fitted on them and allowed to descend. When desirable, for example in forming a dam, the sheeting itself may be slightly rammed subsequently by special means, independently of the piles which have already been driven in and which serve to support the sheeting.

In Figs. 8, 9 and 10 the same letters of reference are used as in the preceding figures for like parts. In order to simplify the drawing the reinforcing bars of the pile have not been indicated in Fig. 8 throughout the entire length of the pile but only at the ends. The square *v*, *w*, *y*, *z* in Fig. 9 represents both the exterior of the pile and the hole in the ribs of the buttresses of the sheeting by means of which the said sheeting is passed on to the pile. By way of example the pile is shown hooped with a helix *b* coiled upon a rectangle of round bars *a*. The sheeting is reinforced vertically upon one of its faces by a sheet of expanded metal D and upon the other face by vertical bars *j* and *k*.

Figs. 1 to 10 represent the sheeting piles with a lighter sheeting. Figs. 11 to 13 represent a strong and simpler construction in which the sheeting is only an enlargement of the pile without diminution in thickness.

The improved sheeting pile may be specially applied to the economical construction of jetties or dikes. In this case the sheeting piles are strengthened to resist the waves by means of ordinary wooden piles or preferably reinforced cement or hooped cement piles arranged behind them. The arrangement shown in Fig. 14 is given by way of example where A D is the sheeting pile and E H and J M are ordinary piles; B G, F, L and A F are struts and B F, F K, A E, and E J are horizontal connections. The piles may be provided in advance at one or more points in their height with fittings for the connections to be made at the points A and B; E F and G; J K and L. The fittings for the points G and L are specially devised for a connection easily effected under water. As far as possible the points B F and K should be a little above the level of low water *b m* the high water level being represented by *h n*. The lengths of the rammed piles may then be reduced to B D, F H, K M, the upper parts A B, E F, J K, being constructed and connected subsequently. The sheeting piles might also be consolidated by piles planted obliquely as shown in Fig. 16; the arrangements in Figs. 14 and 16 might also be combined. Owing to the great pressure exerted by the waves each sheeting pile A B C (Fig. 14 or 16) will act in the manner of a part subjected to great flexure between A and B on the one hand and between B and C on the other hand. In order to resist this flexure the pile may be given a rectangular section elongated in the direction perpendicular to the sheeting and strongly reinforced or there may be added to the sheeting preferably behind (on the jetty side) vertical ribs of strongly reinforced cement forming one with it and of uniform height or rather in form of equal resistance corresponding to the curve of the bending moments.

The jetty of the type illustrated in Fig. 14 or 16 may be completed in case of urgency by large slabs of reinforced cement arranged flat on the ground extending considerably in front of the piles which pass through them with a square or rectangular fitting which maintains the slabs well in position. The object of this arrangement is to prevent the hollowing action of the waves in front of the jetty. The slabs represented at N G in Fig. 14 and at P Q R S in Fig. 15 overlap slightly at the lines of junction if necessary. They may be more or less complicated in form and construction, so as to adapt themselves to the ground and resist the lifting action of the waves.

Figs. 14 and 16 show sheeting piles on one side of the jetty only, that is to say the outside but if desirable they may be provided on both sides and then the supplementary piles and struts are arranged for resisting the waves which may come up on the two

sides respectively. Another maritime application of the sheeting pile consists in planting the sheeting piles in disconnected lines where the piles remain completely independent of each other as shown in Fig. 17. A line of sheeting piles thus constituted will break the action of the waves and render the water calm behind it in proportion to the ratio between the filled and vacant spaces in the sort of vertical grating opposed to the waves. If it be desired to prevent agitation of the surface while at the same time allowing the water to flow freely beneath, the arrangement illustrated in Fig. 18 may be adopted. On the other hand in order to shorten the piles they may terminate below the level of high water which arrangement allows the agitation of the surface to pass freely at high water and only stops the ground swell as shown in the right hand of Fig. 17. If at a certain distance behind a line of sheeting piles of one of these three types, another line is arranged a fresh deadening of the waves will result. Three successive lines or even more may be provided according to circumstances so as to obtain behind the last line either a perfect calm or merely the degree of calmness desired. In order to produce a perfect calm the sheeting of the last line may be arranged almost continuous as shown in Fig. 19. The lines of sheeting piles thus formed are readily maintained because if some of the piles are demolished by a storm it is only necessary to add others at the side.

In order to render the sheeting piles better able to resist the effort of the waves vertical cement ribs strongly reinforced may be added to them or the pile proper may be given a rectangular section elongated in the direction perpendicular to the sheeting. Each pile may be considered as embedded to the level of the ground or slightly below it as having to experience at this point the strongest bending moment so that it is at this height that the ribs or the increase of section of the pile in the direction perpendicular to the sheeting should be greatest. By forming a suitable hypothesis as to the pressure of the waves per unit of surface it is possible in each case to calculate the bending moments of the pile at the different heights and to deduce therefrom a rational system of ribbing or reinforcement.

In order that the embedding may be improved in proximity to the place where the pile enters the ground and especially if this ground is not stable, it is advisable to drive the sheeting in slightly or if the sheeting is of the type represented in Fig. 18 to add to the pile a wing of sheeting at the place where it enters the ground (Fig. 20). From the same point of view the pile might be given a T-shaped cross section for the whole or a part of its embedded length as shown in Fig. 21; the upper bar of the T thus constituted is appreciably narrower than the sheeting existing above.

Fig. 22 represents for the lines of sheeting piles, a modification consisting in arranging the units slightly obliquely. With this arrangement the force of the sea passing through the first line of piles will be partially deflected laterally parallel with this line as indicated by the arrows which will be advantageous in diminishing the effort upon the second line of piles which may either be of the same oblique type with a different inclination or of the known oblique type previously described.

In order to prevent undermining at the foot of the sheeting piles when the arrangements illustrated in Figs. 17 to 19 and 22 are adopted, slabs of reinforced cement may be used; the piles pass through these slabs and retain them as described with reference to the arrangement shown in Fig. 14. Holes may be provided in these slabs for the reception of supplementary piles in case repairs are necessary. The screens of lines of sheeting piles formed in the manner described may be used for protecting works of any kind. In particular if the sea is generally very rough in the locality such screens may be arranged in front of jetties of the type represented in Fig. 14 of the present invention thereby reducing the strain on such jetties. On the other hand if the conditions of the sea are relatively calm so that the piles are not subjected to excessive shocks and so that there is practically no danger that the waves in breaking against the piles will send up excessively high jets or sheets of water, it is possible in a screen of lines of disconnected sheeting piles of the type illustrated in Fig. 19 to connect the heads of the sheeting piles, arrange planking upon the transverse connections and thereby constitute a jetty differing from that represented in Fig. 14 owing to the fact that the sea will become deadened below instead of in front. Ties half way up and obliquely arranged may be also fitted between the piles as shown in Fig. 14.

I claim as my invention:

1. A single pile of reinforced or hooped concrete having an enlarged portion extending beyond both sides of the pile and constituting a monolithic sheeting, but being of ordinary cross-section at its lower or pointed end.

2. A pile of reinforced or hooped concrete having an enlarged portion constituting sheeting, said sheeting portion being independent of the pile core and being adapted to be passed on said core after the latter has been rammed, substantially as described.

3. A single pile having an enlarged portion extending beyond both sides thereof constituting a monolithic sheeting, the ver-

tical edges of said sheeting being shaped to engage the edge of an adjacent sheeting and form an open joint therewith adapted to be filled with a suitable binder, substantially as described.

4. A pile of reinforced or hooped concrete having an enlarged portion constituting sheeting but being of ordinary cross section at its lower or pointed end, in combination with anchor plates of concrete perforated to permit the passage of said pointed end therethrough, substantially as described.

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

SYLVAIN LOUIS RAVIER.

Witnesses:
CHARLES DRURY,
EUGEN HEMET.