

March 25, 1930.

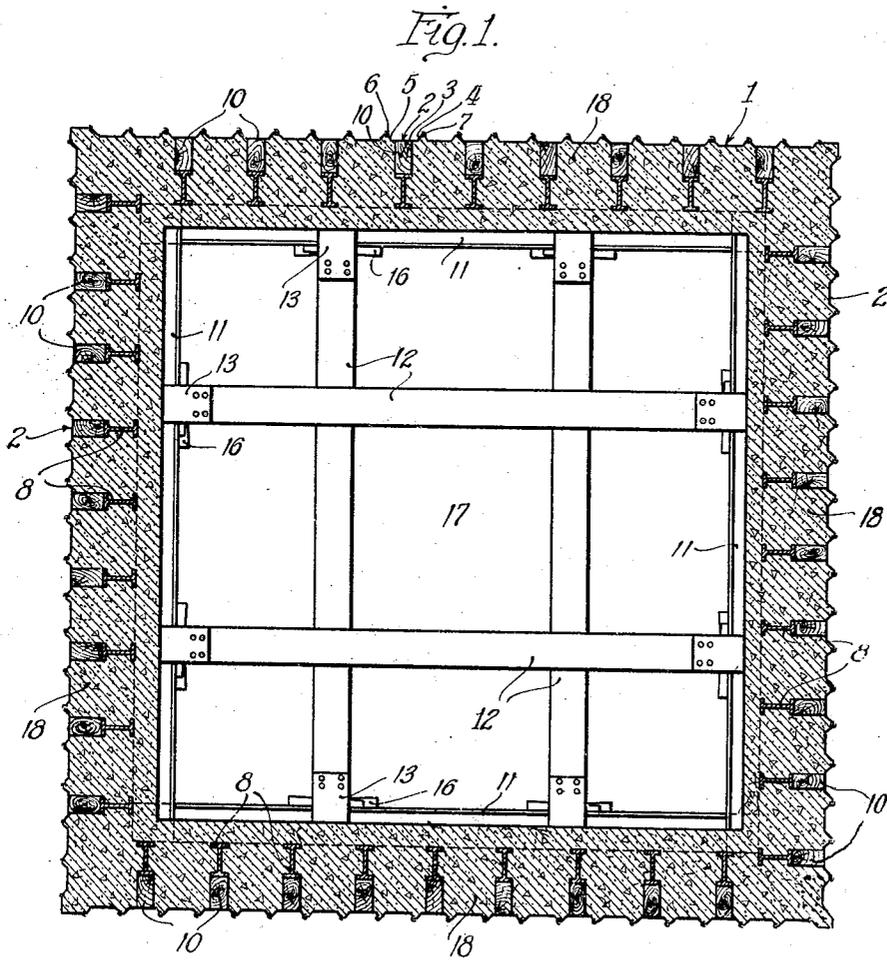
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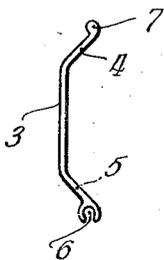
COFFER DAM AND METHOD OF CONSTRUCTION

Filed Oct. 27, 1927

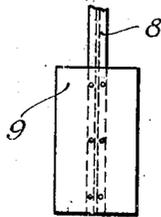
3 Sheets-Sheet 1



*Fig. 4.*



*Fig. 6.*



*Fig. 5.*



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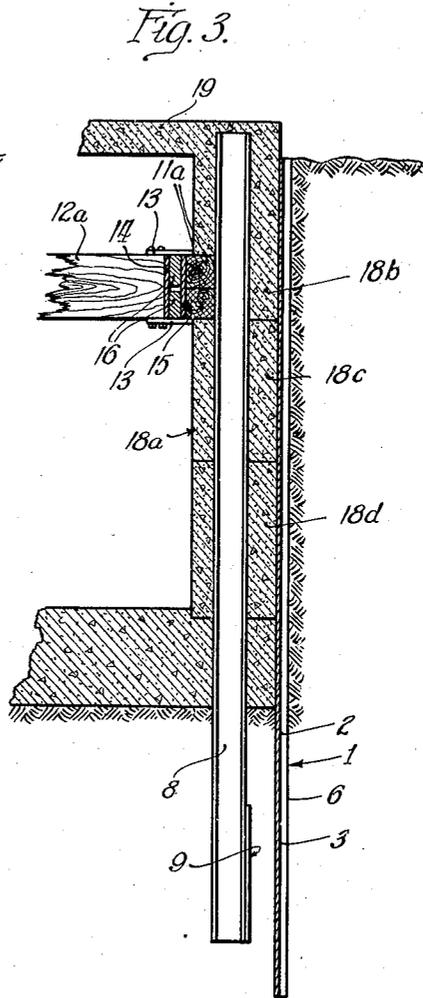
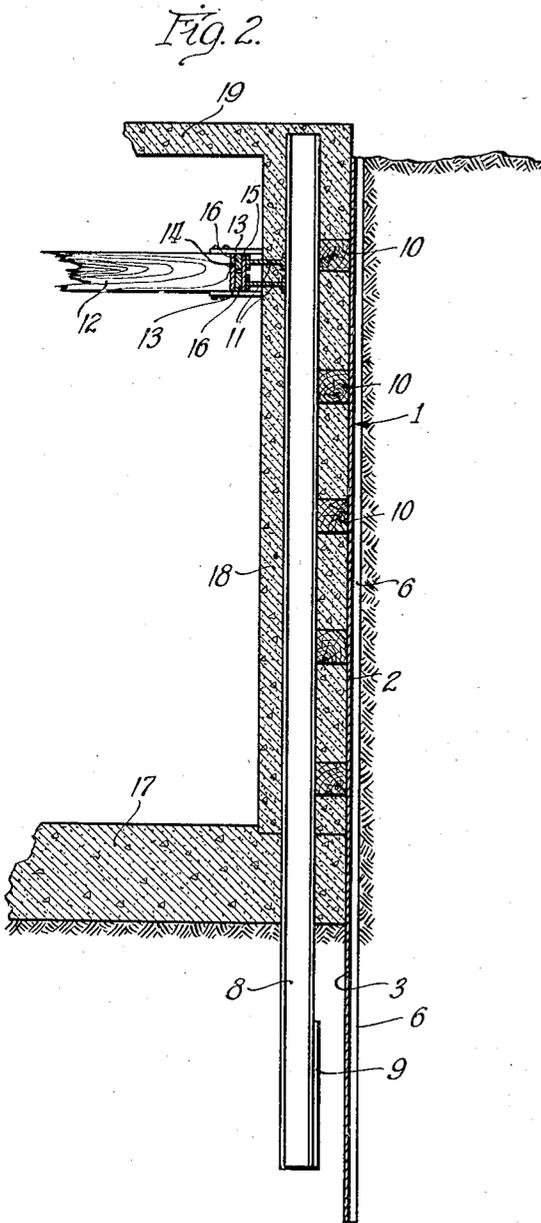
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COFFER DAM AND METHOD OF CONSTRUCTION

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3 Sheets-Sheet 2



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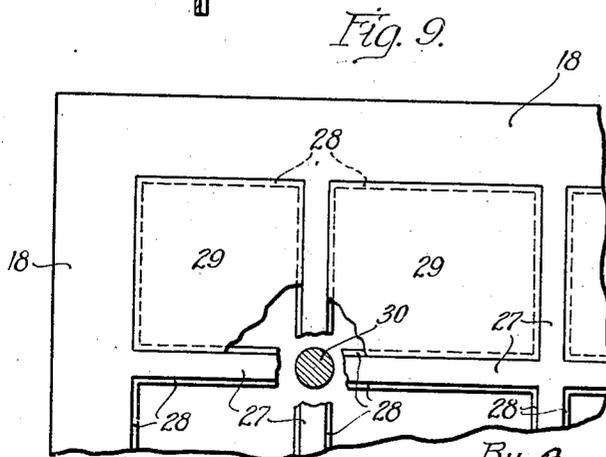
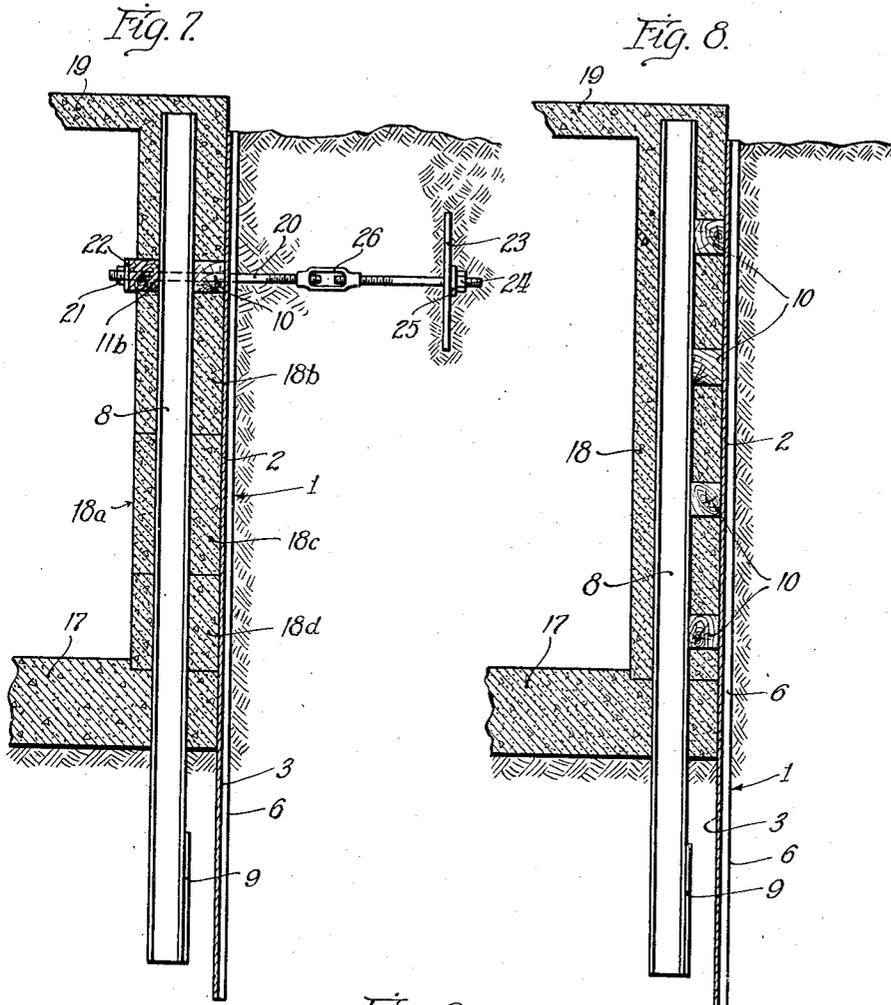
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COFFER DAM AND METHOD OF CONSTRUCTION

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3 Sheets-Sheet 3



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# UNITED STATES PATENT OFFICE

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## COFFERDAM AND METHOD OF CONSTRUCTION

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This invention relates to coffer dams, and more particularly to the means and method of constructing a coffer dam and erecting a permanent structure as removal of the excavated material progresses.

As is well understood in this art, coffer dams are used under conditions where the enclosing sheet pile structure is subjected to severe pressures from the outside. It is essential, therefore, that the sheet pile structure be effectively braced so as to prevent collapse of the dam and insure safety of the workmen. To obtain this result it is the present practice to install heavy horizontal bracing as the excavation progresses, which necessity we avoid by our invention.

The purpose of a coffer-dam is to maintain an open working space in which to build structures that extend some distance below the surface of the water or the ground. When the sheet piling of a coffer-dam is first driven it is not subjected to any appreciable external pressures since such pressures are counteracted by the pressure of the material enclosed by the coffer-dam. As the material is removed from within the dam, however, it is subjected to external pressure. This external pressure increases progressively with the removal of the excavated material.

The present practice in construction of coffer-dams is to drive the sheet piling three or four feet outside of the line of the finished surface of the concrete. This is to allow for the installation of wales or other bracing members to take the earth pressure against the sheeting and also to allow room for the construction of forms for the concrete. This means that the coffer-dam has to be very much larger than the size of the finished concrete and the volume of excavated material is therefore greater than that of the finished concrete. It also means that a considerable amount of back filling has to be done after the concrete is finished. The horizontal braces and struts in the ordinary coffer dam construction have to be placed so close together, especially in the lower part of the excavation, that they seriously interfere with the work of excavating.

We have found that it is possible by driv-

ing steel beams or steel piles to brace the sheet piling and by arranging these so that they can be built into the permanent structure and properly bracing these steel piles, the number of horizontal struts used in the coffer-dam can be very greatly reduced and the sheet piling can be driven immediately outside of the finished line of concrete.

This method greatly reduces the amount of material to be excavated and also facilitates and expedites the process of excavating because the interference caused by the horizontal struts is very much less than in the ordinary types of coffer-dam.

With our method of construction the sheet piling can be used as the outside form for the concrete which greatly reduces the amount of form work, and by painting the sheet piling, or covering it with paper, it can be pulled out after the work is finished and used over again. Our method therefore effects a very material saving over the present practice in both time and material in the excavation, form work, and in the construction of the coffer-dam with a corresponding saving in the cost of the completed structure. By our method the forms for the concrete walls can be erected within the coffer-dam as the excavation progresses and if desired the concrete can be poured as excavation of the material progresses, which further facilitates and expedites the work. Further objects and advantages will appear from the detail description.

In the drawings:—

Fig. 1 is a horizontal sectional view taken through a coffer-dam constructed in accordance with our invention on a plane adjacent the top of the dam;

Fig. 2 is a fragmentary vertical sectional view through the coffer-dam;

Fig. 3 is a view similar to Fig. 2 through a modified form of dam;

Fig. 4 is a detail of one of the sheet piles used in constructing the dam;

Fig. 5 is an end view of one of the brace members;

Fig. 6 is a fragmentary outer face view of the lower portion of one of the brace members;

Fig. 7 is a fragmentary sectional view of another modified form of coffer-dam;

Fig. 8 is a fragmentary sectional view of a third modified form of coffer-dam; and

Fig. 9 is a plan view of a fourth modified form of coffer-dam, partly broken away and in section.

In constructing the coffer-dam we first provide an outer structure 1 formed of metal or wood sheet piles which are driven into the ground to the proper depth and on the lines of the permanent structure to be erected, this pile structure enclosing the material to be removed. The piles 2 used in this structure may be of any suitable or preferred type. In Figure 4 we have illustrated a type of pile which we have found to be very satisfactory. This pile is rolled from steel and includes a flat body 3 having lateral angularly disposed flanges 4 and 5. One of the flanges, as flange 5, is provided, at its outer edge, with an enlargement forming a substantially circular socket 6 for reception of a correspondingly shaped bead 7 at the outer edge of flange 4, it being understood that bead 7 engages into socket 6 of an adjacent pile. In this manner the piles are locked together as they are driven and form a substantially water tight enclosure.

After the pile structure 1 has been completed a plurality of brace members 8 are driven within the pile structure parallel to and spaced a short distance from the walls thereof. These brace members 8 may be of any suitable form but are preferably in the form of I-beams which we have found to be very satisfactory for this purpose as possessing great strength and being readily driven into the soil. Preferably, though not necessarily, each of the members 8 is provided, adjacent its lower end, with a plate 9 which is secured on the outer face of the brace member by riveting or in any other suitable or preferred manner. This plate may vary considerably in size and shape though we find that a plate of substantially rectangular shape is very satisfactory. The plate 9 is shown as disposed across the outer face of brace member 8 at right angles thereto, but this plate may be disposed on either the inner face or the outer face of member 8. The plate 9 applied in this manner readily enters the soil when the brace member is driven and acts to increase the bearing capacity of the lower end of brace 8 and as an anchor to firmly secure the lower end portion of the brace member in the ground and hold it against either inward or outward movement. Preferably the brace members 8 are of such length as to extend a short distance above the sheet piles 2.

After the sheet pile structure has been erected and the brace members have been driven, in the manner described, the mate-

rial enclosed by the sheet pile structure is excavated or removed.

In accordance with our invention, after the enclosed material has been removed to a slight depth, spacing members or blocks 10 of hard wood or other suitable material are inserted between the brace members 8 and the flat inner faces of the body portion 3 of certain of the sheet piles 2. Wales 11, which may be formed of I-beams, are then placed along the sides of the enclosure and bear upon the inner faces of the brace members 8. The wales at opposite sides of the enclosure are held apart by cross beams 12 provided at their ends with upper and lower plates 13 secured thereto and projecting beyond the beams. The plates extend across the upper and lower edges of metal plates 14 and 15 bearing against the end of the beam 12 and the inner faces or heads of the wales 11, respectively. Steel wedges 16 are driven between the plates 14 and 15 and exert great pressure thereon so as to effectively brace the wales 11, and consequently the upper portions of the brace members 8, against inward movement. As removal of the material progresses additional blocks 10 are inserted between the brace members 8 and the sheet piles 2 of the structure 1. In view of the fact that the upper portions of the brace members are effectively held against inward movement, and the lower portions of these members are driven into the ground well below the bottom of the excavation, the intermediate blocks 10 are effectively held against inward movement and serve to very effectively brace the intermediate portion of the sheet pile structure. In this manner the completion of the reinforcement for the sheet pile structure continues simultaneously with the removal of the material, and the bracing of the structure progresses in accordance with the progress of removal of the material and increase of pressure on the sheet pile structure. This renders it possible to remove the material and to simultaneously reinforce the sheet pile structure in accordance with increase in external pressure thereon, effecting a very material saving in time and labor over the present method. It is also to be noted that the interior of the coffer-dam is unobstructed for practically its entire depth, which greatly facilitates removal of the material, particularly when excavating soil and analogous materials.

After the removal of the material has been completed, a base 17 of concrete, or other suitable material, is constructed at the bottom of the excavation, this base forming a permanent bottom for the pit and supporting reinforcing side walls 18 also preferably formed of concrete. These side walls enclose the brace members 8 and the blocks 10 and serve to connect the brace members so as to very materially increase the resistance of the

structure as a whole to external pressures. The side walls 18 may be poured after the removal of the material has been completed, suitable forms being set up inside of the brace members 8 as will be readily understood, or these walls may be poured progressively as the removal of the material proceeds. In the latter case, after the material has been removed to a depth corresponding approximately to the distance between two of the blocks 10, taken vertically, a form is set up and, in the case of the pouring of the top section or portion of the wall, the concrete mixture is poured into the space between the form and the sheet pile structure from the top thereof. This first section takes its initial set as the removal of the material proceeds. After the second step or batch has been removed, the form is lowered so as to rest upon the bottom of the excavation produced, the upper portion of this form overlapping the lower portion of the upper section of the wall which has been poured. The concrete mixture is then forced into the space inclosed by the form, the first section of the wall, the bottom of the excavation and the sheet pile structure, in any suitable manner, the spacing blocks 10 being first properly placed before the form is erected. After this space has been completely filled with the concrete mixture under pressure, the removal of the material proceeds, the form being again lowered and a third portion or section of the wall poured under pressure, the pouring of the walls thus proceeding as the removal of the material proceeds. The advantage of this method is that the forms are comparatively small and can be quickly and easily handled, and all necessity for providing an elaborate system for bracing the forms is eliminated effecting a material saving in time and labor, as well as cost of material. In Fig. 3 we have illustrated a wall 18<sup>a</sup> constructed in this manner and formed in three sections 18<sup>b</sup>, 18<sup>c</sup> and 18<sup>d</sup>, respectively. For purposes of illustration these sections of the wall have been indicated as separate from each other though, in practice, the sections will be poured successively and will be effectually united so as to form a monolithic structure.

The walls 18 form the foundation or lower portion of the permanent structure to be erected. In constructing these walls the forms will be spaced from the pile structure the proper distance to produce walls of the desired thickness to support the load of the superstructure. In this connection, the vertical braces or I-beams 8 are of proper strength to carry whichever is the greater load; the earth thrust during construction or the load imposed by the completed structure. Where circumstances require, other reinforcing members in addition to the I-beams 8, may be embedded in the walls 18 during pouring

thereof. In this manner it is possible, by our method, to construct the supporting walls of the permanent structure as removal of the material progresses, these walls being completed practically simultaneously with the completion of removal of such material. This effects a great saving in time and labor over the present practice and a corresponding saving in cost.

In the modified form illustrated in Figure 3 the spacing blocks 10 have been omitted, the spaces between the brace members 8 and the sheet piles 2 being filled by the concrete of the wall 18<sup>a</sup>. It is entirely feasible to do this when the wall is poured in sections progressing downwardly with the progress of the removal of the material as the partially set wall section and the material thereof between the piles and the brace members is amply able to resist the inward pressure to which the pile structure is subjected, the upper portions of the brace members 8 being held against inward movement by cross beams 12<sup>a</sup> associated with wales 11<sup>a</sup> and wedges 16 driven between the plates 14 and 15. The wales 11<sup>a</sup> are formed of wooden beams but they may be replaced by the I-beams 11 of Figure 2, if desired.

While we have illustrated and described wooden blocks as spacers between the piles and the I-beams, any other suitable or equivalent means may be employed for this purpose. Under certain conditions, as explained above and as illustrated in Fig. 3, the spacing members between the piles and the braces or I-beams may be omitted. It is also to be understood that any suitable means other than the plates 9 may be employed to increase the bearing capacity of the lower ends of the I-beams 8, such as, by way of example, by driving short pieces of steel sheet piling, steel plates, or other structural members immediately in front of the I-beams. These steel members could be burned off after completion of the excavation, if desirable.

The coffer-dam thus constructed may be used as a foundation for a suitable superstructure as above set forth, or, if it is to be used in connection with the construction of a platform, such as a wharf or other landing, a suitable top or closure structure 19, which may be suitably reinforced if desired, may be constructed across the upper end of the coffer-dam. If the super-structure is to be of great weight, the coffer-dam may be filled in with proper material to provide a suitable foundation.

Under proper conditions the bracing within the coffer-dam may be omitted, the vertical braces or I-beams being held against inward movement by tie rods and associated parts. This construction is illustrated in Figure 7.

Suitably spaced tie rods 20 are inserted through openings in wales 11<sup>b</sup> and receive nuts 21 and washers 22 which hold the rods

against outward movement. The outer end of each rod passes through an anchor member or deadman 23 buried in the soil, and receives a nut 24 and washer 25 which prevent withdrawal of the rod from member 23. The rod includes a turnbuckle 26 by means of which proper tension can be placed on the rod to effectively brace the I-beams 8 against inward movement. This form has the advantage of leaving the interior of the coffer-dam entirely unobstructed, greatly facilitating excavation of the material and work within the dam.

In the form illustrated in Figure 8 the wales and all bracing have been omitted. This form is used in localities of good firm soil, and where the dam is relatively shallow. Under such conditions the coffer-dam acts as a cantilever and is well able to withstand the strains to which it is subjected by external pressure, and all wales, cross braces, anchor rods or other bracing of a similar nature are omitted.

In Figure 9 we have illustrated another modification in which the cross braces or beams 27 are formed of concrete and are integrally united with the side walls 18 to form therewith a monolithic structure. One way of doing this is to first excavate the soil about the entire sheet piling structure to a depth corresponding to the depth of the first section of the walls 18 to be poured, the width of the trench thus formed corresponding to the thickness of the wall 18. Intersecting trenches are then dug in the soil within the sheet piling structure, these trenches being at right angles to the walls of this structure and of a depth corresponding to the desired vertical thickness of the beams 27. These trenches open into the trench about the inner face of the sheet piling structure. All of the trenches are then filled with concrete which sets as the excavation of the material between the trenches proceeds. After the material has been excavated to the depth of the first section of the walls 18, suitable forms are set up and the succeeding section of the wall is poured, the pouring of the walls proceeding progressively with the excavation of the soil, as previously described. A second method of constructing this form of dam is to remove the soil for the full cross-area of the enclosed space to a proper depth, after which suitable forms are set up and the cross-braces or beams 27 and the top section of the walls 18 are formed simultaneously. In either case, the walls and the cross-beams are integrally united and form a monolithic structure. Where necessary, or desired, the beams 27 can be provided with suitable reinforcing members, such as steel bars, embedded therein in a known manner. Preferably, though not necessarily, each of the beams 27 is formed with a rabbet 28 at each side and in its upper face. These rabbets are for reception of con-

crete slabs 29, which may be suitably reinforced, these slabs closing the spaces between the beams and seating snugly in the rabbets thereof. This construction is particularly well adapted for platforms, wharfs, and other flat top structures. In cases where the beams 27 are of appreciable length or have to support heavy loads, suitably spaced columns 30 may be provided beneath these beams at the points of intersection thereof, and at other points also, if desired. In this construction we avoid the necessity of using wales or cross-braces which are later removed, the beams 27 forming part of the permanent structure, this effecting a material saving in time, material, and work with a resulting saving in the total cost of the structure.

What we claim is:—

1. In a coffer-dam, an outer sheet pile structure, inner brace members driven adjacent the pile structure, spacing means confined between the brace members and the pile structure, and an inner reinforcing wall enclosing and connecting the brace members, said wall including as elements thereof said spacing means confined between the brace members and the pile structure.

2. The method of constructing a coffer-dam and erecting a permanent structure thereon, consisting in driving a structure of sheet piles enclosing the material to be removed, driving a plurality of brace members within and adjacent the sheet pile structure, inserting spacing means between the sheet pile structure and certain of the brace members, removing the enclosed material, and erecting walls between and about the brace members, the outer faces of the walls being defined by the sheet pile structure, the brace members becoming permanently associated with said walls and forming reinforcing elements therefor and the walls thus erected forming the foundation walls of the permanent structure.

In witness whereof we have hereunder subscribed our names this 24th day of October, 1927.

WILLIAM S. MONROE.  
JOHN C. SANDERSON.