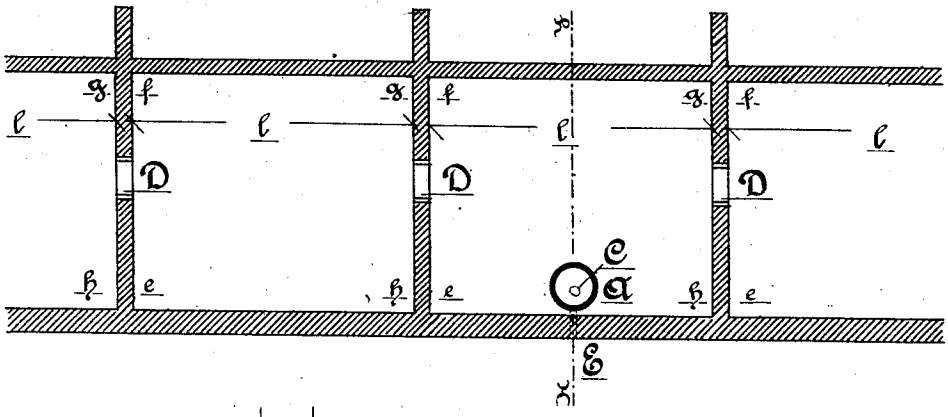
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WALL RESISTING THRUST OF EARTH AND WATER.

APPLICATION FILED JUNE 12, 1919.

**1,360,767.** **Patented Nov. 30, 1920.**

*FIG. 1.*



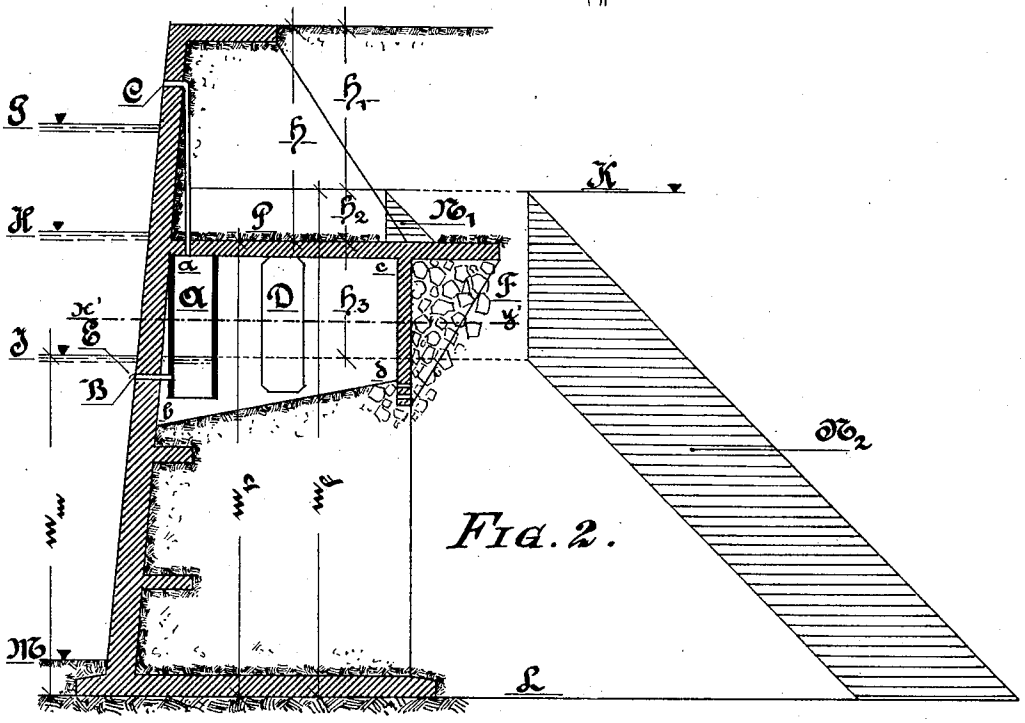


*FIG. 2.*

Section x-y.

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## WALL RESISTING THRUST OF EARTH AND WATER.

1,360,767. Specification of Letters Patent. Patented Nov. 30, 1920.

Application filed June 12, 1919. Serial No. 303,570.

*To all whom it may concern:*

Be it known that I, EDUARDO LACAZE, a citizen of the Argentine Republic, residing at Calle Maipú 671, Buenos Aires, Argentine Republic, have invented new and useful Improvements in Walls Resisting Thrust of Earth and Water, of which the following is a specification.

For the purpose of saving building materials in the construction of walls designed to generally resist by their own weight the horizontal thrust of the earth and of the water, a method has been adopted according to which such walls are erected by casting shaped walls of pure or reinforced concrete, in which the weight of the filling serves to substitute the weight lacking in the wall for assuring the stability of the same.

In accordance with the invention hereinafter to be described, provision is made for using the weight of the phreatic water for obtaining the stability of walls. This method allows at the same time of the efficient and sure drainage of such structures, that is, the elimination of the horizontal thrust of the water which would act on the wall in case the level of the water in front of the same should descend to a level below that of the phreatic water to the rear of the wall, a phenomenon which frequently occurs in connection with the walls of sluices, high water docks open to rivers, moles, etc.

In other words, by the novel system of walls with drainage, the same favorable conditions of stability are secured for a high level as well as for a low level of water in front of the wall, thereby rendering unnecessary the reinforcement heretofore required for the purpose of stabilizing the wall, even in the extreme event of a maximum rise of the phreatic water coincident with a maximum descent of the free water. The wall profile stable for high water levels will in all cases also be stable without any reinforcement for low water levels.

The force which I utilize in order to attain the above favorable results, is the atmospheric pressure which is adapted to balance a water column of a height of up to about 10 m. Without determining the shape of the wall, the material to be employed in its construction or the method of erecting the same, the utilization of atmospheric pressure requires the consideration of the following points:

1. A hollow space within the wall, closed at least at its upper end or top and laterally, with its upper thread below the level of the phreatic water. This hollow space within the wall, whose walls are to be watertight, is filled with water owing to its position within the phreatic water. This water remains within the hollow space owing to the lack of drainage and because the air is prevented from gaining access thereto, even if the free water in front of the wall should descend to a level lower than that of the phreatic water.

2. Separated from this hollow space, by means of any suitable watertight structure, such as intermediate divisions, etc., are sections or compartments provided with an inlet pipe for the air and another pipe for draining the water, so that such separate hollow spaces may drain according to the position of the drainage pipe and the accidental level of the free water of the dock, river or the like.

In case no restrictions are imposed by the method of construction of the wall, etc., the lateral walls of the hollow space should conveniently extend as far as the lowest possible level to be reached by the free water. The drainage pipe will also be arranged below that level.

The hollow space which extends through the whole length of the wall, is impervious to air, not only on account of its watertight construction but also because said space is submerged within the phreatic water which perfectly isolates the same from the air.

The water contained within the separate and ventilated sections or compartments is exhausted, whereby a depression of the level of the water is produced, in accordance with the position of the drainage pipe and the low tide in front of the wall. The remainder of the hollow space in the wall will hold its contents of water which will now only be under the pressure of the depressed level of the separate compartments and no more under the pressure of the level of the phreatic water. In consequence, the difference of pressure between the phreatic water and that of the drained compartments, will allow of part of the phreatic water filtering through the filling and entering into the general hollow space below the wall, filled with water, but at a lower pressure than that of the phreatic water, according to the reduced level of the water in the interposed sections or compartments. The said incoming phreatic water will partially displace the

water contained within the hollow space which thereupon enters into the sections or compartments provided with draining means by which it may freely issue toward the dock, river, etc.

For the above reason, the dimensions and number of draining outlets are to be selected in accordance with the amount of the water entering by infiltration, as above set forth, in order to assure in all cases the depression of the level in the separate hollow space as the level of the free water in front of the wall descends.

For the purpose of assuring at any event the working of the drainage, suitable means or devices may be provided for exactly measuring the depression.

The depression of the water in the separate sections or compartments thus having been assured, the entire amount or body of water in the hollow space along the wall will be under the depressed or reduced pressure of the sections with drainage and will in consequence act as weight on the upper tread and the side walls of the hollow space of the wall, being retained and balanced by the action of the atmospheric pressure.

The effect of this system of wall with drainage as regards stability, is as follows:

1. As the free water descends and the horizontal thrust of the phreatic water increases, the weight of the wall owing to the weight of the body of water retained therein, will increase, by the action of the drainage and by the heavier specific weight of the earth which rests on the wall, owing to the elimination of the sub-pressure.

2. Decrease and even elimination of the increase of thrust of the phreatic water on the wall is secured, owing to the descent of the free water in front of the wall to a level lower than that of the phreatic water behind the same.

For the clearer understanding of this specification, illustrative drawings have been annexed thereto, in which:

Figure 1 is a diagrammatic representation of the construction of the conjoint of a wall with its drainage means, not limited however to any particular profile or construction, etc.

Fig. 2 is a section on the line *x*—*y* of Fig. 1.

The hollow space without drainage and filled with phreatic water is indicated by *a b c d* in the cross section and by *e f g h* in the horizontal section. The openings D illustrate how the communication between the several sections or compartments of the hollow space formed on account of the particular profile selected for the wall, is established, in order to assure the common action of the whole drainage system. The separate compartment or section, indicated at A, is formed in the present case (by way of example), by a cylinder of reinforced concrete; B is the drainage pipe and C the air inlet pipe. In order to prevent the water of a higher level than that of the phreatic water from unfavorably acting on its level, the drainage pipe B is provided with a check valve E.

The reduced level of the water in the cylinder is marked by the height of the water in front of the wall.

In certain special cases, the provision of a stone drainage F, at the rear of the wall, may be convenient in order to facilitate the filtration of the phreatic water and avoid the erosion of the filling material. The letters G, H and I respectively indicate the levels attained by the free water at flood tide, medium tide and ebb tide. K indicates the normal level of the phreatic water. The different levels shown in Fig. 2 indicate the values for the increase of the overload and decrease of the thrust of the water for the same wall, with or without drainage.

As I have already extensively set forth in the specification annexed to this application for Letters Patent, in the profile of the wall a water and air-tight hollow space is provided, of which the upper coping stone or plate is situated below the level of the phreatic water. This hollow space closed at all sides with exception of its lower face is in no connection with the outer open air nor with the water in front of the wall, but only communicates by its lower open side with the phreatic water behind the wall. In the drawings, in Fig. 1 (horizontal section) the hollow space is marked by the letters "*e f g h*" and in Fig. 2 (vertical section), by the letters "*a b c d*." In this hollow space, a certain number of separate compartments are formed, shown in the drawings as being formed of the cylinders A, constructed of watertight materials, in a number to be determined by special reasons. These cylinders A communicate with the outer air by means of the pipe C and communcate also, by means of the pipe B, with the free water in front of the wall, or, in other words, only the special sections or compartments formed by the watertight cylinders A are provided with inlets for the air and outlets for the water, contrarily to what happens with the general void or hollow space *a b c d* below the wall. Owing to the possibility of the entrance of air, the water of the cylinders A may drain away as the water in front of the wall descends and as the contents of the cylinders A are very small, the level of the water within the same will always coincide with the level of the free descending water. The cylinder A, open at its lower side, communicates with the hollow space *a b c d* and through this latter, with the phreatic water behind the wall, so that there is a possibility for part of the phreatic water draining

away through the hollow space *a b c d* by the pipe B into the water in front of the wall.

The equilibrium of the water below the wall within the void space *a b c d* is destroyed by the drainage of the cylinders, a difference of level being formed between the water contained within the cylinders A and the phreatic water. The water from the void space cannot drain for want of entrance of air and only can be substituted by the water which under the higher pressure of the phreatic water will enter into the void or hollow space as an equal amount of water is draining away by the cylinder A and the pipe B. As suitable means are provided for allowing of the entrance of the phreatic water into the void space below the wall, such water drains away by the cylinders A whenever the level of the water in front of the wall is lower than the level of the phreatic water.

According to some constructions already carried out, to the rear of the wall and along its entire extension a drainage for collecting the water filtered in from the phreatic water and for facilitating its entrance into the hollow space below the wall and its discharge through the cylinders A is provided. Said compartments or cylinders with outlet ducts B should be provided in such number and of such dimensions that the phreatic water filtered in through the drainages, may be discharged without loss of pressure, that is to say, the level of the water within the cylinder and that of the water in front of the wall will practically always be the same during low tide.

In a manner analogous to the method of depression of the phreatic water by means of multiple wells, during low tide a transitory depression of the level of the phreatic water to the rear of the wall takes place, practically reaching the level of the depression measured within the cylinder, which at turn coincides with the level of the free tide water, omission being made of the small difference of pressure required for producing the speed for the passage of the infiltrating water through the void space *a b c d*, the cylinder A and the discharge pipe B. The number and dimensions of the draining ducts will be of sufficient amplitude in order that the degree of pressure shall be very reduced, so that, practically, the depression of the level of the phreatic water will occur simultaneously with low tide in front of the wall, that is to say, the thrust of the phreatic water against the wall in the case of low tides in front of the same, will automatically be eliminated. Considering the foregoing explanations, it follows that as regards the stability of the wall, the phreatic water infiltrates by the draining ducts provided in the hollow space *a b c d* and is discharged by the cylinder A and the pipe B, while the water *a b c d* cannot be discharged, being retained within said space owing to lack of entrance of air. As the level of the water within the cylinder A descends, an analogous depression of the level of the phreatic water occurs immediately behind the wall. Owing to this fact, the action of the phreatic water on the wall which normally exerts pressure on the same when the free water in front of the wall descends to a level lower than that of the said phreatic water, is thus eliminated.

The immediate drainage of the infiltrated water will be obtained by providing a suitable number of cylinders A.

Without the provision of the cylinder A, that is to say, by causing the hollow space or void *a b c d* to communicate with the water in front of the wall only by means of the pipe B, all the water of the void *a b c d* would be discharged simultaneously with the infiltrated phreatic water, as happened in connection with all the walls provided with the normal drainage systems used up to this date. By the interposition of the cylinder A, the amount of water to be drained is practically reduced to the amount of infiltrated phreatic water not taking into account the reduced contents of the cylinders themselves which are also drained. The condition for the retention of the water in the void *a b c d*, consists in absolutely preventing any entrance of air. Owing to this reason, the cylinder must attain a greater depth than the pipe B which by the depth of its position determines the lowest water level which may occur within the cylinder A and of the consequent local depression in the phreatic water along the wall. The head of water remaining within the cylinder A from the level of the pipe B and its lower side prevents the air from entering into *a b c d* by the pipe B in the case of an extraordinary low tide, lower than the level of the pipe B.

It has been ascertained that owing to the impossibility of the entrance of air into *a b c d*, this void remains filled with water although the open water in front of the wall and the phreatic water along the same should descend to a level lower than that of the phreatic water. The body of water from the depressed level of the phreatic water and the low open or free water to the level of the tread P actuates now as a weight or charge imposed on the wall, counterbalanced by the atmospheric pressure which is adapted to counterbalance a head of water of up to 10 m.

The employment of the cylinder A allows of the drainage taking place behind the wall in the same way as in the method used before, without cylinder but with a connecting pipe B; the novel arrangement prevents

at the same time the drainage of the void *a b c d*, reducing to a minimum the movement of water below and behind the wall. Owing to the amount of water retained within *a b c d*, the weight of the wall is increased during the time at which the level of the low tide is lower than that of the phreatic water. The increase of weight as well as the elimination of the horizontal thrust of the water thus result in a greater stability of the wall, obtained according to the novel drainage system to be patented.

In case there are restrictions as to the profile or shape of the wall and of the hollow space according to the method selected for the construction thereof, it may also be convenient to use the method above described in order to partially eliminate the thrust of the water and obtain the increase of weight for stabilizing the wall.

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 the construction of walls situated within phreatic water, a wall having a hollow space formed with separate compartments distributed over the length of the wall, certain of said compartments being provided with a pipe for the admission of air and a separate pipe for drainage of the phreatic and overflow water.

2. A wall for resisting the thrust of earth and water, comprising a shell-like structure divided into a series of separate sections or compartments over the length of the wall to form hollow spaces, said hollow spaces being designed to receive the phreatic water and overflow water against the wall above a predetermined level, certain of the compartments being placed in communication and certain of the compartments being provided with means for the admission of air and for the drainage of water therefrom.

3. The construction of walls situated within the phreatic water, characterized by the provision of a plurality of sections or compartments, a tread along the wall and having a vertical portion and an overhanging ledge, the divided walls of the compartment being provided with openings placing the compartments in communication, a pipe for the admission of air to certain of the compartments and a pipe for the drainage of the water from the corresponding compartment.

4. In the construction of walls situated within phreatic water, a wall divided into a plurality of sections in rear of the wall forming compartments, there being a depression of the level of the water produced to the level of the low tide water in front of the wall, a drainage pipe for certain of the compartments, the depression extending to the level marked by the position of the drainage pipe for simultaneously effecting a drainage behind the wall, and means for controlling the drainage of the water.

5. A wall for resisting the thrust of earth and water comprising an inclined wall structure having a base portion and a top ledge, a series of vertical walls extending at right angles to the first named wall and forming compartments having communicating openings therethrough, a horizontal tread above said compartments and having a depending portion spaced from the wall, a cylinder in certain of said compartments adjacent to the wall and having a drain pipe leading from within the same to the water wall, and an air inlet pipe extending into the top of the cylinder through said tread and through the wall above the high water level for the admission of air as specified.

6. A wall for resisting the thrust of earth and water comprising an inclined wall structure having a base portion and a top ledge, a series of vertical walls extending at right angles to the first named wall and forming compartments having communicating openings therethrough, a horizontal tread above said compartments and having a depending portion spaced from the wall, a cylinder in certain of said compartments adjacent to the wall and having a drain pipe leading from within the same to the water wall, and an air inlet pipe extending into the top of the cylinder through said tread and through the wall above the high water level, said wall being backed by earth above and below said compartments, said compartments being arranged to drain through said cylinder and pipe leading therefrom after the drainage of the cylinder whereby owing to the increase of the weight of the wall, a simultaneous reduction of the horizontal thrust will be effected during the change of level of the water during flood and ebb for each constellation of outer forces whereby similar static conditions are produced on each side of the wall.

EDUARDO LACAZE.

Witnesses:
A. L. BELLO,
ROSENDO ROMUR.