

[54] EARTHEN DAM REPAIR

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[51] Int. Cl. E02d 29/00, E02d 5/20

[58] Field of Search 61/35, 50, 36 R, 39, 59

[56] References Cited

UNITED STATES PATENTS

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1,665,798	4/1928	Sipe	61/53.62
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3,310,952	3/1967	Veder	61/50
3,326,003	6/1967	Marconi.....	61/35
3,429,126	2/1969	Wey	61/35

Primary Examiner—W. C. Reynolds

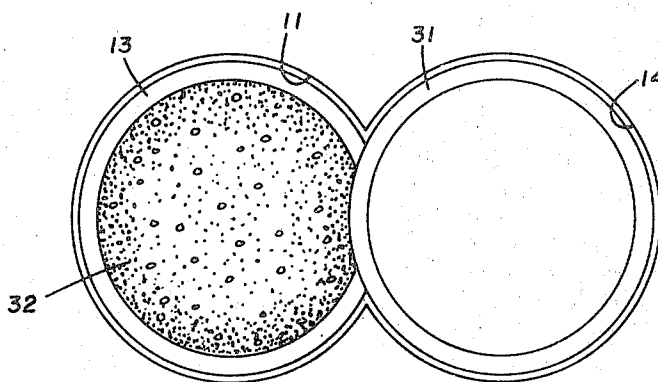
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[57] ABSTRACT

An earthen dam is repaired without draining the water from the lake behind the dam and without disturbing the integrity of the earthen dam. A first hole is bored into the dam. As the hole is being drilled, drilling mud is circulated through the hole to remove cuttings and to maintain the integrity of the earthen dam. The first hole is lined with a casing. A second hole is bored into the earthen dam immediately adjacent and partially overlapping the first hole. The boring of the second hole disintegrates a portion of the casing in the first hole providing an interconnection between said first hole and said second hole. Drilling mud is circulated in the second hole during the boring of said second hole to remove cuttings and to maintain integrity of the earthen dam. The second hole is lined with a casing and the first hole is filled with concrete. The concrete displaces the drilling mud in the first hole and the concrete will not enter the second hole because of the lining in the second hole. By repeatedly drilling holes in the aforementioned manner, a monolithic fluid impervious underground wall is constructed along the center of the dam thereby substantially reinforcing the earthen dam.

7 Claims, 4 Drawing Figures



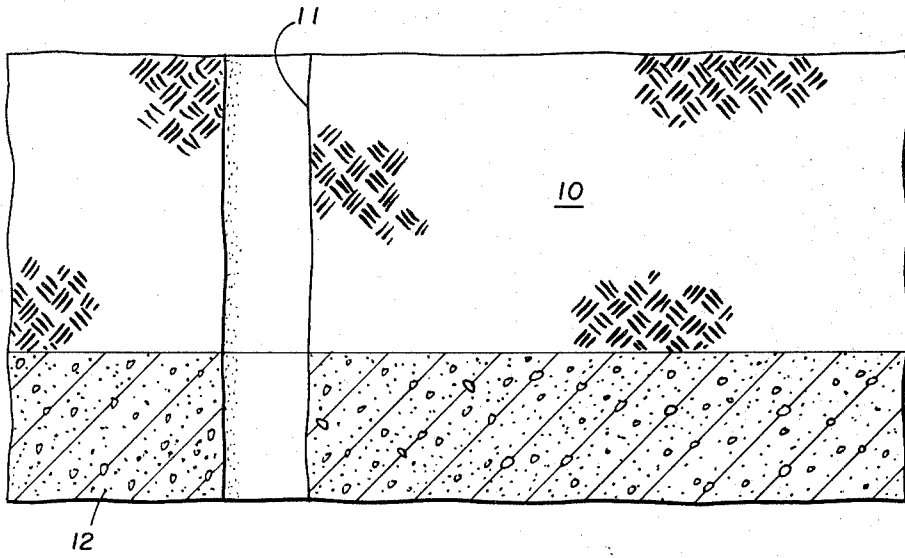


FIG. 1

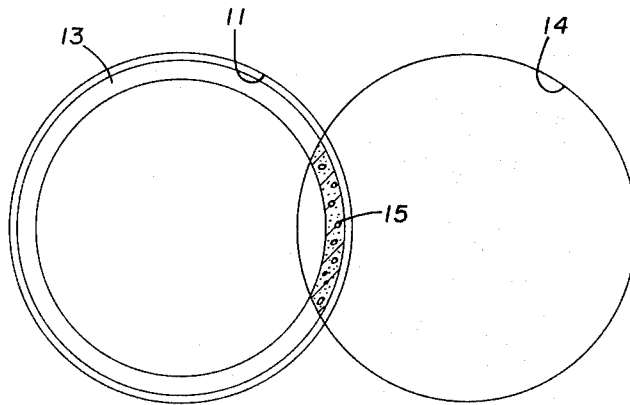


FIG. 2

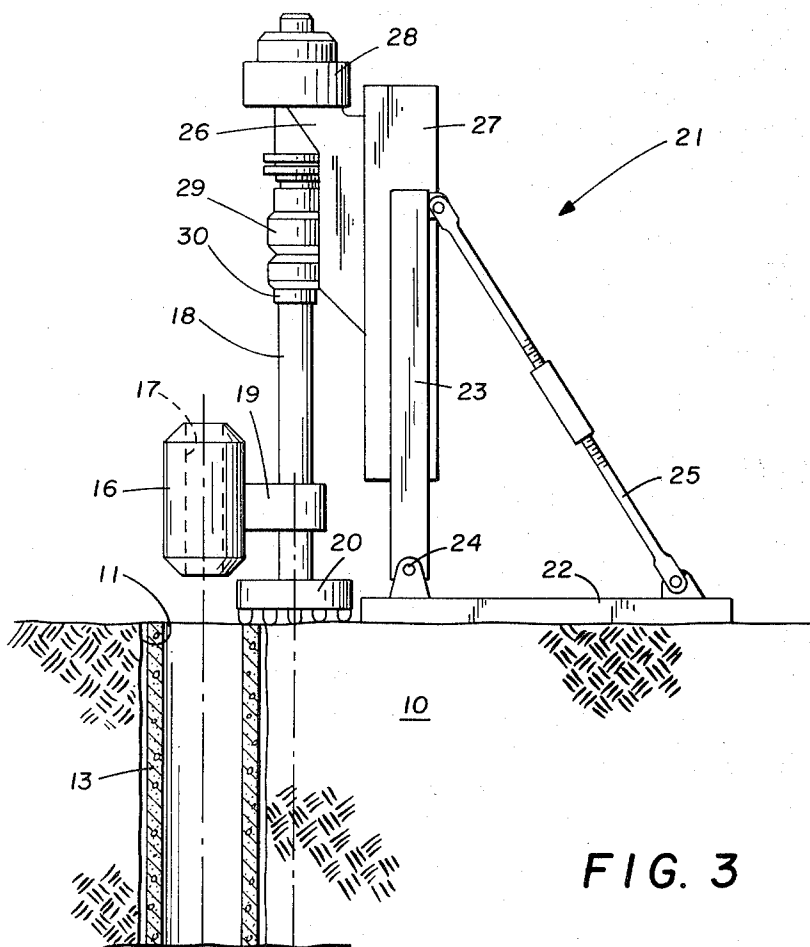


FIG. 3

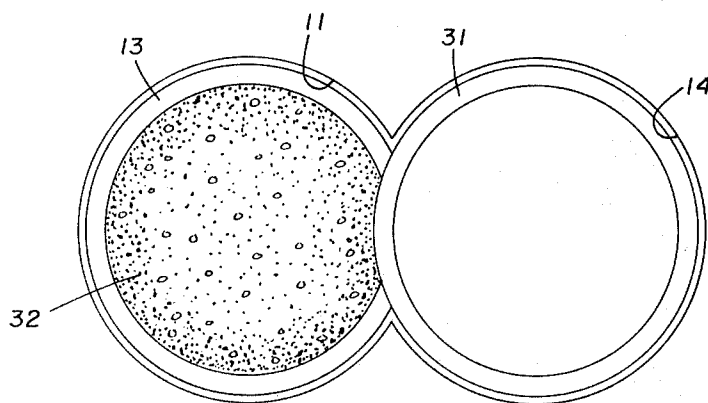


FIG. 4

EARTHEN DAM REPAIR

BACKGROUND OF THE INVENTION

The present invention relates to the construction of a fluid impervious underground wall and more particularly provides for the repair of an earthen dam.

A number of earthen dams are now in existence that for one reason or another are in need of repair and reinforcement. Although it is possible to drain the water from the lake behind the dam and perform the necessary repairs on the dam, this is a very expensive and time-consuming operation. If the dam is used for the production of hydro-electric power, the draining of the lake behind the dam will result in the loss of this source of energy during the time the dam is under repair.

Another method of repairing the dam is by excavating a trench through the center of the dam while simultaneously replacing each part of the excavation with an equal part of bentonite or similar material to maintain the integrity of the dam. Concrete is pumped into the trench displacing the bentonite material and providing a wall along the center of the dam. After the trench has been filled with concrete, holes are drilled through the concrete in the trench into bed rock. The holes are filled with concrete to anchor the wall and dam to bed rock. This method has a number of disadvantages. An elaborate pumping system is required to handle the large volume of bentonite and concrete required in the trenching method. The large volume of bentonite results in a serious disposal problem. The trench must be fairly wide in order to attain any significant depth, and special equipment is generally required in digging the trench since the conventional drag lines, backhoes and other types of trenching equipment are limited in their digging ability. The trench must be constructed vertically and the bottom of the trench must be cleaned before the trench is filled with concrete. The trench produces an obstacle to machines and places the dam in a somewhat weakened condition until the trench is filled with concrete. The trenching operation is also slow and expensive.

The construction of a fluid impervious underground wall has a substantial number of uses other than in the repair of an earthen dam. For example, an underground wall has many civil engineering applications, particularly where it is necessary to prevent underground seepage. An underground wall may be required during construction of large buildings to reduce the flow of ground water into the excavation during construction. An underground wall may be used in the construction of levees, for the storage of ground water for municipal or irrigation supply, for the prevention of salt water seeping back underground from the ocean or bays into zones of fresh ground water and for the isolation of zones of contaminating ground water such as industrial wastes.

It will, therefore, be appreciated that a need clearly exists for a system of constructing a monolithic fluid impervious underground wall quickly, economically, with safety, and while maintaining the integrity of the earth formations. In particular it will be appreciated that a need clearly exists for a reliable and efficient system for repairing an earthen dam that will not require draining of the lake behind the dam and that will not disturb the integrity of the dam during the repair.

DESCRIPTION OF PRIOR ART

In U.S. Pat. No. 3,326,003 to G. Marconi, patented June 20, 1967, a method of forming a ground cut-off wall is shown. The wall is constructed by digging a long and narrow trench. As the trench is being dug, it is kept filled with liquid mud in order to keep the walls of the trench from collapsing. After a trench of the required depth is dug, it is filled with a wall forming material, thereby replacing the liquid mud. After a wall paneling has been formed, successive panels can be constructed in alignment with each other to make a wall of any desired length and curvature.

In U.S. Pat. No. 3,645,101 to J. L. Sherard, patented Feb. 29, 1972, a method and apparatus for constructing impervious underground walls is shown. The underground wall is then constructed by continuously enlarging an excavation by dislodging and fragmenting earth material to form a trench of long length and narrow width in the ground, adding a slurry to the excavation and mixing the fragmented earth material with the slurry in situ. The method comprises the steps of providing a movable but rigid barrier member within an initial slurry filled starter hole or trench so that fluid columns of the slurry are formed on the front and rear sides of the barrier; placing an earth-cutting tool so as to remove progressively thin layers of material from the advancing face of the trench mixing the excavated material with the slurry of the front fluid column; adding additional fresh slurry; and causing the fluid mixture of slurry and cutting to circulate to the rear column as the barrier-cutting tool continuously advances through the ground.

In U.S. Pat. No. 3,429,126 to G. Wey, patented Feb. 25, 1969, a method of producing a continuous bore pile wall is shown. The method disclosed is for constructing a continuous wall of piles for retaining walls, the sides of excavations and the like, and comprises boring a plurality of holes such that in the final arrangement of bore holes the distance between the centers of two adjacent holes is less than the diameter of each hole, placing a filling material or removable filling member which can be shaped to the profile of an adjacent overlapping bore hole in each hole before boring an overlapping adjacent hole and thereafter filling the bore holes with concrete and/or injecting cement grout into the filling material.

In U.S. Pat. No. 3,449,293 to Seiji Kato, patented Mar. 10, 1970, a method and apparatus for forming underground construction in situ is shown. A casing is first driven into the ground using an auger and vibrating means, and preferably forcing water or liquid into the hole being formed ahead of the auger and conducting the soil excavated at the bottom of the hole up the spiral blade of the auger along with the water or other liquid. Thereafter, and before all of the earth is forced out of the auger, mortar is forced into the casing through a conduit in the auger or in the casing under pressure, the auger and the earth in the blade thereof acting as a plug against which the pressure can be exerted. Either the auger alone or the auger and casing together can be withdrawn while continuing to vibrate both the auger and the casing. Thereafter a reinforcing cage can be lowered into the mortar. Where a wall is to be built, further casings are placed side by side.

In U.S. Pat. No. 3,310,952 to C. Veder, patented Mar. 28, 1967, a method for the construction of a wall

in the ground is shown. The method comprises the steps of excavating a bore hole substantially vertically until a desired initial depth has been achieved, making a series of similar overlapping bore holes extending horizontally to form an initial zone of predetermined depth, simultaneously, as the excavating proceeds, circulating therein a thixotropic fluid in order to cause consolidation of vertical walls on penetration of the thixotropic fluid thereto. Thereafter repeating the excavation of the greater depth in order to cause consolidation of vertical walls on penetrating of the thixotropic fluid thereto. Thereafter repeating the excavation of the greater depth in order to form a second zone while maintaining the excavation flow of the thixotropic fluid, and repeating the steps until the final depth is reached.

SUMMARY OF THE INVENTION

The present invention provides for the construction of a fluid impervious underground wall. A preferred embodiment of the present invention provides for repairing an earthen dam. A first hole is bored into the dam. During the boring of said first hole, a fluid drilling mud is circulated through the first hole to remove cuttings and to maintain the integrity of the earthen dam. The first hole is lined with a casing. A second hole is bored into the earth immediately adjacent and partially overlapping the first hole. During the boring of said second hole a fluid-drilling mud is circulated to remove cuttings and to maintain the integrity of the earthen dam. The second hole is lined with a casing. The first hole is filled with a wall forming material. Additional holes are drilled in this manner to form the desired length of wall. The above and other features and advantages of the present invention will become apparent from a consideration of the following detailed description of the invention when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a cross section of an earthen dam with a first hole having been bored through the dam into bed rock.

FIG. 2 illustrates the boring of a second hole adjacent the first hole.

FIG. 3 shows one embodiment of an apparatus used to bore the holes.

FIG. 4 illustrates the second hole lined with a casing and the first hole filled with cement.

DETAILED DESCRIPTION OF THE INVENTION

An earthen dam is repaired by installing a monolithic structure within the dam and securing the monolithic structure to bed rock beneath the base of the dam. The dam is repaired without draining the water from the lake behind the dam or disturbing the integrity of the existing dam. Referring now to FIG. 1, a cross section of an earthen dam 10 is illustrated. A hole 11 has been bored through the dam 10 and into the bed rock 12 beneath the dam. During the drilling of hole 11, a fluid drilling mud is circulated through the hole 11 to remove the drill cuttings from the hole 11. The hole 11 is maintained full of the fluid drilling mud. Since the drilling mud is heavier than water, the fluid pressure in hole 11 is greater than the pressure of ground water in the dam 10 and the mud tends to flow out of hole 11. As the mud seeps out of hole 11, a thin skin of the drill-

ling mud is deposited on the wall of the hole 11. This thin skin of mud cake is extremely impervious and creates an impervious lining on the wall of the hole 11 thereby maintaining the integrity of the earthen dam.

Once the first hole is completed, it is lined with a hollow casing 13 as shown in FIG. 2. The casing 13 may be in the form of concrete pipe that may be lowered into the hole 11 in sections and connected together end to end until the entire hole 11 is fully lined. A second hole 14 is bored immediately adjacent and partially overlapping hole 13. During the boring of hole 14, a section of the casing 15 is disintegrated so that holes 13 and 14 are interconnected. A fluid drilling mud is circulated through hole 14 during the boring operation to remove the drill cuttings and to maintain the integrity of the earthen dam 10. Drilling mud within the first hole 11 may, of course, flow into the second hole 14 and drilling mud in the second hole 14 may flow into the first hole 11.

Apparatus for boring contiguous holes requires critical alignment between the respective holes to maintain an initial overlap throughout the entire length of the holes so that the resulting structure is truly interconnected and a fluid impervious seal will be maintained by a monolithic structure. Referring now to FIG. 3, an embodiment of an apparatus for boring the overlapping holes is shown. A torpedo 16 of a size that fits within the casing 13 is provided. The torpedo 16 includes a central passage 17 from end to end to allow the drilling mud in the hole 11 and casing 13 to pass through the torpedo 16 as the torpedo 16 traverses hole 11. The torpedo 16 is connected to the drill string 18 by an arm 19. The arm 19 will pass through the opening that is left as the section 15 of casing 13 is disintegrated by the bit 20. As the second hole 14 progresses downward, the torpedo 16 will travel along the inside of the casing 13 guiding the bit 20 along its downward path and insuring that adjacent hole 14 remains aligned with and partially overlapping hole 11.

An earth boring machine 21 provides the required forces for boring the holes. The earth boring machine 21 includes a base 22 positioned on the dam 10. A pair of support columns are connected to base 22 with one of the columns 23 being shown in FIG. 3. Column 23 is connected to the base 22 by a pin connection 24. An adjustable brace 25 is connected between the upper portion of the column 23 and base 22. The brace 25 controls the angle that column 23 makes with the base 22 and accordingly the drilling angle. A traveling carriage 26 is mounted between the support columns. A double acting thrust cylinder 27 connected between the base 22 and the traveling carriage 26 provides force for raising or lowering traveling carriage 26. A motor 28 positioned on the traveling carriage 26 provides rotary force for rotating the drill string 18. The rotary force from motor 28 is transmitted to the drill string 18 through a transmission 29 and a drill chuck 30. The arm 19 is connected to the drill string 18 by a bearing means that allows the drill string 18 to rotate and maintains the arm 19 at a fixed distance from the bit 20.

Referring now to FIG. 4 the second hole 14 is shown lined with a hollow casing 31. This casing 31 may be in the form of concrete pipe that can be lowered into the hole 14 in sections and connected together end to end until the entire hole 14 is fully lined. With the casing 31 in place, the first hole 11 is filled with concrete 32 or

other wall forming material. The concrete 32 displaces the fluid drilling mud and the integrity of the earthen dam is maintained at all times. The concrete 32 is prevented from flowing into hole 14 by the casing 31. The operation is repeated by progressively drilling contiguous holes along the center of the dam and lining and filling the holes with concrete in order to form a monolithic fluid impervious wall along the center of the dam. A relatively small volume of drilling mud is required during the drilling of the holes and the integrity of the dam is maintained throughout the entire operation. The operation can also be used to construct an underground wall for uses other than repairing an earthen dam.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of constructing a wall within the earth, comprising the steps of:
 boring a first hole in the earth,
 lining the first hole with a casing, said casing having an axial passage,
 boring a second hole immediately adjacent and partially overlapping said first hole, said second hole and said casing extending into said axial passage,
 maintaining a liquid in said first and second holes during the boring of said holes,
 lining said second hole with a casing,
 filling said first hole with a wall forming material and boring additional axially aligned overlapping holes by repeating the aforementioned steps.
2. The method of claim 1 including maintaining said first and second holes filled with drilling mud during the boring of said holes.
3. A method of constructing a wall within the earth comprising boring a plurality of overlapping holes such that in the final arrangement of holes the distance between the centers of two adjacent holes is less than the diameter of an individual hole, lining each hole with casing having an axial passage prior to the boring of the next adjacent hole, said next adjacent hole being bored in such a manner that said next adjacent hole extends into said axial passage, maintaining a liquid in said next adjacent hole and the previous hole during the boring of said holes, lining said next adjacent hole and filling the previous lined hole with a wall forming material.
4. A method of constructing a wall within the earth comprising the steps of:
 boring a first hole in the earth while,
 circulating a fluid drilling mud through said first hole during the boring of said first hole,
 lining said first hole with a casing, said casing having an axial passage,
 boring a second hole immediately adjacent and partially overlapping said first hole and said casing in said first hole, said second hole extending into said axial passage,

circulating a fluid drilling mud through said second hole during the boring of said second hole,
 lining said second hole with a casing,
 filling said first hole with a wall forming material and boring additional axially aligned overlapping holes by repeating the aforementioned steps.

5. A method of repairing an earthen dam, comprising the steps of:

boring a first hole from the surface of said dam through said dam,
 circulating a drilling mud through said first hole during the boring of said first hole,
 lining said first hole with a destructible casing, said destructible casing having an axial passage,
 boring a second hole from the surface of the dam through said dam immediately adjacent and partially overlapping said first hole and said destructible casing, said second hole extending into said axial passage,
 circulating a drilling mud through said second hole during the boring of said second hole,
 lining said second hole with a destructible casing, and

filling said first hole with a wall forming material.

6. The method of claim 5 including the steps of boring a multiplicity of additional holes from the surface of said dam through said dam by repeatedly boring immediately adjacent and partially overlapping holes, lining each hole with a destructible casing having an axial passage prior to the boring of the next adjacent hole, with the next adjacent hole extending into said axial passage, circulating a drilling mud through said holes during the boring of said holes, and filling the prior hole with a wall forming material.

7. A method of repairing an earthen dam by drilling a multiplicity of axially aligned overlapping holes, comprising the steps of:

boring the first hole from the surface of the dam through the dam,
 circulating a drilling mud through said first hole during the boring of said first hole,
 lining said first hole with a destructible casing, said destructible casing having an axial passage,
 boring the second hole immediately adjacent and partially overlapping said first hole thereby disintegrating a portion of the destructible casing in said first hole, and causing said second hole to extend into said axial passage,
 circulating a drilling mud through said second hole during the boring of said second hole,
 lining said second hole with a destructible casing, filling said first hole with a wall forming material, and

boring additional axially aligned overlapping holes by repeating the aforementioned steps.

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