

Sept. 28, 1971

**D. F. LEVY ET AL**  
**METHOD AND APPARATUS FOR INJECTING RELATIVELY**  
**WATER-IMPERVIOUS DIKES IN RELATIVELY**  
**PERMEABLE EARTH FORMATIONS, AND**  
**FORMING EARTH-FILLED TANKS**  
**AND CANALS THEREWITH**

3,608,318

Filed May 12, 1969

2 Sheets-Sheet 1

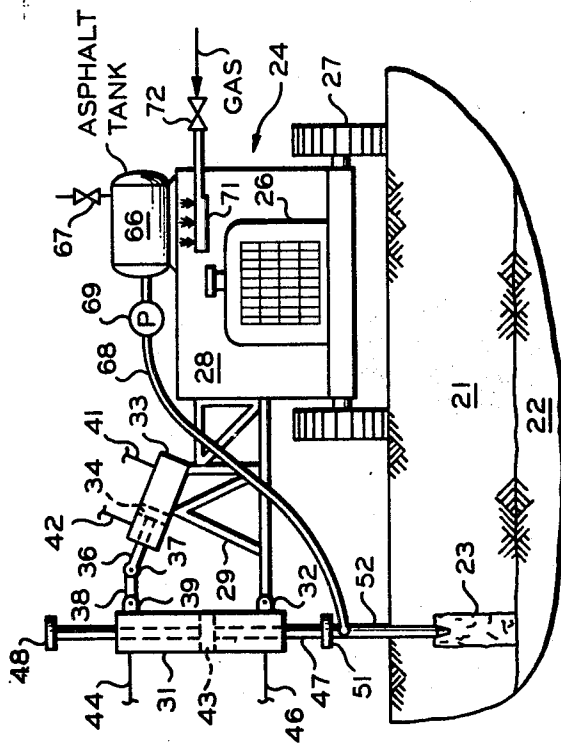


FIG. 1

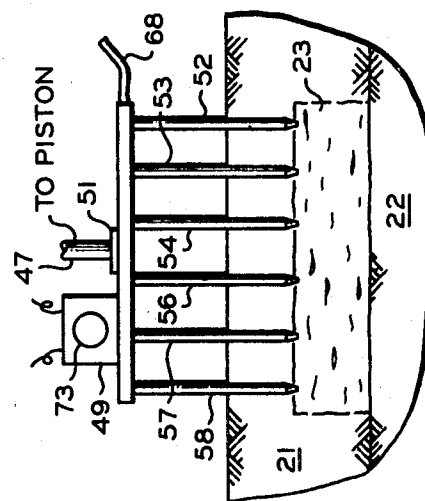


FIG. 2

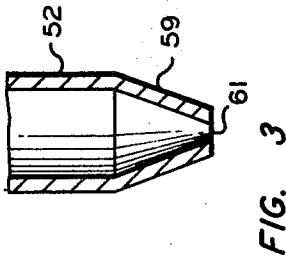


FIG. 3

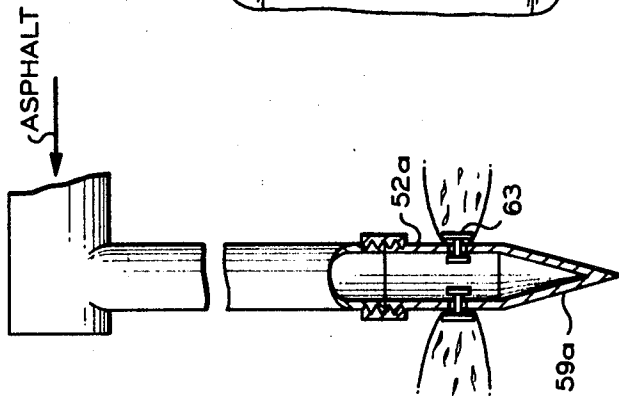


FIG. 4

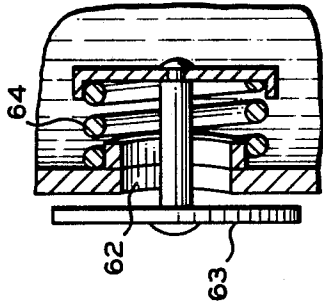


FIG. 5

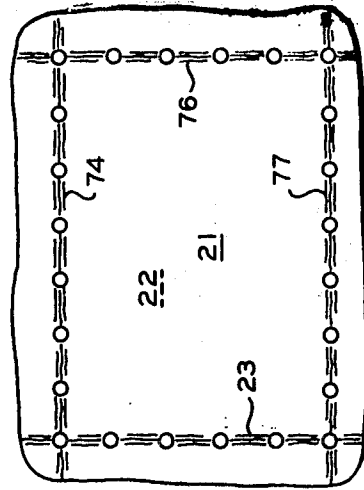


FIG. 6

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2 Sheets-Sheet 2

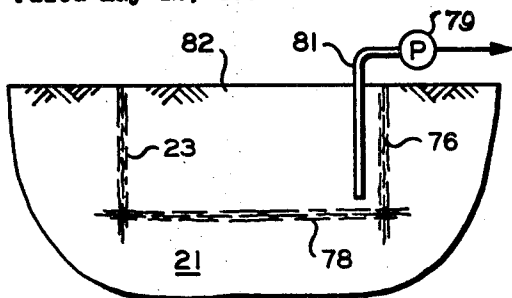


FIG. 7

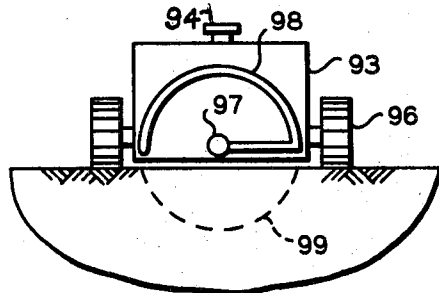


FIG. 11

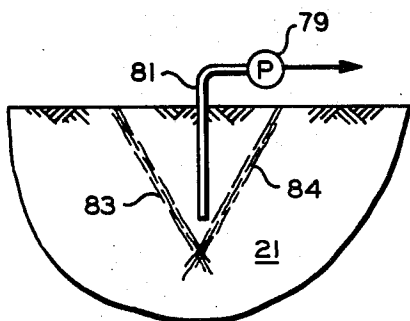


FIG. 8

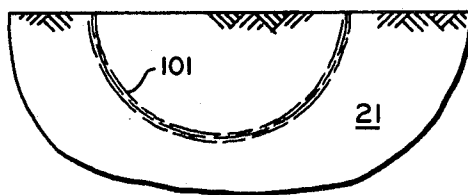


FIG. 12

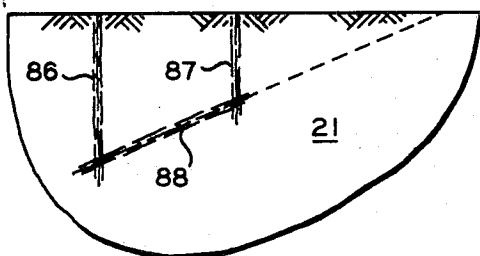


FIG. 9

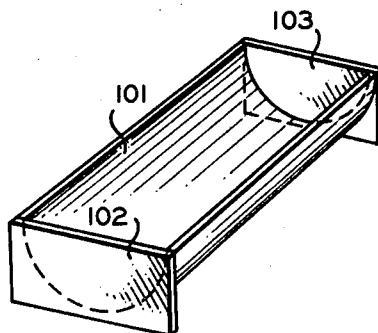


FIG. 13

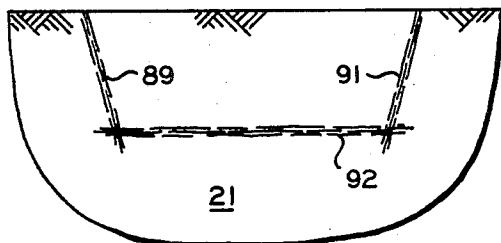


FIG. 10

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**METHOD AND APPARATUS FOR INJECTING  
RELATIVELY WATER-IMPERVIOUS DIKES  
IN RELATIVELY PERMEABLE EARTH FOR-  
MATIONS, AND FORMING EARTH-FILLED  
TANKS AND CANALS THEREWITH**  
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7 Claims

## ABSTRACT OF THE DISCLOSURE

This invention is a process of and apparatus for forming walls, dikes or subterranean tanks or canals in loose unconsolidated soil by inserting a pipe or plurality of pipes into the loose soil and then injecting a liquid comprising molten asphalt or asphalt-water emulsion, or other liquid which will harden into a solid, through the pipe or pipes as they are withdrawn to form walls or dikes in the soil. These walls or dikes can be used to form subterranean tanks or canals. If desired, the liquid can be injected from the pipes through check valves permitting the liquid to emerge but preventing its return to the interior of the pipe. Two forms of apparatus are shown, one injecting through vertical or slanted moving pipes and the other injecting through a rotating semi-circular pipe.

## FIELD OF THE INVENTION

This invention relates of Class 61, Hydraulic and Earth Engineering, Subclass 1, Water Control. However, it is obvious that other subclasses of Class 61 may be involved, such as Subclass 36, Earth Control, Solidifying or Thawing Earth.

## DESCRIPTION OF THE PRIOR ART

A short preliminary search uncovered the following prior art patents, which are believed representative of those available in the prior art.

| U.S. Patent Number | Inventor             | Class | Subclass |
|--------------------|----------------------|-------|----------|
| 2,075,244          | Van Hulst            | 61    | 36       |
| 2,258,829          | Van den Berge et al. | 61    | 36       |
| 2,313,109          | Wertz                | 61    | 36       |
| 2,556,162          | Benson               | 61    | 36       |
| 2,851,824          | Campbell             | 47    | 58       |
| 3,159,976          | Brandt et al.        | 61    | 36       |
| 3,260,053          | Miller               | 61    | 36       |
| 3,276,208          | Bolt                 | 61    | 36       |
| 3,408,819          | Delfosse             | 61    | 35       |

The patent to Van Hulst cited above drills a round well in the ground, fills the well with loose rock and then injects asphalt into the well. Such a process cannot anticipate our process, apparatus or article of manufacture.

The patent to Van den Berge et al. is merely generic to injection of solutions of asphaltic bitumens into the soil and cannot anticipate the specific processes, apparatus and articles of manufacture of the present application.

Wertz merely inserts a nozzle into a borehole, anchors it at one depth and injects asphalt.

Benson is operating with jets spaced above the surface of the ground and can only create very shallow ridges.

Campbell is spraying the surface of the ground with asphalt and then plowing it in.

Brandt et al. inject asphalt emulsion and emulsion-breaking agent to make the asphalt set in a mine.

Miller uses a slitted plug in his injection line in a well in a mine to inject asphalt generally to stabilize the roof.

Bolt is plowing and injecting asphalt into the ground to form horizontal subterranean sheets. While this process is suggested herein as a suitable process for laying the horizontal flat floor shown in our FIGS. 7 and 10, it is not useful for the vertical walls or slanting floors or walls of our FIGS. 7 to 12.

Delfosse is vibrating a grid of injection jets as it is moved transversely, which is not pertinent to the present invention.

## SUMMARY OF THE INVENTION

This invention is a process of and apparatus for forming walls, dikes or subterranean tanks or canals in loose unconsolidated soil by inserting a pipe or plurality of pipes into the loose soil and then injecting a liquid comprising molten asphalt or asphalt-water emulsion, or other liquid which will harden into a solid, through the pipe or pipes as they are withdrawn to form walls or dikes in the soil. These walls or dikes can be used to form subterranean tanks or canals. If desired, the liquid can be injected from the pipes through check valves permitting the liquid to emerge but preventing its return to the interior of the pipe. Two forms of apparatus are shown, one injecting through vertical or slanted moving pipes and the other injecting through a rotating semi-circular pipe.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view with the ground in cross section of an apparatus embodying the present invention mounted on a tractor and being used to form a vertical impervious dike of the present invention in a permeable earth formation in a process embodying the present invention.

FIG. 2 is an elevational view with the ground in cross section showing just a portion of the plurality of injection pipes in the shape of a rake. FIG. 2 is taken at right angles from FIG. 1.

FIG. 3 is an enlarged cross-sectional view of the lower tip of the injection nozzles on the rake shown in FIGS. 1 and 2.

FIG. 4 is an elevational view with parts broken away and in cross section of a second modified form of nozzle in which loose valves or plugs are employed, which nozzle may replace the first nozzle shown in FIGS. 1 and 2.

FIG. 5 is a cross-sectional elevational view of a portion of a third modified form of nozzle embodying a spring-pressed check valve, which nozzle may replace the first or second nozzles shown in FIGS. 1 to 4.

FIG. 6 is a plan view showing rows of holes formed in the ground by said rake forming a rectangle and four vertical walls of injected asphalt joining all the holes on each side of the rectangle.

FIG. 7 is a vertical, cross-sectional view of the rectangle shown in FIG. 6 but also showing an injected asphalt bottom to the rectangle, which may be injected by deflecting the injection pipes as in FIGS. 8, 9 and 11, or may be first plowed into position as taught by U.S. Pat. 3,276,208 to Bolt to form a subterranean tank or canal.

FIG. 8 is a vertical, cross-sectional view showing a subterranean tank or canal, two walls of which are injected on a slant to intersect to form the bottom of the tank.

FIG. 9 is a vertical, cross-sectional view showing a subterranean tank or canal having a slanting bottom.

FIG. 10 is a view similar to FIG. 7, except the side walls slant.

FIG. 11 is an elevational view of a modified asphalt injector which can be used in place of that shown in FIG. 1. This modified injector injects along the dotted line shown in the ground, which is in cross section, to form a

circular dike as shown in FIG. 12, to form a circular subterranean tank or canal.

FIG. 12 is a vertical, cross-sectional view of a semi-cylindrical tank or canal laid by the device of FIG. 11.

FIG. 13 is a perspective view of the cylindrical tank of FIG. 12 when supplied with vertical end walls injected as taught in FIGS. 1 and 2. The asphalt tank has been removed and cleared of earth in FIG. 13 for purposes of exposing its structure.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 the ground, shown in cross section, is comprised of two strata 21 and 22. Stratum 21 is more permeable to liquids than more consolidated stratum 22. Otherwise, they may be identical. It is assumed it has been decided it will be useful to build a wall or dike 23 inside of stratum 21 which will be more resistant to water flow than permeable stratum 21. Dike 23 does not have to be perfect to have value in conserving underground water by resisting its flow from one side of dike 23 to the other side.

A tractor, generally designated as 24, preferably is provided with an engine 26 to drive it over the land by means of wheels 27 or an endless belt track (not shown). The body 28 is provided with a frame 29 on which a first hydraulic cylinder 31 is pivoted at 32. A second hydraulic cylinder 33 is mounted on frame 29 having a piston 34 connected to said first hydraulic cylinder by piston rod 36 pivoted at 37 to connecting rod 38 pivoted at 39 to cylinder 31. By supplying hydraulic fluid under pressure through pipes 41 or 42, cylinder 31 may be tilted at any angle at pivot 32.

Cylinder 31 is provided with a piston 43 which may be moved up or down by hydraulic fluid injected through pipes 44 and 46 to move piston rod 47 up or down. In case difficulty is encountered on moving rod 47 down, a plate 48 is provided which may be hammered on; and when moving rod 47 up, plate 48 can be pulled on. A vibrator 49 of FIG. 2 may be applied to either plate 48 or 51 of FIG. 1 if desired.

Piston rod 47 is connected by plate 51 to an asphalt injection tube 52. This may be a single tube, but preferably is a plurality of tubes 52, 53, 54, 56, 57 and 58 as shown in FIG. 2. The lower end of each tube, such as 52, is preferably provided with a tapered tip 59 with an end opening 61 as shown in FIG. 3, or is provided as tube 52a as in FIGS. 4 and 5, with a sharp point 59a and one or more side openings 62. The side openings 62 are preferably provided with anti-backflow check valves 63, which can be loose as shown in FIG. 4 or provided with helical compressing springs 64 as shown in FIG. 5, to urge valve 63 to close opening 62.

As shown in FIG. 1, tractor 24 preferably supports asphalt or asphalt emulsion tank 66 which is provided with inlet valve 67, outlet line 68 connecting to tubes 52, 53, 54, 56, 57 and 58, and pump 69 to pump the asphalt or emulsion through line 68.

As the use of asphalt and/or asphalt emulsion is old in the nine prior art patents cited above, and many other uncited patents, it is believed unnecessary to state more than the fact that any asphalt or asphalt emulsion, or any other liquid that will harden into a solid, used in the prior art may be employed very successfully in practicing the present invention. If heat is needed to reduce the viscosity, the heat can be supplied by gas burner 71 controlled by valve 72.

While hydraulic cylinders 31 and 33, electric vibrator 49, pump 69 and gas burner 71 are shown, obviously pneumatic cylinders and vibrators, different pumps, electric heaters, and other obvious equivalents can be substituted without invention. Vibrator 49 as shown has an electric motor rotate an eccentric weight 73 to cause the vibration, but pneumatic rappers are well known in the art of laying concrete as equivalent.

In addition to laying vertical dikes like 23 of FIG. 1,

this invention is useful in providing underground tanks or enclosures as shown in FIGS. 6, 7, 8, 9 and 10.

In FIG. 6, four dikes 23, 74, 76 and 77 have been injected in the soil 21 to form a rectangular underground tank, the bottom of which may be the less permeable stratum 22 (see FIG. 1).

In FIG. 7, a bottom 78 has been provided in permeable soil 21 by first plowing in an asphalt sheet as taught by U.S. Pat. 3,276,208 to Bolt. Dikes 23, 74, 76 and 77 are then injected as shown in FIG. 1 to form a rectangular tank. A pump 79 and sump line 81 may be provided to empty the tank, which is filled when rain falls on surface 82 inside the dikes.

In FIG. 8, the underground tank or canal is formed with intersecting sloping dikes 83 and 84, laid by tilting cylinder 31 in FIG. 1 with piston rod 36.

In FIG. 9, the tank has dikes 86 and 87 laid vertically and floor 88 laid at a slant, all by the apparatus of FIG. 1.

In FIG. 10, the slanting dikes 89 and 91 are laid as dikes 83 and 84 were laid in FIG. 8, while the floor 92 was laid as floor 78 was in FIG. 7.

In FIGS. 11, 12 and 13, an alternative form of apparatus, process and product is shown in which the asphalt or asphalt emulsion injection is through a rotating semi-circular pipe or pipes to form a semi-cylindrical underground canal or tank.

In FIG. 11, a tractor 93 is provided with an engine 94 which drives wheels 96 to move the tractor into position. Then the tractor is stopped and motor 94 rotates hollow shaft 97, which causes semi-circular asphalt injection pipe or pipes 98 to move into and out of the ground along dotted line 99. Then reversing the rotation, asphalt is added from a tank (not shown) like tank 66 of FIG. 1, the injection of asphalt through pipe 98 as it is withdrawn being exactly the same as the injection of asphalt through pipe 52 in FIG. 1 as it is withdrawn.

The resulting semi-cylindrical underground canal 101 is shown in FIG. 12.

Ends 102 and 103 may be then provided by the machine of FIG. 1, making an underground tank, which has been uncovered in FIG. 13 so it may be seen clearly.

While certain specific embodiments have been shown in FIGS. 1-13 for purposes of illustration, the invention obviously is not limited thereto. Check valves 63 prevent loose soil from plugging pipe 52a as it is thrust into the soil. Plate 48 and collar 51 can be spaced to act as longitudinal motion stopping means which prevent piston 43 from contacting the cylinder heads of cylinder 31.

Having described our invention, we claim:

1. The process of forming a dike in unconsolidated soil comprising the steps of:

inserting a plurality of injection conduits into the soil at a first location to the depth desired in a first plane; injecting into said soil through said conduits while withdrawing said conduits a liquid which will harden into a solid to produce a first dike;

inserting a plurality of injection conduits into such soil at a second location in a second plane at an angle to said first plane to a depth sufficient to intercept said first dike; and

injecting into said soil through said conduits of said second plane while withdrawing said conduits a liquid which will harden into a solid to produce a second dike intersecting said first dike thereby forming a subterranean canal.

2. The process of claim 1 in which the injection conduit is vibrated during withdrawal.

3. The process of claim 1 including the step of forming at least one additional dike intersecting said first and second dikes thereby producing a subterranean tank.

4. Apparatus for injecting a liquid into unconsolidated soil comprising in combination:

an arcuate injection conduit means, means to rotate said conduit to insert said conduit into the soil in an arcuate path;

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means to withdraw said conduit from said soil in the same path in which it was introduced; and means to supply and inject said liquid through said conduit during withdrawal.

5. The apparatus of claim 4 in which there is means to vibrate said conduit means during withdrawal.

6. The apparatus of claim 4 in which the injection conduit means comprises a plurality of parallel pipes.

7. The apparatus of claim 4 in which the injection conduit means contains a check valve to prevent return of said liquid to said conduit after injection into the soil.

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U.S. Cl. X.R.

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