April 1, 1941. A. K. B. LYMAN 2,236,759

COMPACTING SOIL

Filed Aug. 10, 1939 2 Sheets-Sheet 1

Fig. 1

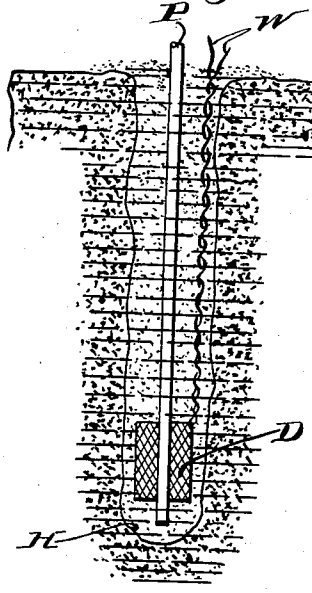


Fig. 2

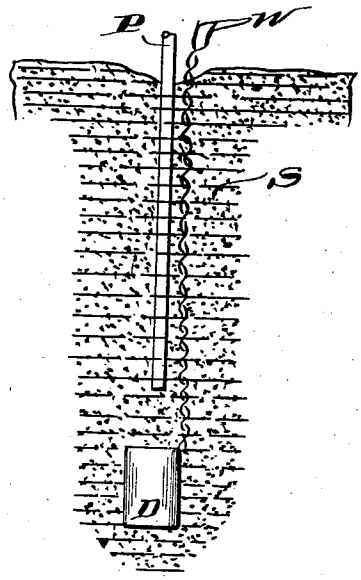
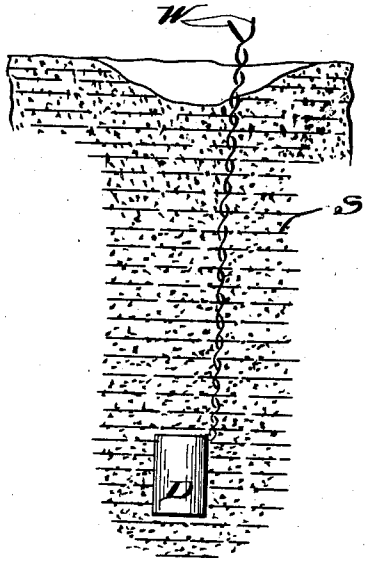


Fig. 3



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Filed Aug. 10, 1939 2 Sheets-Sheet 2

Fig. 4

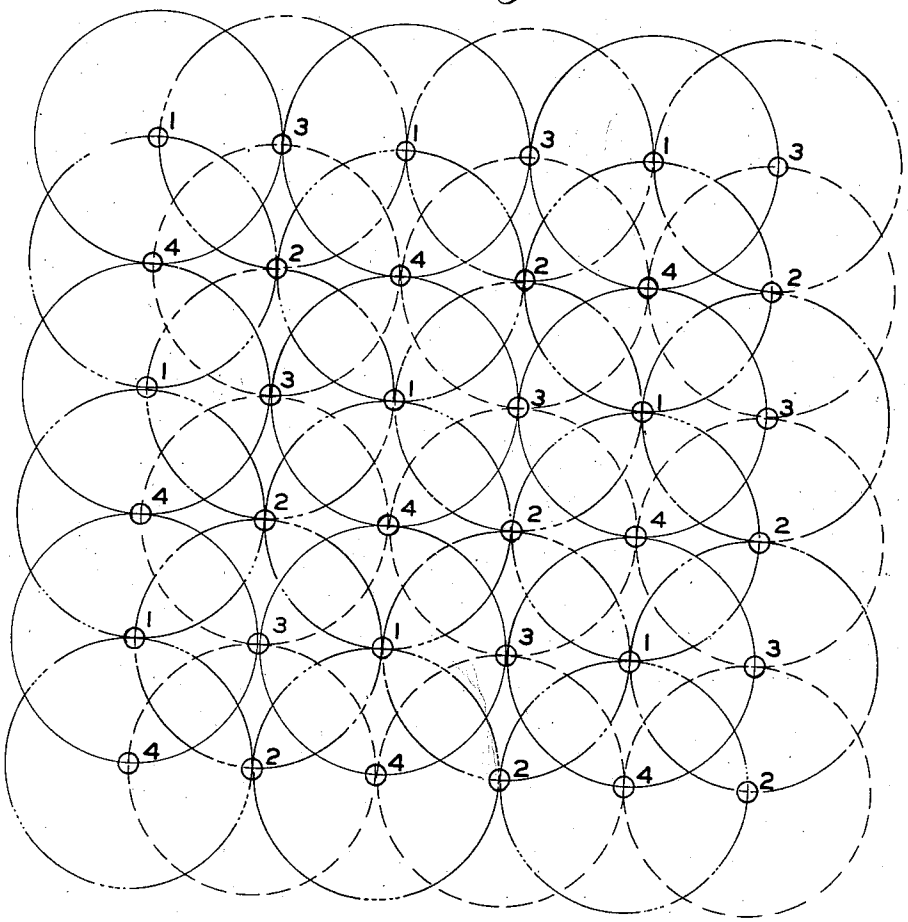
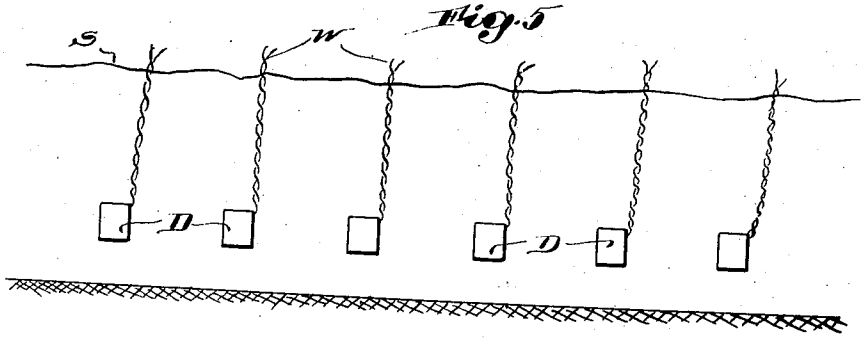


Fig. 5



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UNITED STATES PATENT OFFICE

2,236,759

COMPACTING SOIL

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Application August 10, 1939, Serial No. 289,358

5 Claims. (Cl. 61—35)

In many classes of construction work it is necessary to compact large deposits of soil. In most cases the deposits are natural deposits of sand or the like but in some cases they are in the form of artificial fills or embankments. While deposits will naturally settle more or less in the course of time, for most classes of work this natural settlement is not only too slow but it is incomplete and insufficient for the loads to be supported.

This invention relates to a method of inducing and stimulating settlement in, and consolidating and making denser, a mass of cohesionless or partially cemented soil which forms or will form the foundation under bridge piers, buildings, roads, dams, levees, airports, parks, stadiums, towers, storage tanks, wharves and piers, storage and transfer yards, and other structures. This method also embraces the settlement of masses of cohesionless or partially cemented soils which are artificially piled up to form earth structures such as dams, levees, embankments and similar structures which rise in elevation above the surrounding terrain. The method likewise includes the settlement of masses of cohesionless or partially cemented soils which are used to fill in, and raise in elevation, areas which are depressed below the surrounding terrain, such as filling material for airports, parks, storage and transfer yards, pier and terminal facilities, road beds and railroad beds and other fill materials in depressed areas.

The method operates by subjecting the soil grain to a violent shock of both a vibratory and a blow-like nature, through the medium of detonating charges of explosives either individually or in combinations of groups, within the soil mass. The effectiveness of the explosions is ordinarily increased if the mass of soil be saturated with water either naturally or artificially by raising the ground water level by means such as pumping or injecting water into the soil mass, or by detaining water over the soil mass, or by using levees, walls or other barriers. The presence of the saturating water is desirable because it assists in transmitting the force of the explosion extensively throughout the soil mass, thereby agitating the soil grains out of their initial position and placing them in positions where the void spaces between the grains are smaller than initially. The consequent reduction in volume of the void spaces causes water to be squeezed out of the soil mass, this water being forced in a generally upward direction. Perforated pipes and other drainage provisions may be placed within the mass to facilitate the escape of the surplus water in the void spaces of the soil and thereby promote and accelerate the consolidation of the soil mass.

In cases where the loose soil deposit extends downwardly from the surface, the charges of explosive may be placed somewhat below the middle of the depth throughout which agitation is to be effected, thereby permitting the use of a heavier charge without disrupting the surface of the soil in the form of a crater. For example, in the case of a deposit of sand extending from the surface of the earth downwardly twenty feet, the explosive charges are preferably placed about fifteen feet below the surface of the earth rather than ten feet below the surface. However if the deposit of sand is overlaid by a stratum of peat or the like, the explosive charges are preferably placed in the middle of the stratum which is to be shaken down.

The size of the explosive charge may be varied to suit different conditions. In treating a stratum of loose material lying at a considerable depth, with an overlying surface stratum, the explosive charge may be heavy enough to shatter the underlying stratum throughout its entire depth. However in the case of a loose surface stratum, the charge should be reduced to the point where it does not blow up a crater at the surface of the ground, although it may be strong enough to loosen the surface somewhat and perhaps momentarily lift it to some extent. Either the explosive should be waterproof or it should be enclosed in a water-tight container. Ordinary dynamite is very satisfactory.

The charges may be placed at the required depth by jetting the explosive into the soil with a water jet. They can also be placed by driving a casing pipe to the required depth and lowering the explosive through the pipe. They can also be placed by boring or otherwise extending holes into the soil to the required depth. In filling areas the charges may be placed before or during the filling operation, so that the charges are buried to the desired depth when the fill is completed.

In treating a considerable area of soil the charges should be spaced horizontally so that the horizontal radius of shattering of each charge should just reach or slightly overlap the radius of shattering of the adjacent charges.

For the purpose of illustration a typical embodiment of the invention is shown in the accompanying drawings in which—

Figs. 1, 2 and 3 are vertical sections through

a soil deposit illustrating successive steps of the method;

Fig. 4 is a plan view of an area showing the preferred arrangement of charges; and

Fig. 5 is a vertical section through a soil deposit showing the preferred distribution of charges.

In the drawings D designates the explosive charge, W the detonating wires, and S the soil to be shaken down. The horizontal lines in Figs. 1, 2, 3 and 5 indicate that the ground is saturated with water. As illustrated in Figs. 1, 2 and 3 the preferred method of planting the charges consist in mounting a charge on the end of a water pipe P and then forcing water through the pipe at a velocity sufficient to flush away the soil immediately below the end of the pipe as indicated at H. In this way a charge may be sunk very quickly to a depth of many feet in most kinds of soil. After the charge has been sunk to the required depth the water is turned off to permit the sand to close in over the charge, thereby holding the charge while the pipe is pulled out as shown in Fig. 2. In some kinds of soil it is desirable to wait several minutes after the water is turned off before the pipe is removed. After the pipe is removed the charge may be detonated by the wires W.

In treating a large area the charges are preferably distributed throughout the area as illustrated in Figs. 4 and 5, charges being placed at each of the locations designated 1, 2, 3 and 4. The circle surrounding each charge indicates the circumference of the region substantially affected by that particular charge, and as indicated by the circles in Fig. 4 the charges are preferably placed so that the influence of each charge extends substantially to each of the next adjacent four charges. Thus each square section of soil defined by the four charges at the corners of the square is substantially affected by each of the four charges. Inasmuch as the soil is compacted to a greater intensity by subjecting it to successive shocks, it is preferable to fire the charges in the order indicated by their numbers, charges 1 being fired first, charges 2 secondly, charges 3 thirdly and charges 4 lastly. Thus each of the aforesaid square sections is affected first by the charge 1 at one of its corners, then by charge 2 at its opposite corner, then by charge 3 at the third corner and finally by charge 4 at its fourth corner.

Instead of arranging the charges in a pattern constituting a multiplicity of squares they may be placed in patterns representing triangles or hexagons, the triangular arrangement being particularly suited to a series of three groups of explosions rather than four and the hexagonal arrangement being particularly suited to six successive groups of explosions.

The interval between successive blasts depends upon the rate of water evolution from a preceding blast. A succeeding blast should be fired just as water ceases evolving from the soil as a result of the preceding blast. This interval may range from a few minutes to many hours depending upon the soil conditions. While the time intervals between successive groups of explosions may be varied widely, for treating certain natural deposits of sand it has been found that the groups of explosions should be spaced apart about twenty-four hours in order to secure optimum results.

As a typical example, the method may be applied to a loose deposit of fine glacial sand extending downwardly from the surface, with the material fully saturated in the natural state. In preparing such a deposit at a dam site, charges comprising eight pounds of gelatin dynamite may be jetted down to a depth of fifteen feet at intervals ten feet apart, the groups of charges being fired in the order indicated in Fig. 4. The number of times each section of the soil need be shocked may be determined by noting the amount of settlement at the surface of the ground after the explosion. Normally the ground will settle to a smaller extent after each successive explosion, and when the settlement decreases to a predetermined minimum the treatment is discontinued.

From the foregoing it will be evident that this compaction method is fundamentally different from the well-known method of building a road across a swamp which comprises building up a ridge of sand, gravel or other fill material on the swamp along the proposed site of the road, and then blasting out the underlying muck to permit the fill to drop down into position on solid ground. In the road-building method the fill material is bodily shifted in position from a higher to a lower level with little if any compaction, whereas in the present compaction method the deposit is vibrated to compact the soil without substantial change in location or shift in position.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. In the art of settling and compacting large deposits of substantially cohesionless soil which extend below the surface of the deposit a considerable distance, the method of transmitting vibratory waves throughout the soil without substantially changing its location, comprising planting in the soil a charge of explosive, and detonating the charge while the soil is substantially saturated with water, the size and depth of the charge being correlated to transmit the vibratory waves without blowing up a substantial crater at the surface of the ground.

2. In the art of settling and compacting large deposits of substantially cohesionless soil which extend below the surface of the deposit a considerable distance, the method of transmitting vibratory waves throughout the soil without substantially changing its location, comprising flooding the soil, planting a charge of explosive in the soil, and detonating the charge while the soil is flooded, the size and depth of the charge being correlated to transmit vibratory waves through the soil without blowing up a substantial crater at the surface of the ground.

3. In the art of settling and compacting large deposits of substantially cohesionless soil which extend below the surface of the deposit a considerable distance, the method of transmitting vibratory waves throughout the soil without substantially changing its location, comprising planting charges of explosive at locations spaced throughout the deposit, flooding the soil and firing the charges, the size and depth of the charges being correlated to transmit the vibratory waves without blowing up substantial craters at the surface of the ground.

4. In the art of settling and compacting large deposits of substantially cohesionless saturated soil which extend below the surface of the deposit a considerable distance, the method of

transmitting vibratory waves throughout the soil without substantially changing its location, comprising planting charges of explosive in groups, the charges of each group being spaced apart in the deposit and firing the groups successively at intervals of time spaced sufficiently to permit the soil to settle between the explosions of successive groups, the size and depth of the charges being correlated to transmit the vibratory waves without blowing up substantial craters at the surface of the ground.

5. In the art of settling and compacting large deposits of substantially cohesionless soil which extend below the surface of the deposit a considerable distance, the method of transmitting vibratory waves throughout the soil without substantially changing its location, comprising planting charges of explosive at locations spaced throughout the deposit, and detonating the charges simultaneously, the size and depth of the charges being correlated to transmit the vibratory waves without blowing up substantial craters at the surface of the ground.

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