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METHOD FOR THE STEPWISE DISPLACEMENT OF A HEAVY BODY OVER OR THROUGH THE GROUND

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FIG. 1

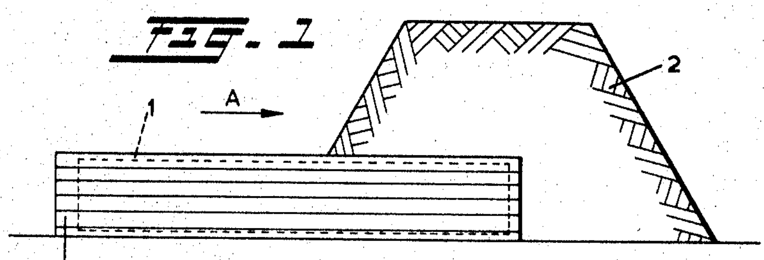


FIG. 2

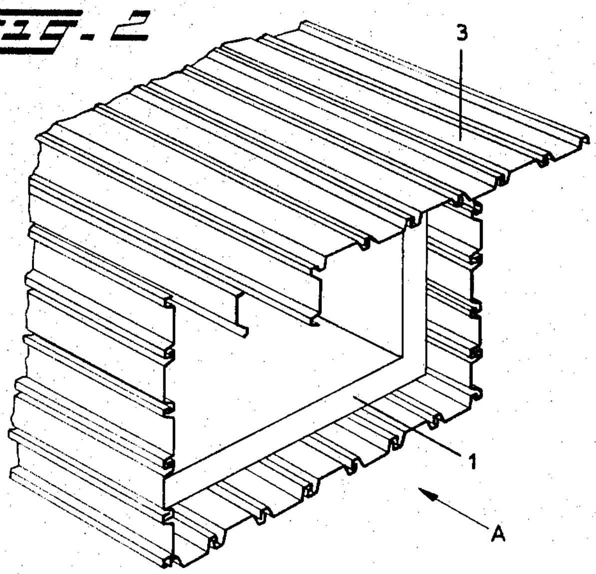
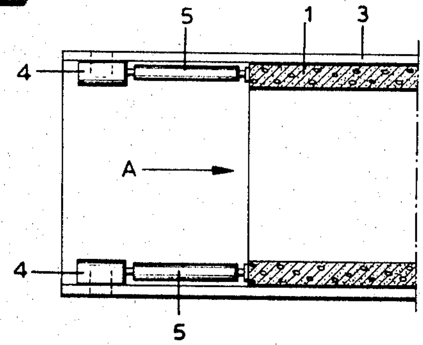


FIG. 3



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METHOD FOR THE STEPWISE DISPLACEMENT OF A HEAVY BODY OVER OR THROUGH THE GROUND

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U.S. Cl. 61—42 7 Claims

ABSTRACT OF THE DISCLOSURE

There is disclosed a method of advancing a heavy structural body relative to the ground, said method comprising, encasing the body within a longitudinal open ended container composed of longitudinally interlocked and independently and relatively-longitudinally slidable sections, each of a length greater than the length of said body, moving the container longitudinally in successive steps relative to the ground, each step effected by sliding of individual sections thereof longitudinally relatively to each other the ground and the body, and moving the body stepwise relative to the container and the ground after each such section-by-section movement of the container relative to the ground and the body, and there is also disclosed the article combination of the mentioned container of interlocked sections and the contained heavy structural body.

The present invention relates to a method for the stepwise displacement of a heavy body, such as a structure or part thereof, for example, a tunnel segment or similar body, over or through the ground, wherein said body and the ground are separated from each other by an intermediate layer.

It is conventional in the methods of this type hitherto known to displace the heavy body together with the intermediate layer stepwise each time, said body and said intermediate layer actually forming an integral whole. In those methods the body together with the intermediate layer are then either pulled from the direction in which they are to be moved, or pushed from the direction from which they are moved. The supporting forces coming from the pulling or pushing means are to be received by an anchorage in the ground. The provisions required to this end, in the form of poles driven into the ground, heavy blocks resting on the ground, buried anchors and the like, are cumbersome, time-consuming and costly. Besides it is also very time-consuming and difficult to displace these provisions transferring the reaction force to the ground, which displacement is necessary each time after a number of steps, particularly when the body is pushed on.

Naturally, the friction between the intermediate layer and the ground on which that layer rests can be decreased, for example, conditions permitting, by laying out on the ground a track of plates, girders or similar elements, with respect to which the intermediate layer can be moved with less tension than with respect to the ground. In this connection fat, rollers or other friction-decreasing means may be employed. However, this method involves an increased use of material. Moreover, the material used for the track is loaded very adversely and suffers badly by the frequent displacements, especially when the path of displacement of the load is long, because then, in order to avoid the necessity of too large a number of elements, the elements of the track that have become free will be shifted each time to form another track portion.

In the method of displacement referred to in the beginning of this specification the intermediate layer is,

at least for the greater part, formed of a thixotropic fluid. The body is moved on each time along the fluid layer. It is difficult, however, to ensure a friction-decreasing fluid layer which is uniform in all places and properly effective.

If the body is displaced through the ground, the earth above said body and that which is located on that earth are carried along when the height of the earth layer on the body is small relative to the size of the body measured transversely of the direction of displacement.

It is an object of the present invention to provide a method of the type described in the beginning, which avoids the drawbacks referred to as well as other, similar drawbacks that have been experienced hitherto with such displacements.

To that effect, the method according to this invention is characterized in that each step of displacement is effected by first moving successively of the entire intermediate layer, which is divided into a plurality of parallel strips extending in the direction of displacement, each individual strip one step with respect to the other strips between the ground and the body, and subsequently having said body take the step of displacement relative to the intermediate layer thus displaced. It stands to reason that instead of one strip at a time also a number of strips can be displaced simultaneously.

In this embodiment the intermediate layer is segmented in a direction transversely of the direction of displacement, i.e. said intermediate layer consists of a plurality of strips extending in the direction of displacement. Naturally, the reaction forces that are to be received with each step of displacement when these strips are separately moved are considerably less than when the assembly of intermediate layer and body bearing on or against said layer is moved as a whole. For decisiveness of the reaction forces when the strips are displaced is the friction between each strip and the earth on the one hand and the friction between that strip and the body on the other, possibly increased by the friction with the adjacent strips. The friction with the load and perhaps with the adjacent strips of the intermediate layer can be kept relatively low by applying friction-decreasing means, such as rollers, fat or similar provisions. Even without the application of these provisions, however, it is possible for the reaction forces occurring during those steps of displacement of the individual strips to be received by the common other strips together with the heavy load resting for the greater part thereon, and/or by the load itself. Consequently, cumbersome and costly anchorages in the ground are superfluous in this embodiment. It is equally possible in the displacement of the body on the common strips of the intermediate layer, which before have all been individually displaced one step, that the reaction forces are received by these joint strips. To achieve this, the individual strips may be efficiently interconnected, for instance, by means of a connecting beam extending transversely of the direction of displacement or similar provisions, in that last phase of each cycle.

It is advantageous that the force for the steps of displacement of the heavy body relative to the intermediate layer, which force is to be received as the reaction force by the intermediate layer, can, naturally, be kept considerably smaller than in the prior method for overcoming the friction between the body-loaded intermediate layer and the ground. Besides it is no longer necessary to provide separate anchorages in the ground.

For all of the steps of displacement, i.e. first those of the strips of the intermediate layer and then of the heavy body relative to said intermediate layer as a whole, jacks, winches, or similar known pushing or pulling means can be used, and, if desired, in combination.

It will be understood that all the strips of that intermediate layer project from the front or back of the heavy body over a distance similar to at least the length of the step of displacement to be effected in the direction of movement.

Although the foregoing has especially been concerned with ground with respect to which the body is to be displaced, the same applies, naturally, when this is not a mowing field or body of earth in a conventional sense, but, for example, the floor of a works, over which a heavy machine or any other load is to be displaced.

In addition to the strips of the intermediate layer being entirely independent of one another, these strips may, in accordance with another embodiment of the invention, also have a guiding effect upon each other during their individual steps of displacement, for example, because of said strips being constructed as steel piling strips intermeshing by means of the conventional joints, or grooved and tongued timber sections, or otherwise.

Finally the present invention also relates to a heavy load, such as a structure or part thereof, for example, a tunnel segment or similar body, which has been displaced with respect to the ground supporting the body or supported by said body, in accordance with the invented method.

In illustration of the invention one embodiment will now be described with reference to the accompanying drawings, in which it is schematically shown how, by use of the invented method, a tunnel or culvert body can be driven through a dam of earth.

FIG. 1 is a cross-section of a body of earth, with an elevation of the intermediate layer between the tunnel or culvert body to be driven through said dam of earth;

FIG. 2 is a perspective view of an enlarged scale of the end of the tunnel segment surrounded by the intermediate layer during that phase of the method in which the strips of the intermediate layer are individually moved;

FIG. 3 is a vertical longitudinal section of the projecting end of the tunnel body with an elevation of hydraulic pushing jacks for displacing the tunnel or culvert body relative to the intermediate layer.

Referring to the drawings, a tunnel or culvert body **1** of reinforced concrete is to be provided through a dam or dyke **2** of earth.

FIGURES 1 and 2 show that the concrete body **1** is surrounded at its outer periphery by a container-like intermediate layer **3** which is composed of steel piling strips extending longitudinally of the tunnel or culvert body and intermeshing at their longitudinal side edges by means of the conventional sheet piling joints.

Depicted in FIG. 1 is the phase in which the tunnel or culvert body has been driven through the body of earth for some distance, namely, at the beginning of a new cycle in which the individual piling sheets of the container-like intermediate layer **3** are moved on one by one some way. Partly decisive of the length of the steps of this step-wise displacement of the individual piling sheets is the pressure of the earth above the tunnel or culvert body. This will be explained in detail hereinafter. By reference to FIG. 1 of the drawing it must be apparent from the foregoing that the heavy body **1** and the surrounding intermediate layer **3** composed of a plurality of individual and relatively movable sections or piling sheets have been moved both over and through the ground, "over the ground" while moving toward the right and approaching the dyke **2**, and "through the ground" to the extent to which the body **1** and layer **3** have penetrated the dyke as shown in FIG. 1.

Starting from the situation shown in FIG. 1, the piling sheets of the container **3** are individually moved forwards by means of ropes pulled by winches, or similar means. FIG. 2 shows the left-hand end view of the tunnel body as depicted in FIG. 1, in which the steps of displacement for the individual piling sheets of the side walls and the bottom of the container-like intermediate layer have been completed, except for the two uppermost sheets of the front side wall of the container shown in FIG. 2. For this displacement the reaction forces can be transferred direct, at least for the greater part, to the tunnel or culvert body owing to, for example, the arrangement of rope blocks fastened to the piling sheet and the projecting end of the tunnel, body, with a rope from a winch which is arranged on the ground passing to and fro over said blocks a few times. As a result of the large friction of the tunnel or culvert body with all the other piling sheets, said body will be firm in position during these treatments.

When, after the situation shown in FIG. 2, the uppermost side wall sheets as well as the sheets of the upper boundary of the container-like intermediate layer have also been displaced, a sufficient amount of earth can be removed from the body of earth at the insert end of the intermediate layer with a view to the subsequent displacement of the tunnel or culvert body in the container-like intermediate layer. It is obvious that the piling sheets must be rigid enough, or sufficiently supported by substrata, in order to receive the ground pressure occurring after the earth in the insert end of the container-like intermediate layer has been taken away.

In the drawings no details are shown of the temporally formed ground slopes of working platforms for digging away the earth at the head of the tunnel, nor of supports or connections for the cross beams **4**.

Afterwards the last step of the cycle can be executed, which comprises displacing the tunnel or culvert body in the direction of the arrow A relative to the container that has been moved forwards, to which effect, as shown in FIG. 3, the sections of sheet piling extending at the projecting end of the container beyond the end of the body are interconnected, for example, by means of cross beams **4**, and jacks **5** are provided between said cross beams and the projecting face of the tunnel or culvert body. Thus the cycle has come to an end, and in a similar way the next stepwise displacement, first of the individual piling sheets of the container **3** and then of the tunnel or culvert body, can take place. Finally, the piling sheets **3** are separately removed from between the ground and the tunnel body which has reached its ultimate position.

The drawings clearly show the great simplicity of the invented method, and illustrate by what simple means the displacement contemplated can be realized.

The above embodiment for the displacement of a tunnel or tunnel segment has the additional and very important advantage that even with a small ground covering the earth above the tunnel, including that which is located on that earth, is not carried along when the tunnel is displaced, but will stay in position. The smallest possible ground covering at which the upper ground will stay in position without any special steps is about equal to the width of one strip of the intermediate layer. When the ground covering is still smaller, partitions will have to be provided transversely of the direction of displacement.

As a result of this it is possible, therefore, to drive a culvert or tunnel through the ground at a very small depth under a thoroughfare or railway, without the road traffic or railway traffic being hampered thereby. This is highly advantageous, since by-passes and slowly driving are avoided, and auxiliary bridges or any other expensive provisions are not necessary either.

A similar advantage is obtained by the invented method when a tunnel is to be constructed under an existing building, because the distance between the top of the tunnel and the lowermost boundary of the foundation of the building can be very small. If, under similar conditions, the tunnel is built according to the so-called shield method, the same advantage can be reached when, in addition to the shield, the segmented intermediate layer according to the invention is applied. Besides, the work can be performed more rapidly, because, in advancing the shield, said shield can be pushed off—not from the tunnel segments—but from the somewhat extended, intermediate layer. Consequently, the positioning of the tunnel segments can proceed without any interruption.

It will be understood that a flat intermediate layer will suffice, instead of the container-like intermediate layer used for the tunnel body of the embodiment described, when heavy loads are to be displaced over the ground.

It goes without saying that numerous modifications of the embodiment here shown and described are possible, without departing from the scope of the invention.

By way of example the displacement of a tunnel through earth of little bearing power is mentioned yet, wherein a pile or shaft foundation is required. The tunnel segments should then be built on supporting joists which are held loose therefrom, and on which those segments can be moved in the manner conventional hitherto.

It is to be understood that the references made herein in descriptive matter and in the claims to movements of or advancing of a heavy structural body "relative to the ground" are made in the generic sense and are to be construed as covering movements over the ground and/or movements through the ground, as through dykes, dunes, mounds or the like.

The intermediate layers according to the present invention, which consist of strips and are not required here for the underside of the floor plate, can be advantageously applied to either only the upper face or also to the side faces. The supporting joists to be piled should then be extended each time when the tunnel is displaced.

I claim:

1. Method for the stepwise displacement of a heavy body relative to the ground, wherein said body and the ground are separated from each other by an encasing layer surrounding the cross section of the body, and said body, with each step of displacement, is moved relative to said layer, characterized in that each step of displacement is effected by first moving successively of the entire layer, which is divided into a plurality of relatively slidable edge interconnected parallel strips extending in the direction of displacement, each individual strip one step with respect to the other strips between the ground and the body, and subsequently imparting to said body the step of displacement relative to the layer thus displaced.

2. Method as claimed in claim **1**, characterized in that the displacement of the individual strips is effected with the supporting force being delivered by the body itself, and the displacement of said body is effected with the supporting force being delivered by at least a number of said strips together.

3. Method as claimed in claim **1**, wherein the supporting force for effecting the displacement of the individual strips is obtained from the body itself, and the supporting

force for effecting the displacement of said body is obtained from at least a number of said strips collectively through interconnection of said strips.

4. The herein described method of advancing a heavy structural body relative to the ground, said method comprising supporting the body on an underlying support layer resting on the ground and composed of longitudinally interlocked and independently and relatively-longitudinally slidable sections each of a length greater than the length of said body, moving the support layer longitudinally in successive steps relative to the ground each step effected by sliding of individual sections thereof relatively to each other the ground and the body, and moving the body stepwise relative to the support layer and the ground after each such section-by-section movement of the support layer relative to the ground.

5. The method defined in claim **4** with the individual sections of the support layer being selected in form and manner of interlock to present less areas for contact with the body than the overall opposing area of the body, thereby to reduce frictional resistance to relative movements between sections and body.

6. Method as claimed in claim **4**, wherein the supporting force for effecting the displacement of the individual strips is obtained from the body itself, and the supporting force for effecting the displacement of said body is obtained from at least a number of said strips collectively through interconnection of said strips.

7. Method as claimed in claim **5**, wherein the supporting force for effecting the displacement of the individual strips is obtained from the body itself, and the supporting force for effecting the displacement of said body is obtained from at least a number of said strips collectively through interconnection of said strips.

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JACOB SHAPIRO, *Primary Examiner.*

U.S. Cl. X.R.

61—16; 193—38, 41; 254—105