

United States Patent [19]

Kuck

[11] 3,792,906

[45] Feb. 19, 1974

[54] EXCAVATION OR EARTH REMOVAL BY
LANDSLIDING SAME ON A FLUID
LUBRICANT

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[21] Appl. No.: **274,799**

[52] U.S. Cl. **299/13**, 61/35, 102/23,
299/18

[51] Int. Cl. **E21c 37/14**

[58] Field of Search 299/13; 102/22, 23; 37/195;
61/35

[56] **References Cited**

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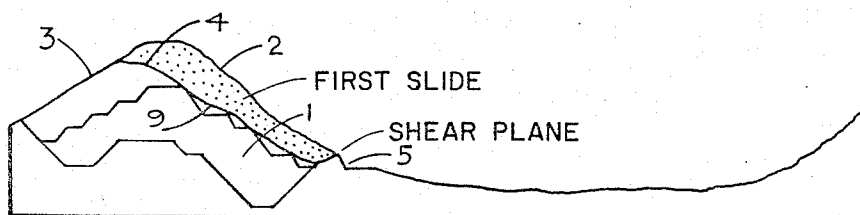
"Casting Overburden With Explosives," Coal Age,
March, 1961, pages 78-82.

Primary Examiner—Ernest R. Purser
Attorney, Agent, or Firm—Pike H. Sullivan

[57] **ABSTRACT**

The present invention relates to the excavation or removal of large masses of earth situated on a down-slope by means of landsliding the same on a layer or cushion of gaseous lubricant which is preferably generated or produced in situ. The plane of shear is determined and thereupon the subterranean rock is fractured by conventional hydrofracturing technique to produce a plane of shear substantially along the bottom of the earth mass. After the desired plane has been formed, a substantial quantity of liquid type explosive is forced into the fracture forming the shear plane and is thereupon detonated to produce a large quantity of gas which lifts the mass and serves as a lubricant so that its speed down slope accelerates very rapidly. Provision may be made for supplementing the gaseous lubricant layer as the mass moves toward the desired area of disposal. This may be accomplished by explosive charges located down stream and which are detonated while the mass is over them.

8 Claims, 18 Drawing Figures



SHEET 1 OF 4

FIG. 1

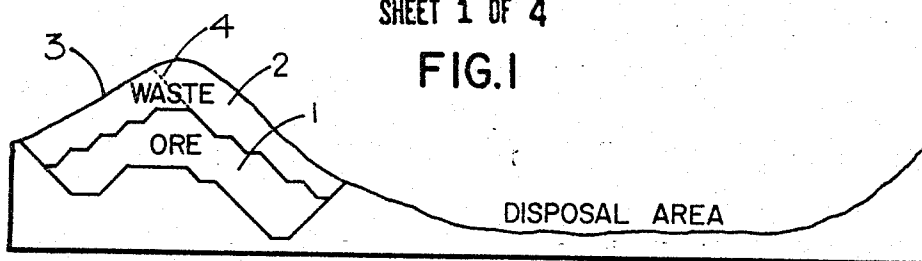


FIG. 2

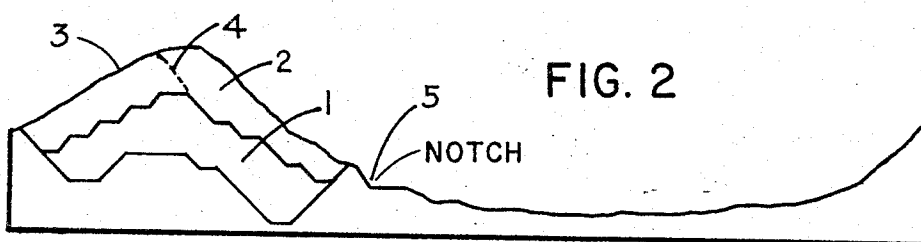


FIG. 3

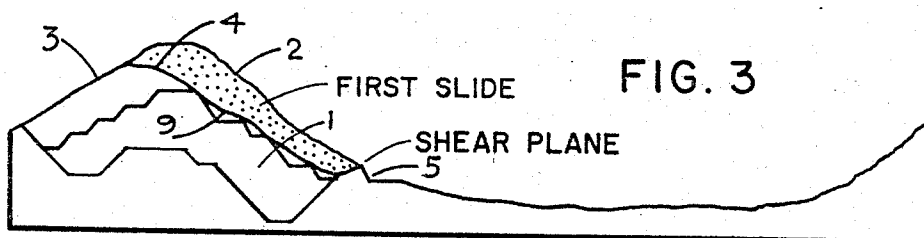


FIG. 4

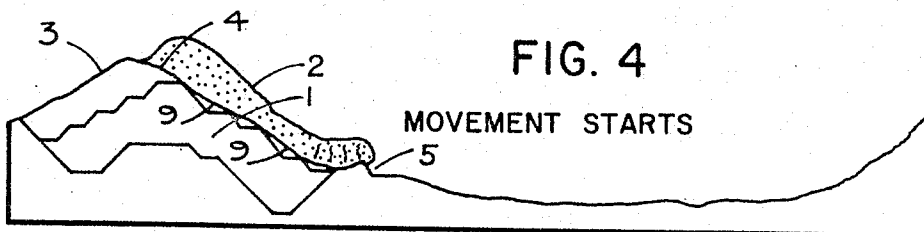


FIG. 5

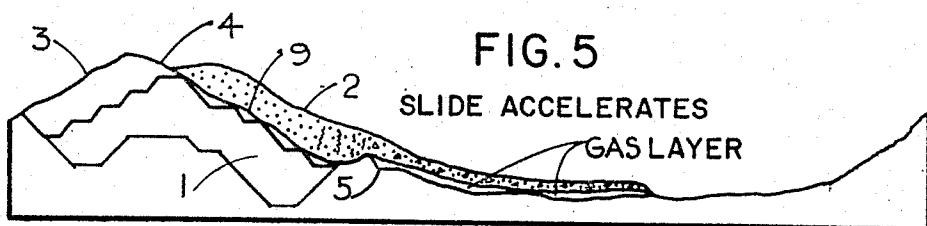
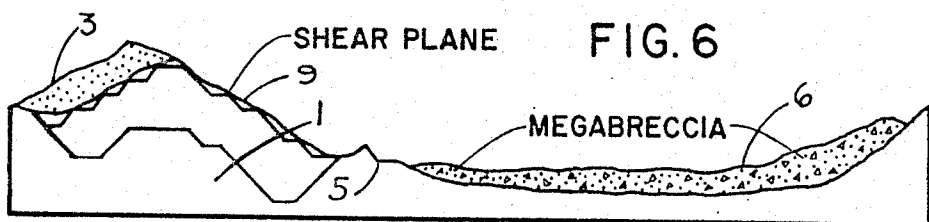


FIG. 6



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FIG. 7

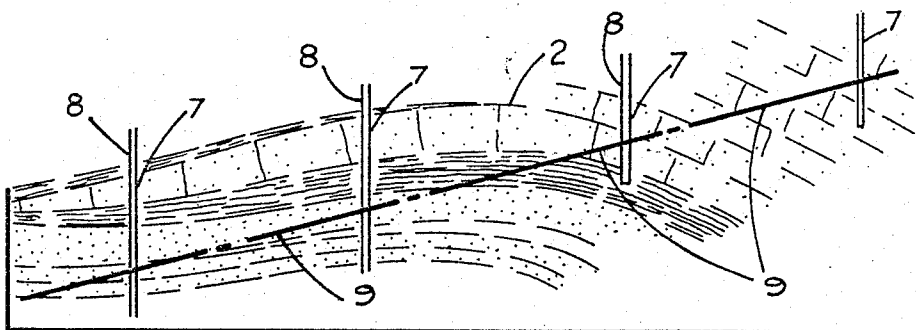


FIG. 8

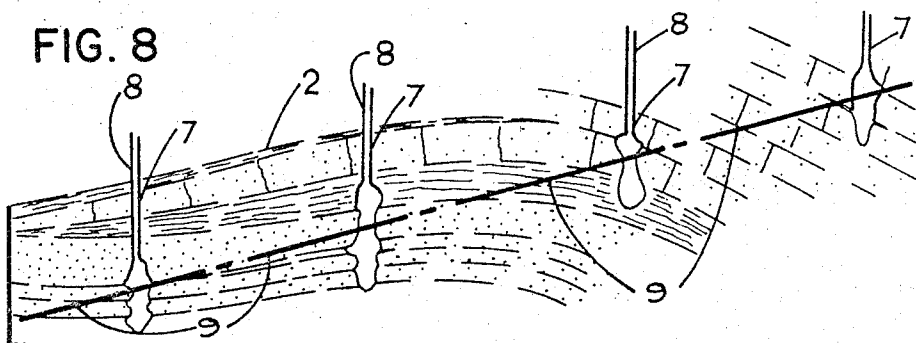


FIG. 9

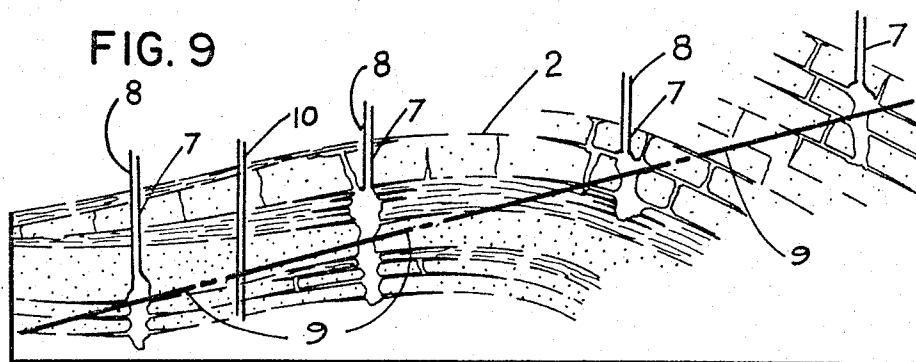


FIG. 10

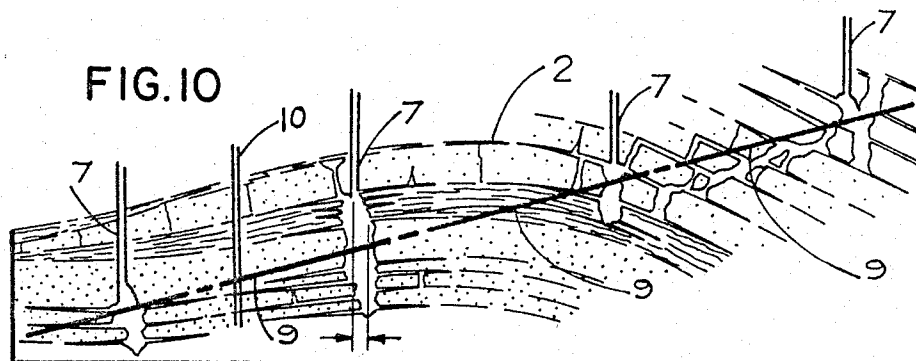


FIG. 11

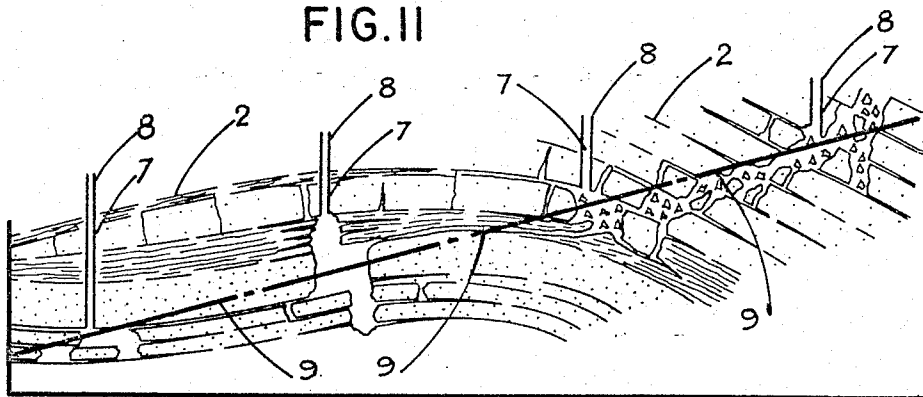
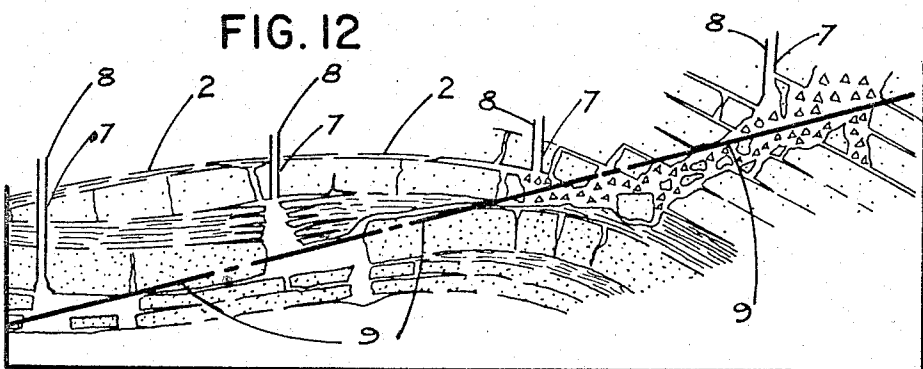


FIG. 12



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FIG. 13

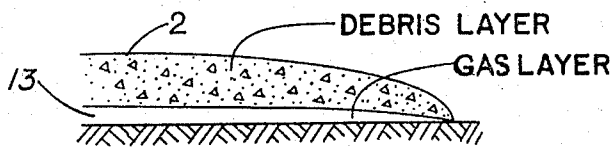
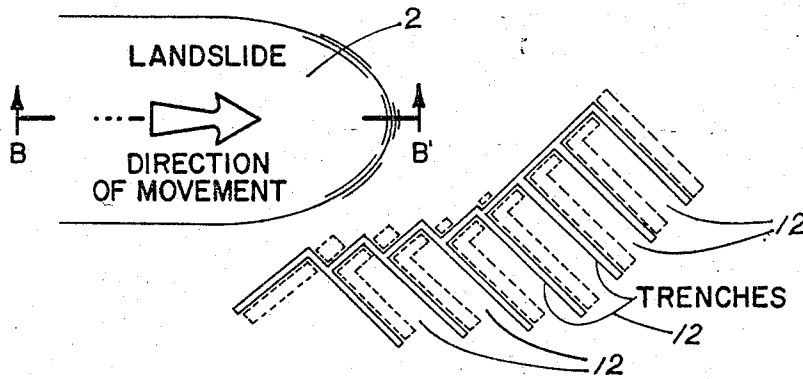


FIG. 14

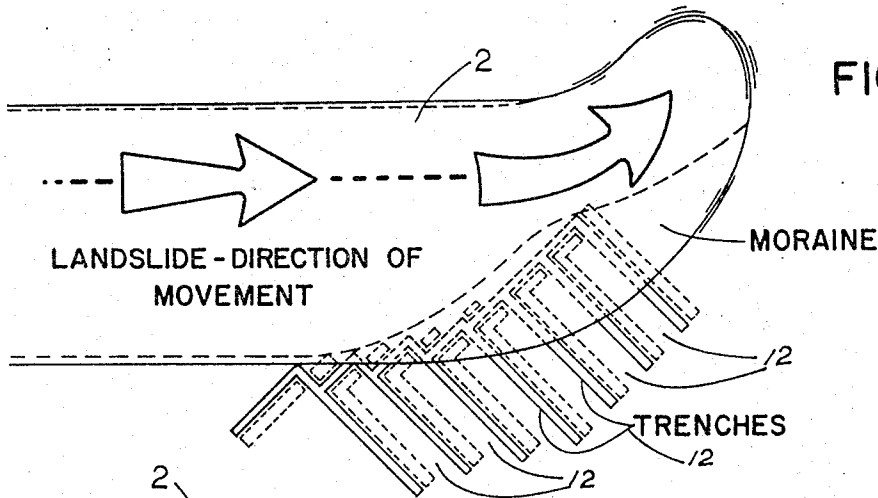


FIG. 15

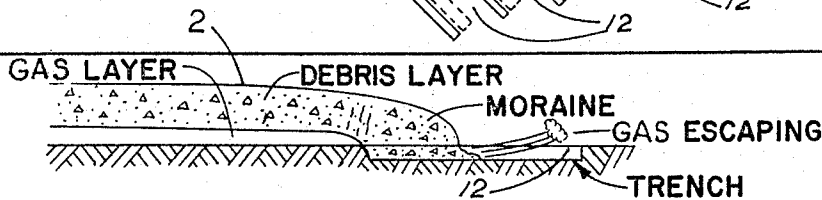


FIG. 16

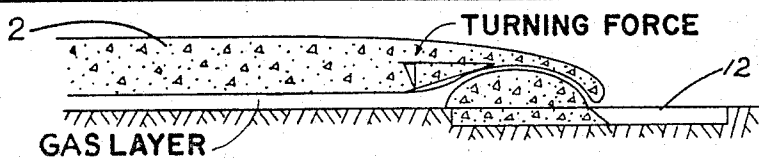


FIG. 17

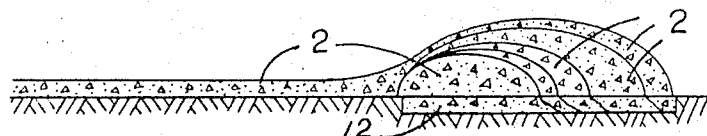


FIG. 18

EXCAVATION OR EARTH REMOVAL BY LANDSLIDING SAME ON A FLUID LUBRICANT

The present invention relates to removing or excavating earth by means of landsliding the same on a fluid lubricant, ordinarily gaseous, and more specifically involves the steps and/or procedures for effecting the desired landsliding movement.

Objects of the invention include the following:

To provide a rapid method of earth moving or excavation on a very large scale.

To reduce operating expense by providing the equivalent of loading and hauling in a single operation of sliding the mass of earth downslope in a few minutes time.

To reduce capital expenditures by eliminating the loading and hauling system.

To provide a rapid method of transporting excavated material over long distances from site of excavation to site of disposal.

To free land that would otherwise be tied up for long periods of time by the conventional excavating and removal systems.

To provide a method which may be used for submarine excavation or removal to another site, as well as excavation and such removal on land.

The above and other objects, features and advantages of this invention will be fully understood from the following description considered in connection with the accompanying illustrative drawings.

In the drawing:

FIGS. 1 through 6 comprise a series of diagrammatic sections across a hypothetical ore body, with waste overburden, the series of sections showing different stages of the removal of a substantial portion of the waste overburden;

FIGS. 7 through 10 comprise a series of diagrammatic sections across a hypothetical folded body of sedimentary rocks, the series of sections showing the development of a shear plane substantially between the waste overburden and the ore containing structures;

FIGS. 11 and 12 are a continuation of FIGS. 7 through 10 and comprise a series of diagrammatic sections showing beginning of substantial movement of the overburden layer.

FIGS. 13 through 18 comprise a series of diagrammatic views of a system for changing the direction of a landslide.

Referring more specifically to the drawings, FIG. 1 shows diagrammatically a ridge, the top portion of which comprises an overburden or layer of waste covering a body of valuable ore 1. This is designated in two portions, 2 and 3, approximately divisible at line 4. These two portions of overburden may be moved in the form of two independent masses to points well removed from the ore body 1 by means of the present invention. Such removal of portion 2 will be hereinafter described in detail. As shown in FIG. 2, a notch 5 is cut transversely across the lower face of the ridge below portion 2 of the overburden so that substantial amounts of air will be entrapped underneath the overburden portion 2 when it is rapidly moving down the slope of the ridge in the form of a landslide generated and sustained in accordance with the present invention. Such entrapped air will provide an additional lubricant to further aid the rapid movement of the mass of earth 2 in order that its rate of speed may be accelerated, or at least sus-

tained, so that the mass 2 will flow into a valley and even part way up a slope, as shown in FIGS. 5 and 6, where it comes to rest as megabreccia 6.

FIGS. 7 through 12 show different stages in carrying out my invention to effect removal of undesired overburden comprising folded sedimentary rocks. When, the desired shear plane has been determined, i.e., the plane above which the overburden is removed, a series of spaced holes 7 is drilled in the formation 2. If desired, or, if the character of the structure makes it advisable, casings 8 may be put into the holes 7 and cemented in the usual manner. Ordinarily explosive charges are placed in the holes 7 at the shear plane 9 and detonated so as to rupture or "spring" the rock at the shear plane. Note, FIG. 8. This is followed by employing hydrofracturing technique to further effect the desired fracturing to develop the shear plane 9. (Note FIG. 9.) This may be done with various viscous fluids such as water gels, aqueous bentonite, mud slurries, etc. The spacing of the holes 7 and the degree of hydrofracturing should be such as to result in communication among all the holes 7. After hydrofracturing, it is advisable to wash the hydrofracturing fluid from the structure.

Before hydrofracturing, a desirable practice is to drill one or more holes 10 in which are placed deflectometers for indicating the extent of any movement of the overburden 2 along the shear plane 9 during the presence of the hydrofracturing liquid. Such movement would assure that the shear plane had been developed. If such movement does not transpire during hydrofracturing treatment, then a lower viscosity, or in some instances even aeriated, lubricating liquid, may be pressure injected so as to provide sufficient lubrication to cause relatively slow movement, or creep, of the upper mass 2 along the shear plane 9. Care should be taken to avoid premature or too rapid movement of the overburden mass 2. If such lubrication is used to complete development of the shear plane 9, it should be washed out after it has served its purpose. The extent or degree of movement effected, during hydrofracturing or with the employment of a lubricating liquid thereafter, should be relatively slight, for example, as shown in FIG. 10.

After the shear plane has been developed and the overburden 2 has experienced some movement down the slope or grade, the structure is washed to remove the hydrofrac liquid or the lubricant, as the case may be.

The next step is to effect a landslide type movement of the overburden layer or mass 2 down the shear plane 9, the downslope there below, and the area beyond the downslope. (Note FIG. 1.) A pumpable type of explosive, such as a powdered aluminum accelerated ammonium nitrate explosive, is pumped into the structure through the holes 7. Any other suitable liquid or slurry explosive may be used. This should be in sufficient amount and forced under such pressure as to be widely distributed throughout the shear plane 9 and the other fissures and openings generated in forming the shear plane 9. Additional explosive charges may be placed at spaced points on the slope below the mass 2 of the overburden. Suitable detonators may be provided to set off these additional charges when the sliding mass 2 is passing over them. The amount of explosive pumped into the structure should be sufficient to generate a body of gas which will function as a lubricant on which

the mass 2 will slide down the grade or slope and will be in sufficient amount so as to avoid the mass becoming grounded before it is over the additional downstream explosives which will provide additional gaseous fluid to assure the mass 2 reaching the point desired.

The explosive charge in the formation is then detonated and the mass 2 begins to slide downward on the gaseous layer of fluid generated thereby. (Note FIG. 11.), and accelerates its downward speed (Note FIG. 12.).

Before the initial body of gas is dissipated to the point where lubricity is lost, the downslope explosive charges are detonated to supply the desired additional gaseous lubricant. As indicated in FIG. 6, the speed of the flow or landslide was such that the mass 2 flowed into a valley and partly up the side of a ridge before it broke up from grounding into megabreccia. Instead of using explosives, the downstream supplemental gaseous fluid lubricant can be supplied via pipe lines from a suitable source, such as an air compressor or a generating device that produces flue or combustion gases by the burning therein of a suitable fuel. It will be appreciated that substantial amounts of lubricating gases are lost by percolation upwardly through the sliding mass 2. Some gases are lost at the periphery of the moving mass.

It is desired that the sliding mass stop in the disposal area (Note FIG. 6.). To do this, the momentum of the sliding mass must be lost and the gaseous layer must be dissipated to bring the slide to rest in the desired area. This can be done by permitting it to spread over a large area so that it becomes substantially thinner and thereby loses its gaseous lubricant through rapid upward percolation thereof, or the thin sheet may rupture so as to allow the gases to escape. In some instances, it may be desirable to forcefully rupture the sheet or mass of overburden by detonating explosives thereunder to blow upwardly through the same to form large openings or craters through which the gas may quickly escape. The sliding mass can also, in some instances, be permitted to run upslope to dissipate its momentum with or without employing any one or more of the foregoing procedures.

The following specific examples of my invention are based upon assumed or hypothetical situations.

It is desired to remove, in accordance with my invention, an overburden mass, resting on a 5 degree slope (such as the side of a ridge) having an average width of 500 feet, a downslope length of 1,000 feet and an average thickness of 200 feet. Fifty drill holes on 100 foot centers are prepared, cased and cemented. Four holes are drilled and deflectometers or extensometers are placed therein. The shear plane is then developed in accordance with the present invention. Thereupon, pumpable explosive material is forced into the structure through all or most all of the 50 drill holes in an amount which will produce sufficient gas to form a gas cushion about 2 feet thick under a pressure of about 225 pounds per square inch. About 1,000,000 cubic feet of gas (excluding water vapor and other condensibles) at about 225 pounds pressure is necessary to form this cushion. The newly formed gas layer or cushion will have a temperature of about 400° K. About 1,400,000 pounds of ANFO type explosive (ammonium nitrate — fuel oil slurry) will be needed to accomplish this, and about 600,000 pounds of such explosive will be required downstream to replace gases lost up to that point. At the 200 foot depth much more explosive

can be used than the 700 tons mentioned above, if it is desired to have a greater margin of gaseous lubricant to assure desired movement of the overburden mass. For example: If a 5 foot layer or cushion of gas is desired at the 200 foot level, about 34 tons of the above explosive per drill hole can be safely used, as ordinarily cratering will not become a serious factor unless substantially more, for example, 50 tons is used per drill hole.

Let it be assumed the 2 foot gas cushion has been determined to be adequate. The explosive is then detonated within the structure and the mass starts to move down the 5 degree slope. Since it is riding on the gas cushion the mass accelerates rapidly substantially at the rate of 2.8 feet per square second. This is shown by the following table:

Time Sec.	Ft. per Sec.	Mi. per hour	Distance from Origin. Ft.
5	14	10	35
10	28	19	140
20	56	38	562
30	84	57	1,263
40	112	76	2,250
50	140	96	3,510
60	168	115	5,060

The above figures are based upon substantially no friction by reason of an adequate gaseous fluid layer or cushion being maintained throughout the entire period of movement referred to in the above table. With a 15 percent slope (8°32') the mass will be moving at about 195 miles per hour at the end of 1 minute and will have traversed a distance of almost 8,600 feet.

It will be understood that the present invention may be employed to move submarine formations in substantially the same manner as hereinabove described. The minimal downslope for submarine operations may be substantially less than that for non-marine operations; under some circumstances a slope of as little as one degree will prove to be adequate.

As indicated above, FIGS. 13 through 18 show a system for turning the direction of flow of the moving landsliding mass of overburden debris. A series of trenches 12 in substantially parallel relationship are located so as to extend toward and into the expected path of the over burden mass of debris 2. (Note FIGS. 13 and 15.). When the mass of debris reaches the trenches 12 gas from the layer or cushion 13 will rapidly flow from under the mass and discharge from the trenches 12 with the result the outer portion of the mass adjacent the trenches will become grounded as moriane (Note FIG. 16.). Additional debris will ride its gas cushion so as to overflow the previously grounded debris (Note FIG. 17.). This will continue as a repetitive action until a substantial build-up of grounded debris or moriane will take place (Note FIG. 18.). in the form of a ridge. As additional flow of the mass 2 takes place, it will be diverted in its direction of flow by this ridge formed from debris precipitated by the trenches 12. This ridge of moriane will be in rough alignment with the arrangement or position of the trenches 12. The mass 2 of rapidly moving debris, riding on a gas layer, will now be turned in its direction of movement by the moriane ridge and the air cushion being between the ridge and the mass 2. In effect, one might say that the gas layer is tilted so the effect on the mass 2 is somewhat similar to that of an airplane executing a turn.

While the application of my invention has been described in connection with the removal of overburden

from a body of ore, it is to be understood that my invention is not in any sense restricted to such purpose. It is to be expressly understood that this invention may be employed to excavate or remove a body of earth in any situation where a slope is available or present which extends downwardly from the body or mass of earth to be removed and deposited in a desired disposal area. It is to be understood that the term "earth" is intended to include any one or more of the various types of matter found in the Earth's crust, such as, for example, soil, silt, sand, gravel, rock, etc.

It will be understood that the invention may be embodied otherwise than as hereinabove illustrated or described, and that various changes may be made therefrom without departing from the underlying idea of principles of this invention within the scope of the appended claims.

I claim:

1. The method of removing a mass of earth situated on a downslope which comprises applying a fracturing force to the subterranean rock structure associated with said mass so as to produce a plane of shear extending substantially along the bottom of said earth mass, forcing an explosive into a substantial portion of said shear plane fracture in amount sufficient so that when detonated the gas produced thereby will lift said earth mass and provide a gaseous layer on which it may slide down said slope, and detonating said explosive whereby said earth mass moves rapidly down said slope while supported by the resulting gaseous layer.

2. The method of claim 1 wherein a plurality of spaced holes are drilled from the surface of said earth mass to a depth sufficient to intersect the desired plane of shear, and forcing a viscous liquid into said holes under pressure sufficient to cause the same to flow laterally with respect thereto into said subterranean rock structure to fracture the same and form the desired plane of shear.

3. The method of claim 2 wherein an explosive is detonated in said holes so as to rupture said rock structure in the vicinity of the desired plane of shear, and there-

after introducing said viscous liquid under pressure so as to produce the desired plane of shear.

4. The method of claim 3 wherein the following the hydrofracturing step with pressurized viscous liquid a liquid of substantially lower viscosity is forced into said fracture at the plane of shear under such pressure and in such amount as to cause said earth mass to move slowly downslope to a limited degree, thereupon releasing the pressure on such liquid, removing the same and thereafter injecting the liquid explosive into said plane of shear.

5. The method of claim 1 wherein additional gas is added to the underlying gaseous layer when the earth mass is downstream of the slope and while the said gaseous layer is still supporting said earth mass, the gas so added being in amount sufficient to maintain said gaseous layer until said mass substantially reaches the area of disposal.

6. The method of claim 5 wherein said additional gas is supplied by explosive charges which are detonated as the earth mass is passing over them.

7. The method of claim 1 wherein additional gas is added to the underlying gaseous layer by providing a notch in the downslope extending substantially transverse to the direction of flow of the earth mass whereby substantial amounts of air will be entrapped under the rapidly moving mass.

8. The method of claim 1 wherein the direction of flow of the rapidly moving earth mass is changed by providing a series of trenches in the surface of the ground at the point where such change in direction of flow is desired, said trenches being substantially parallel and extending into the normal path of said moving mass, such trench extensions being progressively greater in a direction corresponding to the normal downstream path of said mass, whereby gases under said mass adjacent the outer portion thereof escape through said trenches and cause such portion to be grounded until a substantial ridge is formed which diverts the flow of following portions of said mass.

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