

United States Patent [19][11] **3,851,478****Ayres**[45] **Dec. 3, 1974****[54] METHODS OF CONTROLLING THE FLOW OF GASES UNDERGROUND****[75] Inventor: Douglas J. Ayres, London, England****[73] Assignee: British Railways Board, London, England****[22] Filed: June 5, 1972****[21] Appl. No.: 259,975****[30] Foreign Application Priority Data**

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[52] U.S. Cl. 61/35, 61/5, 169/46**[51] Int. Cl. A62c 3/02, A62c 1/08, E02d 27/00****[58] Field of Search 169/1 A, 2 R; 61/35, 59, 61/36 R, ..5; 52/169****[56] References Cited****UNITED STATES PATENTS**

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A method of controlling the flow of gases underground, particularly in preventing the spread of subterranean combustion. The method is particularly concerned with cutting off the passage of air or other vapors through the ground and consists of constructing a boundary wall surrounding the source of the gases or vapours such as the seat of a fire by excavating a trench and filling the trench with a clay material in slurry form substantially impervious to the gases.

14 Claims, No Drawings

METHODS OF CONTROLLING THE FLOW OF GASES UNDERGROUND

This invention relates to methods of controlling the flow of gases underground and has particular, but not exclusive, application to the storage of gases and to controlling of fires underground.

The problem of underground fires has been a source of nuisance to mines with the associated problem of allowing tip wagons to pass over burning ground, to railways where the soil movement underground due to loss of volume reduces the support given to the permanent way, and to the general public where the emission of noxious fumes is a general nuisance. Where the fire is known to be very limited in extent and at very shallow depths all burning material may be removed by excavation. If this is not possible, alternative methods are necessary and it is with such methods that the invention is concerned.

The necessary conditions for the continuation of a fire are:

- a. a source of combustible material
- b. a supply of oxygen and
- c. a temperature at which ignition can take place.

Obviously with the initial presence of combustible material, techniques have been addressed to reduce factors (b) and (c) in order to extinguish the fire. Some advantage in reducing the temperature has been derived from pumping in water, but this is of limited effect, and has the disadvantage that water can enter into the chemical reaction at the point of combustion to produce other inflammable gases. Grouting methods are also used but these have less effect in reducing temperature by absorption of heat than in interfering with gas movement and the supply of oxygen. A further technique is the introduction of a chemical which inhibits the rate of chemical reaction but such methods largely resolve to the provision of a gas in the voids other than air or oxygen so that the system resolves to that of preventing a supply of oxygen.

The effect of grouting is well known in published literature and the technique generally is to inject material into voids in the ground surrounding the seat of the fire to prevent the passage of air towards the combustible material. Specialist engineers have improved techniques to plot the movement of the fire and to plan a sequence of grouting tubes to bring the fire under control and preferably extinction as quickly as possible. It is obvious that the greater the depth of combustible material the greater the expense of grouting.

A problem in grouting is that the most economic method of inserting grout tubes by driving them into the ground may be precluded by the occurrence of large stones or other obstructions at particular horizons which would necessitate expensive rotary or auger drilling techniques to provide holes into which the grout tubes would be subsequently inserted.

It is the object of this invention to provide an improved method of cutting off the passage of air or oxygen through the ground for sites of moderate depth which is not only applicable to the restriction of fires but will also be of use in areas where dangerous gases must be controlled as in the case of underground tanks in oil refineries.

It is a well known method to dig trenches at the estimated limits of a fire and to backfill such trenches with sand or other fine aggregate which restricts the air passage through it and, being non-combustible, provides a

heat sink across which the temperature gradient drops to below ignition temperature. The problem is excavating such trenches has been that the exposed face of the trench provides increased air access during the work with a possible sudden movement of the fire towards the trench before backfilling can be completed.

According to one aspect of this invention there is provided a method of controlling the flow of gases underground comprising forming a boundary wall surrounding the source of the gases, said wall being formed by excavating at least one trench underneath a clay slurry.

According to another aspect of this invention a method of limiting the flow of gases underground comprises excavating a trench beneath a clay slurry to define boundary walls and discrete cells bounded vertically by the trench. If desired an impermeable horizontal layer may also be provided to prevent vertical gas flows.

By using a clay slurry comprising a large amount of water and a small amount of clay mineral of a very active type, for example montmorillonite, the sides of the trench are automatically supported and no shuttering is needed.

The use of a slurry trench system at the site of a fire enables the movement of gas to be completely prevented down to the depth of excavation and a combination of trenches enables an area of fires to be completely surrounded and further, allows cross trenches to divide the area into cells for the particular points of combustion to be separately extinguished. Furthermore, a trench can be placed to separate an area of known combustion from another area where it is most necessary that the fire should not reach. The slurry trench allows large obstacles to be removed by grabbing techniques down to depths predetermined or assessed during progress up to the limit of capacity of the grab apparatus and below which depth grout tubes may be driven in to the lower horizons. Additionally tubes, for monitoring the temperatures at these lower depths, may be thus driven to ensure that the extent of fire has been discovered.

As the slurry has a low viscosity it will flow into any large voids in the adjacent ground to cause an impermeable condition. The trench may be filled with concrete to displace the clay slurry, but more economic and simple methods are available as will now be described.

Method 1

A source of fine or all-in aggregate may be dropped into the clay slurry which displaces it as the aggregate falls to the bottom leaving the small amount of clay in the fine voids of the aggregate system thus reducing shrinkage from that of the total slurry to that of the minor remaining in the voids.

Method 2

A grout of density higher than that of the clay slurry may be pumped through a pipe to the base of the excavation to displace the overlying slurry. This grout can have the properties of low shrinkage, can contain hydraulic cement for setting or other inert ingredients such as finely divided silica (PFA) and powdered limestone or limestone or lime which would increase in strength following a fire. Clay flocculating agents can also be included.

The use of limestone either as a grout aggregate or as a filler in the above method has the advantage that when heated, it gives off carbon dioxide thus resisting combustion, it expands to take up shrinkage and to reduce voids, and produces lime or (in the presence of water) quicklime which would react with any silica present to produce a pozzolanic cement.

In both methods 1 and 2 an impermeable sheet can be immersed in the slurry to line the face or faces of the trench before the slurry is displaced. This may take the form of a single or double sheet of plastic film weighted at the bottom, or thin metal foil or asbestos-cement board or the like.

A vibrating instrument such as a concrete poker vibrator or large ground vibrating apparatus may be introduced to the base of the trench to cause collapse of the sides of the trench at the base and further permeation of the clay slurry or of the dense grout introduced to give the effect of an enlarged base at the bottom of the trench.

The trench is formed in the clay slurry by use of specially constructed excavating tools. The impregnating layer may alternatively be formed by the use of the known system of driving steel joists or sheet piles to which have been affixed grout tubes for the introduction of clay slurry as the joist or pile is subsequently withdrawn. In this application the system may be applied with the direct injection of dense grout with the properties above indicated to form a thinner and slightly less effective continuous wall.

One known method of constructing a trench involves drilling and chiselling at the ground while bentonite slurry is injected at and drawn away from the work area back to the storage tank. This removes the spoil and is known as the reverse circulation method. This equipment would allow the placing of dense grout at depth once a desired horizon had been reached with subsequent displacement of the overlying clay slurry.

If it proved necessary to provide a deep boundary wall a trench could first be excavated in the manner described above and then, pipes could be driven in through the base of the trench whilst slurry or other filling material was fed along the pipes. The pipes would then be withdrawn.

I claim:

1. A method for controlling the flow of gases underground which comprises excavating at least one trench, applying a clay slurry to the area excavated in order to form a boundary wall surrounding an underground fire or surrounding an underground storage tank; said slurry being a mixture of clay and water in which the

water predominates, permitting said slurry to impregnate large voids in the adjacent ground to render the adjacent ground substantially impermeable to air and thereby retarding the flow of air through the ground; placing a sheet of flame or corrosion resistant material selected from the group consisting of synthetic plastic material, metal, and fabricated board against at least one face of said at least one trench; and displacing clay slurry by depositing aggregate without cementing material into said at least one trench through the clay slurry and thereby forming a wall of aggregate.

2. The method of claim 1 wherein discrete cells bounded vertically by said at least one trench are formed.

3. Method according to claim 1 wherein a grout of a higher density than that of the slurry is supplied to the lower region of said at least one trench to displace the slurry.

4. Method according to claim 3 wherein the grout contains material selected from the group consisting of calcium hydroxide, finely divided silica, powdered limestone, and pulverized fuel ash.

5. Method according to claim 3 wherein the grout contains a hydraulic cement.

6. Method according to claim 3 wherein the grout contains inert ingredients the strength of which increases with temperature.

7. Method according to claim 3 wherein the grout includes a flocculating agent.

8. Method according to claim 1 wherein a gas-proof vertical sheet is introduced into the trench prior to the addition of an aggregate.

9. Method according to claim 1 wherein the aggregate expands upon heating.

10. Method according to claim 1 wherein the aggregate is limestone.

11. Method according to claim 1 wherein at least one trench is subjected to vibration whereby the lower region of the trench is effectively enlarged in volume.

12. Method according to claim 11 wherein the vibration is used to induce the base of the trench to collapse and mix with the slurry.

13. Method according to claim 1 wherein the slurry trench is produced by driving in steel joists with tubes attached for the introduction of slurry.

14. Method according to claim 1 comprising excavating a slurry trench to a predetermined depth and driving tubular members below said depth through which tubular members the ground below the depth is injected.

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