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STABILIZING MINE ROOFS

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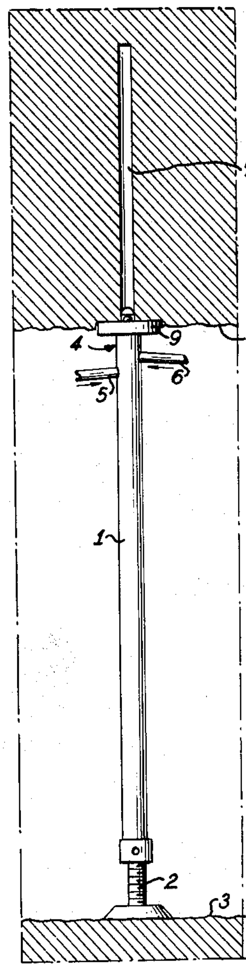

Fig.1

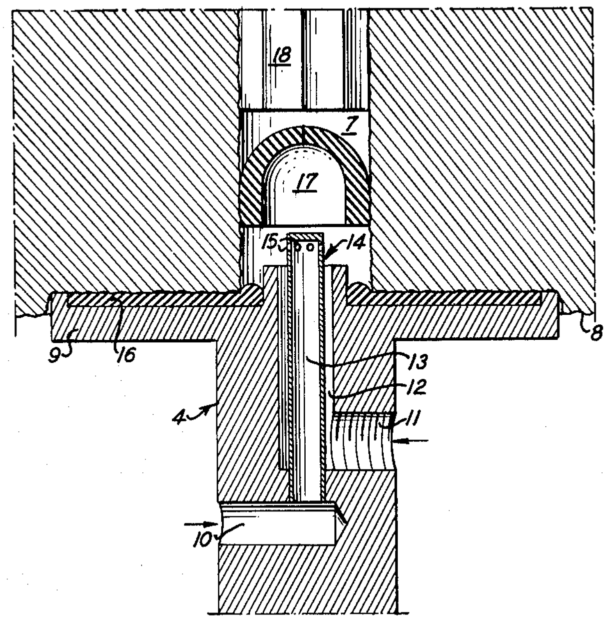

Fig.2

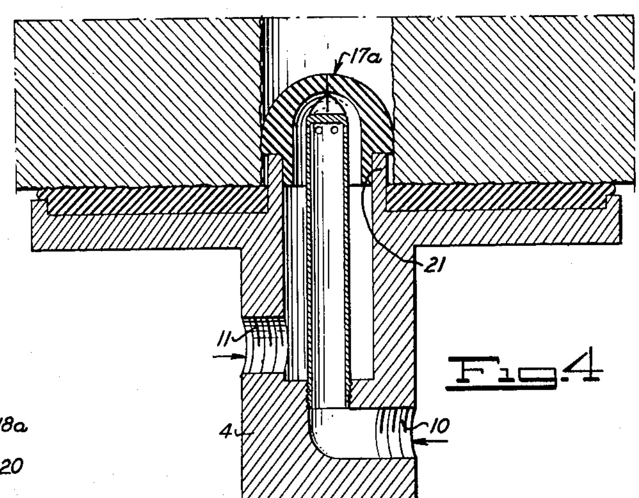

Fig.4

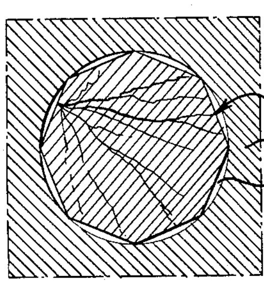

Fig.3

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STABILIZING MINE ROOFS

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5 Claims. (Cl. 61—36)

This application is a division of co-pending application Serial No. 843,517 filed September 30, 1959, now U.S. Patent 3,108,442.

The present invention relates to a method for injecting a binder material into a mine roof formation for the stabilization thereof and to an apparatus for carrying out said method. More particularly, the invention relates to a combination mine prop and injector apparatus capable of injecting hardenable resins into the shale formation above the peripheral roof portion of a mine tunnel via a bore hole drilled for that purpose.

Heretofore, structural roof supports were necessary in coal mine tunnels to carry the weight of the mine roof and to prevent cave-in of the tunnel. Such supports were cumbersome to handle and to erect in the necessarily limited space available in mine tunnels as well as expensive with regard to required equipment and man-hours.

As an attempt to overcome the foregoing drawbacks, roof bolts were introduced. These bolts were inserted into holes drilled into the mine roof and screwed into locking engagement at their remote ends with the surrounding sandy shale located above the coal strata. Such bolts were more easily installed at the working mine face than structural supports. While these roof bolts have proved to be of some value, equipment cost and man-hours, nevertheless, are still sizable factors affecting the overall economy of these operations.

It is an object of the invention to overcome the foregoing drawbacks and to provide a method and portable apparatus for injecting a fast setting binder material under high pressure into the roof formation above the coal strata for stabilizing the same, in a simple and efficient manner and with a minimum of equipment and labor costs.

Other and further objects of the invention will become apparent from a study of the within specification and accompanying drawings in which,

FIG. 1 is a diagrammatic sectional view of a mine tunnel showing the combination roof prop and resin injector of the invention in position against a bore hole;

FIG. 2 is an enlarged sectional view of one embodiment of the resin injector portion of the combination device of the invention in position against a bore hole showing details of construction,

FIG. 3 is a cross-sectional view of a bore hole indicating the disposition therein of an elongated plug or filler in accordance with the invention, and

FIG. 4 is an enlarged sectional view of another embodiment of the resin injector portion similar to that of FIG. 2 wherein a rubber valve plug is inserted simultaneously with the injector nozzle into the bore hole.

It has been found, in accordance with the invention, that the mine roof of a mine tunnel, especially at the working mine face, may be conveniently and inexpensively stabilized by injecting a hardenable resin material into the sandy shale located above the coal strata by a novel method and apparatus. The resin material upon hardening effects the desired stabilization.

In this connection, it is known that in the usual case, the mine roof is composed of an impure coal surface layer, above which is found a thin layer of cannel coal and finally the surrounding sandy shale layer. While it

is believed that the impure coal layer and the cannel coal layer are able to support their own weight, since the sandy shale generally develops internal cracks and voids, the sandy shale is incapable of supporting itself over the mine roof. Thus, the weight of the sandy shale adversely affects the otherwise stable coal strata.

By injecting a hardenable resin material into these cracks and voids, it has been recently found that the sandy shale is rendered stable and structurally coherent so that it is able to support itself in the same way that the cannel coal layer and impure coal layers are able to do. Consequently, the need for multiple structural mine supports or roof bolts is avoided while safe, stable, and unencumbered mine tunnels are provided. Prior injection methods, however, have been unfruitful commercially in view of the quick-hardening properties of the binder and the resultant clogging of the injection apparatus.

In accordance with the invention, holes are drilled into the tunnel roof to a height substantially within the overlying sandy shale layer, i.e. preferably about six feet in length. Then, the hardenable resin material is injected under pressure by the device of the invention until refusal or until it begins to seep out of neighboring holes. Upon setting, the mine supports may be removed without danger since the overlying laminations are bonded together and the overall formations are effectively stabilized.

The resin material which may be used may be any hardenable resin capable of flowing into cracks and voids under pressure and, upon hardening, of withstanding stresses of the surrounding formation. Thermosetting resins, such as epoxy resins and polyester resins in liquid or flowable form have been found to be excellent for these purposes.

The resin material is preferably mixed with a catalyst, which accelerates the rate of hardening, at the point where the resin is injected into the bore hole. A promoter for the resin is also preferably used which initiates the resin solidification, such as hydroxyethyl diethylene triamine. Hardening of the resin may be attained in this way upon allowing the suitably proportioned injected resin, catalyst and promoter mixture to set for only about two minutes. One half of the resin is preferably premixed with the required amount of promoter agent while the other half is premixed with the required amount of catalyst. By this feature, only two injection conduits will be needed rather than three, and a minimum of intermixing will be necessary as the respective flowable materials leave the injector.

The injection pressure which may be used may be any suitable pressure depending on the nature of the cracks and voids and the characteristics of the strata itself. Pressures of about 3000 pounds/square inch have been found particularly suitable although pressures of 500 to 5000 pounds per square inch are possible.

Economies may be provided in accordance with the invention by inserting into the bore hole an expendable elongated plug or filler element which is generally of smaller outside diameter than the inside diameter of the bore hole. Thus, while a suitable surface is exposed for resin injection along the extent of the bore hole, the center portion thereof is occupied by the elongated plug. This results in a saving of resin. The plug may be made of inexpensive wood or similar material, the same being preferably fluted or having a polygonal cross-section, allowing flow of resin within the space defined between the outside surface of the plug and the inside diameter of the bore hole.

Thus, for a bore hole of 1.5 inches diameter, a wood plug of octagonal cross-section having a distance of 1.375 inches between opposite faces may be used. The cross-sectional area of such a bore hole is approximately 1.77

sq. in. while the cross-sectional area of the octagon is approximately 1.57 sq. in., leaving a bore passage area of .20 sq. in. which is sufficient for conducting the flowable binder material therethrough.

Below the optional wood plug, a stop valve plug may be positioned in the bore hole which allows passage of resin material upwardly therethrough but which seals the hole from downward seepage. This also results in a saving of resin.

The apparatus of the invention comprises a combination adjustable roof prop and resin injector adapted to be placed with the injector nozzle and inserted within the mine roof bore hole under the mechanical pressure exerted thereagainst by the roof prop bearing on the mine floor. The roof prop element is adjustable in height and may assume the form of a screw jack or hydraulic jack. It is used to effect sealing engagement between the injector element and borehole and to effect temporary support of the mine roof.

The resin injector element is defined within the uppermost portion of the roof prop and preferably contains separate inlets for the catalyst and resin and a dual channel nozzle which effects mixing just as the resin and catalyst leave the injector. The resin inlet channel is preferably concentric to the catalyst inlet channel within the injector and both are forced out at the uppermost end via the dual nozzle. The injector end is provided with an extended flange to distribute the supporting force, preferably carring a soft gasket such as a rubber gasket on its uppermost side for preventing resin leakage during injection. The flange along its upper surface is placed in sealing abutment with the preferably smooth off roof area surrounding the bore hole by the mechanical pressure of the roof prop.

At a suitable distance above the injector nozzle a rubber stop valve plug with cruciform slits, such as a tulip plug may be optionally inserted in the bore hole. This valve plug permits the resin mixture to pass upwardly into the overlying strata yet prevents back seepage out of the bore hole opening when the injector is withdrawn. Beyond the valve plug, if desired, the fluted or polygonal elongated plug may be inserted which readily allows resin to channel therepast within restricted ducts, to insure complete mixing of the resin mixture, and into the voids and cracks of the overlying formation.

To perform the injecting operation, a bore hole of suitable diameter (e.g. 1½ inch) and depth (e.g. 6 feet) is first drilled and the roof surface area surrounding the hole is then smoothly faced off. The elongated plug or filler, if desired, is inserted into the hole and thereafter the rubber valve plug. Of course, if capillary action and viscosity of the resin mixture are sufficient within restricted ducts, the valve plug may be omitted. The roof prop is then installed with the injector nozzle inserted within the bore hole opening and the flange in abutting contact with the smoothly faced off roof surface thereat. Upon tightening the roof prop in place by the screw jack or hydraulic jack mechanism, the resin and catalyst may be simultaneously injected under pressure. Metered pumps may be used to ensure proper proportions of resin and catalyst. The roof prop may thereafter be removed as soon as at least partial curing of the resin has taken place. The elongated plug and valve plug are left within the hole.

Alternately, the stop valve plug may be releasably mounted on the dual nozzle of the injector for insertion into the bore hole. In this way, after injection of the resin through the plug, the injector may be removed, the valve plug remaining in snug sealing engagement with the wall of the bore hole so as to prevent downward resin seepage.

Referring to FIG. 1, a roof prop **1** is shown in a mine tunnel having a jack **2** at its lower end resting on the mine floor **3** for adjusting the prop height and a resin injector **4** at its upper end. Catalyst supply duct **5** and resin suply duct **6** are searately provided for the injector. The injector **4** is placed in sealed abutment with bore hole **7** of mine room **8** via supporting flange **9** upon expanding the length of the prop **1** at jack **2**.

FIG. 2 shows the resin injector **4** having a separate inlet channel **10** for catalyst and a separate inlet channel **11** for resin. Within injector **4**, the main channel **12** for resin is concentrically disposed with respect to medial channel **13** for catalyst, these channels being separated by tubular portion **14** to eliminate clogging which might otherwise take place if the resin and catalyst were intermixed in a common duct. Tubular portion **14** is closed at its upper end but is provided around the periphery of its upper end with a plurality of radial openings **15**. As resin emerges from the nozzle of the injector, it is thereby intermixed with catalyst emanating from openings **15** under the injection pressure maintained and is forced in admixture into the bore hole. To prevent leakage around the nozzle of injector **4**, the supporting flange **9** is provided with a soft gasket **16**, such as a thick rubber gasket, along its upper surface which is brought into compressed sealing engagement with the roof surface area around the bore hole opening as jack **2** is extended. Gasket **16** may be suitably provided with annular serrations in its upper surface for improved sealing effectiveness.

A dome-shaped stop valve plug **17** with cruciform slits is optionally provided within the bore hole **7** which allows the resin mixture to pass upwardly therethrough but upon removal of the injector **4** prevents back seepage out of the bore hole opening. The valve plug **17** is preferably made of rubber.

Additionally, fluted or polygonal filler or elongated plug member **18** may be inserted along the entire extent of the bore hole above valve plug **17** to ensure intermixing along the restricted channels thereby formed and to effect a significant saving in resin material. FIG. 3 illustrates the restricted channels **19** between the rock **20** surrounding the bore hole and a wooden plug **18*a*** of octagonal cross-section.

In FIG. 4, an alternate embodiment is shown wherein the outer nozzle ring **21** is provided with a dome shaped tulip plug **17*a*** adapted to sealingly engage the surrounding bore hole wall. Plug **17*a*** is fitted over the inner edge of ring **21** and seated thereagainst so that it may be forced within the bore hole by upward movement of ring **21**. Upon completion of the injection operation, plug **17*a*** remains in sealing engagement with the surrounding wall of the bore hole even after ring **21** is dislodged therefrom and removed from the opening. The cruciform or tulip incisions in the dome of plug **17*a*** form petals which may be displaced upwardly and outwardly by the oncoming resin mixture under pressure, permitting free flow. However, these petals cannot be displaced downwardly past the normal position indicated in FIG. 4 because any downward force thereagainst only causes the petals to close together more tightly, thus preventing seepage and resin loss.

In accordance with the preferred embodiment of the invention where an epoxy resin is used, it is either mixed with a catalyst or a reactive hardener for the resin. Thus, one injector duct would carry the catalyst or hardener, and the other would carry the epoxy resin so that the desired pre-mixing would take place outside of the injector itself. Examples of catalysts which may be used with the epoxy resin are: tertiary amines, and boron tri-fluoride. Examples of reactive hardeners which may be used with the epoxy resins are: primary and secondary amines and preferably aliphatic amines.

In addition to epoxy resins other thermosetting resins, such as polyester resins, in liquid or flowable form, may also be used. Where a polyester resin is used a three-component mix is provided including the resin, a catalyst, and a promoter therefor. In this case one injector duct would carry half of the resin with all of the catalyst premixed therewith while the other injector duct would carry the other half of the resin with all of the promoter premixed therewith. Consequently, this ensures a more thorough mixing of the three components while at the same time avoiding any polymerization within the ducts of the injector itself.

Examples of catalysts which may be used with the polyester resin are: benzol-peroxide with tri-cresyl phosphate, di-butyl phthalate with cyclohexanode peroxide, and the like; while examples of the promoter which may be used with the polyester resin include: styrene monomate with cobalt naphthenate, styrene monomate with di-ethyl analine, and styrene monomate with di-methyl analine.

In the case of either the epoxy resin or the polyester resin, the proportions of resin and catalyst and/or promoter depend upon the particular chemical properties, the working temperature and the desired time of polymerization involved. In general, however, the time of polymerization or hardening can be substantially reduced where the final mixing of the particular components is achieved after they leave the injector ducts.

What is claimed is:

1. Method for stabilizing a mine formation containing voids and cracks, which comprises injecting a hardenable binder material component under pressure into a bore hole communicating with said voids and cracks while simultaneously separately injecting into said bore hole under pressure a catalyst component promoting the hardening of said binder material component, one of said components being injected in annular flow into the bore hole and the other of said components being injected in radially outward flow into such annular flow for said separate simultaneous injection of both the binder material component and the catalyst component into said bore hole, and thoroughly intermixing said binder material component and catalyst component under pressure within said bore hole along their common path and conducting the intermixed binder material and catalyst components along said bore hole to said voids and cracks.

2. Method according to claim 1 wherein the binder material component is an epoxy resin.

3. Method according to claim 2 wherein said resin contains an agent capable of initiating the solidification thereof.

4. Method according to claim 3 wherein a reactive hardener is used in place of the catalyst component.

5. Method for stabilizing a mine formation containing voids and cracks which comprises inserting a filler material within a bore hole communicating with said voids and cracks, said filler material providing at least one restricted path in flow communication with the surrounding wall of said bore hole, injecting a hardenable binder material under pressure into said bore hole while simultaneously separately injecting into said bore hole under pressure a catalyst promoting the hardening of said binder material, and conducting under pressure said binder material and catalyst along a common path within said at least one restricted path and said bore hole to said voids and cracks while intermixing said binder material and catalyst along said common path, whereby said binder material and catalyst being conducted pass along said at least one restricted path and are at least partially intermixed within said restricted path.

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