April 9, 1946. Z. S. BEIJL 2,398,130

ROOF OF COLLIERY OR OTHER WORKINGS

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Fig. 1.

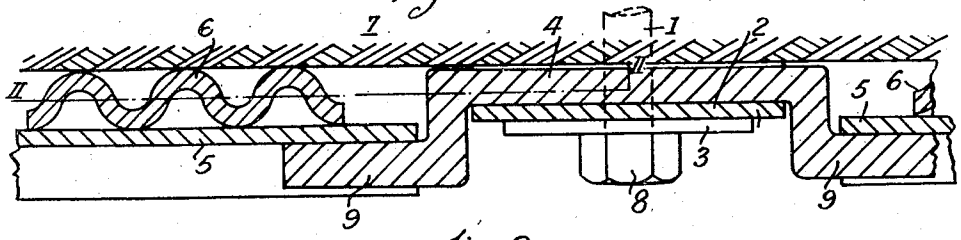


Fig. 2.

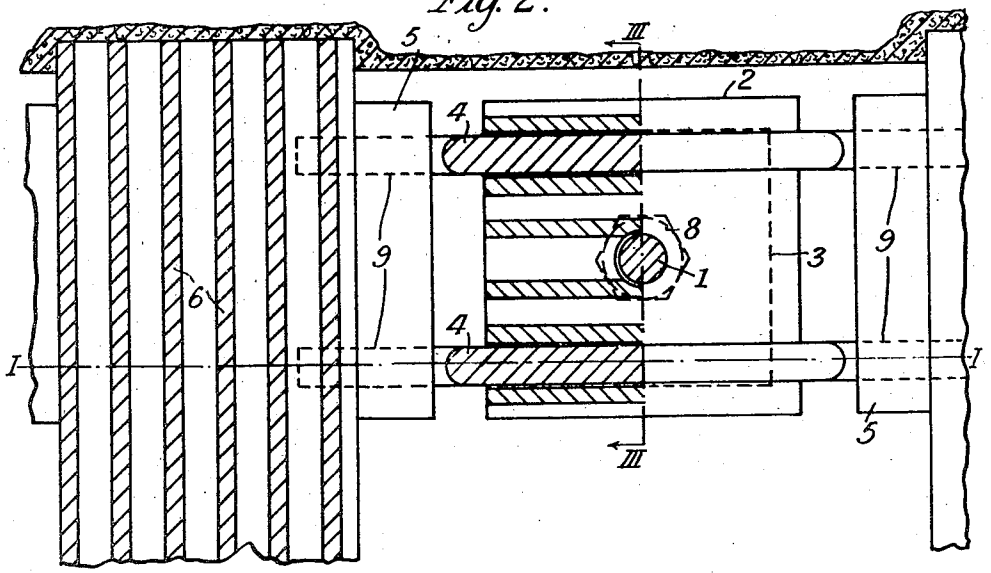
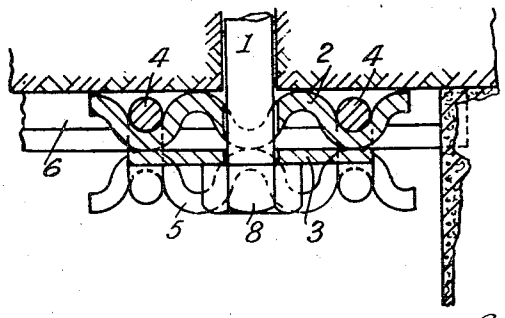


Fig. 3.



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Fig. 4.

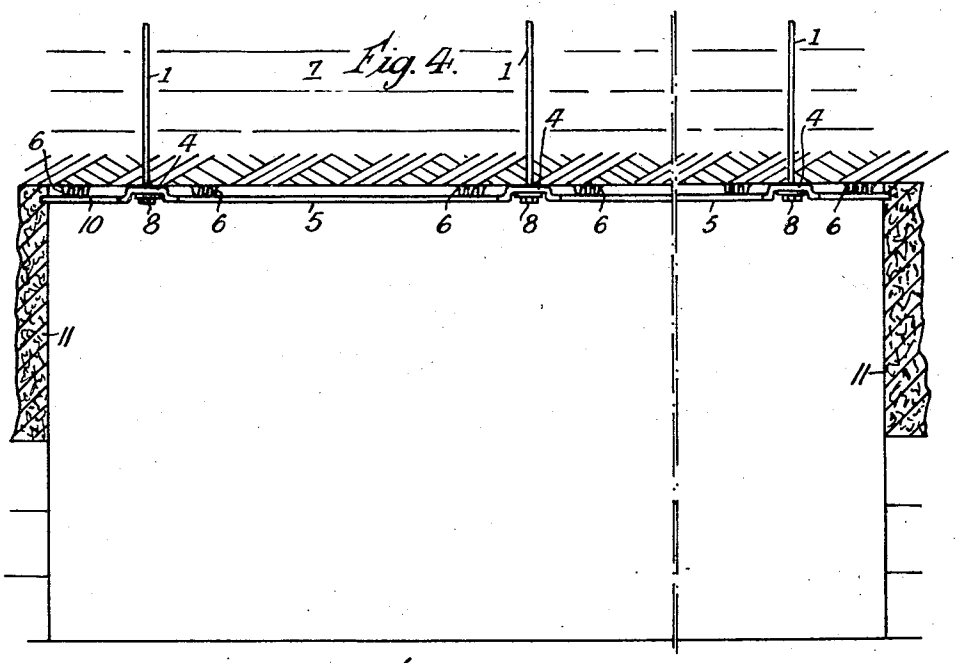
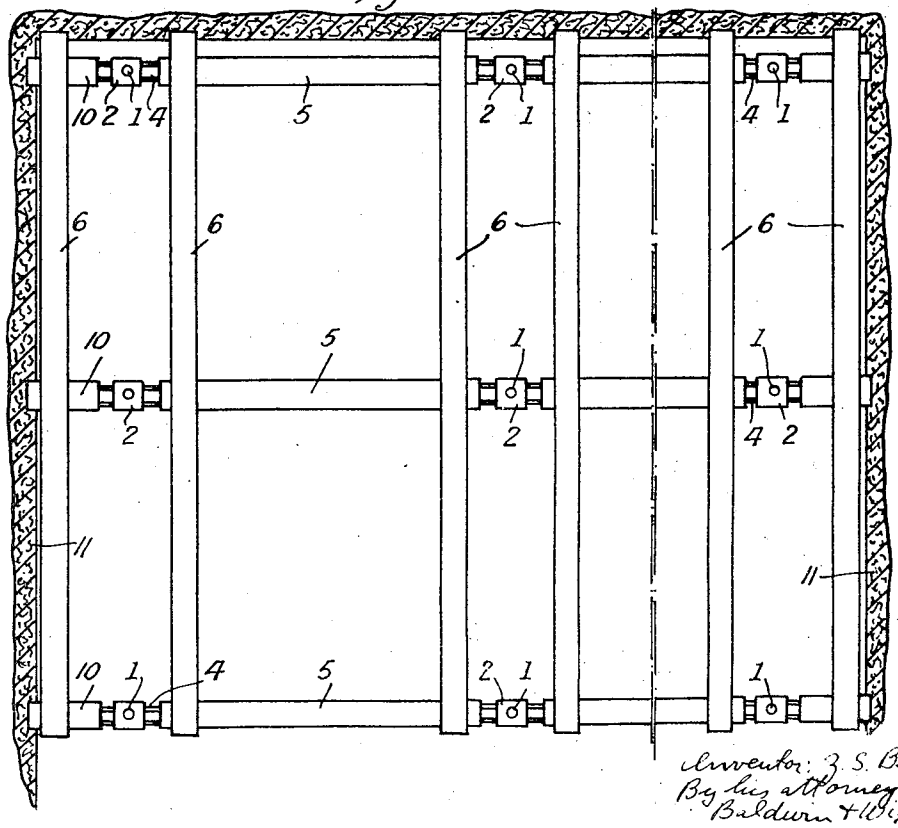


Fig. 5.



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Fig. 6.

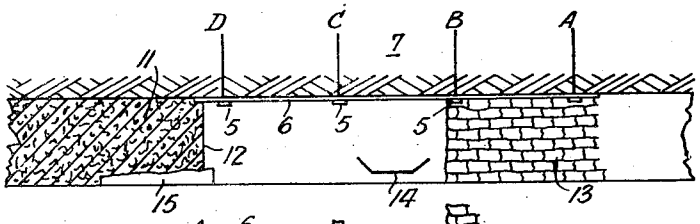


Fig. 7.

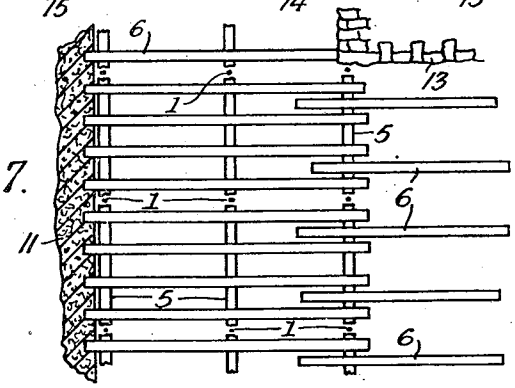


Fig. 8.

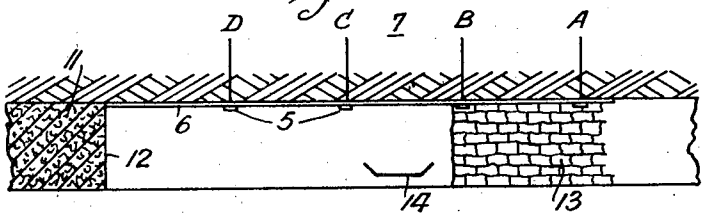
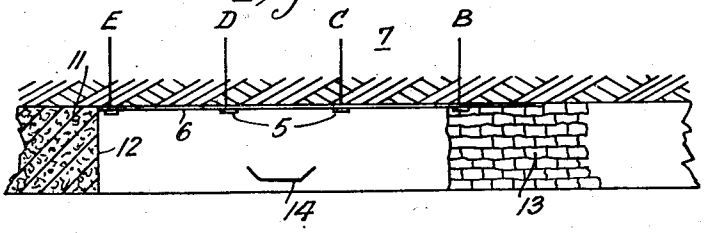


Fig. 9.



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Patented Apr. 9, 1946 2,398,130

UNITED STATES PATENT OFFICE

2,398,130

ROOF OF COLLIERY OR OTHER WORKINGS

Zako Sytse Beijl, London, England

Application January 4, 1943, Serial No. 471,280
In Great Britain December 16, 1941

3 Claims. (Cl. 61—45)

This invention relates to the roofs of colliery or other mineral workings. A seam of coal or other mineral deposit may be part of a plurality of strata or may be covered by such strata and contains planes of weakness. These strata are generally in a heavily strained condition, the reaction of the strain being a stress. This condition is referred to as "pre-stressed" and usually the stress is not beyond the elastic limit of the individual material. Breaks, cracks and joints (cleat) of greater or smaller extent may have been produced in such series of strata by geological or seismic occurrences, but as long as the mineral seam remains intact, the equilibrium of the strata as a whole is not disturbed.

As soon, however, as the mineral is extracted, either in development work or in full exploitation, irrespective of the system or method of extraction which is employed, the equilibrium is disturbed in the mineral deposit and in the superincumbent and subjacent strata, the strain will be relieved and those layers begin to expand in order to re-establish equilibrium. Initial breaks may occur in the most irregular manner, especially in such strata as have inclusion of irregular form or of different material, e. g. ironstone nodules in clay stones. This movement is usually checked or retarded by leaving supporting pillars of the mineral, or by the employment of props, packings, or other means resting on the floor of the mineral deposit, but this expedient amplifies the disequilibrium of the whole complex of strata. The final result is continually increasing movement between the strata in the region from which the mineral has been extracted, together with inner molecular displacements and bending, twisting and disintegration of those strata.

Such movement is a source of direct and continually increasing danger both to the workings and to the workmen. Mining practice deals largely with means for combating this danger, and up to the present time the means adopted have been various forms of external support, i. e. supporting means which are placed underneath the roof strata and rest upon the floor of the mineral deposit or the part serving as such.

It is obvious that these supports cannot be placed in position at any given place until after the mineral has been loosened and removed from the new face. This removal, however, takes time. It is during this time that the immediate roof strata of the newly exposed face start to work, because locally their strain is relieved (quarrymen call this "strain breaking") and endeavor to regain their natural volume, which they have not previously had, since they originate from accumulation and petrification of sand, clay and other substances deposited in water under pressure. And thus it is precisely under the newly exposed part of the roof and in front of the new face that the getters, hewers, machinemen and others have to work without sufficient protection.

It therefore follows that the safety appliances heretofore generally in use cannot be applied until after dangerous movements in and between the various strata (in cases in which these are liable to occur) have already commenced. In other words, these safety appliances are frequently not applied until it is too late and the original strain opposing movement along any existing cracks, breaks or joints has diminished, giving rise to possible initial disintegration of the roof and floor strata as well as of the mineral itself surrounding the cavity made in the deposit.

Moreover, the safety appliances heretofore generally in use permit a certain degree of displacement between the roof strata, which also weakens the roof and constitutes an increased source of danger for the men who have to work beneath it.

However, it sometimes happens that, whether according to M. P. Rudski's theory of diminution of elastic force in such strata in course of time or by slow or sudden seismic phenomena, the strain in the strata has been locally relieved and even a certain amount of disintegration has already taken place before the mineral is taken out.

A special case sometimes occurs in coal seams which have been affected by the previous exploitation of another coal seam, more or less adjacent. In addition to strain relief and initial breaks in the intermediate strata, local separation may have been produced between two adjacent strata. It is obvious that in such a case removal of coal underneath gives much quicker freedom of movement to a roof stratum already separated from the one immediately above than when contact had not been already lost. Such dislocations have more or less the form of blisters, and they will with certainty become enlarged in the lateral sense as soon as the coal underneath is undercut or removed. Props and all the supports at present in use can never prevent such lateral extension.

The risks to which a miner is exposed, due to falls from a stratified roof, would be greatly lessened if the falling of the roof could be retarded, even if it were not found possible or desirable permanently to prevent such falls.

The object of the present invention is to oppose the free relief of strain by providing means for maintaining the strain existing in the strata and thus continuing the conditions of pre-stressing in the various strata.

My invention therefore comprises the method of securing the roof of an underground working having a stratified roof such as in a coal mine which consists in securing together a suitable thickness of the strata constituting the roof by means passing therethrough. In one way of carrying out the invention this is effected by drilling holes through the roof strata to a depth of, say, 2 feet 6 inches and placing therein bolts or ties by means of which the successive layers are clamped together. The alignment of the holes and their spacing should be in agreement with the existing timbering rules in regard to placing props. Once the bolts are in position the mineral already broken or shot down can be removed and hauled and a new cycle of work on the new face can be carried out without danger for the miners. By this means the immediate roof strata can be held temporarily or permanently in a reinforced state, which opposes strain relief, subsidence or breaking up of the roof strata and also prevents any inner separation from spreading. In effect a number of successive layers of the roof are formed into a "composite" stratum constituting one thick layer, which is analogous to a beam which a carpenter makes from planks, using bolts, nails, screws or feathers to prevent the planks from sliding relatively to one another when the beam is loaded to such an extent as to cause it to bend. There is, however, this difference that the elements of the beam are not pre-stressed, a factor which provides an added advantage in the method of the invention.

The invention is illustrated by the accompanying drawings of an embodiment, in which:

Figure 1 is a sectional elevation of a portion of roof reinforcement taken on the line I—I of Figure 2,

Figure 2 is a sectional plan of the same taken on the line II—II of Figure 1,

Figure 3 is a cross-section of the same taken on the line III—III of Figure 2,

Figure 4 is a section corresponding to Figure 1 but on a smaller scale to show the general arrangement of reinforcement in bord and wall working or over a road,

Figure 5 is a plan on the same scale as Figure 4 looking down from the underside of the roof,

Figure 6 is an elevation showing how the invention may be applied to the long wall system,

Figure 7 is a plan corresponding to Figure 6, and

Figures 8 and 9 are similar views to Figure 6 showing further stages of progress.

Referring first to Figures 1 to 5, bolts 1 of suitable length are inserted in holes previously drilled in the roof 7 at suitable spacings. The upper ends are not shown but are provided with means for automatically gripping the top ends of the holes when tension is applied by tightening the nuts 8. The bolts may for example be of the kind having expansible ends or shields, which, after being placed in position, are automatically expanded to engage the walls of the holes when the nuts are tightened up. Such bolts are disclosed in British patent specifications Nos. 444,623 and 538,709.

A corrugated washer 2 is threaded on to the bolt 1 to bed against the roof surface, and a flat washer 3 is interposed between the nut 8 and the corrugated washer 2 to distribute the pressure over the corrugations. Two saddle hooks 4 are placed in corrugations of the washer 2 one on each side of the bolt 1 and have offset horizontal portions 9 at both ends, upon which the end of a corrugated bar 5 rests. The other end of each bar 5 rests on a similar pair of saddle hooks supported by the next bolt 1.

Cross bars 6 are laid across the bars 5 as shown in Figure 5. These bars are also corrugated for strength. In Figure 5 they are shown as spanning three of the bars 5, but they may span two or more than three as may be found suitable in regard to the convenience of manipulation. It is convenient to place the cross bars 6 as close to the bolts 1 as is permitted by the parts 2, 3 and 4, but the bar 6 nearest the coal side is preferably placed as near as possible to the coal, being supported on shortened bars 10 similar to the bars 5 but which have one end of each needled into and resting on the virgin coal, as shown in Figures 4 and 5.

A scheme of operation will now be described by which the invention may be applied to the long wall system of coal cutting. Figures 6 to 9 show various stages in the cycle. The bolts 1 are set in rows parallel to the coal face 4' 6" apart with the bolts 5' 0" apart in the rows. Successive rows are indicated by the references A, B, C, D, E. The bolts are 2' 6" long. As may be seen from Figure 7, in which the parts 2, 3 and 4 are omitted for clarity, there are four cross bars 6 between successive bolts 1 next to the working face but only two over the goaf. Incidentally Figure 7 shows how the bars and cross bars may be assembled from short lengths to form a continuous roof support of any length.

The virgin coal is shown at 11 with the working face at 12. A pack is built up at 13 as the work progresses to maintain an access road, and a conveyor 14 runs parallel to the coal face 12.

On the night shift a cut 15 is made with the coal cutter at the base of the seam 11, and where deemed necessary holes are drilled in the roof behind and in advance of the cutter, and reinforcing bolts 1 are inserted with accessories as described above. Also packs 13 are built up to retain the roads when the remainder of the roof is allowed to subside over the goaf. Figures 6 and 7 show the position at the end of the night shift.

On the day shift the getters remove the coal and carry out forepoling by moving the cross bars 6 forward till their forward ends are needled into the virgin coal along the roof line. The position is then as shown in Figure 8 with the coal face 12 one stage further forward than in Figure 6.

The work of the afternoon shift comprises various operations. Firstly there is the stripping of the roads, either floor or roof as may be considered desirable. Then a new row of holes is drilled at E to take a fresh set of bolts 1 and bars 5 just in front of the new face 12, and the reinforcement is assembled and fixed in place. If necessary the completion of the reinforcement can be left for the following night shift.

The next operation is to shift the conveyor 14 to follow up the removal of coal by the day shift. At the same time the sprags wanted during the night shift should be re-assembled and placed along the conveyor in front of the points where they will be wanted in order to obviate loss of time and irregular placement. Then the back line of reinforcement is removed and also the bolts in the row A, which are already between

the packs 13. The position is then as shown in Figure 9. It will be clearly seen from the drawings how the men are protected by the cross bars 6, which act as a kind of reversed forepoling.

Although the drawings show bolts 1 of equal length, it may often be desirable to use some bolts which are longer than others. For instance every other bolt or every third or fourth bolt might be a longer one than the rest. In certain positions, especially in permanent positions, e. g. over main roads, the bolts may be grouted in. Of course the bolts themselves could not then be recovered when that part of the pit is abandoned, though the bars and washers could be removed.

In certain cases, particularly if the lowest roof stratum shows a tendency towards shattering, extra and denser cover may be laid upon the web of bars and cross bars. This cover may be in the form of bars running in one or more directions, or wire netting can be used in certain cases.

One of the advantages of the novel method of supporting the roof is that the bolts or other means used for the purposes of the invention are closely surrounded by the strata over their whole length and are thereby prevented from bending or buckling, as generally occurs in the case of props. Props, moreover, are liable to slip under off-centre loading just when stability is most required.

Moreover, if, after a bar, washer or like member has been drawn into contact with the roof by means of a bolt, the roof sags a little, which can only happen if the bolt is elongated, the bar or like member will remain as effective as when it was first secured in position, and will not bend, break, or become useless, even if the roof sags still further.

Another great advantage of this method of supporting the roof is that the supporting means can be applied immediately after the mineral is broken down and before its removal, that is as soon as a new part of the roof and a new face have been exposed and before subsidence of the roof has started. The absence of pit props is also a great advantage, as the whole width of the working is free of obstructions.

A further advantage is that the bars and washers can always be recovered intact, and, if using expansible shields, the entire reinforcement can also be recovered, permitting the roof to subside or collapse at the desired time and in the desired manner.

In first applying the invention it may occur that the miner, who is actually accustomed to working in a propped place would feel uncomfortable or unsafe when he has to enter an open face for the first time. Even when reinforcement of the roof strata is applied and the bars with cross bars are fixed to the roof, props can be placed under the latter. In course of time, however, the miner will observe that such props do not function and are practically useless and hence superfluous. From that time the miner will himself desire to dispense with the props.

Still another advantage is that the reaction of any subsidence of a reinforced roof is not directly transmitted to the floor underneath, as always happens with propping, causing local and very irregular pressure on the floor strata. This local and irregular pressure has a very unfavourable influence on the phenomenon of convergence, with its disagreeable, dangerous and disturbing effects on the regular process of the work in a colliery, especially where flat seams are being worked and is rather common experience in the United Kingdom.

Yet a further advantage of the invention accrues in the case of strata which have already been wholly or partly relieved of strain, even where roof separation has taken place locally. In such a case the reinforcing bolts or other means pierced through both the strata and the open space effectively oppose all lateral extension of the latter.

Finally, the advantage may be mentioned that, if the immediate roof strata contain baumpots (petrified trunks of prehistoric trees) and similar inclusions, which always fall out of the roof a short time after it has been exposed as a consequence of loss of cohesion in the strata, such parts will remain locked in the immediate roof stratum and it may even be possible to drill holes through such pieces without danger for the driller working under the web or steel bars and cross bars held against the roof.

What I claim is:

1. A reinforcing system for securing the pre-stressed stratified roof of an underground working comprising bolts adapted to be held in holes drilled in the roof, bars with corrugations running longitudinally thereof, a corrugated washer on each bolt, two saddle hooks resting in corrugations of each washer one on each side of the bolt, and other bars with corrugations running longitudinally thereof for laying across the first bars and adapted to be held against the roof by nuts on the bolts, the reinforced roof comprising a plurality of successive pre-stressed strata which are secured together and are held against lateral sliding or shifting relatively to each other.

2. In a safety roof for an underground working employing corrugated roofing material, a suspending mounting for the material comprising a washer, having grooves in the upper surface thereof, an element suspending the washer from the natural roof of the working, saddle hooks occupying and positioned in said grooves, said saddle hooks having portions extending downwardly and then offset laterally outwardly and disposed beneath and in supporting engagement with the roofing material in adjacent corrugations thereof.

3. In a safety roof for an underground working having corrugated roofing material bedded against the natural roof of the working, a suspending mounting for the material comprising a washer in bedded engagement with the natural roof of the working having parallel grooves in the upper surface, a bolt passing through the washer between said grooves suspending the washer from the said natural roof of the working, a head on the bolt beneath and in supporting engagement with the washer, saddle hooks occupying and positioned in said grooves, said saddle hooks having portions extending downwardly relatively close to adjacent edges of the washer and then offset horizontally and outwardly and disposed beneath and in supporting engagement with the roofing material in adjacent corrugations thereof.

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