In mining coal seams lying at considerable depth beneath the surface the engineer is confronted by difficulties not present in shallow mining. Modern American mining practice requires large output as the first prerequisite of a successful mining operation, for without this it is impossible to mine at a cost per ton low enough to compete with the more shallow mines.

As depth is reached in any coal-field the quantity of explosive gases given off by the coal increases rapidly, requiring a larger quantity of air to properly ventilate the workings. This is the problem of greatest importance, how to supply adequate ventilation, for without abundant ventilation it is impossible to open and work enough rooms or chambers to produce the desired output.

As the depth increases, the roof of all coal-beds, being subjected to greater pressure from the increasing mass of overlying rocks, is more likely to fail, and in deep mines we generally have what the miners call a "bad roof," although the roof may really be a very good one but unable to stand the enormous pressure which comes upon it.

A "bad roof" means increased cost of working, for not only does the roof break and fall in the rooms or working places, but on the main haulage roads and airways as well, involving heavy expenditures for timbering, for the renewal of timber, and for labor in clearing away such roof-falls.

Again, as depth is gained, the risk of closure of the workings by "squeezing" or crushing of the pillars of coal left to support the roof, rapidly increases with the increasing weight of the overlying rocks.
The three important problems presented by deep coal mining then are:

1. To provide ample ventilation, which may be increased as the area of the workings enlarges.
2. To reduce the cost of maintenance due to roof-falls, especially roof-falls on gangways and airways.
3. To limit the possible damage from "squeezing" and to prevent "squeezes" from closing the main haulage roads and airways.

Several systems have been devised and used for providing adequate ventilation under such circumstances (among which may be noted the "Three Entry" system which is largely used), but they all are open to serious objections.

These systems generally use the main haulage roads as intakes for the ventilating current, and these must then be driven very wide to give the necessary cross-sectional area of airway, thus increasing the cost of timbering, and risk of damage from roof-falls. To secure additional area the return airways are either driven double (as in the "Three Entry" system) or of large cross-sectional area, which is objectionable, not perhaps because of increased roof-falls, but because of increased first cost, and a slower rate of developing new territory.

The risk of damage to main roads and airways by "squeezing" is now generally guarded against by leaving a thick pillar of coal separating these from the working places, this pillar being broken only by necessary openings for roads or airways.

It is evident from the outset that the only way to reduce the cost of maintenance of the main haulage roads, and save timber, and the delays and accidents incident to roof-falls is to drive these haulage roads as narrow as possible. It often happens that a gangway 9 or 10 feet wide may require no timbering, the roof standing for years, while if driven 14 feet wide it might require heavy timbering throughout or give constant trouble from roof-falls.

Now, if the main haulage roads are driven narrower to save timbering, cost of maintenance, and delays and accidents from roof-fall, it is evident that they cannot be used
as the main intakes for ventilation, as they will be too small to carry the increasing volume of air required as the workings extend to long distances from the shaft.

The system described below which has been devised to overcome these difficulties should effect a considerable economy in timber, maintenance, operation and first cost of dead work, in addition to providing facilities for efficient ventilation, and reducing the risk of accidents from roof-falls, transportation and explosions. I will attempt only a description of the principal features of this mining method, the details of application of course varying with the conditions present.

The main haulage road (with its airways), whether this be a water-level gangway, a slope to the dip, a plane to the rise, or a face entry driven across the dip, is driven ahead into the new territory, as in present practice, and the water-level gangways or butt entries (each with its airway), from which the chambers or rooms are to be opened, are located at intervals of 300, 400, 600 feet or more as desired.

This main haulage road and airway are driven as narrow as possible to prevent failure of the roof and save timber, a good pillar of coal being left between, broken at intervals by small cross-cuts, such as are essential for ventilation while they are being driven.

Upon driving the desired distance, a water-level gangway (or butt entry) and airway is opened to right and left, and from these, on each side, two rooms or chambers are opened and work back to the last gangway. These rooms or chambers are driven parallel to the main road and airway, an unbroken pillar of 30, 40 or 60 feet separating the first room from the road or airway and a pillar of good thickness separating the two rooms on each side. When these rooms are worked back to the last gangway and holed through, we have, in addition to the first two openings driven, that is, the main road and airway, four wide parallel roads or airways. The outside room on each side is used as a return airway and the inside rooms as intakes, and the original main road and airway are also used as intakes.

The inside rooms may be driven 16 or 18 feet wide and the outside rooms 22 to 28 feet wide.
The inside rooms, in addition to their use as intake airways, are also used as manways or travelling ways, so that miners need travel neither along the haulage road nor in the return airways.

A thick barrier pillar of coal is left beyond the outside rooms, separating these from the working places to protect these airways and the haulage road from damage by squeezing.

This system gives four straight and continuous intakes and two large return airways throughout the length of the main haulage road. The mine workings on each lift or gangway are ventilated by a separate split taken in through the gangway and workings, and returned through the airway to the main return.

The two intake chambers being used as travelling ways may require center props. The main haulage road will require little if any timbering unless the roof be very weak.

In the absence of a diagram and to simplify the description as given above, the method may be described as a modification of that in ordinary use where a barrier pillar is left on each side of the main haulage road and airway, to separate these from the rooms or working places, this modification consisting of transposing a pair of rooms on each side of the barrier pillar from a position outside this pillar to a position inside the pillar, and locating these pillars a corresponding distance away from the main haulage road.

**BOOK NOTICES.**


The present work is intended by the author as an aid to engineers engaged in the designing and construction of works and machinery for the utilization of water for power transmission. The author disclaims the idea that his work deals adequately with all the problems arising in the practice of hydraulic engineering, but he has made a satisfactory attempt to present in intelligible form a description and discussion of the essential features of the subject as they will be called into requisition by the needs of the hydraulic engineer.