Photographic records of outstanding features showing the effects of pressures in mines and various designs of mine supports.

Illustrations accompanying Thesis for the degree of Ph.D. submitted by William Reid B.Sc.
1. **ROOF FRACTURE.**

This view is taken in L.1 seam Colliery No. 11 where the roof consists of a massive sandstone 60' thick. It breaks periodically, every three days or so, near the face, but steel props 5" O.D., \( \frac{1}{8} \) thick and numerous hardwood chocks keep the face open. The roof lowering on the waste side of the fracture is \( 4\frac{1}{2}' \) more than on the face side. The floor consists of 12" of soft fireclay which offers small resistance to props, chocks and packs. This, together with the difficulty in obtaining sufficient packing material (as it has to be blasted) is the primary cause of the formation of the periodic breaks.

2. **A COLLAPSED WASTE.**

This view shews the roof at the position seen in View 1 after it has collapsed in the waste. This stone measured 40' long and was 5' thick. The waste stone in this seam has to be bored by compressed air and blasted to provide packing material, as it falls in large masses.
3 & 4. ROOF BREAKS.

In seam L.1 Colliery 8 roof breaks are formed daily parallel to the face. Their distance apart is about equal to the depth of the undercut.

View 3 shews a break 3' from the face with a displacement of about 2". The two props seen are set 3'6" apart and the 4'6" long strap overlaps 6" at the face side.

View 4 shews a break formed 4½' previously. Its displacement is about 6". The prop seen was set with the strap overlapping at the waste side. Consequently the strap has been bent and the prop is being forced out.

The foreground shews coal travelling down the conveyor.
5. A SERIOUS ROOF BREAK ON A FACE LINE.

This is a view taken in seam L.1 Colliery No. 11 where the roof is of massive sandstone and the floor is of soft fireclay. Packs 15' wide were arranged with 40' waste spaces. Chocks were erected at the waste line at 12' intervals, and the props had contact areas to the floor of about 20 sq. ins.

Large masses of sandstone had to be removed from the face of this break to allow operations to continue at the face.

Conditions have been greatly improved by the erection, before coalcutting, of chocks between the conveyor and the face, and though fractures are still evident, their displacements are greatly diminished.

6. ROOF COLLAPSE IN THE WASTE.

In Colliery No. 7, seam L.1 there is a strong sandstone floor and the resistance of the packs, props and chocks is fully developed as only a small amount of penetration is possible. The rate of convergence is less than in the same seam in Colliery No. 11 and much better roof control is obtained. The massive sandstone roof falls more regularly in the waste and no periodic "bumping" takes place.
7. **STEEL PROPS ERECTED TO A FRACTURED ROOF.**

This view is taken in seam J.1 Colliery 9. Coal has been extracted from a seam below, and fractures are already formed in the strata before seam J.1 is worked. Care has to be taken to ensure that the supports on this face are as effective as possible to reduce further damage to the beds to a minimum.

Notwithstanding every precaution, such roof conditions as shewn cannot be avoided but steel supports give a greater degree of safety than wood supports and the face is more likely to be kept open.

8. **ROOF COLLAPSE IN THE WASTE.**

Even where the roof condition is abnormal, regular well controlled collapsing of the roof in the waste can be obtained. This is a view on the same face as that above. The packs and props are effective and the effects of the previous working is minimised.
9. **A FALL AT A COAL FACE.**

In seam J.1 Colliery 8, it was found impracticable to instal steel props on the face due to the frequency of faulting.

Falls, though rare, occasionally occurred at faults while the coal was being cut. This view shews the result of a fall at which the props were swung out of position and broken.

On such a face where there are variations in heights, an extensible steel prop would prove useful.

10. **SUPPORTS AT A FAULT.**

This view is taken from the waste line on the same face as above shewing the variation in height mentioned. Faulting such as this does not allow a rigid system of support. Great care has to be exercised in the replacing of broken props such as those seen in these photographs.
11-12. **THE USE OF SIX FEET LONG STRAPS WITH A 4½' UNDERCUT.**

The coalcutter requires a space of about 2'6" between the front line of props and the face if the temporary removal of props is to be avoided.

The view 11 shews 6' straps in use with two props to each and overhanging the front line of props so that they abutt on or are needled into the coal, providing some support to the roof over the coalcutter space. This has been found particularly suitable where the roof is weak and friable or where there is liability of V-shaped breaks.
13. PROPS LEFT IN THE WASTE.

This view was taken 30 feet behind a longwall face in seam K. Colliery 3, where the waste spaces were small to protect an adjacent seam. The dirt rib in this seam was thrown into the waste but the debris seen in the foreground had fallen from the roof. Bed separation can be seen in the roof beds exposed by the fall.

Falls such as this shewed that the practice of leaving props in the waste was bad and they were withdrawn, but to preserve the roof beds, the waste space distance between packs had to be reduced from 20' to 14'. This change has proved effective.

14. A LONGWALL MAIN ROADHEAD.

This view is taken in seam K. Colliery 3, where the roof is of strong fakes about 18" thick with a bed of sandstone 3½" thick above. Wood bars are used as roof supports, the sides being strong. The long wood bar seen erected to the face of the brushing is set as a preventative measure in case an invisible fracture is formed in the sandstone, such as would lead to a portion falling off.
15. PROPS AND STRAPS IMPROPERLY SET.

The view shews joist props set with their flanges at right angles to the face line. The joist section is weakest in the plane parallel to the web and hence props of this section should be set with the flanges parallel to the face line, so that the props will develop the largest resistance possible before the buckling load is reached.

The straps shewn in the view overlap at the waste side. This overlap should be avoided as the falling waste may bend the strap and even cause the prop to fall towards the face.

16. A HARDWOOD CHOCK.

This shews a hardwood chock set on a hard floor with soft wood topping pieces to prevent damage to the chock pieces. The withdrawal device (Meco) is released by tapping up the keps seen protruding at each side.

This chock, with others, is set at the waste edge in K.seam 11 Colliery, where the adjacent roof parts from a massive sandstone above it. This separation was the cause of periodic "bumps" which crushed the coal badly and caused severe roof breaks both in advance of and behind the coal face. These breaks have been obviated by the use of the chocks at the edges of the waste.
17. **ROADHEAD SUPPORT.**

This view is taken at a roadhead in seam K, Colliery No.3, where a new conveyor face is being developed. The roadhead is specially supported by cross bars under the brushing close together so that adequate protection is afforded. This use of round wood bars or wood legs, however, is not the best practice as the contact area of the bars to the roof may be insufficient and also because the resistance of a round bar on a leg is not fully developed before considerable convergence has taken place.

On longwall face roadheads the usual practice is to set either steel channels or joists on steel prop legs under the brushing.

18. **TOP LONGWALL FACE ROAD WITH COAL SIDE.**

The view shows a road in seam H. 4' thick with a massive sandstone roof. This road forms the loading road for the next face to the rise. Arches are not used at this stage. It has been found that where arches are necessary as a support, there must be a good pack between the road and the coal side.
19. CRUSHED COAL AT A STOOP EDGE.

This view is taken in L.1 seam Colliery 9, where stoops 100 yards wide have been formed by driving 10' wide roads to a recognised boundary. The roof is of blaes and the floor of fairly hard fireclay. Little floor heave is observed except within a short distance in advance of the retreating longwall faces but crushing is noticeable on the roads near the face. The roads are supported by bars needled into the coal there being no side supports but it has been found necessary to use about 10 sets of 10' x 7' circle arches on the road to afford protection near the face. These arches are moved forward one at a time as the road is abandoned.

20. CRUSHED COAL DUE TO LOWER WORKINGS.

This view is taken in seam B Colliery 5 where seam A has been worked out from below. The 18' of intervening strata consists of 9' of blaes below 9' of sandstone. It is often found that the strata has fractured up to and through this seam. The view shews such a position where the coal has been badly crushed and displaced 8". Irregular horizontal as well as vertical fractures are formed. Where the lower coal has been worked more recently and packing has been effective, such displacements are seldom noticeable.
21. **THE USE OF THE CAMBER ARCH.**

This is a dipping road in G.1 seam, No. 11 Colliery. The cambers in use are of 5" x 3" section, 12' long, radius 20' and set on one side into the blaes roof of the seam and on the other on to a stone pack erected to give support at a fault line which followed the roadside for some distance. The view is taken about 200 yards from the face looking to the dip.

On the left side, one arch can be seen supported by a wood leg. The blaes at this side collapsed and the arch was re-erected as shewn.

Each arch was originally strutted by three wood props 4' long most of which have since given way and dropped out.

22. **THE USE OF THE SHALLOW ARCH.**

This is a view in the main road of a conveyor unit in S. seam; the depth is 576 feet; 14 Colliery. The supports in use are shallow arches of 5" x 3" joist section, 12 lbs./ft. 12' wide, with a 4' rise at the crown, made in halves and fishplated. Each arch is strutted by means of 4' by 2 1/2" x 2 1/2" x 5/8 angle iron struts connected by bolts. The arches are set 4' apart.

This seam has an immediate roof of soft blaes varying in thickness from 3" to 5'0". The seam itself is 42" thick. Above the blaes there is massive sandstone more than 20 feet thick. The floor consists of 9" of fireclay followed by 27" of blaes and then sandstone bands.

When circle arches were in use, it was found that the standard 10' x 8' arch with ample stilt protection required a minimum height of 10' for setting. This was at times found difficult as both the sandstone beds in the roof and floor were difficult to brush. As a consequence, many arches were not sufficiently protected by stilts and were unduly distorted.

Camber arches were tried but the blaes sides could not support them, and shallow arches as seen were installed. These rest on the roadside packs and have proved satisfactory. The view is taken in the direction of the face, but 130 yards from it.

The haulage is by direct rope.
This view was taken on the top roadway for a conveyor face having solid coal along the higher side.

Each pair of arches were strutted when erected 12 months ago, with six 4' long 4" diam. soft wood struts set in parallel lines. The struts were unseasoned and were wet. On a portion of roadway having 50 arches complete with 300 struts, there are now 135 struts still in position, the others having been broken or fallen out. Fortunately, the arches are not under severe pressure otherwise they would have been damaged. This is clearly seen in the main level where similar wood struts have dropped out or have been broken and the arches are considerably distorted.

Taken in Seam P Colliery No. 14

View 24 shews a recent portion of the same roadway with wood struts in position.
CROWN JOINT OF ARCHES ELEVATED.

This is a common form of failure, there being lack of crown load due to penetration at crown in a weak bed. The view is taken in L.1 seam No. 9 Colliery. The brushing is in banded sandstone with a wasted area above. The bands vary from 6' to 10' in thickness and lateral movement is prevalent. Out of 100 straight leg 10' x 7½' arches 5" x 3" joist section set at 4' intervals in this road, 60 had failed as shewn, 25 had failed due to lack of sufficient struts and 17 were slightly reduced in width at the feet.

Curved splay legged arches were introduced with flattened crowns and no distortion of any consequence can be observed on 65 arches now set.

All arches are set at the coal face on stilts.

A BUTT JOINT FOR ARCHES.

In many roadways the primary position of the failure of arches is at the crown.

This butt joint has been applied to an arch set amongst arches with channel fishplate joints for comparison and it is now after 12 weeks the only arch in the neighbourhood undamaged at the crown.
In seam H. Colliery No. 11 the method of working required that several roads to the rise be driven through wastes. The drivage was in dark banded sandstone.

The first road was through the waste of a conveyor unit which was worked before attention had been paid specially to packing. Great difficulty was encountered in the drivage as the new work disturbed the unstable strata and fresh movements set up severely damaged the arches erected.

The roadway seen in photo No. 28 was driven 200 feet behind the coalface, where the packing had been improved, and apart from several bent steel struts no damage has been done to the arches and the drivage was completed in much less time as the strata had consolidated and no fresh movement was noted.
29. CIRCLE ARCHES LACKING SHOULDERT CONTACT.

This view is taken in seam K. Colliery No. 11.

These arches are steel strutted, steel stilted and yet lack proper lagging on the rise side. They are being flattened at the crown, and pushed in at the feet. The spaces behind the shoulder can be seen. The remedy applied successfully is to place steel lagging behind or between the arches on the rise side and to fill tightly behind with small material. This is a common defect in circle arched roadways where a large floor brushing is taken.

30. LAGGING THE RISE SIDE SHOULDER OF CIRCLE ARCHES.

This view was taken on the road seen in No. 29, having a 6' thick floor brushing. The arches were previously severely damaged because of lack of shoulder contact. Out of 100 in a portion of the road further outbye, 86 are distorted due primarily to the above defect.

A form of steel lagging, "Strutlagging", was introduced between the arches as shown and the space behind was tightly packed with small material.

The arches so treated in this road are undamaged.
31. **FLOOR HEAVE IN ROAD.**

This view is taken in J. seam No. 9 Colliery where 10' x 7½' straight leg circle arches of 5" x 3" section were set on stilts at 4' intervals on the mid road of a longwall conveyor face some 9 months ago. The roadside packs were 12 to 15 feet wide built of sandstone bands from the roof brushing. The floor consisted of fireclay and was wet. The roof is of friable blaes. The stilts penetrated the floor and caused local heaving. This was followed by a general heaving of the floor which continued to the stage shewn in the print.

The packs were poor and the excessive load on the arches caused the stilts to penetrate the floor which had already been seriously weakened by the water.

The view shews a back brushing where circle arches with inverts were deemed necessary.

32. **ABANDONED ROAD WHERE ARCHES HAVE BEEN WITHDRAWN.**

The view is taken in seam P. Colliery No. 14 where brushing is done in mixed coal and blae beds, and is taken five months after the 10' x 8' circle arches have been withdrawn. Portions of the road are standing very well still measuring 9'6" wide but this portion shewn is gradually closing, the lateral movement being greater than the vertical. The roadside packs were not built tightly as no special attention was paid to them at this part. Wood can be seen protruding in all directions from them and some of the debris in the foreground is a portion of the pack material which has burst out.

No regular breaks can be seen in the banded sandstone roof. Convergence is continuing and the roadway at this part now measures 7½ wide and 5½ feet high. The arches withdrawn were not distorted.
33. FAILURE OF THE CROWN OF AN ARCH DUE TO DEPRESSION.

This is the second type of common crown failure. This view is taken in seam L. Colliery No. 9 where the brushing is in blaes about 5' thick to a sandstone bed. In this roadway out of 100 arches set at the face, 52 failed as shewn, due to lack of contact round the shoulders, 14 due to lack of struts, 11 to lack of sufficient protection by stelling. At a part of the road where the blaes was stronger, 23 arches were undamaged, because sufficient contact areas round the arches had been obtained.

34. THE USE OF HALF A CIRCLE ARCH IN STEEP SEAMS.

This view is taken in seam E. Colliery 5 where the roof is of soft blaes and the floor is hard. The half arch is set to the rise side and a wood extension is clamped to the crown. Special straight joist extensions with specially curved fishplate joints are in satisfactory use but the life of this road did not merit their use. This type of support has proved serviceable in inclinations greater than 18° and it is found that the arch is seldom damaged.
35. **ERECTING A CIRCLE ARCH.**

The view shews a road in seam K. colliery No. 11 where only a floor brushing is taken and the road is formed 12' in advance of the longwall face. The material for the rise side pack is obtained from the waste, and from the floor brushing for the dip side. The inferior coal seam is taken to the surface. In this case the immediate roof is of strong blaes 4' thick with weaker beds above. The floor beds are soft down to a strong sandstone bed 6' below the coal and prior to the floor being brushed to this level, there was considerable trouble with floor heave.

Where angle steel struts are used, they can be a considerable aid in the erection of circle arches as shewn. Even where the arches are large, as in this case, 12' wide by 10' high, two men can erect them.

At the rise side, the arches are steel lagged and small material is packed into the shoulder between the roadside pack and the lagging. This is important in preserving the arches from damage.

View 36 shews struts and steel lagging to the left.
View 25 shows the failure of the arches prior to the introduction of this design. These arches are in the main level of a conveyor unit in J. seam, with inclination of 1 in 3, Colliery No. 9. Four steel struts are in use as seen, it being considered after trial that others are unnecessary in this case. The arches are 10' wide and 7' high with dished channel fishplate joints.

View 37 shows the old and new shapes of arches on the same road. On the left, the old type is showing distinct indications of distortion due to side pressure.
39. **THE CURVED STEEL STILT.**

Curved stilts are a necessary complement to curved splay legged arches erected at the face. This view shews a curved stilt 3' long which has been damaged due to excessive roof movement at a fault. Severe weighting on the rise side of the roadway caused this girder to swing slightly to the dip side thus damaging the dip side stilt. This is the only curved stilt damaged out of about 750 in use.

A contributory factor damaging this stilt is the lack of support at the side of the foot of the arch.

40. **100 TON HORIZONTAL TESTING MACHINE.**

The view shews a test proceeding on a steel roof strap. This machine has a 1/2" ram and is worked hydraulically. Pressure is applied by a lever with a short stroke so that the rate of loading is nearly constant. Tests have also been made in this machine of wood and steel props between two vertical faces.
41. AN S.M.R.B. CONVERGENCE RECORDER.

The convergence records obtained for the work are made by instruments kindly lent by the Safety in Mines Research Board.

The recorder is of the direct measurement type, the lower portion having a telescopic action with a fixed rod carrying a pencil or copper stylo. The clock, which can be made to rotate at varying speeds by means of gearing, is enclosed in a dustproof case. Extensions to suit various heights can be screwed on to the tube portions as required. The instruments are accurate and durable in use.

42. DAMAGED STEEL PROPS.

(1) A single capped 5" x 4\(\frac{1}{2}\)" joist prop with the flanges bent over to form the cap. It has been found that this cap fails at the web at a load of 50 tons.

(2) A double capped 5" x 4\(\frac{1}{2}\)" joist prop as above with a \(\frac{1}{4}\)" plate inserted between the turned over flanges and the web. Similar failure at 62 tons has been noted.

(3) A single channel riveted capped 5" x 4\(\frac{1}{2}\)" joist prop which has failed in a plain, parallel to the web.

(4) A Paton double capped 5" x 4\(\frac{1}{2}\)" prop with failure as in 4.

(5) A 4" diam. \(\frac{1}{4}\" thick composite tubular prop with the metal torn at one end, possibly caused by core protruding too much initially and causing bursting.

(6) A 5" diam. \(\frac{1}{4}\" thick prop as in 5, but with failure due to tearing in withdrawal.