COLLIERY WORKING AND MANAGEMENT

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AND

MANAGEMENT

COMPRISING

THE DUTIES OF A COLLIERY MANAGER
THE SUPERINTENDENCE & ARRANGEMENT OF LABOUR & WAGES
AND
THE DIFFERENT SYSTEMS OF WORKING COAL SEAMS

BY

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AND

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With Underground Photographs and Numerous other Illustrations

FOURTH EDITION, THOROUGHLY REVISED AND MUCH ENLARGED

LONDON
CROSBY LOCKWOOD AND SON
STATIONERS' HALL COURT, LUDGATE HILL, E.C. 4
1925

PRINTED IN GREAT BRITAIN AT
THE DARIEN PRESS, EDINBURGH

PREFACE.

The years which have passed since the last edition of this book was published in 1912, have seen momentous changes in Colliery Working and Management.

Arising from the Great War, there were four years of Government Control, from the commencement of the year 1917 to the end of 1920; rapid alterations in miners' wages, in the cost of producing coal and its selling price; and in the years 1920 and 1921 serious disputes and stoppages of work which led up to a National Agreement for the regulation of miners' wages.

In legislation there have been the Minimum Wage Act of 1912; the Statutory Rules and Orders under the Coal Mines Act, 1911, issued on 1st November 1913; the Seven Hours Act of 1919; and other Rules and Regulations, as well as the Coal Mines (Emergency) Act of 1920; the Mining Industry Act, 1920; and the Mines Facilities and Support Act, 1923.

On the technical side the outstanding feature has been the progress made in the construction of coal-cutting machines, mechanical conveyors, hammer-picks and percussive machines, and in their practical application to underground work.

Much of the book has been rewritten, with the addition of a good deal of new matter and the statistics brought up to date.

An explanation of the National Agreement for the regulation of wages and the events which led up to it are incorporated in the chapter on "Labour and Wages."

The new arrangements of Hours and Shifts of Work following on the Seven Hours Act are set out. The Forms of Wages Bills and Cost Sheets, and of Daily and other Reports, are new, and much increased in number, as required by Government Regulations.

The considerable advance which has been made in machine mining has necessitated a complete revision of the chapter on "Tools and Appliances."

The chapters on "The Working of Two Seams near Together" and on "The Working of Thick Seams" have been enlarged by giving further examples of recent practice.

Without some account of Accidents and their Prevention, a book on Colliery Working and Management is hardly complete, and an additional chapter deals briefly with this subject.

The Authors hope that the work may continue to be of some service in promoting the efficient working and management of collieries.

THE AUTHORS.

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COLLIERY WORKING AND MANAGEMENT.

CHAPTER I.

EARLIER METHODS OF WORKING COAL.

WHEN one reflects that the British Coal Trade has been in existence for seven centuries—that coal has been worked in this country and sold as an article of commerce since about A.D. 1215, the date of Magna Charta, which gave security to the right of private property—one naturally inquires what progress has been made in the getting of coal during all these years, and what has been the process of development.*

The first step would doubtless be simple digging of the coal where actually exposed at the surface of the soil. In early times, in districts where only a few feet of overlying strata hindered access to the coal, small holes or shafts, 3 or 4 feet in diameter, were put down to the seam and then widened out, so as to allow of the excavation of as much coal as possible without causing the upper strata to fall in. These are known as "bell pits." That this method was followed in very early times is proved by the fact that pits thus fashioned were evidently made in some instances for the purpose of obtaining, not coal but

* Though the English coal *trade* does not date back earlier than the thirteenth century, coal was known and used long before this. About B.C. 371, Theophrastus, a pupil of Aristotle, mentions in a treatise "On Stones," fossil substances "that are called coals, which kindle and burn like wood coals." "These are found in Liguria and in Elis, in the way to Olympias, over the mountains; they are used by the smiths." This is probably the earliest mention of true coal (not charcoal) on record. The first record of its use in England is often stated to be in A.D. 852, when it is recorded that the Abbot of Peterborough received "twelve cart loads of coal," but it is doubtful whether the Anglo-Saxon word translated here "coal," does not mean "peat." See "The Archæology of the Coal Trade," by T. John Taylor (1852).

ironstone,* coal adjoining the ironstone having been left—showing that the work was done before the value of coal was known. In the "Buke of Boldon"—an inventory of the estates held by the see of Durham in 1183, when Hugh Pudsey was Bishop—the use of coal † is mentioned several times. The references to it are in connection with grants of land made to certain individuals for finding coals. This duty seems usually to have fallen to the smith, no doubt an important village functionary, who required coals "for the iron-work of the ploughs" made by him.

There is a very early reference to coal in Warwickshire in connection with Chilvers Coton, one Alexander de Compton accounting in 1275 for "36s. received for 1 perch of sea coal sold" there.‡ The following year he accounted for 103s. 4d. from 3 rods of sea coal sold that year. "Throughout the mediæval period, wherever profits arising from coal are mentioned in connection with this district, it is always found to have been sold by the rod or perch, which suggests that it was here the custom for the owner of the land to sell the right to take coal from a definite place rather than for him to sell the coal itself."§

In the fourteenth ‖ century coal was being mined by shaft and adit, the adit being a horizontal tunnel driven from the surface on some hillside at such a level as to drain off the water from the workings. The coal was raised up the shaft by a jack-roll or common winch moved by manual labour, or by men or women carrying it on their backs up ladders. Narrow passages were driven in the coal seam, leaving small pillars to support the roof. When difficulties arose from want of air, from too much water, or from crush of the strata, the shaft was abandoned, and a new one

* See "Ancient Mining at the Coppice, Sedgley," by J. Meachem, jun., *Fed. Inst. of Mining Engineers Trans.*, vol. vi., p. 554.

† Whether this was mineral coal or charcoal is not certain.

‡ Mining Accounts 36,909, fol. 10. See article, "Coal Mining," in the "History of Warwickshire Victoria County History," by R. A. S. Redmayne.

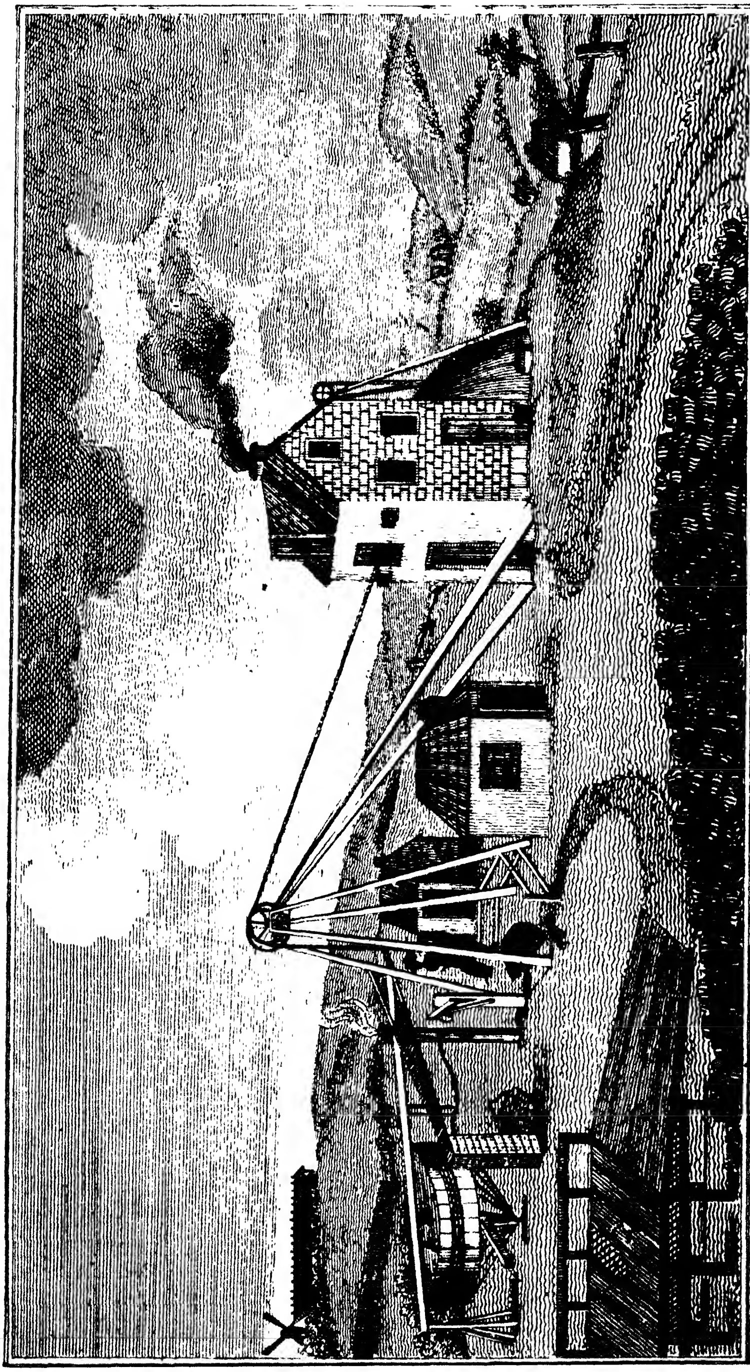
§ *Ibid.*, p. 219. See also the Nuneaton deeds preserved in the British Museum.

‖ In 1356, Bishop Hatfield of Durham granted on lease five mines in the Manor of Whickham to Sir Thomas de Gray, knight, and Sir John Pulhore, rector of Whickham, for twelve years at 500 marks rent per annum (= £333. 13s. 4d. £1 in those days would be equivalent to about £20 now). The lessees were to work the mines as far as they could be wrought by five barrowmen, according to the view and oath of the chief forester and of the viewers ("par cynk Barrowemen par la vewe et serrement du chief fforester et des veiours"), and they were limited to one keel a day (probably about 20 tons).—*Archæologia Æliana,* Part 24, vol. viii., of Society of Antiquaries of Newcastle-on-Tyne.

PLATE II.

Mouth of a Day-drift, with Group of Coal-Hewers.

[*To face page* 2.



Sketch of the Harrington Mill Pit Colliery.

A—A whim gin. **B**—A corf.

[*To face page* 3.

sunk not far off, the depth being only a few fathoms. Thus in ancient mining districts, such as West Durham, old shafts may be seen in almost every field—sometimes, indeed, several in one field. Old plans of Tanfield Moor, a considerable area in West Durham, show that there was a shaft to every 10 or 11 acres.

In hilly districts where coal seams "crop out to the day" in the sides of the hills, day-drifts were, and must always remain, the readiest means of access to them. Plate II. is a photograph of the mouth of a day-drift driven in at the outcrop of a coal seam. It shows the strata immediately overlying the seam, and also a group of coal-hewers, who have just come out of the mine, and are on their way home.

During the fifteenth, sixteenth, and seventeenth centuries, few improvements of any note were introduced. The water being the greatest difficulty, attempts were made to raise it in several stages by chain pumps, operated by water wheels or by horses; and whim gins worked by horses (see A, Plate III.) were substituted for jack-rolls in raising the coal. The depth of the workings was limited for the most part by the level at which free outlet for the water could be obtained through day-drifts, so that in 1610 it was stated in Parliament that the coal mines at Newcastle would not last out the term of their leases of twenty-one years.

Considerable light is thrown upon the methods of working at the beginning of the seventeenth century by the early accounts of the Griff collieries in Warwickshire, now preserved at Arbury (owned by Mr Frank Newdigate-Newdegate). When a pit was to be sunk a small sum, usually 1s., was paid to the sinkers "in earnest"; the pit was then marked out and work begun. The top of the pit, when ready for working, was protected by a "hovel," roofed with faggots. In the course of sinking one pit in 1604 there are payments for making a lade hole to lade the water to the water pit "sumpe." There is also a payment of 7s. "for feing the earth that was fallen in by reason the work was rooffed with water," and also "for timbering and recovering his shaft running in by reason of the flood." The water was dealt with by surface drains, baling engines or "gins," often worked by horses, water pits, and soughs, the latter being closed wooden drains, of which sections were called "dearns." That there were occasional outbreaks of fire is shown by such entries as "filling up Walton's pit to damp the fire out," filling the top of the pit where the "fire bred first." There is also an instance in 1604 when the colliers are said to have been "hindered with the dampe."

The tools used in mining at this time included, we learn from the same accounts, mattocks, picks, mandrels, wedges, and shovels, the latter being of wood shod with iron.

Coal was worked in Pembrokeshire in South Wales in Elizabethan days, but the method of working was of a most rudimentary character, and the workings very shallow. A description of the method as practised in those days is given on p. 19 of a work published in 1888, "On the South Wales Coal Trade," by Charles Wilkins, F.G.S., in which, quoting from an ancient document, he shows that the working was limited to the outcrops in the sides of hills, driving levels to drain off the water. It is stated that the number of persons in such a pit was about sixteen all told. Even in these small mines it was found that working could not be carried on in hot weather as the candles would not burn.

There is a record of coal working in Glamorganshire in the time of James I., and of "large" coal mines at Hirwuan, but in reality these mines must have been extremely small, as several were let at a rent of from £7 to £13 per annum.

In a pamphlet published in 1705 * there is a description of coal working in Glamorganshire in which it is stated: "Some time previous to 1695 the coal works wrought at that time lay chiefly under the common lands belonging to the town of Neath, and the coals were wrought by the Burgesses—each Burgess sinking a pit for himself. The Burgesses at last came to cross each other's works, which caused great differences and several lawsuits, and these led to an arrangement by which the Burgesses granted a lease of the coal works to Daniel Evans of Neath, Esq., a Burgess, yielding the Burgesses sufficient coal for their firing at the rate of twopence for each barrow of coal and also a rent or duty of 1s. to the ton for each wey of coal sent to sea." A wey was equivalent to a weight of 10 tons. Wilkins in his book, "On the South Wales Coal Trade," states that one of the earliest mineral leases which he had seen, and a copy of which he had been favoured with by a descendant of John Gowernllwyn, Dowlais, is dated 1757. This lease, known as the Dowlais lease, empowered the company to work ironstone and coal and to rent three furnaces, the rent chargeable being only £26 per annum. The coal was not required for smelting the iron in the primitive iron works. Both at Aberdare and Dowlais the iron masters sold a little coal in sacks. They

* "The Case of Sir H. Mackworth," &c. (London, 1705), mentioned by Wilkins, p. 26.

would exchange a sack of coal for a sack of lime, getting a halfpenny by the barter. The farmers would take the coal away and divide each sack into three, and journey away into Breconshire and Herefordshire, charging tenpence per sack.

The very restricted character of the coal workings in South Wales even towards the close of the eighteenth century is evidenced by the terms of a lease dated 20th June 1786, a copy of which is contained in Mr John Lloyd's "Early History of the South Wales Iron Works" (published in 1906): the lease was granted by the Dowlais Company to the Pennydarren Company. The annual certain rent was £140. 8s. for an area of 1,232 yards by 1,232 yards and for an annual output of 5,616 tons.

The invention of the atmospheric engine by Thomas Newcomen, an ironmonger at Dartmouth, in 1710, changed the whole aspect of the industry. At that time 60 fathoms was about the maximum depth of shafts, and their diameter 7 or 8 feet, and the area worked to one shaft was seldom more than 200 yards radius round the shaft. Fifty years later Walker colliery, on the Tyne, was sunk to the Main coal, a depth of 100 fathoms, and in 1763 a pumping engine was erected there, having a cylinder 72 inches in diameter and 10½ feet long. The steam engine was first applied to drawing coals in 1780 at Willington colliery, Northumberland, and the first Boulton & Watt engine, with close-topped cylinder, was erected at St Anthony's, near Newcastle, in 1790.

Deeper shafts, and more extensive areas of workings, brought in the era of big explosions, of which we have not yet seen the end. Repeated disasters in the pits led to the formation at Sunderland, in 1813, of "A Society for Prevention of Accidents in Coal Mines," and it was the members of this society who were instrumental in engaging Sir Humphry Davy in the exertions which, in 1815, culminated in the invention of his safety-lamp.

As regards the working of the coal, it would soon be found that planes of cleavage run through the seams in two directions at right angles to each other—roughly, north and south, and east and west, in the Newcastle coal-field—and that the cleavage in the former direction is more pronounced than that in the latter.* Roads, therefore, can be most easily cut in an east-and-west direction, or at right angles to the main cleavage planes. These ways came to be

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* See Chapter on Bord and Pillar Working, p. 189, and Chapter VI., p. 97.

called "bords"—a term said to be derived from an old Saxon word meaning a road or way. In the eighteenth century these bords were usually made 3 yards wide, and pillars of coal, 4 or 5 yards wide, left between them. In an old paper bearing date 6th December 1768, and headed "Mems. of Urpeth and Ouston Colliery, by Wm. Wanless," it is noted :—"*Middle West Pasture Pit.*—Wrought in the Main Coal, and not in the walls ; 8 yards to a winning ; bord 3 and wall 5 yards. The north headways driven about 19 winnings or 152 yards ; the Mothergate Westward 7 pillars at 30 yards to a pillar, the first and second pillars = 20 yards, so that the Mothergate Westward will be 190 yards west." The term "wall" is used to denote both the passage between the bords at the end of each pillar, and also the width of solid coal or pillar measured along the headways—that is, between the bords—and this width, *plus* the width of the bord, is termed a "winning." As (in the instance just cited) the headways advances every 8 yards, room for another bord is "won out." The temptation of making walls thin, in order to get a number of bords won out quickly, is apparent. Judging from old "views" dated about the middle of the last century, it was usual to get as much coal as possible in the first working with little consideration for a second working of the pillars. For instance, in a "view" of Murton colliery, near Berwick-on-Tweed, dated 11th November 1754, the viewer states : "I find the men win about 7 yards of headways to a winning, and take 3 yards of that for a bord, and leave 4 yards for a wall, and hole these walls at 4 yards long, so that the pillars are a square of 4 yards the side. . . . By the above method of working there is a great quantity of coal lost, for they cannot make a second working. Therefore I recommend for the future that the bords be driven 4 yards wide, and the headways twixt 4 feet 6 inches and 6 feet wide, and the pillars left 20 yards long and 4 yards thick, by which method there may be a second working, and the coal will work much rounder, for these pillars will probably prevent a thrust at any time when working the broken mine, and in all probability near six-eighths of the coal may be got, whereas by present method of working not more than two-thirds is got." Again, in "A View of Ravensworth Colliery, taken 18th May 1742," we read : "The Bridge Pit is working in the Top Coal, the seam 5 feet 6 inches, out of which thrown out as stone and refuse 4 inches. They take about 8 yards to a winning, take 4 and leave 4, but as it appears on measuring the bord, they don't work it very regular."

"Mothergate" is a term which is often found in mining reports or "views" of pits of the last century, but it has become almost obsolete in the bord-and-pillar system of working. It is still used, however, in longwall. It meant a main road in an east-and-west direction, along which the coals were brought out, the term now used being "rolleyway bord" or "going bord." The length of a bord is usually the length of a pillar. The solid coal left is variously spoken of as "walls" or "pillars." Thus, in "A View at South Birtley Colliery, for Mr Maddison and Pts., by William Unthank and John Allon," dated 18th November 1769, the viewers report as follows: "As the Five-quarter Coal Seam is the uppermost seam to be wrought there, the regular and best way of working it is, in our opinion, that the lessees begin to work that part of it which lies to the east of the Prosperous Dyke first in the whole coal and then in the *walls and pillars*; after that to begin on the west side of the Prosperous Dyke, and work away the whole coal if there be any, and then the *walls and pillars* to the rise, securing the said watercourse."

As pits got deeper, it was found necessary to make the pillars wider, in order to resist the crush of the overlying strata, which operates in two different ways, known respectively as "**creep**" and "**thrust.**" "Creep" occurs when the area of pillars is not sufficient to support the superincumbent pressure, and the floor (or "thill") of the seam is *soft*. The pillars are then forced downwards, and the floor "rises" where the coal has been removed, until floor and roof come together. This movement goes on until all the excavations are filled up, no timbering for the support of the roof being strong enough to resist an extensive creep. Districts of pillars several acres in extent have been known to creep tight in a single day. Creep was not an uncommon occurrence in the early part of the nineteenth century. "Thrust," on the other hand, is the term used to describe what occurs when there is not sufficient support for the superincumbent pressure, and when also the floor of the seam is *hard*, and does not rise in the bords and walls, as in creep. In thrust, therefore, the pillars are crushed, with the result that the coal is rendered worthless; whereas large areas of "crept" pillars have been subsequently opened out, and the coal got.

John Buddle, who is sometimes called the Father of Mining Engineers, writing in 1834, relates * that in working the Main Coal

* John Buddle on "Mining Records," *Proceedings of Natural History Society of Northumberland and Durham*, 23rd December 1834.

seam at Wallsend colliery, at a depth of 226 yards—the thickness of the seam being 6 feet 6 inches, and the pillars 8 to 10 yards wide, by 22 yards long, with bords 4 or 5 yards wide—a creep took place which shook severely the village of Wallsend on the surface ; and that in subsequently working the Metal Coal seam, which was 14 to 16 yards below the Main Seam, the Metal Coal was found to be broken and forced upwards below all the old bord rooms in the Main Seam, so that it could not be worked to profit.

Mr R. L. Galloway * tells an anecdote of what occurred at Longbenton church (Longbenton is a village about four miles from Newcastle-on-Tyne) in the early days of the nineteenth century. During the service one Sunday, the congregation were so much disturbed by pieces of plaster falling from the building, and other signs of movement, that they gradually dispersed, leaving the vicar alone, in spite of his repeated assurances that "it was only a creep ; only a creep."

Mr J. H. H. Holmes,† in a book published in 1816, mentions that when working one of the seams in the Harrington pit, a creep occurred, "which caused a rent through the whole upper strata and alluvial earth to the surface through near 100 fathoms in thickness."

Under the system of working which was general in Durham and Northumberland, until the present century was well advanced, creep and thrust were imminent dangers in the deeper mines. Consulting viewers used to be called in to advise what was the smallest amount of coal necessary to be left to prevent creep. It was the fear of thus losing the colliery—combined with the great difficulty, in gassy mines, before the era of safety-lamps and improved ventilation, of removing the gas sufficiently to prevent explosions—which hindered the working away of the narrow coal pillars then universal.

The state of a gassy colliery at the beginning of this century is well illustrated by an authentic account of what the famous John Buddle was accustomed to do at Wallsend colliery, as related by the principal performer, one Anthony Sharp, afterwards "keeker" at Kibblesworth colliery. The scientific and humanitarian interest which was beginning to be awakened in connection with coal-mine explosions, and Mr Buddle's reputation, brought to Wallsend many visitors of various degrees, from Russian Czars downwards. Not far from the bottom of the shaft, Mr Buddle had prepared an opening of considerable height and size, where gas was nearly

* "A History of Coal Mining in Great Britain," by R. L. Galloway.
† "Coal Mines of Durham and Northumberland," by J. H. H. Holmes.

always found lurking next the roof. This chamber served as a laboratory for the practical demonstration of a pit explosion on a small scale, as described in a local newspaper some years ago. "The *modus operandi* was as follows :—When a party was expected, Mr Buddle would say, 'Now, Anty, dis thoo think thoo can give us a crack the day?' 'Wey, aa'll try,' was Anty's usual reply. After getting 'belaa' with infinite care at the proper time, Anty would go forward a little into the chamber already described, with a lighted tarry rope-end in his hand, Mr Buddle and his visitors following. At the proper place, swinging his extemporised torch around his head, he would throw it up as high as possible, and then, flinging himself flat upon his face, would there await results. The explosion almost invariably occurred, sometimes with greater force than even Mr Buddle bargained for, and as the noise echoed and re-echoed through the workings, the party generally concluded that they had had enough of coal mining for that day at least, and were glad to be hauled up the shaft again to fresh air and safety."

Less than a hundred years ago, the condition of a large fiery mine must have been deplorable. On the day previous to a great explosion at Wallsend (a colliery under the most skilled management of the day—a great financial success), in the year 1835, whereby 102 persons lost their lives, the pit was in so dangerous a state that a hewer named John Bell, and five men working with him, were obliged to come away, extinguishing their Davy lamps, which had already become red hot. According to the report of the "South Shields Committee for the Investigation of Accidents in Mines" (formed in 1839), "on the morning of the explosion, before Bell left work at eleven o'clock in the forenoon, all the six Davys were on fire." To take another instance, at Lord Dudley's Netherton pits, in South Staffordshire, it was customary at the beginning of the nineteenth century to regularly remove the gas three times a day—at 4 A.M., at noon, and at 7 P.M.—by *burning* it.

The art of coal-mine ventilation has only reached its present more satisfactory condition through long years of struggle with great difficulties and dangers. A coal mine naturally emits poisonous and dangerous gases. To keep the atmosphere pure, and fit for the healthy existence of men engaged in vigorous physical exertion, through miles of confined passages, which too often can only be kept open by constant labour and watchfulness, is no easy problem. Of the pioneers in its solution the names of Spedding, Buddle, and Atkinson are prominent. Carlisle Spedding had charge of Sir James Lowther's collieries at Whitehaven in the early part of the eighteenth century, and under his able management many improvements were introduced. He was the inventor of the "steel mill," the earliest attempt at producing an artificial light which would not explode firedamp. About 1760 his son, James Spedding,* who succeeded him in the management of the Whitehaven collieries, introduced "coursing the air" in place of "face airing." Hitherto it had been usual to confine the air-current to the working face, leaving the numerous passages already made to take care of themselves; and consequently in fiery seams they became filled with gas, which on a fall of roof, or decrease in atmospheric pressure, was forced out into the working faces. James Spedding, by means of stoppings and doors, caused the air to flow up and down these passages after passing the working face, thus clearing away the gas, if the air-current was strong enough. At Walker colliery, on the Tyne—a colliery of great renown a hundred years ago—the air was carried in one current through a distance of about thirty miles. Matthias Dunn, in his book on the "Working of Collieries" (published in 1848), stated that "during many years the practice of maintaining one continuous column of air throughout the whole workings prevailed, so that it was no uncommon occurrence for the air to travel thirty or forty miles from leaving the downcast pit to regaining the surface." This system was soon found to be inadequate for ventilating extensive workings in fiery mines. The friction due to the great length of airway was very great, and as the current was accumulating gas all the way, it was sometimes in a dangerously explosive state on reaching the furnace, then the only ventilating power used.

It was in these circumstances that Mr John Buddle was led to introduce the system of dividing or splitting the air-current into several smaller currents, by the aid of air-crossings and regulators, and of dividing the workings into separate districts by leaving barriers of coal between. By this means each district gets a supply of fresh air, and the resistance which the air-current has to overcome is much reduced, so that the same ventilating power produces a larger total volume of air.

Atkinson devoted his mathematical genius to the elucidation of the laws which govern the flow of air through mines, determining the relation of the volume to the resistances with which it meets, and to the power producing it. In a series of masterly papers,

* There is some uncertainty whether Carlisle Spedding or his son James first introduced "coursing the air."

which may be found in the early volumes of the *Transactions of the North of England Mining Institute* (1854 to 1863), he laid for the English-speaking races the scientific basis of modern mine ventilation.

The practical test of a well-ventilated mine is the condition of the atmosphere at the coal face, and wherever men are at work. With modern appliances it is easy to have large volumes of air flowing along the main roads; but to ensure that throughout the ramifications of an extensive mine every individual shall be surrounded by a healthy atmosphere, requires in deep and fiery mines the exercise of knowledge, care, and ingenuity.

At the beginning of the present century, according to Mr Buddle,* the maximum produce of a fiery seam, attainable under any mode of working, was considered to be 45½ per cent., the pillars being made 6 yards by 22 yards. At Walker colliery, in 1795, Mr Thomas Barnes partly worked some pillars in a fiery seam as follows: He formed the old workings into districts of 10 to 20 acres in area, by stowing with stones the bord rooms and walls surrounding it, so as to form a solid barrier of 40 to 50 yards in breadth. Five yards width of coal was then removed from each end of every pillar, leaving only 10 yards by 6 yards of coal standing. The artificial barrier hindered creep from spreading to the adjoining pillars. This plan was adopted at Wallsend, and other of the adjoining collieries. Mr J. H. H. Holmes, F.S.A., in his book already mentioned, states that "the Wallsend coals are so valuable, that Mr Russel [the owner] is taking away all the coals, and substituting stone walls." In 1809 Mr Buddle improved upon this by leaving barriers of solid coal round each district, an arrangement known as "panel work."

The date at which it became customary to remove pillars formed by a previous working has been a point of some importance in determining claims for damage to the surface, and many such claims in which the point arose have led to legal proceedings. That damage of the kind was done at an early date is proved by the records of the Halmote Court for the County of Durham. Early in the fifteenth century, there was an inquiry before that court about a case which had occurred in the parish of Whickham, as to which it is recorded: "It is found by the jury that John de Penrith is injured by a coal mine of Roger de Thornton, so that the house of the said John is almost thrown down, to the damage of

* Mr Buddle on "Mining Records, 1838."

the said John of 20s. assessed by the jury; therefore it is considered that the said Roger repair the said house to the value aforesaid, or satisfy the said sum." * And a century and a half later, in a lease from Queen Elizabeth to Sir Nicholas Tempest of coal mines in Stella, it was stipulated that sufficient pillars (" columnæ vel pillers ") should be left to support the roof.†

The " Compleat Collier," a small work which was published in 1708, bears beyond dispute internal evidence of having been written by some one well acquainted with the practical working of collieries in " northern parts " about that date. In that work, describing the system of working, the author says: " And in this method it is that we carry on this coal work, taking away 3 yards or better, according to the strength or softness of the coal, and leaving 4 yards standing for pillars to support the roof and weight of the earth above." The depth is assumed to be 60 fathoms. There is no mention in the pamphlet of any subsequent working of the pillars. This is strong evidence that at that date it was customary to leave more than half the seam standing in pillars, and that no attempt was made to remove the pillars. The pamphlet was cited as testimony to this effect by Mr G. C. Greenwell in his evidence in the case of *Shafto* v. *Bolckow, Vaughan, & Co. and the Ecclesiastical Commissioners for England*, tried in April and May 1888.

In the old shallow mines the pillars were small, and frequently no attempt was made to remove them. When seams lying at greater depths came to be worked, larger pillars were required, and more coal was therefore lost if they were abandoned, and the practice of thinning or splitting them became general. The amount that might be taken off the pillars was a question which received careful consideration. Five viewers, who reported on Byker colliery in 1746, wrote: " We, whose names are underwritten, have viewed Byker Colliery, and finde ye same to be fairly and regularly wrought, 9 yards to ye winning, ye pillars 5 yards thick, and to ye best of our opinion there may be three-quarters of a yard taken off the walls in the Hagg and Bird Pits, and one yard taken off the walls in the Chance, Speedwell, and Virgin Pits." They kept themselves safe, however, by adding: " When this is done, we cannot certify the Colliery will be upstanding." ‡

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* "History of Durham," Francis Whellan & Co.

† T. J. Taylor's "Archæology of the Coal Trade."

‡ "Archæology of the Coal Trade," by T. J. Taylor, from *Proceedings of Archæological Institute*, Newcastle-on-Tyne, 1852.

Mr Matthias Dunn, in his book on the "Coal Trade" (1844), states that "the working away of pillars in the fiery collieries was first practised at Chartershaugh, on the Wear, in 1738, Edward Smith being then viewer." Mr Nicholas Wood, speaking in 1860, said: "Pillars were taken away at a very early period. I have reports as far back as 1740 or 1750, and upwards, as to mode of taking away pillars, and have travelled in Old Benton Waste, where large districts of pillars have been worked entirely away. Benton was abandoned somewhere before 1765, so that before 1765 there must have been a very extensive system of taking away pillars. If you inquire of old people, they say it was the practice to leave pillars till they got to the extremity, and then they came back and took them away. The records of very old collieries show that it was the practice to take away pillars." And again: "The great difficulty, before the lamp was invented, was to know how much you could take away with candles, and whether, after taking away a certain quantity, you could take away more without producing a creep." *

One Luke Curry, writing on 3rd October 1757, states: "I have this day viewed Ford Colliery (Northumberland), and find that they have by working the walls or pillars of the said colliery in an irregular manner brought a thrust upon their watercourse for 130 yards in length," &c.

In a report on Copley Bent colliery, dated 11th July 1780, it was stated that "a barrier of whole coal should be left to support the roof, instead of which the pillars have been wrought, and thrust brought within 2 yards of the water-level."

From documents in the Durham Chapter offices, the Low Main seam appears to have been worked under the Durham Grammar School so far back as 1623, and scarcely any coal left.

In a "Copy of a View at Mr Carr's Colliery, Birtley, by Anthony Waters and William Unthank, dated the 17th June 1767," the viewers state: "We this day viewed that part of Birtley Colliery belonging to Mr Strother Carr, and find the Peggy Pit working the walls in the Maudlin Coal towards the west in a regular manner. That towards the east, it appears the walls of the Maudlin Coal are wrought. The barroway from the Peggy Pit is in some danger of running together, which should be taken care of and prevented, so as the walls towards the west as far as the Ash Pit may be brought thereto, and as far farther west

* *Transactions of North of England Mining Institute*, vol. ix., p. 32.

as shall be thought proper. . . . And we are of opinion that the said Maudlin Coal Walls may be wrought with the least hazard at present of bringing down the feeders of water in the Upper Main Coal, and ought to be wrought before any walls are touched in the Low Main Coal and Hutton Seam in the east part of the colliery." The expression " working the walls in a regular manner," in this document, seems to imply that it was customary at that date to partially remove ("rob") the pillars in the shallower collieries which were free from gas, and this is confirmed by the old reports already quoted.

In estimates dated 1766, and now extant, of the probable amount of workable coal to be obtained from a given area, a fourth part is allowed for as left.

In old collieries it is not unusual even now to find districts of old pillars, only a few yards in width, which have been abandoned by former workers. The period of advance towards larger pillars and their entire removal is indicated in the following extract from a report dated 4th March 1791 : "*Copy of Mr Ramsay's report of Ramshaw Colliery.*—Then descended a pit in this colliery to the Main Coal Seam at the depth of 13 fathoms. Height of the seam, 5 feet 4 inches of merchantable clean coal. On examining the workings, find the same irregular, the winnings being made at 5, 6, and 7 yards, and the bords drove in breadth from 3½ to 4 yards ; also the pillars are in length from 10 to 20 yards, and from this mode of working nearly one-third of the mine is left, as the pillars now standing are too small to admit of a second working. On viewing the seam in consideration of the lightness of cover, I think it advisable in the New Pit, which is now sinking, to make the winnings at 8 yards, and the length of the pillars 20 yards, to make a second working, if the coals can be made merchantable. By this mode of working, a greater quantity of coals will be obtained, which will be a profit both to the Lessor and Lessee."

The advantage of leaving wide pillars, amply sufficient to prevent creep or thrust during their removal, does not seem, however, to have been generally realised until the nineteenth century had well advanced. In many cases the pillars were " robbed " (to use a technical expression)—that is, partially removed—either by driving a narrow place called a " jenkin " through the pillar in a bordways direction, leaving a foot or two of coal on either side, or by taking off lifts at each end. The old workers seem to have had a strong objection to letting the roof fall, and the evidence goes to show that the practice of leaving large-sized pillars, with a view to removing them *entirely* in a second working, did not become *general* till the early years of the nineteenth century.

In a report on Fallowfield colliery, in the neighbourhood of Hexham, Northumberland, dated 10th November 1828, Mr Nicholas Wood stated: "On inspecting the workings I found they were pursuing the mode, almost universally practised in the district, of making the winning 9 yards, taking out or working as a bord 5 yards, and leaving unwrought or standing 4 yards as a pillar; and as it does not seem to be the practice to work the pillars out afterwards, four-ninths of the coal is therefore lost. When the coal is drained by engine power, and when in working the pillars there is a risk in raising water, which by overpowering the engine might endanger the permanent safety of the colliery, it is often advisable to leave the pillars. But when the coal is drained by a free water-course, as in the present case, and no such risk can therefore occur, it is quite practicable by pursuing a different mode of working to obtain the whole of the coal, which, while it produces to the land-lord four-ninths more coal, is not incompatible with the interests of the tenant. . . . The principle on which the colliery has hitherto been worked, not only during the present take, but in all previous ones, has been with a view of not obtaining the coals left as pillars, and this has been sanctioned by the custom of the district."

In a report made by Messrs G. Johnson and N. Wood in November 1823, they recommended that in "winning out to the north a thick wall or barrier of 40 yards in breadth be left at intervals of every sixteen bords. . . . And in general, as from the peculiar situations of the different royalties a working of the pillars must be resorted to at no distant period, we would direct the attention of the viewer to the expediency of leaving sufficient barriers, that he may be able to obtain not only the greatest quantity of coal, but also in the greatest perfection."

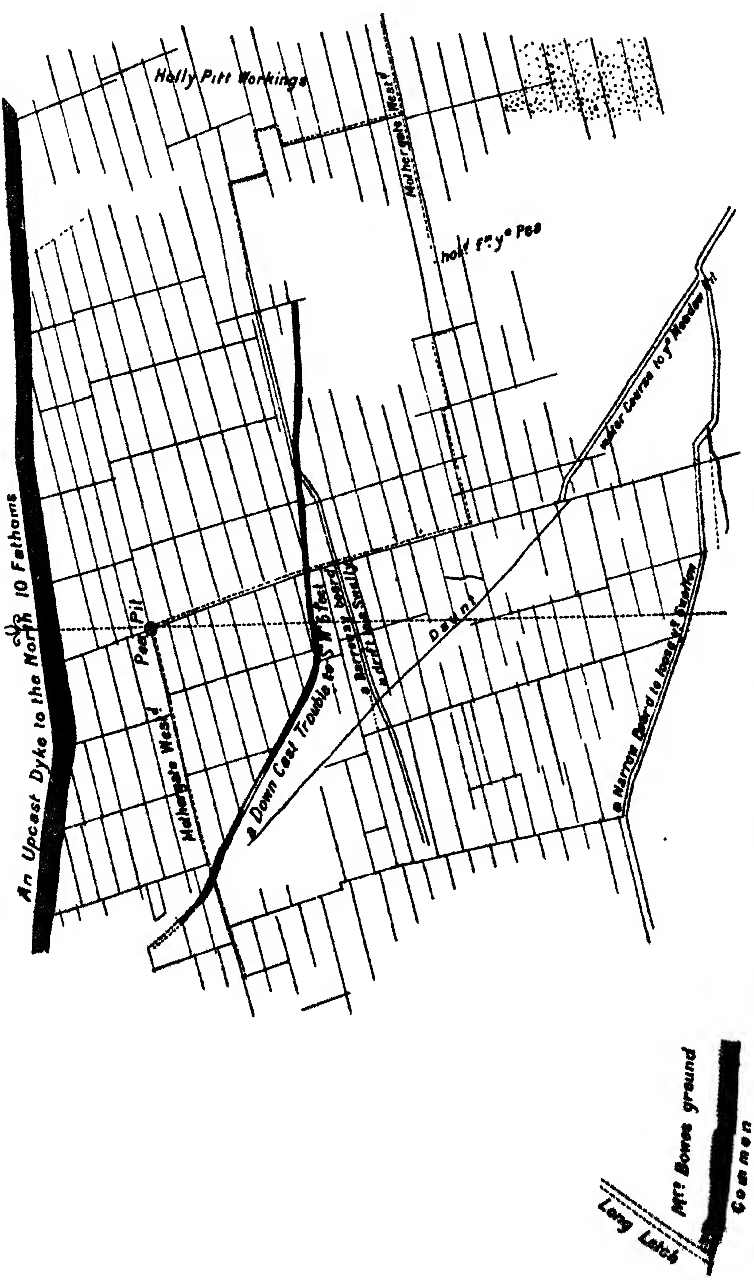
Messrs Easton and Dunn, in a report made in 1827, write as follows: "The width of the excavations, and the quantity of coals to be obtained by the first working, form a very important feature in the management of so extensive a mine as this; and are very much governed by the future practicability of taking away the pillars." And "as no question can exist of the advantage of large pillars for the effectual working of them," they went on to recommend the addition of 1 yard to the width of pillar. They continued: "In order generally to provide for such pillar working, districts should be preserved by coal or other barriers of from 8 to 15 acres in extent, as circumstances may point out; where defended by coal only, the barriers to be left from 40 to 60 yards."

From the evidence given by Mr John Buddle before a Committee of the Lords on the state of the coal trade in 1829, it would appear that the entire removal of pillars—at any rate in the deeper collieries—did not become a generally recognised practice until the earlier years of the nineteenth century, for he stated that "the introduction of the Davy lamp might be considered as a new era in the coal trade; and it is rather singular that it should have happened to be introduced about the time of peace, being made at that time when many of the collieries producing best coals had been nearly worked out upon a system in which the working of the pillars was not contemplated. Nothing but the first working, by which perhaps a little more than 40 per cent. at the depth of 100 fathoms could be obtained from those mines; consequently the remainder was given up as lost. It was not expected that the coal could be brought to the market at all. In 1795 an attempt was made to work pillars which succeeded to a certain extent as a partial working. The whole of these pillars were considered necessary for securing the roof, and no attempt was made to reduce them from the apprehension of producing a creep. In 1795, when collieries became exhausted in the whole mine, an attempt was made at partial working by removing half of every alternate pillar."

Reporting on the working of the Main Coal seam at Hetton colliery in 1832, Messrs G. Johnson and N. Wood recommended that the winnings should be increased from 14 yards to 16 yards—viz., 12 yards for the pillar and 4 yards for the bord—"taking into consideration the depth of the seam and the nature of the coal."

Where pillars had been left, it was customary to apply to the mining agents of the lessors for permission to work them, and this permission was only given in some cases on certain conditions, such as building stone pillars over a certain area, to "prevent the progress of the weight."

From the various extracts given above (and many more to the same effect might be added) we learn that as the result of the slow evolution of practical experience, and of increased facilities of lighting and ventilation, important improvements in the bord-and-pillar system of working were introduced in the period about 1830-40—namely, a greater width of pillar; and in the deeper and fiery mines the isolation of districts by leaving barriers of solid coal round them, to be removed subsequently; thus by these means getting eventually the whole of the seam.



A Plan of the Workings of the Pea Pit in Hedley Grounds.

Reproduction (on reduced scale) of Plan of Underground Workings made about the Middle of the Eighteenth Century.

[To face page 16.

The following up of the whole by the broken—that is, the working of the pillars close behind the first working in the whole coal—was also practised early in the nineteenth century. Mr Nicholas Wood, reporting on Tanfield Moor colliery in 1836, wrote: "The mode now almost universally practised, whenever circumstances will allow, is to make the partial working and taking away the pillars one operation; or take off the pillars immediately following the first working."

Summing up, the documentary evidence cited goes to show that, previously to 1708, the general practice was to leave small pillars of coal standing for the support of the roof; thirty years later, pillars were being partially, sometimes entirely, removed, and during the remainder of that century in mines free from gas a second working of the pillars was frequently carried out. In the deeper and fiery collieries, which began to be developed about the middle of the eighteenth century, the risk of creep, as well as of gas explosions, prevented the removal of the pillars. The invention of the safety-lamp, improvements in ventilation, and the formation of much larger pillars in the first working, were changes for the better, which were introduced during the first thirty to forty years of the nineteenth century, and which enabled the pillars to be removed in a second working—sometimes immediately following the first, and sometimes deferred for a considerable period, according to circumstances.

The annexed plan—Plate IV.—which is a reproduction (on a reduced scale) of the original in the authors' possession, made about the middle of the eighteenth century, shows the workings at that time of the Pea Pit in Hedley Grounds, in the County of Durham. It may be regarded as a fair specimen of the sort of pit plan then in vogue at North country collieries. The pillars vary a good deal in length, but in width are regular, the winnings being 10 yards. Dotted lines are freely used as distinctive features, indicating both the main roads and the north line. There is no indication of pillar working, unless the dotted area in the bottom right-hand corner is meant to indicate goaf.

CHAPTER II.

WORKING COSTS AND RESULTS—PAST AND PRESENT.

WORKING COSTS.

As regards the cost of working coal, the following is a summary of some instances taken from old papers and reports in the authors' possession, covering a period of over seventy years, from 1763 to 1836. In most cases, further details or copies of the documents from which the particulars have been taken are given subsequently.

County.	Name of Colliery.	Date.	Cost per Ton. s.	d.		Remarks.
Northumberland	Longbenton	1763	1	7½	In the Whole	This does not include anything for rent, taxes, or materials.
			1	3½	In the Pillars	Do.
Durham ...	Tanfield Moor	1771	1	5	Hard Coal Seam	Rent and taxes not included.
			0	11½	Hutton Seam	
Northumberland	Walbottle ...	1771	1	10.3	... ...	Do.
Durham ...	Mount Moor	1790–95	1	9.3		
Do. ...	Brandon High Colliery	1796	2	11	... ...	Including 3.3d. per ton for rent, but nothing for materials.
Northumberland	Willow Bridge	1819	3	0	... ...	Includes rent, taxes, materials, and all cost for putting into waggons at the pit.
Durham ...	Mount Moor	1827	4	2	... ...	Do.
Northumberland	Acomb ...	1827	3	3½	... ...	Do.
Do. ...	Montagu Main	1827	4	0	Pillar working	Do.
Durham ...	Blackboy ...	1832	4	6	... ...	Do.
Do. ...	Witton Park	1834	2	7½	... ...	No rent included.
Do. ...	Pittington ...	1834	4	8	Includes house rents, taxes, materials, and all cost for putting into waggons at the pit (excepting royalty rent).	
Do. ...	Tanfield Lea	1836	3	3½	Includes rent, taxes, materials, and all cost for putting into waggons at the pit.	

If these may be taken as average cases (and the authors know of no reason why they should not), the average cost of putting coal into waggons at the pit was below 3s. a ton during the eighteenth century, but the cost increased materially during the early years of the nineteenth century.

Coming to more recent times, the cost of putting coals into waggons at the pit mouth per ton of unscreened coals, including all labour, materials, rents, taxes, and incidentals, at three collieries, 1874-79, was as shown in the Tables on the next page.

No. 1 was an old colliery, working two seams, both giving off a good deal of gas—one a seam of house coal, at a depth of 230 yards, varying from 4 feet 6 inches to 8 feet in thickness, with workings extending over a wide area; and the other, a hard steam coal seam of an average thickness of 3 feet, depth 360 yards.

No. 2 was also an old colliery, with widely extended workings in one seam, a steam coal, averaging 4 feet thick, at a depth of 120 yards.

No. 3 was a new colliery, working two seams—one 4 feet to 5 feet thick at a depth of 70 yards, and the other 3 feet to 4 feet thick at 200 yards.

In 1887 the cost of working a hard 3-feet seam at a depth of 80 yards was as follows:—

Unscreened coals vended	81,300 tons.
All labour	3s. 7.30d. per ton.
Materials consumed	0s. 6.00d. „
Incidentals and taxes	0s. 4.44d. „
Rents	0s. 5.65d. „
Total cost per ton at the pit mouth	4s. 11.39d.

In 1902 the cost of working several soft seams of coal, con stituting a colliery in the Midlands, the seams lying at depths from the surface of 600, 746, and 859 yards respectively, and being from 5 feet to 5 feet 6 inches in thickness, was as follows:—

Output for the year of all classes of coal	**211,003 tons.**
Total labour	**4s. 8.68d. per ton.**
Materials	**1s. 0.87d. „**
Miscellaneous charges, including rent ..	**0s. 10.71d. „**
Total cost per ton free on rail ..	**6s. 8.20d.**

(See p. 19.)	No. 1.				No. 2.			No. 3.		
	1874.	1875.	1876.	1879.	1874.	1876.	1879.	1874.	1875.	1876.
Unscreened coals vended ...	Tons. 64,499	Tons. 70,666	Tons. 53,516	Tons. 66,692	Tons. 81,649	Tons. 95,323	Tons. 97,310	Tons. 77,409	Tons. 80,109	Tons. 77,801
	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*	Per Ton. *s.* *d.*
Underground labour and screening	8 5.4	6 11.9	6 7.79	3 0.79	6 3.46	4 7.41	3 5.68	5 3.21	5 1.4	5 4.18
Mechanics	0 11.49	0 8.21	0 8.46	0 4.18	0 11.11	0 5.73	0 4.50	0 5.64	0 6 84	0 6.79
Materials consumed	2 11.61	2 6.02	1 10.36	1 1.06	2 7.77	1 1.72	0 10 76	1 3.25	1 0.61	0 10.65
Incidentals and taxes	0 3.88	0 2.93	0 4.76	0 2.70	0 3.53	0 3 18	0 2.25	0 1.76	0 1.99	0 2.04
Rents	0 5.66	0 5.60	0 5.26	0 6.00	0 8.00	0 5.28	0 5.28	0 9 00	0 9.00	0 4.18
Total cost per ton at pit mouth ...	13 2.04	10 10.72	10 0.63	5 2.73	10 9.87	6 11.32	5 4.47	7 10.86	7 7.84	7 3.84

The figures given in these three Tables suffice to show how much the cost of working varies at different collieries, and what rapid and violent fluctuations sometimes occur in it, even at the same colliery.

The years 1873, 1874, it may be mentioned, were "record" years, in which the cost of labour and materials reached the highest flood-tide of that century, and probably of any previous century, the immediate cause being the Franco-German War. The recoil was as rapid as the spring had been, and in 1879 the working cost of collieries was in many instances one-half of what it was in 1874.

As might be expected, a greater fall took place in the price of coal. In 1873 the price of best coal imported into London was 31s. 3d. a ton at the ship's side, exclusive of dues, while in 1880 it was 14s. 11d.—a fall of 52 per cent. in seven years. The years 1900, 1901 were also "record" years, coal being sold at higher average prices than at any time since 1874.

In 1905 a fair average working cost of putting coal into waggons at the pit bank was 6s. a ton.

The similar experience during the Great War 1914-18 is an example of how history repeats itself. In 1913—the last complete pre-war year—the costs of working were not far removed from those of the mid-seventies. They were estimated to average for the whole country :—

	1913. Per Ton.	Quarter Year ended 30th September 1918. Per Ton.
Wages	5s. 6d.	13s. 7.56d.
Stores and timber	1s. 0d.	3s. 6.48d.
Other costs, including everything except depreciation and interest	1s. 3d.	1s. 4.30d.
Total cost	7s. 9d.	18s. 6.34d.

By 1918 the cost had more than doubled, the figures for the quarter year ended 30th September 1918 being as shown above.

The subjoined documents illustrate, and will further explain, the particulars given on page 18 :—

I. An Account of the Charge in Working a* Ten of Coals at Longbenton, 23rd September 1763.

	In the Whole Mine. Per Ten.	In the Pillars. Per Ten.
For hewing	£0 18 0	£0 9 0
„ driving	0 9 0	0 6 0
„ headways	0 1 6	...
„ setting on	0 0 9	0 0 9
„ trapping	0 1 1½	0 0 1½
„ overman	0 1 10½	0 0 10½
„ sledding	0 3 0	0 3 0
„ corving	0 3 9	0 3 9
„ †drawing	0 15 0	0 13 6
„ †wailing, &c.	0 0 9	0 0 9
„ putting	0 18 0	0 18 6
Candles and oil	0 4 6	0 3 9
Smiths and wrights	0 1 3	0 1 3
	£3 18 6	£3 1 3

II. An Estimate of the Charge of Working the Hard Coal Seam, Tanfield Moor Colliery, 9th Oct. 1771.

			s.	d.	
With a 16 ‡ Peck Corf.	Hewing	at	2	0	per score.
	Putting in a mean ...	...	1	3	„
	Corving	...	0	3	„
19 bolls to a waggon, and 22 waggons to a ten = 418 bolls.	Sledding	...	0	3½	„
	Overman for headway, and candles, &c. ...	...	0	9	„
16 pecks = 2 bolls.	Driving levels, &c. ...	...	0	4	„
	Props and deals ...	...	0	9	„
If 2 b. : 1 c. :: 418 b. = 10 score 10 c. to a ten.	Shovelling and wailing	...	1	3	„
	Drawing	...	1	2	„
	Smith and wright ...	...	0	1½	„
N.B.—The putters with trams have 8d. per score the first change or 60 yards from the shaft, and advance 1d. for every 20 yards after in a mean bord.	Ropes, shovels, &c. ...	...	0	3	„
	Agency, &c.	...	0	3	„
			6	10	„

10½ score to a ten at 6s. 10d. per score is = £3. 11s. 9d. per ten.

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* At 48 tons to the ten, this is 1s. 7½d. per ton in the whole, and 1s. 3½d. in the pillars. See p. 28 footnote.

† "Wailing" is picking the stones from amongst the coals; "drawing," raising the coals up the shaft.

‡ One peck = 0.3 cwt. = 1209 cubic inches.

The Charge of Working the Hutton Seam.

With a 24 Peck Corf.

418 bolls to a ten.

If 3 b. : 1 c. :: 418 b. = 7 score per ten.

N.B.—The drivers have 10d. per day through the year.

	Per Score.			Per Score.	
Hewing in the whole	1	8	in pillars	1	2
Putting „	1	6	„	1	6
Corving „	0	3½	„	0	3½
Sledding „	0	3½	„	0	3½
Overman for headway and candles ...	0	5	„	0	6
Driving levels, &c. ...	0	3	„	0	3
Props and deals ...	0	4	„	0	6
Shovelling and wailing	0	3	„	0	3
Drawing	1	6	„	1	6
Smith and wright ...	0	1½	„	0	1½
Ropes and shovels ...	0	2½	„	0	2½
Agency	0	2	„	0	2
	7	0		6	9

7 score a ten at 7s. per score = £2. 9s. 0d. per ten.
„ at 6s. 9d. „ = £2. 7s. 3d. „

III. An Estimate to take Walbottle Colliery by the Ten or Score with a 16 Peck Corf.

	s.	*d.*
To hewing by the score with a 16 peck corf	2	0
„ putting with barrowmen or horses, finding horse-geers, drivers, horse-keepers, and attendance	1	6
„ overmanship, with headways, oil, and candles	0	8
„ rolleys, trams, sledges, and wright works	0	2
„ smith-work and iron geer	0	2
„ wet and double working	0	0½
„ timber and deals, with brick and deal stoppings, &c.	0	3½
„ drawing the coals and rubbish to bank	2	2
„ corving and sledding	0	7
„ ropes and gynns*	0	2
„ fail of stock	0	1
„ driving all winning headways, water-level drifts, above 1s. 4d. per yard, the owner to pay if overplus	0	1
„ examining the waist and shift work	0	1
„ drive levels, set over troubles, pump and lead water to the height of 3 feet or under, if above that to be in the owner's hand ...	0	2
„ finding stuff, make and hang trap-doors, and keeping them ...	0	1½
„ keeping fire-lamps and oil-lamps	0	1
„ wailing and shovelling in the heaps	0	3
„ agents	0	1½
„ lamp coals used at bank and underground and loss of coals ...	0	1
	8	11

At 10 score 10 c. to a ten it will be £4. 13s. 7½d. per ten.

* "Gynn" was the machine used for winding the corves up the shaft. See Plate III.

IV. Cost of Working Brandon High Colliery, Cornforth, 13th January 1796.

Per score of 8 Peck Corves.

	s.	d.
Hewing	1	8
Putting	1	6
Headways	0	2
Overman and candles	0	6
Sledding and corving	0	4
Wailing, 4½d.; props, 2d.	0	6
Smith and wright	0	1
Drawing	0	6
Interest on money sunk	0	6
Sinking and drifting / Unforeseen	0	6
	6	4
Rent	0	8
2s. 11d. per ton =	7	0

V. An Estimate of the Expense of Working Willow Bridge Colliery upon 2,400 Scores of Coals, 21 Corves to the Score, which ought to produce 2,100 Chaldrons and keep the Pit going one year.

		£	s.	d.
Hewing and putting 2,400 score at 2s. 6d. per score		300	0	0
Driving narrow work		10	0	0
One overman, a part of his time, with house and fire		30	10	0
One bankman, 21s. per week, house and fire, say 50 weeks ...		57	0	0
Two enginemen, 18s. per week, house and fire, 52 weeks		102	12	0
One gin driver, 1s. 3d. per day for 300 days		18	15	0
Keep of one horse and interest upon his value		40	0	0
Ropes, iron, timber, leather, and all other materials usually included in tradesmen's accounts, also blacksmith's work		100	0	0
Corving and rods		6	0	0
Damage of ground		5	0	0
Colliery rent payable to Lord Barrington	£60 0 0			
" " Vicar of Bedlington	20 0 0			
		80	0	0
Gratuity to Mr Gibbon for surrendering his agreement		30	0	0
		£779	7	0

The quantity of coals to be led above ground for this sum is 2,100 chaldrons
The pumping engine consumes 2* fothers per day for 365 days 243 "

Quantity remaining for sale ... ... 1,857 "

* 1 Fother = 77414.4 cubic inches.

Makes the expense for working 8s. 5d. per chaldron, but for the engine coals the expense would be 7s. 5d. a chaldron, and as the water may be expected to continue to abate, probably 8s. per chaldron may be fairly stated as the rate of working for the ensuing year. 8s. a chaldron = 3s. a ton.

VI. Mount Moor Colliery. An Estimate of the Expense of Working and Leading Coals per Score, from February 1790 to and with 1795.

	Swang Pit.		Spring Pit.	Gate Pit.
	High Main Seam, 6 Ton Score, 20 Peck Corf.	Low Main Seam, 4.8 Ton Sc., 16 Peck Corf.	High Main Seam, 6 Ton Score, 20 Peck Corf.	Hutton Seam, 6 Ton Score, 20 Peck Corf.
	s. d.	*s. d.*	*s. d.*	*s. d.*
Hewing	2 3½	2 6	4 0	2 2
Putting from face to crane ...	0 9	0 7	1 8	1 3½
Putting from crane to shaft	1 0½	0 10	...	...
Laying a waggon way 700 yards at 1s. 6d.	0 2	0 1¾	0 1½	...
Cranemen	0 1½	...	0 1	...
Overmen and deputies ...	0 3	0 3	0 5	0 3
Candles and oil	0 3½	0 4	0 4	0 3½
Holing walls	0 2½	0 3½	0 4	0 0½
Barrow way deals	0 1½	0 1½	0 0½	0 1½
Double	0 1	0 1	...	...
Sledges, trams, rolleys ...	0 0¾	0 0½	0 0¾	0 0¾
Setting on	0 1	0 1½	0 1½	0 1
Trappers	0 1	...	0 0¼	...
Fire lamps	0 1	0 1	0 1	0 1
Stoppings	0 1	0 1	0 1	0 1
Air and water courses ...	0 1	0 1	0 0½	0 1
Repairing shaft	0 0½	0 0½	0 0½	0 0½
Engine level drift	0 0½	0 0½	...	0 0½
Smith-work	0 2	0 1½	0 2	0 2
Gins	0 0½	...	...	0 0½
Drawing water to engine level	0 0½	0 0½	...	0 0½
Drawing coals 184 fms. with horses	2 9	75 fms. 2 0	...	87 fms. 2 9
Sledding out	0 4	0 3½	0 4	0 4
Corving, 3½d. per score; finding ropes, 3½d. per score	0 7	0 6¼	0 4	0 7
Wailing and shovelling ...	0 2¼	0 2	0 3½	0 2½
Engine and workmen's coals	0 4	0 3½	0 2	0 3
Binding pitmen	0 3½	0 3	0 3½	0 3
Salaries	0 6	0 6	0 6	0 6
Per score	11 1½	9 10	9 7	9 9¼
Average 1s. 9.3d. per ton =	1 10.1	2 0.5	1 7.1	1 7.5

VII. An Estimate of the Expense of Working the Hutton, Maudlin, and High Main Seams in the Springwell Royalty to the Vale Pit of Mount Moor Colliery in February 1827 totals up to £11,027 for an annual vend of 20,000 chaldrons (53,000 tons), including all labour and materials, keep of horses, rents, taxes, and incidentals. This is equal to 11s. a chaldron, or 4s. 2d. a ton.

VIII. An Estimate of the Expense of Working Acomb Colliery, near Hexham, dated 4th May 1827, on an annual vend of 6,240 tons, reaches the total of £1,028. 6s. 8d., including all labour and materials, royalty rents, taxes and cesses, and incidentals. This is equal to 3s. 3.5d. per ton.

IX. The Estimated Cost, dated May 1827, of Working Montague Main Colliery, near Newcastle, in the High Main Seam Pillars (depth of seam 36 fathoms), was £14,300 for an output of 13,800 score of 16 peck corves = 66,240 tons = 4s. 4d. a ton. This includes the same items as above, and also 9d. a chaldron = 3.4d. per ton for leading and staith charges.

X. The Cost of Working Blackboy Colliery in 1832, then the most expensive colliery in the Auckland district, was for "working coals and putting them into waggons at the pit, including rent of mine, agents' salaries, and all other expenses, 12s. per chaldron = 4s. 6d. a ton."

XI. From a Valuation of Witton Park Colliery, May 1834, by Messrs Thomas Storey and John Turner. "The expense of putting these coals into waggons at the colliery, including all expenses (except rent of mine and a probable expenditure in sinking pits and laying waggon ways), will amount to 7s. per chaldron."

XII. THE COST OF RAISING 19,972 SCORE = 29,958 CHALDRONS = 79,388 TONS OF COALS AT PITTINGTON COLLIERY, NEAR DURHAM, during the first ten months of the year 1834, amounted to £18,563. 13s. 10d., including all labour and materials, £1,332 for house rents, rates, taxes and incidentals, but not royalty rents. This is equal to 12s. 5d. per chaldron, or 4s. 8d. per ton.

XIII. ESTIMATE OF THE EXPENSE OF WORKING COALS AT TANFIELD LEA COLLIERY. Supposed annual vend 20,000 chaldrons (= 53,000 tons).

		s.	*d.*
= 1s. 4d. a ton.	Expense of labour expended in laying the coals on bank, including hewing, putting, overmanship, shift work, corving, brakemen, wailing, &c., 8s. per score, with a 20 peck corf, is per chaldron ...	4	0
	Keeping underground horses, 10 at £40	0	4¾
	Main engine, including engineman, fireman, hemp, tallow, and repairs, £350	0	4¼
	Leading workmen's fire coal, gin horses, and other labourage, 4 horses at £45	0	2½
	Joiners, £120; smith-work, £110; masons, including bricks and lime, is £300	0	4
	Keeping machines in repair	0	1
= 3.73d.	Materials, viz., props, £400; timber and deals, £100; iron and rails, £100; cast-iron, £120; ropes, £70; grease, £35 = £825	0	10
	Agencies and surgical attendance, £400	0	4¾
	Labourers and cartmen leading workmen's fire coal, 3 men and 1 horse-keeper at 12s. per week each	0	1½
= 6.00d.	Colliery rent, 20s. per ten, is per chaldron	1	2
	Poor cess, highway rate, taxes, &c.	0	2
	Sundry expenses, putting through troubles, drifting	0	5
	Multifarious loss by house rents	0	3½
	= 3s. 3½d. a ton per chaldron	8	9¼

SELLING PRICE OF COAL.

Some notice of the market value of coal during the past is not without interest. One of the earliest transactions on record* is a purchase in 1366 of 676 "chalders" of sea coals at Wynlatone for £47. 17s. 8d., by Henry de Strothre, the Sheriff of Northumberland, by order of the King (Edward III.), for works at Windsor

* Pipe Rolls, 40 Ed. III., 1367.

Castle. The chalder at this time was probably about 1 ton, as 20 of them went to the keel. The price therefore was 1s. 5d. a ton; but money is said to have been then about ten times its present value. These coals were brought down the river in "keels" (flat-bottomed vessels of very early origin peculiar to the Tyne and Wear, now obsolete) from the neighbourhood of Winlaton to the ships which carried them to London.*

The total cost in London was £165. 5s. 2d., or 4s. 11d. per chaldron of about 1 ton.

During the sixteenth century there was a general rise of prices, in which coals shared. The price rose from 2s. 6d a chaldron at Newcastle to 9s. A charter from Queen Elizabeth to the town of Newcastle-on-Tyne in 1600 dealt with the coal trade, and amongst other regulations limited the price of best coals to 10s. a chaldron, of second class to 9s., and of "meane coles" to 8s.

During the seventeenth century the price on board ship at Newcastle ran from 10s. to 12s. a chaldron, leaving out of account such exceptional prices as that obtained in 1644, when Newcastle was besieged by the Scots, and coal was sold at 80s. a chaldron.†

At the beginning of the eighteenth century we find "The Compleat Collier" (1708) lamenting the low price of coal. "Was it ever heard of or known that this Noble, this Main Coale was

* "In the 9th year of King Henry V., A.D. 1421, . . . the burden of keels was limited by statute to 20 chaldrons, 9th King Henry V., c. 10." See Hutchinson's "Durham," p. 607.

"The keel-load long continued to be the principal standard of measure. Thus in 1604, an order of the Privy Council is addressed to the Hoastmen of Newcastle to prevent loading ships by bulk, instead of by 'the juste and trewe measured kele,' and another order in 1613 directs that 'coals are to be sold onlie by the measuredde keles.' It is manifest that the *kele* and the *ten* were at this period synonymous, and that the keel carried ten of those chaldrons, the size of which is afterwards particularly specified in the Act of 30 Car. II., and which constituted the then Newcastle chaldron. It is also clear that the keel-load consists of ten scores of the bolls of that period—twenty-one to a score.

"By statute 30 Car. II., c. 8, the bowl-tub of Newcastle is declared to contain twenty-two gallons and a pottle (22½ gallons) Winchester measure; it was twenty-seven inches in diameter, and there were twenty-one bolls heaped measure to each chaldron. By the same Act the content of each wain is to be seven bolls, and each cart three bolls and one bushel heaped measure, and three wains or six carts are to be a chaldron."—*The Archæology of the Coal Trade*, by T. John Taylor, 1852.

By 6 & 7 Will. III., c. 10 (1700), the Newcastle chaldron was declared to consist of its present weight, 53 cwt. The original chaldron was 2,000 lbs. weight.

† "England's Grievances Discovered," by Ralph Gardiner, 1655.

sold, as lately it was, or now is, for 8s. per chaldron, Water or Newcastle or Sunderland Measure."

In 1727 the Durham coalowners entered into an agreement for seven years not to sell for less than 11s. 6d a chaldron.

Screens were first introduced about 1770, being then made of wood, and it is not till after that date that we begin to read of "round" and "small" coals. The demand for coal in the London market rapidly increased about this time. This increased demand, and the Continental wars, doubled the price of coal between 1790 and 1815, and the North country coalowners endeavoured to keep up these high prices by regulating the vend.

Regulation of the vend (or "management of the vent," as it is called in an old document) was practised as long ago as 1605, under the control of the Hoastmen of Newcastle, a very ancient fraternity, and early in the nineteenth century the matter engaged the attention of Parliament. As the regulation of the vend is sometimes advccated at the present day, the following explanation of how it was done sixty years ago is interesting. It is given in the words of Mr Brandling, a large colliery owner of that day, on his examination by a Select Committee of the House of Commons, as stated in their report, presented 13th July 1830:—

"When it is understood by the coalowners that all parties interested in the coal trade on the Tyne and Wear are willing to enter into an arrangement of this nature, a representative is named for each of the collieries. These representatives meet together, and from amongst them choose a committee of nine for the Tyne and seven for the Wear, which is, I think, the number of collieries on the Wear. This being done, the proprietors of the best coals are called upon to name the price at which they intend to sell their coals for the succeeding twelve months. According to this price the remaining proprietors fix their prices. This being accomplished, each colliery is requested to send in a statement of the different sorts of coal they raise, and the powers of the colliery—that is, the quantity that each particular colliery could raise at full work; and upon these statements the committee, assuming an imaginary basis, fix the relative proportions as to quantity between all the collieries, which proportions are observed, whatever quantity the markets may demand. The committees then meet once a month, and according to the probable demand for the ensuing month, they issue so much per 1,000 to the different collieries—that is, if they give me an imaginary basis of 30,000, and my neighbour 20,000, according to the quality of our coal, and our power of raising them in the monthly quantity, if they issue 100 to the 1,000, I raise and sell 3,000 during the month, and my neighbour 2,000; but in fixing the relative quantities, if we take 800,000 chaldrons as the probable demand of the different markets for the year, if the markets should require more, an increased quantity would be given out monthly, so as to raise the annual quantity to meet that demand were it double the original quantity assumed."

The Committee, in their report, observe that "this system, which, by the report made to the House in 1800, appears to have been in operation as early as the year 1771, and which probably existed at an earlier period, has continued in operation with occasional interruptions to the present time."

This compact had a marked effect in keeping up the price of coals in those days, when the northern coal-field almost monopolised the London market. Thus in 1828, with the regulation described above in force, the price for screened coals was 30s. to 36s. 6d. a Newcastle chaldron—say 12s. 6d. a ton—on the Tyne. In 1833, with open trade, the price fell to 18s. a chaldron (=6s. 9d. a ton); but in the following year, the regulation of the vend being reinstated, the price was soon raised to 28s. 6d., and gradually to 30s. 6d.

Mr Matthias Dunn, writing in 1852,* stated that "the regulation of vends was maintained in various states of imperfection, and with numerous discontinuances, until the year 1845. . . . The ruling cause of the permanent dissolution of the regulation arose from the overweening influence of the proprietors of the great collieries."

The increase in the output of coal of the United Kingdom during the last seventy years has been enormous. At the beginning of the nineteenth century it is estimated to have been about 10,000,000 tons annually; in 1850, 42,000,000 tons (estimated); in 1853, 56,550,000 tons (estimated); in 1854, 64,661,401 tons (accurate figures from this date); in 1864, 92,787,873 tons; in 1874, 125,043,257 tons; in 1884, 160,757,779 tons; in 1894, 188,277,525 tons; in 1903, 230,334,469 tons; and in 1913 it was 287,114,869 tons, which is the greatest annual output yet achieved.

From a Parliamentary return issued in 1886, showing the average price of best coal imported into London since 1820, at the ship's side, exclusive of city or other dues, we gather that the price in 1838 was 23s. a ton. In 1851 it had decreased to 15s. From 1852

* "Working and Winning of Collieries," M. Dunn.

to 1885 inclusive, the average price over the thirty-four years was 18s. 9d.—the minimum being 15s. 5d. in 1852, and the maximum 31s. 3d. in 1873. For the decennial period 1855-65 it averaged 17s. 11d.; for 1865-75, 21s. 2d.; for 1875-85, 16s. 10d.; and for 1885-95 the prices in the London market gave an average of 16s.* to 17s. a ton. In 1913 the retail price for Derby Brights delivered in Central London was 27s., and in May 1922 it was 51s.

In more recent years (avoiding the abnormal war period) the value of coal at the pit's mouth has fluctuated considerably as the following figures show :—

1896	5s. 10d. per ton.	1901	9s. 4d. per ton.
1897	5s. 11d. ,,	1902	8s. 3d. ,,
1899	7s. 7d. ,,	1903	7s. 8d. ,,
1900	10s. 10d. ,,	1913	10s. 2d. ,,

The Annual Report issued from the Home Office gave the following figures for 1903 :—

	Tons.	Value.		Per Ton.
England	*160,562,348	£60,844,296	=	7s. 6.95d.
Wales	†34,666,895	16,409,362	=	9s. 5.6d.
Scotland	*34,992,240	10,922,922	=	6s. 2.92d.
Ireland	102,812	48,558	=	9s. 5.35d
	230,324,295	£88,225,138	=	7s. 7.93d.

* From *mines* only, the small quantity derived from quarries not being included.
† Monmouthshire is included in England.

It is interesting to compare these figures with those for 1913, the year which holds the record for highest output of coal :—

	Tons.	Value.		Per Ton.
England	199,911,209	£98,510,746	=	9s. 10.2d.
Wales	44,961,623	26,459,396	=	11s. 9.2d.
Scotland	42,456,516	20,514,873	=	9s. 7.9d.
Ireland	82,521	50,654	=	12s. 3.3d.
United Kingdom ..	287,114,869	£145,535,669	=	10s. 1.6d.

Interest on Invested Capital.

With regard to the average return upon capital invested in collieries, it is difficult to make any general statement owing to the violent fluctuations in prices which characterise the trade. Such

* As stated by the Secretary of Mines in House of Commons on 29th May 1922.

evidence as is available is somewhat conflicting, but the average interest per cent. received by the colliery owner has certainly not increased in the same ratio as the increase in wages secured by the working miner.

A statement of profits for the year 1742 of some collieries in the neighbourhood of Newcastle-on-Tyne (known as Byker, Jesmond, Bushblades, Byermoor, and the Lands) shows that 41,482 chaldrons (109,927 tons) of coals had been sold for a total sum of £23,295, making the average selling price 4s. 2.9d. per ton. The expenditure was £18,029, or 3s. 3.3d. per ton, leaving a profit of £5,266, or 11.6d. per ton.

When giving evidence before a Parliamentary Committee in 1830, Mr John Buddle asserted that 5 per cent. was the average profit after returning the capital, and the highest rate he knew was 14 per cent., including redemption of capital. The late Sir George Elliot—in his scheme for a National Coal Trust, made public in September 1893—estimated that an average selling price of 7s. 3d. a ton at the pit-bank would suffice, at the then annual rate of output, to give an interest of 5 per cent. on the debentures which were to form one-third of the capital of the Trust, and from 10 to 15 per cent. on the ordinary stock which was to constitute the remaining two-thirds of the capital. Independently of this, there was to be a sinking fund for the redemption of capital to make the consolidated property permanent.

From evidence given before the Royal Commission on Mining Royalties, Mr T. H. Elliott drew up a report in compliance with the instructions of the President of the Board of Trade, in which he distributed the whole product of the Coal Trade for the year 1889 as follows :—

Wages	55 per cent.	£30,896,250
Royalties	8 "	4,494,000
Other charges	25 "	14,043,750
Profits	12 "	6,741,000
		£56,275,000

He also gave figures supplied by seven colliery companies, showing the trade profits for the year to be £220,922 on an aggregate capital of £2,986,086, or 7.40 per cent.

It is instructive to compare these figures with the following which show the approximate distribution of the gross selling value of all the coal produced in the Federated Area (*i.e.*, Yorkshire, Lancashire, Cheshire, Derbyshire, Nottinghamshire, Leicestershire, Shropshire, part of Staffordshire, Warwickshire, and North Wales) during the four years 1908-11 :—*

Labour	£121,000,000	69.4 per cent.
Materials	28,000,000	16.0 ,,
Royalties, rates, &c.	13,000,000	7.4 ,,
Profits	12,500,000	7.2 ,,
		100.0

Out of profits has to be taken the money required for new plant and machinery, and for extension and development, so that the average return on capital does not appear to be more than 5 per cent.

In the Report of the Labour Commission (1893) it is stated that "in the coal trade of the United Kingdom there is embarked a capital of probably not less than £100,000,000 sterling, and if the average profits on mines assessed to income-tax over the period of ten years ending 1890 were made in coal alone, they would not have paid † 6 per cent. on the capital embarked on that industry. . . . Several witnesses informed the Coal Committee of 1873 that the average profits made in the coal trade of this country over a long period of years had not exceeded 2½ or 3 per cent."

Sir Josiah Stamp, in his evidence before the Royal Commission on the Coal-Mining Industry in March 1919, showed that the profits of the coalowners—apart from Royalty owners—had reached from £13,000,000 to £14,000,000 in the five years before the war, that is, inclusive of interest on capital whether that capital was borrowed or owned by the colliery proprietors. And he estimated that the capital value of the collieries would be £135,000,000.‡

Sir James Joicey (now Lord Joicey) estimated the amount of the capital invested in the collieries in 1896 at £110,000,000, but it is very difficult, if not impossible, to arrive at any satisfactory conclusion

* See *Iron and Coal Trades Review*, 23rd May 1913.

† A more recent investigation in 1898 by Dr J. B. Simpson led him to the conclusion that the average return on capital invested in coal mining is not more than 5 per cent. (See paper, "Capital and Labour Employed in Coal Mining during the Past Two Hundred Years," Newcastle Economic Society, March 1898.)

‡ See p. 6, "The British Coal-Mining Industry During the War," by Sir R. A. S. Redmayne.

in respect of this. Taking his figures, however, as being near the mark, and calculating on the computations stated above as being the correct division of the total receipts, we arrive at a profit return which gives but 4.7 per cent. on the capital invested, and this without allowing anything for the redemption of capital.

Three of the largest coal and iron companies in South Wales, with a total capitalisation of nearly three and three-quarter millions, have paid, over a term of twenty years, average yearly dividends of 1.1, 3.1, and 1.8 per cent.

The late Mr G. P. Bidder, Q.C., in his article on "The Profits of Coal Pits," in the *Nineteenth Century* for May 1894, stated (what will hardly be denied) that "an annual return of 10 per cent. on the capital, to include both interest and depreciation or redemption of capital, is surely a very reasonable remuneration. . . . No man would embark his money in colliery property unless he had a fair prospect of obtaining at least this return for it." *

In the year 1903 the Board of Trade issued a return showing the quantity of coal produced in the United Kingdom, its value, the number of coal miners and their average wages for the years 1901 and 1902, with the estimated amounts expended on miners' wages, with the balance for other expenses, and profits of coal-owners. Though these figures cannot, for reasons that it is needless to consider in these pages, be taken as strictly accurate for the separate coal-mining districts, the probable errors are much smaller for the United Kingdom as a whole. This return shows that for the decennial period 1892-1901 the average output of coal was 198,785,000 tons, valued at £73,052,000 at pits' mouth prices, or an average value of 7s. 4.20d. per ton. The *estimated* number of workpeople employed in coal mining averaging 699,500; the estimated number of tons of coal raised per person employed per year in coal mining being 284; and the computed average rate of weekly wages 28s. 3d., or, assuming fifty weeks' full employment for each person employed, no allowance being made for disputes affecting employment and production, a total sum for wages of £49,402,000; leaves a computed amount for expenses other than wages and for coalowners' profits of £23,649,000. Sir James Joicey drew some deductions from the Board of Trade figures which had been issued in May 1901, and his letter appeared in the *Times* of 22nd May 1901. He took the costs, other than wages, as amounting

* How the cost of working is increased, and profits are reduced, by restriction of the output, is clearly shown in this article.

to 1s. 6d. per ton, though experts agree that this should be 1s. 9d. at least. It can be shown * that the total receipts may be divided up as follows :—

Wages	4s. 7.01d. per ton.
Rents	0s. 6.50d.* ,,
Materials, &c.	1s. 1.50d. ,,
Profit	0s. 6.64d. ,,
	6s. 9.65d.

* Estimated at 5¾d. in 1889 by the Royal Commission, but these were below the average for three years over which these figures are taken.

For the year 1922 the results, as shown by the official statements issued by the Mines Department, were as follows :—

		Cost per Ton Disposable.† s.	d.	Per Cent.
COSTS—				
Wages	£129,550,476	12	1.8	66.6
Stores and timber	24,637,408	2	3.3	12.6
Other costs ‡	33,294,961	3	1.6	17.1
Miners' welfare fund contributions	974,628	0	1.1	0.5
Royalties	6,128,747	0	7.0	3.2
Total costs	£194,586,220	18	2.8	100.0
Deduct proceeds, miners' coal ..	1,092,262	0	1.2	
Net costs	£193,493,958	18	1.6	
PROCEEDS—				
Commercial disposals	£203,850,718	19	1.3	
Credit balance	£10,356,760	0	11.7	

THE FUTURE OF COAL MINING AS AN INVESTMENT AND AN INDUSTRY.

The general tendency in the coal trade, as in most other great industries, is for labour to receive more and capital less. " Foreign economic writers are already beginning to remark that one of the most striking of recent economic phenomena in England

* See " Colliery Manager's Pocket Book " for 1902, *et seq.*

† The tonnage available for commercial disposal was 213,291,000 tons, and the total output of saleable coal 234,149,000 tons, the difference, viz., 20,858,000 tons, being the amount consumed at the collieries and supplied to the miners as fire coal.

‡ Other costs include management, salaries, insurances, repairs, office and general expenses, depreciation, &c.

is the check which appears to have been given to the growth of large fortunes, and the wider and more even distribution of wealth which is taking place." * This phenomenon is unmistakably apparent in the coal trade, of which it may be said—as regards every district in the United Kingdom—that the spoils of the scientific triumphs of the century have gone to labour rather than to capital. "In ordinary times" (to quote a high authority, alike in the Coal and the Iron trades †) "practically the whole of the proceeds of manufacturing operations tend more and more to go into the pocket of the worker, and very often for long-continued periods these proceeds have themselves to be supplemented out of that of the employer, who can only look for anything like an adequate return for his enterprise in those spurts in trade due to some exceptional temporary conditions, which apparently tend to become both fewer and further between in proportion to the development of the resources of the world and the ever-increasing resulting competition. It may be that at one time manufacturing concerns were carried on too exclusively for the benefit of the capitalist. It would almost seem that at the present day the pendulum had swung to the other extreme, and that the programme of some of our advanced social reformers, that capital should be employed and works carried on solely for the benefit of the workers, was practically establishing itself as an accomplished fact."

Besides competition between producers as capitalists, there are influences at work among the manual workers tending in the same direction of advancement in the security of their position. "The diffusion of knowledge, the improvement of education, the growth of prudent habits among the masses of the people, and the opportunities which the new methods of business offer for the safe investment of small capitals—all these forces are telling on the side of the poorer classes as a whole relatively to the richer." ‡

In the coal-mining industry a larger proportion of the proceeds goes to labour and less to capital than in other industries.

Dr Arthur L. Bowley (Professor of Statistics in the University of London) estimates that in coal mining 75 per cent. of the product goes in wages, 3 per cent. in salaries, and 22 per cent. in profits, interests, rents, royalties, and advertisements, the corresponding

* "Social Evolution," by Benjamin Kidd.

† The late Sir David Dale, in his Presidential Address (1895) to the Iron and Steel Institute.

‡ "Elements of the Economics of Industry," by Professor Alfred Marshall.

figures for other industries being 58 per cent. in wages, 10 per cent. in salaries, and 32 per cent. in profits, &c. ("The Division of the Product of Industry; an Analysis of National Income before the War.")

The chief impression left by an historical review of coal mining in the United Kingdom is the enormous progress made during the last two or three generations in every respect *except* the return made to capital. This is apparent when one reflects that such everyday features of colliery working at the present time as shaft cages and guides, the safety-lamp, the steam locomotive, the trade in coke, ventilating fans, wire ropes, mechanical haulage, mechanical screening, mechanical coal-cutting, the use of compressed air, and the application of electricity to signalling, lighting, and motive power, have all been introduced in the course of the last hundred years. The progress which has been made may be estimated to some extent by comparing the frontispiece with Plate III., showing an average modern colliery and one at the beginning of this century. There is hardly an appliance (save the simplest tools) or a machine in use at a modern colliery which could have been made a hundred years ago; and even as regards old forms of tools there have been almost equally noteworthy changes as regards the material used in their production, as well as in the means of producing them—resulting in greater durability and cheaper cost. From rude and barbarous beginnings, coal mining has risen to the rank of a well-ordered industry, in which many of the latest developments of scientific research and mechanical invention are usefully employed.

CHAPTER III.

CONDITIONS OF LABOUR IN COLLIERIES—PAST AND PRESENT.

Former Conditions of Labour.—Labour plays an exceedingly important part in coal mining, as much as 60 to 70 per cent. of the cost of "getting" the coal being represented by workmen's wages. That "the old men" were skilful and laborious workmen, who proved their capacity in dealing with problems and difficulties unknown in the present conditions of coal mining, is shown by some of their work still to be seen in old mining districts. Many of the old watercourses—upon which, before the era of pumping engines, the existence of most collieries absolutely depended—are monuments of careful toil, being in some cases as much as 12 feet in depth, partly in stone, and partly in coal, and not more than 30 inches in width. Some of them are narrower than this, the width being insufficient to allow a man to turn round, and yet they show straight sides from top to bottom. In the deeper ones, a wooden scaffolding or floor used to be fixed at about half the depth, which served as a half-way stage for removing the stone during the progress of the cutting, and subsequently as a floor for persons walking along the "level." Both in these "water levels," and also in some of the bords driven in the coal, a division for the air current was often provided by cutting in one side of the stone or coal a recess, about a foot square by a foot deep—sometimes called a "grip"—the front of which was covered by a wooden plank, so as to form a separate passage. This was done before the days of bratticing. Water-ways were also sometimes cut in the coal by the side of a place. In some old workings, in a 6-feet seam with a clay band in the middle, one of the authors of this volume has seen a trough formed in the coal above the band and rising at such a level as to allow water filled into it at the face to run away to the back of the place.

It is needless, perhaps, to remark that in the old days labour was cheap, and the hours of labour long. Boys used to work from sixteen to eighteen hours a day, so that they literally never saw the sun from one week's end to another, and they had an uncommonly rough time of it when they were at work, especially the putters, before the days of metal rails. This is graphically described in the racy Tyneside vernacular by Thomas Wilson, in some well-known verses :—

THE PITMAN'S PAY.

But heavy puttin's now forgetten,
  Sic as we had i' former days,
Ower holey thill * and dyels a' splettin' †
  Trams now a' run on metal ways.

This was the wark for trying mettle
  Here ivry tuil his level fand :
Sic tussels nobbut pluck could settle,
  For nowse less could the racket stand.

And had wor bits o' yammerin' yeps
  That wowl about wor barrow-way
To slave and drudge like langsyne cheps,
  They wadn't worsel out a day.

God bliss the man wi' peace and plenty,
  That furst invented metal plates ; ‡
Draw out his years to five times twenty,
  Then slide him through the heevenly gates.

For if the human frame te spare
  Frae toil and pain ayont conceivin',
Ha'e ought te de wi' gettin' there,
  Aw think he mun gan strite te heeven.

The hewers' hours were shorter, being eight or ten. Within the memory of old pitmen of the present day, it was usual for a man hewing singly in a bord or wall to hew as long as he could get tubs to fill, and then to lay his place full of coals to be filled after his departure by the putter. Sometimes he would be joined at 7 A.M. by his marrow (or partner) of the back shift, and the two would hew together till about 2 P.M., by which time the fore-shift man had usually had enough of it, and went home. In pillar workings, where the coal can be got more easily, they worked shorter hours.

Terms of Hiring.—The custom was to engage men once a year for the whole year, under certain conditions specified in a

* The natural floor of the seam over which the trams were dragged.

† Deals split by constant wear.

‡ Metal plates were introduced underground about 1803.

written document, which was legally binding. The "binding day" used to be an important event. Subjoined is a copy of a Pitman's Yearly Bond, dated 3rd October 1706, for which the authors are indebted to the late Mr John Robinson, of Newcastle-on-Tyne. It does not bear signs of legal or literary draughtsmanship :—

"AN AGREEMENT made between Sir Francis Blake of Ford Castle, Knight, and Thomas Wear, William Gardiner, George Williamson, Robert Head, John Ponmant, Alexander Hunter, and James Anderson, all hughers at Gaderick Colliery. Four of the said seven have agreed to work the Stoney Coale, and they are to drive her no wider than ye colliery will beare, and as to the Dip Room, they agree to condy it very strongly as they go on. And it is agreed between all ye said Parties that the said Collyers are to have three bowls out of all they work be they great or small, and ye fourth bowle either great or small, is to be for ye use of the said Sir Francis Blake, and the said Sir Francis is to have his said fourth bowle daily, and is to be put into ye Banksman's hands for Sir Francis' use, and ye said hughers do hereby covenant that they will work five full days in said colliery every week till Easter next, or untill Sir Francis gets on the Main Colliery. And ye said hughers are to pay unto Sir Francis for the use of his Mills three Corfs of small Coles as long as this Agreement continues, and each man to pay one bowle of coals weekly unto Thomas Stuart and ye other three hughers are to work at the Drift until it is finished according to a former agreement. In witness whereof we and each of us, in the penalty of Twenty Pounds every one for ye true performance of said agreement have hereunto set our hands this 3rd day of October 1706.

his	his	
THOMAS X WEAR	WILLIAM X GARDINER	
mark.	mark.	&c. &c.

Witness F. R. BLAKE."

The bowl, which originally was probably a measure containing as much coal as a man could conveniently carry, has come down to the present day in connection with tentale rents. The rents payable to lessors of coal royalties were fixed until recently at so much per ton of coals of so many "bolls," usually 418 or 440 bolls—1 boll = 2.23⅓ cwt. A rent per ton is now more usual.

The system of yearly bindings received its death-blow from the great strike of 1844, but it was still carried on in a modified form at some collieries until recently.

At the binding, each man and boy was paid a certain sum. A yearly bond of 1763—engaging 110 hewers and 55 drivers at collieries in West Durham, worked by Lady Windsor and Alderman John Simpson—shows that the binding money was 6d. each.

In a letter from John Buddle, addressed to Richard Clayton, Esq., of Newcastle-on-Tyne, dated 3rd October 1809, informing him of the conditions of binding agreed upon at a meeting of coal-owners, it is stated that the binding money was to be " for a hewer being a householder, on the Tyne, 5s. ; on the Wear, 10s. 6d. For a hewer being a single man, on the Tyne, 8s. ; on the Wear, 13s. 6d. Driver on the Tyne, 3s. ; on the Wear, 5s. 6d. A tram [there were two putters to each tram] on the Tyne, 16s. ; on the Wear, £1. 1s. . . . The drivers on the Tyne to work fourteen hours to the shift or day's work in single-shift pits, unless the coals can be filled and put out in a shorter time." *

The highest binding money ever paid was probably in 1804, when " from twelve to fourteen guineas per man was given upon the Tyne, and eighteen guineas upon the Wear ; and progressive exorbitant bounties were paid to putters, drivers, and irregular workmen. Drink was lavished in the utmost profusion, and every sort of extravagance perpetrated." † This was due to an extraordinary increase in the demand for coals which had taken place during the year, and to the fear of not being able to procure a sufficient number of men, owing no doubt to the continental war then prevailing.

Former Rates of Wages.—The rate of hewers' wages prevailing at the beginning of the eighteenth century is illustrated by the following literal copy of a wage bill (1707) of Gaderick colliery, in Northumberland :— ‡

GATHERICK, 18*th October* 1707.

All. Hunter, 4 days, Great Cole 1½, Small 38½, Wadges	..	00	02	05½
Jo. Ponmant, 4 days, Great Cole 1½, Small 38½, Wadges	..	00	02	05½
Thomas Weir, 4 days, Great Cole 1, Small 39, Wadges	..	00	02	05
Will. Gordon, 4 days, Great Cole 1, Small 39, Wadges	..	00	02	05
Jas. Anderson, 4 days, Great Cole 1, Small 39, Wadges	..	00	02	05
Robert Hood, 4 days, Great Cole 1, Small 39, Wadges	..	00	02	05
		00	14	07

* *Transactions of the Derwent Vale Naturalists' Field Club*, vol. ii., p. 22. Paper by Mr James F. Robinson.

† Dunn on " The Coal Trade," p. 28.

‡ For this interesting document the authors are indebted to Mr John Robinson, of Newcastle-on-Tyne.

For putting 240 boles at 5d. per score	00	05	00
For banking	00	04	00
George Wilkinson...	00	04	00
Other Men's Wadges	00	02	00
	00	15	00
For setting a scaffold	00	02	00
	00	17	00

About 1708, it was "most usual to agree with your Hewers of Coals or Miners, by the Score of Corves, by chance for ten pence or twelve pence for each score, according to the tenderness or hardness of the coal, or according to what the Mine will afford, and not by the Day or Shift Work, for it is common to give about twelve pence or fourteen pence for each Shift, when perhaps you will not have above thirteen or fifteen corves a man per shift; so that it is clearly best to agree by the score, and then good Hand, good Hire, as we say, and you pay for no more than you have wrought, or comes out of the Pit." This we learn from that quaint old pamphlet "The Compleat Collier."*

The corf (see B, Plate III.) was a basket made of young hazel rods, varying in size, holding from 8 to 24 pecks of coal—that is, from 2½ cwt. to 7 cwt., a peck being 0.30 cwt. The corf was fitted with an iron bow, by which it was attached to the winding rope and drawn up the shaft, and (according to the authority just quoted) was "subject to Clash and Beat against the Shaft sides, and so beats down your Corfe dayly, that if your Corves be not dayly beat up, and mended, you may lose more than one Inch dayly, which would bring your measure or Corfe, of fourteen or fifteen Pecks, down to nine or ten Pecks, and so lose you a third of your measure, and cost of Working or Hewing." The corver, a man who kept the corves in repair, was a regular and important institution before the days of coal tubs.

As to putters' wages at the same period, we learn as follows from "The Compleat Collier": "Besides these Miners, called Hewers, there is another sort of Labourers which are called Barrow-Men or Coal Putters, these Persons take the hewed Coals from the Hewers, as they work them, or as fast as they can, and filling the Corves with these wrought Coals, put or pull away the full Corves of Coals, which are set upon a Sledge of Wood, and so hauled all along the Barrow-way to the Pit Shaft by two or three

* London: "Printed for G. Conyers at the Ring in Little-Brittain, 1708."

Persons, one before, and the other behind the Corfe. . . . The Wages for the Barrow-men is usually about twenty pence or two and twenty pence a day for each Tram (that is to say) for putting so many loaden Corves, as are carried on one Sledge, or Tram in one day to the Pit Shaft."

In those early days the hewer did not fill his coals. This was done by the putter or barrow-man, and as recently as forty to fifty years ago it was usual, as already mentioned, for a hewer at the end of his shift to lay his "place" full of coals, and then go home, leaving them for the putter to fill.

From the same source we learn that sinkers' wages at this time were about 12d. or 14d. per day.

In 1752, at a colliery on Cockfield Fell, near Barnard Castle, County Durham, mechanics and masons were getting 1s. 4d. a day, and sinkers, shifters, and labourers 1s. a day.*

A wage bill of Byermoor colliery, in West Durham, for the fortnight ended 28th February 1770, shows that eighteen hewers and eight putters were employed; that the hewers were paid at the rate of 1s. per score of corves (12 peck corf) = 3.3d. per ton; and the putters 9d. per score, or 2½d. a ton. The average earnings of the hewers were 1s. a shift, and of the putters 1s. 8¼d. The pit worked nine days during the fortnight, and drew 162 score 5 corves = 584 tons of coals.

In April 1752 a wage bill for repairs done to a waggon-way from Pontop to Derwent Haugh, a distance of 8½ miles, shows that wrights were paid 1s. 4d. to 1s. 8d. a day, and labourers 10d. a day; and that the price for the hire of a cart and horse was 2s. 6d. a day.*

At the same period, an engineman's wage appears, from the document cited below,† to have been 8s. per week:—

18th October 1760.

AGREED with THOMAS LOGAN to work as Engineman in the New Winning for one year to come from the date hereof, and to be paid for the same Eight Shillings per Week. The said THOMAS LOGAN is to attend the Engine by night or day as occasion offers.

I agree to perform the above agreement. THOMAS LOGAN.

Witnesses—WILL. DOBSON, LUKE CURRY, ALEX. MANCHESTER, JOSEPH WHEATLEY.

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* *Transactions of the Vale of Derwent Naturalists' Field Club.* Papers by James F. Robinson.

† See "The Delaval Papers," by John Robinson.

A blacksmith got 7s. 6d. a week :—

SEATON SLUICE, *5th March* 1763.

AGREED with GEORGE ALLEN, Blacksmith, for one year, to commence the Twenty-first day of March 1763 at Seven Shillings and Sixpence per week.

From an "Estimate of the Charge of Working Tanfield Moor Colliery, County Durham," dated 9th October 1771 (see page 22)—a colliery which was "won" in 1768—we find that the hewing price in the Hard Coal seam was 5d. a ton; that the putting price averaged 3.12d. per ton; and that the cost of working—including all underground and surface labour, timber, and other materials, and also agency—was 1s. 5d. a ton. The cost of working the Hutton seam at the same colliery, including the same items, was 11.66d. per ton in the whole, and 11.25d. per ton in the pillars; the hewing price in the whole being 2¾d. a ton, and in the broken 1.94d. per ton.

A pay bill of the Moor Machine pit, Pontop Pike colliery, County Durham, for the fortnight ended 4th December 1786, shows that the pit worked ten days, and raised 207 scores of corves of coal; that thirty hewers were employed; and that the average wage per hewer per day was 1s. 9d. Yet these were considered high wages at that time, for William Hutchinson, in his "History of Durham," published in 1787, when writing of the pitmen living in the neighbourhood of Whickham, stated that they "earn great wages, which recompense every other evil."

The following is a *verbatim et literatim* copy of an old statement of wages, which was kindly placed in the authors' hands by the late Mr John Robinson :—

	£	s.	d.
SR and plese your oner, there is the ful of six mens work Each mans 36 Bowls p. day which makes 216 Bowls att 2d p . . is ...	£1	16	0
SR and pleas your oner there is the ful Account of all the Expences this Pay	£	s.	d.
Lise you in for* To six mans Days att 1s. 8d. pr		10	0
Banks Day		1	8
Do. Tuging one Day		2	4
Gin Driveing „ Day		0	8
To three men att the water cours att 18d. p.		4	6
To tow men att the stone Dreft att 1s. 8d. pr...		3	4
To Candels used att the tow Drefts		0	3
To Coals over the heap this Pay 56 Bowls at 2 p		9	4
To putting ten score & 16 Bowls att 5¼d. pr		4	8
	1	15	9

* "Lets you in for"—that is, "There is due from you."

To Mr Robinson belongs the credit of having discovered and brought to light the interesting Delaval Papers. The document here quoted is endorsed on the back in the handwriting of Sir John Hussey Delaval, who was elevated to the peerage in 1786.

In 1740 hewers' wages were from 1s. 6d. to 1s. 10d. a day, and they remained at about this rate up to the last ten years of that century, when there was a great rise in the cost of all labour, owing to the wars in which England was then engaged, and to the consequent demand for men. According to one authority,* in 1799 "the wages of pitmen had increased 50 per cent. within ten years;" and in 1813 "wages for hewing had advanced during the last twelve years from 2s. 3d. to 3s. 4d. a day." In other mining districts the increase was apparently much the same as in Northumberland and Durham. Thus in West Cumberland, in 1675, hewers were getting 8½d. a day; in 1709 they were getting 10d. per day, and other workmen as follows:—Trailers (putters), 8d.; brakesmen, 8d.; winders, 8d.; and corvers, 1s. At the same date, the cost of bringing coal to the surface at one of the Whitehaven pits was about 11d. a ton. In 1737 the cost f.o.b. at Whitehaven was 1s. 7¾d. a ton. In 1781 hewing was costing 9d., and trailing 5½d. a ton; and by 1838 it had more than doubled, being 2s. 9d. to 3s. 3d. a ton for hewing and trailing.†

In 1826 the Pitmen's Union was founded in the Newcastle-on-Tyne district for the procuring of higher wages, and in 1831 there was a general strike which resulted in "a very considerable advance of wages." This success led to another strike, with the same object in view, in the following year, but the result was that the owners were led to bring men from all parts of the country. In the end a surplus of labour ensued, and a fall alike in prices and in wages occurred.

Wages in 1833 and in 1905.—The ordinary wages paid at collieries in the neighbourhood of the river Tyne in 1833 are given below, with the corresponding wages paid in 1905:—

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* Dunn on "The Coal Trade."

† *Trans. N. E. Inst.*, vol. xxxiv., "History of Mining in Cumberland and North Lancashire," by J. D. Kendall; also *Trans. Fed. Inst. M. E.*, vol. vii., "Historical Sketch of the Whitehaven Collieries," by R. W. Moore.

	Wages in 1833.	Durham 1905 (July).	Northumberland, 1905 (July).
Fore-Overman	24/ a week with privilege of finding oil and candles for deputies, cranemen, drivers, &c., at 1½d. a day, and 1½d. per score for finding grease for rollers.	About the same as in Northumberland.	54/ a week.
Back-Overman	.. ..	About the same as in Northumberland.	46/ a week.
Deputies ..	3/ a day.	4/8½ a shift of 7½ hours, basis rate.*	Whole and backbye, 4/9. Broken and L. wall, 4/3. (Per shift, basis rate.*)
Rolleywaymen.	2/10 a day, finding their own candles.	Datal, 10½ hours, 3/5¾ per shift, basis rate; piece, 10½ hours, 4/2 per shift, basis rate.	Long hours,† 3/7. Short hours,† 3/5. (Per shift, basis rate.*)
Hewing ..	2/10 a score; when employed by the shift, 2/10 a shift.	4/2 per shift, basis rate.	Steam coal,‡ short hours, 4/9½. Steam coal, long hours, 5/2. Soft coal, short hours, 4/7½. Soft coal, long hours, 5/. (Per shift, basis rate.*)
Drivers ..	1/2 a day.	1/4 per shift of 10 hours, basis rate.	Same as in Durham.
Furnacemen	14/ a week, hewing and putting the coal required.	16/6 per week and work 8 hours per shift, basis rate, coal brought to them.	18/10.52 per week, basis rate, coal brought to them.
Horse-keepers	14/ a week.	16/9 per week, including percentage.	18/10.52 per week, basis rate.
Shifters ..	2/4 to 2/10 a day.	3/0¾ per shift of 8 hours, basis rate.	3/1 per shift of 8 hours, basis rate.
Brakesmen	18/ a week.	?	?
Heapkeeper	2/8 a day.	?	?
Screeners ..	1/4 to 2/6 a day.	2/10 per shift of 10½ hours, basis rate.	Short hours,† 2/9¾; long hours, 2/11½, basis rate.

* By "Basis Rate" is meant standard wage, for instance, the percentage of wages above standards at the time of writing (11th July 1905) is, in the various districts, as follows:—Northumberland, 15 per cent.; Durham, 27½ per cent.; Federated Area, 40 per cent.; South Wales and Monmouthshire, 33¾ per cent.; Scotland, 37½ per cent. Therefore, in the case of Northumberland and Durham, 15 and 27½ per cent. must be added to the respective basis wages given above in order to have the current county rate.

† A long hour pit is one that draws coals for eleven hours, a short one for ten hours.

‡ The great bulk of the coal worked in Northumberland is steam coal, which fetches a higher price and is also harder to hew than most of the coal in Durham.

Perhaps 1d. a shift ought to be added to the wages of hewers and putters in 1833, in consideration of the "binding money," which was paid once a year (see page 40).

According to a Parliamentary Blue-Book issued in January 1888, the wages of pitmen in 1834 were 15s. to 20s. a week, with free house and firing.

Proportion of Classes of Underground Labour.—As regards the relative proportion of hewers (actual coal-getters) to other classes of underground labour—known as off-hand men and boys—from a paper in the authors' possession headed "An Account of the Number of Workmen at Stanley and Kiphill

VERBATIM COPY OF AN ACCOUNT OF THE NUMBER OF WORKMEN AT STANLEY AND KIPHILL COLLIERY,

25th October 1769.

70 Hewers.	10 Overmen.	16 Wailers.	6 Sledders.
50 Putters (lads).	6 Gynn Drivers.	38 Gynn Horses.	2 Spare Horses.
27 Drivers.	6 Banksmen.	20 Underground.	

PRESENT WORKINGS—

	Scores.	Corves.	
Hare Pitt	16	...	per day.
Jenny Pitt	15	...	„
Charlotte Pitt	13	10	„
Hound Pitt	16	10	„
	61	0	

Supposing 3 Pitts to Work—

	Fath.			Hewers.	Lads.	Gynn Horses.	Under-ground Drivers.	Under-ground Horses.	Banksmen.	Sled. Horses.	Overmen.	Gynn Drivers.	Wailers.
72*Coggs Double	51	viz., Hare Pitt	18 p. day	19	13	12	10	10	2	2	2	2	4
30 Foot do.	57	Jenny „	18 „	20	14	12	10	10	2	2	2	2	4
72 Coggs Single	25	Hound „	25 „	22	32	8	...	...	2	2	2	1	4
		Knab „	...	...	...	4	...	...	...	...	...	...	...
			61 „	61	59	36	20	20	6	6	6	5	12
Makes to Spare				9	18	2	7	...	...	...	4	1	4
				70	77	38	27	20	6	6	10	6	16

[* NOTE BY THE AUTHORS.—"Coggs" refers to the construction of the cog and rung gins used for raising and lowering the corves in the shaft. This gin, in which the winding drum was on the second motion, was a step in advance of the older whim gin, in which the winding drum was on the first motion,—viz., on the vertical shaft, rotated by the horses.]

Colliery, 25th October 1769" (see page 47), we learn that out of a total of 157 employed underground, 70 were hewers, and the output from four pits was 61 score a day. The size of the corf is not stated. By laying off one pit, and getting the same output from three pits, it is estimated that they would save 9 hewers, 18 lads, 7 drivers, and 4 overmen, or 38 hands underground. With the four pits working, the proportion of hewers was therefore 44 per cent. of the total underground hands, and after the proposed change it would be 51 per cent. According to a Parliamentary Return issued in July 1890 this proportion was then about 50 per cent. in Northumberland and Durham.

With this may be compared the number of workmen employed at a Durham colliery in 1907—a comparatively small colliery having a vendable output of about 6,000 tons a fortnight :—

Per Cent.	Underground.	
63	Hewers	240
	Putters	47
	Shifters	21
	Stonemen	16
	Drivers	11
	Inclines	10
	Helpers up	8
	Rolleywaymen	3
	Waterleaders	4
	Onsetters	2
	Horsekeeper	1
	Deputies	13
	Overmen	2
100	Underground	378
	Surface	46
	Total	424

Surface.	
Winding enginemen	3
Hauling enginemen	1
Screenmen	10
Banking out	3
Labouring	3
Lampmen	3
Weighman	1
Carting	1
Railways	2
Smiths	5
Joiners	4
Masons	2
Cottage work	5
Coal washing, &c.	2
Stone teemer	1
	46

(See Mr T. Y. Greener, "Evidence Before Eight Hours Committee," 1907.)

In this case 63 per cent. of the total workmen employed underground—considerably more than half—were hewers.

The proportion of hewers, or coal-getters, to other classes of labour varies a good deal at different collieries and in different districts. For instance, in South Wales, where the structure of the seams allows the coal to be easily got, and where, too, the pressure on the roads is often very heavy, the proportion of men employed in coal-getting is smaller, and the proportion employed in repairing roads is larger than in other districts.

The late Mr Hugh Bramwell, when Chairman of the South Wales Coal Owners' Association, in giving evidence before a Departmental Committee in September 1915, made the following statement of the relative proportion of the different classes of labour employed in a group of Welsh steam coal collieries :—

		Per Cent.
Underground labour—		
Colliers (*i.e.*, men and boys employed in getting and filling coal at the faces)	36	
Repairers (engaged mostly in afternoons and nights)	28	
Traffic men (hauliers, engine-drivers, hitchers, &c.)	18	
Officials (overmen and foremen)	2	
	—	84
Surface labour—		
Traffic and screening	6	
Enginemen and stokers	2	
Mechanics	3	
Foremen, clerks, and weighers	1½	
Sundry labourers	3	
	—	16
		100

At the Durham colliery the shifters and stonemen, corresponding to the repairers of the Welsh collieries, formed only 9 per cent. of the whole as against 28 per cent. in the other case, and the hewers or colliers 56 per cent. in comparison with 36 per cent. The surface hands are 10 per cent. of the total employed at the Durham colliery, and 16 per cent. at the Welsh collieries. For the whole country the surface hands in 1913 formed just under 20 per cent. of all engaged at collieries.

The effect of recent legislation and of reduced hours of work has been to increase the proportion of off-hand men and boys.

At November 1913 the proportion of getters to the totals of underground workers for all districts was 40.8 per cent., and at November 1918 37.7 per cent., *i.e.*, the proportion of off-hand men and boys had increased from 59.2 per cent. to 62.3 per cent. (See "Report of Coal Industry Commission," 1919.)

This necessarily carries with it a lower output per person employed, and an increased cost of production.

Past and Present Wages Compared.—It seems, therefore, that the hewers' wages were at the beginning of the eighteenth century 1s. to 1s. 2d. a shift. One hundred years later they had doubled, being at the beginning of the nineteenth century 2s. 3d. to 2s. 6d. for a shift of eight to twelve hours ; and in 1913, the last pre-war year, they were from 7s. to 8s. for a shift of seven hours. The privileges of free house and free coals remain the same in the district referred to, the money value of which at the present time, 1922, can hardly be stated at less than 1s. 8d. a shift. Calculating it per hour worked, it may be reckoned that the hewers' money wage, without allowing for the increased purchasing power of money, was trebled during the nineteenth century.

A hewer *working full time*—say 270 shifts in the year—earned £72 at the July 1905 average rate of earnings in Co. Durham.* Assuming that he had two sons working, a not unusual circumstance, one (say a pony putter) about 17 years old, and another (a driver) aged 14, the former received about £45 in the year, and the latter £18, making the yearly income of the family about £135, with a free house and coals. These were average earnings. Under favourable circumstances, a pony putter will put 6 or 7 score of tubs in his shift, and earn as much as an average hewer; and some hewers will make 7s. to 8s. a shift. From the hewers' wages are deducted each fortnightly pay certain sums in payment for benefits received, such as—

Medical attendance	1s. 6d.
Permanent relief fund	1s. 4d.
Water supply	6d.†
Fire coal leading	6d.
Pick sharping	3d.

and also fines for "laid-out" tubs, if he has filled up stone and dirt with the coal.

With regard to most other classes of underground labour, the increase in pay has hardly been so great, but the wages were in 1905 on an average at least 50 per cent. higher than they were sixty years before, and the hours worked daily quite 20 per cent. less.

Purchasing Power of Wages.—A few remarks may here be interpolated as to the increased purchasing power of money, with its consequent effect of enhancing the money value of the wages of the labouring classes, which took place during the nineteenth century—points upon which all authorities agree. Mr Augustus Sauerbeck, in the instructive papers read by him before

* At the end of 1913, the last full year before the war, the hewers' average earnings in Co. Durham were 7s. 6d. a shift of seven hours. At this rate, working 270 shifts in the year, he would earn £101.

† This varies at different collieries, being in some cases 3d. a fortnight, and sometimes no deduction at all is made for water supply.

the Royal Statistical Society in 1886 and 1893 (vols. xlix. and lvi.), shows that there was a gradual decline in prices of commodities generally, from the early part of the century to the period of the great gold discoveries in California and Australia about the middle of the century. An increase then took place, culminating about the year 1873; after that year the fall was extraordinary, prices in 1896 being on the whole lower than at any previous period of that century. This was due, as pointed out by Mr Sauerbeck, to a variety of causes, the principal of which were (i.) alterations in currencies, the demonetisation of silver, and an insufficient supply of gold relatively to the enormous increase in production; (ii.) cheapening of transport; (iii.) reduction in cost of production, by improved appliances and the development of new sources of supply.

Professor Marshall, in his "Economics of Industry," 1892, stated that the additions to the real purchasing power of the wages of the working classes in this country were very great, and constantly increasing, during the nineteenth century, owing to the improvement of the means and the arts of transport, aided by the adoption of the policy of free trade in the middle of the century, and the subsequent development of large areas of land in America especially suited for growing grain and meat.

In modern England (as was (1896) remarked in the *Newcastle Daily Chronicle*) the "standard of living has been continually rising for a long time; and the average wages of the working classes, owing to the absolute increase of the money remuneration received, and to the great fall in prices, command twice as much of the necessaries of life as did the wages of the working man two generations ago." Or, in other words, as expressed by another writer (Mr P. D. Kenny), "a given amount of wages, as expressed in £ *s. d.*, received by a labourer to-day, can secure to that labourer at least 25 per cent. more of decency, comfort, or anything else, than it would have done thirty years ago." In a paper by Mr A. L. Bowley, on "Changes in Average Wages (Nominal and Real) in the United Kingdom between 1860 and 1891," read before the Royal Statistical Society, the general conclusion was reached, that allowing for the increased purchasing power of money, the average wages in the chief industries of the country have *doubled* during that period of thirty years.

The change in the purchasing power of gold is well shown by the alteration in its value in exchange with such common commodities as English wheat and iron. 123.27 grains of standard gold would exchange for 171 lbs. of English wheat at the average price during the period 1867-77, and for 394 lbs. in 1893. While, taking iron, 123.27 grains of gold would exchange for 272 lbs. of iron at the average price during the period 1867-77, and for 448 lbs. in 1893.*

These remarkable changes in value were referred to by Sir David Dale in his address (1895) as President of the Iron and Steel Institute, when he said that " for every sovereign expended, the world can now get more than four times the length of rails, and more than twice the quantity of wheat, that it could a little over twenty years ago."

The *real value* of wages depends upon their purchasing power.

This truth has been brought home to most people by their experience during the Great War of 1914-18 and the subsequent years. During this period the money wages of manual workers generally have been adjusted to suit the changes in the selling prices of certain things which were taken to be essential to a normal standard of living.

Index Numbers published month by month in the *Labour Gazette* showing the change in the selling prices of these presumably essential requisites were taken to express the change in the cost of living. Money wages generally were regulated by the rise or fall in these selling prices.

On the whole wage-earners were better off during the war than they had ever been before. But as Professor Bowley has remarked, " It is worse than futile to raise wages for the purpose of purchasing goods which do not exist."

So long ago as 1904 the Board of Trade began investigations with a view to determining the cost of living of an average working-class household.

The following figures were estimated to be the weekly expenditure of an average working-class family in July 1914, just before the war broke out :—

Food	£1	5	11	per week.
Rent	0	6	0	,,
Clothing	0	5	0	,,
Fuel and light	0	3	0	,,
Sundries	0	1	6	,,
	£2	1	5	per week.

* These figures are taken from a Table constructed by Mr J. W. Miller and published in the *Manchester Guardian* of 10th July 1894. They were quoted by Professor J. Shield Nicholson in an article on " The Influence of the Production of the Precious Metals on Industry and Trade," which appeared in the *Co-operative Wholesale Societies' Annual* for 1895.

Relying on information obtained from the census of 1911 an average working-class family was taken to consist of two wage-earners and two and a half dependents.

Or—to avoid splitting the individual—two households consist of nine persons, four of whom are wage-earners, and they spend altogether about 82s. a week. This is equal to 20s. 6d. per wage-earner.

Since July 1914 the cost of providing the same quantities and qualities of food, clothing, house accommodation, &c., has been calculated month by month, and the result expressed by an index number, the pre-war level of July 1914 being the base figure—100.

Thus at 1st October 1920 this index number was 264, indicating that the cost of these things had risen from 20s. 6d. to 54s. 9d. per wage-earner per week.

The question arises, Is this a satisfactory method of regulating wages?

Adverse criticism, coming in increasing volume from various quarters, suggests that it is not. The wage-earner seeks for an ever-improving standard of living, and does not like it to be tethered to any fixed point or period.

To fix a normal cost of living which shall be fair to all wage-earners is practically impossible; the standard of living varies so greatly in accordance with the size of the family and the character of its members.

Again it must be relative to the available wealth, and this is a variable quantity. The available wealth was heavily reduced by the war. In 1923 it is not sufficient to maintain the same standard of living as in 1913 or 1914 before the war.

Higher wages tend to cause higher prices, especially when the supply of goods is seriously curtailed as in the war, and if higher prices are followed again by higher wages, a vicious circle is established which must lead to bankruptcy and unemployment.

Such has been the experience since the war. Much misunderstanding and ill-will have arisen from the inconsiderate use of such vague phrases as "a living wage" and "the cost of living." To raise the standard of living the amount of wealth produced in the country as a whole must be raised, and this can be done only by an increased output of marketable goods and services. Wages must depend on the ability of industry to pay, rather than on the cost of living.*

Present Conditions of Labour in Collieries.—The bulk of the labour employed in coal mines is better remunerated than that employed in most other great industries, and although much

* "It is possible to increase the well-being of the working man—not by having him do less work, but by aiding him to do more."—"My Life and

of the work is hard, it is not usually unhealthy or unpleasant to strong men. By the aid of science and engineering skill conditions naturally adverse and dangerous have been much ameliorated, and these improvements and safeguards are enforced by stringent legislation.

As a class, the mining population are inclined to err on the side of extravagance rather than of parsimony, but in most colliery villages there are at least a few men who have saved money, and invested it in house property, or with a local co-operative society, or in some cases in shares in joint-stock companies. The local co-operative stores in such villages have undoubtedly done much to encourage and promote thrift; the buildings in which their operations are carried on are frequently the most prominent architectural feature of the neighbourhood; and they are under the control of the miners themselves.

It is not easy to obtain reliable figures, showing the actual expenditure of an average family employed in coal mining. According to a Report of the Commissioners of Labour of the United States, 1890, the expenditure for a year of a coal miner in Great Britain on all objects—food, clothing, house, furniture, recreation, &c., with a family consisting (besides himself) of a wife and three children ranging in age from three to nine years—amounted to £87. 5s. 11d., as compared with an income of £99. 14s. 4d., leaving him a surplus of £12. 8s. 5d. The details given by the Commissioners appear in the following abstract from the *Journal of the Royal Statistical Society*, vol. lvi. (Paper on "Workmen's Budgets," by Henry Higgs):—

INCOME AND EXPENDITURE FOR A YEAR OF A COAL MINER IN GREAT BRITAIN.—BITUMINOUS COAL.

(*Extracted from Sixth Report of the Commissioners of Labour of the United States*, 1890.)

Husband, 33; wife, 33; first child, boy, 9; second, girl, 5; third, boy, 3—Total, 5. Income, husband, $478.64 = £99. 14s. 4d.

Expenditure for food—		
Hog products		**$25.30**
Meat		**75.92**
Eggs		**12.65**
Lard	**26 lbs.**	**3.16**
Butter	**78 „**	**18.98**
Tea	**26 „**	**12.65**
Sugar	**104 „**	**4.22**
Molasses		**1.58**

Potatoes	$8.11	
Milk	16.87	
Flour and meal	39.42	
Rice	1.22	
Vegetables	2.43	
Food not specified	41.86	
	$264.37	= £55 1 6

Expenditure other than for food—

Rent (3 rooms)	$40.06	
Fuel (coal)	12.16	
Lighting (oil)	4.38	
Clothing husband	14.60	
„ wife	12.16	
„ children	9.73	
Furniture and utensils...	2.43	
Insurance life	8.44	
Organisations—labour	6.33	
„ other	6.33	
Charity	1.46	
Books and newpapers	1.46	
Amusements	2.43	
Intoxicating liquors	18.98	
Tobacco	12.65	
Sickness and death	1.05	
Total for year	$154.65	= £32 4 5

Expenditure for—

Rent		$40.06	= £8 6 11
Food		264.37	= 55 1 6
All other purposes		114.59	= 23 17 6
	= £87 5 11	$419.02	
Income ...	99 14 4	478.64	
Surplus ...	£12 8 5	$59.62	

Dollar = 4s. 2d.

In 1896 in pit villages in the Northumberland and Durham district, the expenditure at co-operative stores, where most of the supplies of food and clothing are bought, ran from 18s. to 24s. per family per week. Unmarried hewers in the county of Durham, where only married hewers are entitled to free houses, paid from 12s. to 15s. a week for board and lodging.

In 1852-53, when the cost of living was high, a man, still living, in 1896 was occupying the position of back-overman at a wage of 22s. a week, with free house and firing. His eldest son was working as a "wailer" (picking stones out from amongst the coals), and was earning 5s. 9d. a fortnight = 2s. 10½d. a week. The receipts, amounting to £1. 4s. 10d. a week, represented the entire income of the family; and upon this the man supported a wife, six children, and himself—eight souls—without getting into debt. Much, no doubt, depends upon the wife.

To take another instance of a man who has worked as a blacksmith for over fifty years at a Durham colliery. Shortly after his marriage in 1845 (he celebrated his golden wedding in 1895), he and his wife determined to lay by a certain sum every pay. This they did regularly, the sum saved amounting to £1 a fortnight on the average. In 1896 they possessed capital to the extent of nearly £2,000, and brought up nine children, all of whom did well. For many years the wife used to take the money every month to a savings bank in the neighbouring town, walking a distance of about seven miles on each occasion.

It cannot be denied that, in too many cases, a large portion of the wages is spent at the public-house, and in sports and gambling. A popular public-house in an average colliery district will take from £50 to £100 over the "pay" week end." The authors do not wish, however, to convey the impression that most miners are drunkards or gamblers, for this is not the case. As in all large classes of men, the individuals differ much in character, tastes, and disposition—from the man who reads and takes an intelligent and active interest in all that tends towards social and intellectual development, to the man whose main idea of enjoyment is a "good boose" in a public-house, or who finds his chief recreation in risking his money on some sporting event.

As regards house accommodation, miners, on the whole, are well housed, although there are a good many exceptions to this rule, especially in the older districts, where the houses were built many years ago. The provision made for individuals may be learnt from statistics gathered in a large colliery district, from which it appears that 5,291 persons are living in 946 houses belonging to colliery owners. This gives an average of 5.59 persons living in each house. About 32 per cent. of the total number are working at the collieries, so that the proportion of workers per house is barely two. 44 per cent. of the houses contain two rooms, 30 per cent. three rooms, and 26 per cent. four or more rooms.

Benefit and provident societies, such as the Ancient Order of Foresters and the Independent Order of Oddfellows, are well supported by the miners, and there are also local societies of a similar character, such as the Northumberland and Durham Miners' Permanent Relief Fund, an excellent institution, with a membership in 1913 of 209,589, and a total revenue of £332,372. The payment of a miner to this fund is at present 1s. 4d. a fortnight for a full member. The Trade Unions also make their claim on the miner's earnings of about 6d. to 10d. a fortnight. Notwithstanding the unthrifty habits of many miners, and the demands on the earnings of the class from the quarters just indicated, money is saved by an appreciable number.

One thousand pounds during the year is not an unusual amount to be deposited in a Post-Office Savings Bank in a colliery district, comprising some six hundred or seven hundred families living by mining.

The coal miner, with his very capable representatives in Parliament and elsewhere—men who have themselves risen from the ranks of working miners—is an important factor in that evolution of democracy, and new adjustment of industrial and social conditions, which is perhaps the most prominent feature of our day. The great change for the better in nearly all the conditions of life amongst working miners—which has been secured, partly by their own exertions, but in greater measure as a result of the general raising of the standard of obligation to the manual worker—and which presents a striking contrast, not only to the state of things prevailing say a century ago, but to what prevailed within a period covering the working life of many miners now at work, will have been largely illustrated in the particulars given in this chapter.

The best hope of raising wages and the standard of living lies in raising the efficiency of labour, or, in other words, in raising the output per person employed.

This fact stands out clearly from a review of the varying relation between wages and output, during the year 1922, in the different mining districts into which the country has been divided under the National Agreement.

In seven districts the average output per shift was only 14.75 cwt., and in these districts wages have been "on the minimum."

In five districts the output per shift averaged 19.01 cwt., and wages have been considerably higher—well above "the minimum."

CHAPTER IV.

THE PRACTICAL MANAGEMENT OF A COLLIERY.

WHAT manner of man ought a colliery manager to be ? It is not easy to answer this question in the form of a neat definition. In an admirable address given by the late Sir George Elliot as President of the North of England Mining Institute in 1868, he said : " I have seen it asked, What is it to be a gentleman ? Is it to be honest, to be gentle, to be generous, to be brave, to be wise, &c., &c. ? In some such spirit would I like the question to be asked, What is it to be a mining engineer ? Is it to become reverently acquainted with the secrets of nature ? Is it to show courage, wisdom, and tact in dealing with grave scientific problems, and in the discharge of the delicate duties pertaining to all called upon to be leaders of men ? . . . Let us then, gentlemen, in estimating our profession, and in seeking to gauge its future, be true to each other and ourselves. . . . Believe me, the knowledge and skill of the physician, the chivalrous bravery of the soldier, the gentle charity of the priest, the far-seeing toleration of the philosopher, might all find an ample field for their display in the regular duties and professional emergencies of our career. No vocation can be more useful, more worthy, or more honourable ; there is none which we could follow with more advantage to others, or with greater moral or material benefit to ourselves. The teaching of our profession is as varied as it is endless, and the wisest and best among us has but to strive humbly for wisdom to comprehend, and strength to improve upon, the lessons of his daily life, to become not merely a more skilful miner, but a more useful citizen, and a more worthy man."

Another President of the same Institute, the late Mr Edward Fenwick Boyd, in his presidential address in 1869, referring to the wide range of information useful to the mining engineer, and the necessity of constant advance in knowledge, said that "the experience of fifty years of a mining engineer's life would lead him . . . to impress upon his hearers the idea that in his profession there was scarcely a subject of interest to the well-informed and patiently adjusted mind with which the mining engineer ought not to have acquainted himself—from the evaporation of fluids to the combination of mechanical forces; from the sanitary necessities of drainage and water-supply to the delicate construction of the coffin-bone of the foot of the horse; from the building of a boiler to the barometrical pressure of the atmosphere; from the deposition of dew to the insinuating influences of a galvanic battery; from the forging of an engine axle to the proper interpretation of a legal mining document."

The late Mr T. Forster Brown, when speaking at the annual dinner of the National Association of Colliery Managers in September 1894, said: "The colliery managers of to-day had to grapple with very different things from what they had to grapple with forty years ago. They had to work the coal from great depths; they had to labour under stringent legislative enactments, imposing very serious personal responsibilities. A successful colliery manager of the present day needs to be a first-rate organiser, not only as regards labour, but in other ways, and in fact is an entirely different person from his predecessor thirty or forty years ago. The ideal colliery manager ought to be a scientific philosopher, with a thoroughly practical knowledge of mining, of men, and of applied mechanics; he ought to have great firmness of purpose, great perseverance, and (he thought he might add) a good digestion."

These three quotations from men thoroughly qualified by extensive experience to speak on the subject, are sufficient to bring home the fact that the position of a colliery manager is no sinecure.

The "useful performance" of a colliery, in its strictly material aspect, can hardly be better defined than by the expression already quoted in the Preface, "The getting of the largest possible proportion of the available coal in the best possible condition [that is, in such a condition as to realise the highest value in money] at the lowest cost, and with the greatest safety and comfort to those employed." This implies that the coal shall be worked by the particular method or methods best adapted to the special circumstances and conditions of the particular colliery and the seams worked thereat; that the coal when got shall be conveyed to the surface in the most economical and speedy way; that on the surface it shall be so treated and separated into the different qualities required, that without loss of time it is placed in waggons in such a condition as to satisfy the needs of the several classes of purchasers, and command the best market price. It implies, also, that all the machinery and appliances in connection with the colliery are those best adapted to its requirements; that the materials are the most suitable, and are bought in the cheapest market; that the labour is arranged and directed in the most efficient way; that the workmen, and all officials acting under the direction of the manager, do their work with goodwill and efficiency; that every available precaution is taken against accidents; that there is no extravagance or waste, whether of time, labour, or materials, in any department. It implies, moreover, that the colliery is conducted and managed on a consecutive and long-sighted policy, with a view to its future as well as to its present development. A large quantity of coal may sometimes be easily got, at a low working cost, for a brief period, but this in such a manner that this apparently satisfactory result may have a disastrous effect on the prosperity of the colliery viewed as a whole.

What knowledge, then, and what personal qualities are desirable in the colliery manager? The reply to such a question may be conveniently considered under three heads: (1) He should be a well-trained mining engineer; (2) he should be a good man of business; (3) he should understand human nature, and be capable of dealing effectively with men of varying characteristics and qualifications.

Dealing with the first of these requirements, that he should be a *well-trained mining engineer*, the provisions of the Coal Mines Act, 1911, ensure that a colliery manager shall have had a fairly good training in the theory and practice of coal mining and allied subjects. The qualifications demanded by the Act are more closely defined and amplified under the rules of the Board for Mining Examinations. A candidate must be not less than twenty-five years of age and, if an apprentice, must have had either (*a*) not less than five years' experience at a mine coming within the terms of the Act, three years at least of which he must have been engaged in definite practical experience or in personal supervision of practical work, or (*b*) he must have obtained a diploma in mining and allied subjects at some institution approved by the Secretary for Mines, and have had, in addition, three years' experience at a mine under the Coal Mines Act, the greater part of which shall have been gained in direct practical experience underground or in the personal supervision of such practical work. He must also have obtained a fireman's certificate, *i.e.*, as to ability to detect "gas," and a certificate under the St John's Ambulance, St Andrew's, or the Red Cross Society in first aid to the injured. If the candidate is a practical miner, the same requirements as to length of experience and diploma hold good, but he must have had experience in or about the coal face, *i.e.*, in the getting of mineral and in timbering.

The necessity of a good scientific training has of late years become much more important. In the words of the late Mr Emerson Bainbridge,* "One finds, as step by step the various phases of the engineering of mines are examined and studied, that an extensive acquaintance with the sciences of geology, chemistry, mineralogy, metallurgy, meteorology, and the whole of the wide field of research comprised by the term 'mechanics,' is essentially necessary in order to enable the mining engineer to deal with the many and various questions and difficulties which will arise in the course of his experience." The progress of both scientific discovery and industrial invention, as applied to mining matters, is very rapid, and is likely to become more so, owing to extended opportunities for observation and experiment, the spread and improvement of technical education, and the increasing keenness of competition in every walk of life. It is only necessary to glance over the last ten years to realise this. During that period valuable additions have been made to our knowledge of the dangerous properties of coal-dust, of the safest explosives, of the use of electricity for lighting, signalling, and for the transmission of power. Great improvements have been made in safety-lamps, in ventilating fans, in pumping machinery, in appliances for preventing over-winding, in the banking, screening, and cleaning of coals, in mechanical coal-cutting, and in almost every department of mine

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* "On the Education of Mining Engineers," *Brit. Soc. Min. Stud.*, vol. i., p. 229.

engineering. The opinion, on any of these points, of a colliery manager who should be content with the knowledge available ten years ago, or even five years ago, would be worth very little to-day. To keep himself abreast of the latest knowledge, and of the best appliances and inventions bearing on his work, a manager must always be something of a student. Not only must he devote some time to reading, but to visiting places where the latest improvements may be seen in operation.

He should know what is the best appliance he can get, or the best course he can pursue, when the necessity for action or decision arises. And this requires not only an acquaintance with machinery and appliances, but a sound judgment as to their suitability to special circumstances. The probable cost of working and attendance, and the cost of maintenance and repairs, are usually much more important factors than the first cost. There can be no doubt of the practical benefit to the colliery proprietor of wide knowledge and sound judgment on the part of the manager. Hundreds of pounds a year may be saved, for instance, by an improved type of engine or boiler. At most collieries there is available a wide margin for economy in the consumption of fuel. The best type of engine now consumes under 2 lbs. of coal per indicated H.P. per hour, but the average consumption of colliery engines is probably three or four times this amount.

In the second place, the colliery manager should be *a good man of business.* A colliery is an extensive and valuable property, in connection with which there is a good deal of business to be transacted, altogether apart from mining and engineering. This is especially the case in districts like Durham and Northumberland, where the miners' houses and often much of the adjoining property belong to the owner of the colliery. There are business relationships with district and parish councils, assessment committees, sanitary authorities, school boards, water companies, railway companies, and such like; a large and varied supply of materials is required, the selection and purchase of which involve negotiation with competing manufacturers and dealers; legal questions will often crop up; farmers and other owners or occupiers of property in the neighbourhood will be claiming compensation for damage caused by underground workings, or other operations incidental to the conduct of the colliery. There are letters to be written; wage bills, cost sheets, and account books have to be examined; while much of the daily routine work of a colliery manager is such ordinary business as is common to the control of all large concerns, and has nothing to do with mining or engineering. He should therefore be a good man of business—that is to say, a man who transacts his business with regularity and despatch, who is clear-headed and has a good memory, and is punctual and methodical in his habits.*

In the third place, the colliery manager should *understand human nature, and be capable of dealing effectively with men.* Probably the most harassing and unpleasant part of the work of many colliery managers is managing the men, and avoiding or settling disputes with them. The position of mine managers in relation to working miners has entirely changed within the last fifty years. In former times a manager was practically an autocrat: he could at once dismiss any man who made difficulties, but during the last thirty years the social progress of the manual labourer has been advancing with accumulating velocity, and in particular the miner of the present day has very different ideas and feelings from those of his predecessors one or two generations back. He has much more time to himself, he goes further afield, and mixes more with other people; on the occasion of a great exhibition he may go so far as Paris or the United States. If a thrifty man, he has money accumulating in his local co-operative society; he has received an elementary school education, which must undoubtedly affect his character, even though he may forget most of what he has learnt. Again, the betterment of labour is in the air; various

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* As a concise statement of what is required nowadays from the manager of a colliery, the authors may quote also the subjoined passage from another work:—"Even a slight acquaintance with the duties and responsibilities of a Colliery Manager will lead to the conclusion that he had need be almost omniscient within his own province. Besides his responsibility for satisfactory results in the opening-out and working of a colliery, under the ever-varying conditions of coal-mining enterprise, there rests upon him a heavy legal as well as moral responsibility which no true man would wish to shirk, and in the discharge of which he has to prepare for that which happens more often, perhaps, in his career than in that of most professional men—viz., *the unexpected.* It becomes him, therefore, to fit himself beforehand in every possible way for the discharge of his onerous duties. In so doing he will have to acquire the rudiments of Geology, Chemistry, and Electrical Engineering; a good deal more than the rudiments of Mechanical Engineering, Surveying, and Plan-making; and to make himself master of the mysteries comprised in the comprehensive terms Practical Mining and Ventilation. Further, he must be thoroughly versed in the obligations imposed upon him and his subordinates by the Acts of Parliament bearing on the subject of Coal Mining, and by the Special Rules in force in any given district."—From Preface to *The Colliery Manager's Handbook*, by Caleb Pamely, M.E. London: Crosby Lockwood & Son.

agencies are at work for his improvement; and last, but not least, he has his powerful Union, and for his representatives in Parliament men who have themselves worked in the mine, and through the Union have reached the House of Commons as members for constituencies in which miners abound. What wonder, if in his new-found liberty the miner is filled with a sense of his own importance, and at times is inclined to be headstrong?

It is quite evident that the miner of the present day cannot be treated in the old arbitrary, high-handed manner. Sympathy, firmness, self-control, and tact are the qualities most required in dealing with men effectively. Without real sympathy a manager will never get on well with his men. In order to influence them, or to lead them to change their point of view, he must realise their state of mind, see with their eyes as it were, and stand in their shoes. In all negotiations he should have a clear conception, in the first place, of what he wants, and in the second place of how they will regard it; and then he should proceed in such a way as to avoid needlessly exciting prejudice or ill-feeling. Here he will find ample scope for the exercise of firmness, self-control, and tact, that intuitive perception of the right thing to do, and how to do it.

It is a mistake to take every opportunity of cutting down wages to the lowest possible point. Such a policy creates a feeling of irritation, which is likely to be more detrimental to the interests of the colliery owner than if he had continued to pay a little more in wages. If men think that a manager will take every advantage of them that he can get, they will naturally look upon him with suspicion. On the other hand, if men are convinced that he will treat every question that comes before him fairly and honestly, without fear or favour, it is a great step gained.

Two Presidents of the National Association of Colliery Managers have referred to this matter of treatment of men, and their words are worth repeating here. The late Mr Rogers, of Wigan, said: "I would impress upon you the fact that colliery managers are men of position, who should respect their office and themselves if they desire to have their office and themselves respected by others. They should be courteous in manner to those under them, while firm in their determination to see that all do their duty. Violence, hasty temper, and bad language only degrade, and do not assist the manager in controlling those under him; whereas a kindly word, and an interest, so far as is practicable, in each collier's work, is a surer method of having the manager's orders obeyed." The late Mr Henry Palmer, when he was one of the mining agents of the Consett Coal Company, gave wise advice when he said : " The object of every manager of mines should be to retain the management of his own workmen in his hands, and to trust as little as may be to the extraneous aid of joint boards or of other constitutions. By so doing I am convinced that harmony and goodwill can almost invariably be ensured between the manager and his men, especially if the golden rule be followed—viz., if a grievance exist, remove it. If a grievance which is non-existent is put forward by the workmen, it is quite within the bounds of possibility to prove that no such grievance as alleged exists, and to restore that harmony which should always prevail."

Miners, it must be remembered, are not machines existing merely for the sake of doing work at the colliery. Like most other men, they are governed by feelings, by prejudices, by habit, much more than by reason, and they are more easily led than driven. It is unavoidable that a manager should often have to refuse what the men want, and to enforce what they dislike. It is well, therefore, that he should cultivate pleasant relationships with them. This he may do by taking a personal interest in their reading-rooms and institutes, their athletic clubs, their musical bands, or in some of the various institutions which usually exist in colliery villages—in short, by taking advantage of opportunities for personal contact with them in circumstances favourable to friendliness and goodwill.

In considering in detail the duties of a colliery manager, the importance of dealing properly with various sorts of men is most apparent. He is every day conferring with his under-officials. These men will insensibly take their tone to a large extent from him. If he takes an active interest in his work, shows a conscientious sense of duty, and is honourable and upright in his dealings, they are likely to be the same; and the opposite is no less true. In the words of an eminent authority, "it should never be forgotten that the example and precepts of those in charge of our pits exercise an enormous influence for good or evil. Show me a community of miners, and I will tell you the character of their chief; let me see *their* daily habits, and I shall form my estimate of *his*." In the ordinary course of his business, too, as already pointed out, the mine manager has to deal with a variety of men not immediately connected with the colliery, and the importance of tact, and the weight which will be attached to character, in one's dealings with those outsiders, as with one's colleagues and workmen, can hardly be overrated.

Personal supervision and control is the burden of the duties imposed by law on the manager of a colliery. Frequent inspection of the whole colliery, both on the surface and below ground, and accurate knowledge of all that is being done, is an essential part of a manager's duty. He needs to cultivate the habit of exact and critical observation, and of good memory. He should be quick to notice defects, remembering that "a stitch in time saves nine," and that a pound or two spent in remedying some small defect at once may save a much larger expenditure subsequently. He should bear in mind that in the management of a colliery there is always scope for improvement. At every colliery there is a tendency to waste—waste of labour by the idleness of workmen, or perhaps by setting too many men to one piece of work (and it should always be remembered that the wages of labour constitute from 60 to 70 per cent. of the total expenditure at collieries); waste of power, by unnecessary weight of machinery or appliances, or by not utilising surplus energy; waste of material, by carelessness and extravagance, or by throwing away old stuff which might be usefully employed. To check this tendency to waste, constant supervision is needed.*

The Check-Viewer.—Before closing this chapter, some reference to the relations to the working of a colliery of the official known as the Check-viewer may not be out of place. The check-viewer acts for the owner of the coal—that is, for the lessor—and his duties are to arrange the terms of the lease; to obtain accurate accounts of the coal worked from the property, as well as of coal from adjoining properties which may be brought through

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* "It is instructive to note at different collieries the difference in the outlook, attitude, and methods both of the management and the men."

"It may perhaps be stated that two factors largely influence the degree of success and smooth working of a colliery concern—the man at the top, who sets the example and pace, controlling operations in all departments, and the men's representative, who has great influence for good or evil at the colliery. If the right man is at the top, taking direct and personal interest in the conduct of the work of those under him, his influence permeates all the way down the scale to the lowest paid and youngest worker."

"*The Miners' Man.*—The right man in this position, enjoying the confidence of the men whose interests he protects, and having as his first thought the promotion of goodwill and efficiency in working, contributes very largely to the success of the colliery, and by so doing undoubtedly performs a great service to those he represents" (*M. and C. Machine Mining*, vol. ii., No. 14, September 1922).

it—the lessor's property—and which is therefore chargeable with outstroke * or wayleave rent; to render accounts for the payment of the rents when due; to see that all the coal is got so far as possible; and generally to look after the interests of the lessor, and to see that the covenants in the lease are fulfilled by the lessees.

The usual lessees' covenants are to pay the specified rents when due; to pay all rates and taxes, except landlords' property-tax or income-tax; to work the coal in the most approved method, and to the satisfaction of the lessor or his agent; to keep account of all coal worked, and to give a copy yearly to the lessor or his agent; to permit the lessor or his agent to examine the books of accounts and the plans, and to make copies, to inspect the mine, and make surveys at all seasonable times, and to render them every facility in so doing; to pay compensation for all damage done to the surface, to houses, or other buildings, to plantations, crops, &c.; to keep the lessors harmless from all actions at law in connection with the lease; not to assign or sub-let without license; to yield up peaceable possession at the end of the lease; to level and restore to a ploughable state, and fit for agricultural purposes, all land used, or to pay compensation not to exceed the value in fee simple. Disputes on any of these points to be settled by arbitration.

The lessor usually reserves to himself power of distraint if rents are not paid within twenty-one days, and power of re-entry and ejectment if rents are not paid within forty days, or if there is a breach of the covenant against alienation without license.

The lessee usually has power to surrender the lease at certain periods, such as any third year of the term, on giving twelve months' notice in writing.

As to the rents, a fixed or certain rent is agreed upon, estimated on the area of the royalty leased, say 20s. or 30s. an acre, which is payable half-yearly, whatever may be the quantity of coal worked. A price per ton is also settled (6d. a ton is an average rent), and when in any year the number of tons worked at this rent exceeds in value the certain rent, the surplus is paid as "overworkings"; but when it falls short, the deficiency is carried forward as "short workings" to the next year's account. The lessee has power to make up "shorts"—that is, to set them against subsequent

* The quantity of coal worked from each royalty per fortnight is stated on the Underground Wage Bill, and is copied from it into a Royalty Book, kept for this purpose.

"overs," in some leases during the whole period of the term, in others during septennial periods only, or sometimes during periods of three years; but whatever the period, if he fail to work enough coal to liquidate the fixed rents which he has paid, he loses the difference at the end of the period. The tendency of this practice is towards over production, as it leads a colliery proprietor to keep up his output of coal, even when he is making little or no profit on it. He may be working at a loss, and yet to reduce his output may cause him greater loss.

The variation of the tonnage rent in proportion to the average selling price of coal at the pit's mouth is an arrangement between lessor and lessee which has been advancing in favour within recent years. This arrangement is facilitated by the practice of employing trained accountants to obtain periodically the average selling price throughout the district. For this purpose all the colliery firms in the district make returns, giving the quantity of coal sold, the money received, &c., which are examined by accountants, who certify the average selling price. The immediate object of this system of periodical returns is to supply data for the settlement of the rate of wages to be paid to workmen in the district. If lessors and lessees agree to accept the selling price thus obtained for the purpose of a sliding scale on which to settle royalty rents, further investigation into the books of a particular colliery is avoided. In Northumberland and Durham, an average ratio between the selling price at the pit's mouth of all coals sold and the royalty rent is 12 to 1—that is, if the selling price is 6s., the rent paid to the lessor will be 6d. a ton; but most sliding scales will allow the lessor a larger proportion as the selling price rises above 6s., and a smaller proportion as it falls, and this appears to be an equitable and satisfactory arrangement for both parties.

In Yorkshire and the Midland District, the lessor is paid on the area of coal worked—so much per acre of a given seam, or sometimes per foot-acre, that is per acre per foot thick of coal. Every six months careful underground surveys are made on behalf of the lessor, and these are verified by comparison with the surveys made by the colliery officials. The area is then computed from the plan, which can be accurately and readily done, when the coal has been worked by longwall, as is usually the case in these districts. With other systems of working, it is much more troublesome to arrive at the exact area worked during a given period. The price per acre is sometimes arranged on a sliding scale with the selling price of the coal. This system of payment by area gives the check-viewer more work than when the payment is on the ton brought to the surface, and he usually employs a staff of surveyors. One advantage of the system is that deductions on account of poor or worthless coal can be readily settled.

The subject of royalty rents has given rise to much discussion from time to time. It has been contended that the rents paid in this country tend to keep down wages, and also to handicap our coal trade in competition with that of foreign countries. A Royal Commission was appointed in 1891 to inquire into the matter, and after a full inquiry, in their final report, dated 24th March 1893 (in which the Commissioners were unanimous), they pointed out that only the consumer would get the advantage of any reduction in royalties, and expressed the opinion that "the system of royalties has not interfered with the development of the mineral resources of the United Kingdom, or with the export trade in coal with foreign countries."

In connection with the subject of royalty rents, it should not be forgotten that they vary in amount at different collieries, from about 3d. to 10d. a ton. In some rare cases as much as 1s. to 2s. a ton has been paid. Viewed in this aspect, the rent may be regarded as "a differential advantage in production," to the extent of about 7d. a ton.

Assuming that the amount is fixed in proportion to the profit-making capacity of the collieries, the rent enables inferior collieries —that is, collieries hampered by disadvantages—to be worked at the same time as superior collieries—that is, collieries possessing the greatest natural advantages; and on this account it is a question whether the prevalent system of royalty rents, so far from being an incubus on the coal trade, is not a blessing in disguise, in enabling coal to be worked which could not otherwise be worked at the present time.

Whether this is a benefit may be disputed, on the ground that even if the inferior collieries were crowded out, there would still be sufficient competition among the superior collieries to keep down the selling price; and when these collieries had been exhausted, then the inferior properties would necessarily be worked under conditions of cost and price regulated by the competition amongst themselves.

The *immediate* result of the abolition of royalty rents would be that the money hitherto paid to the royalty owner would go into the pocket of the colliery owner; labour would very soon assert its claim to a portion; but in the first falling market, the price would fall until the margin of profit would be reduced to its limit, and the consumer alone would receive benefit at the cost of the royalty owner.

The *ultimate* result of abolishing royalty rents would be a reduced selling price, and the stoppage of the inferior collieries unable to bring down their working cost to the required point, and this point would be about 7d. a ton lower than it is now under the existing system of royalty rents.

Colliery Surveying and Plans.—The value of accurate plans of underground workings is a matter beyond dispute. Many accidents have arisen, and much damage resulted, from inaccurate plans. Inundations of water and gas have occurred through communicating unexpectedly with old workings; buildings on the surface have suffered damage, though sufficient coal has been left for their support, but in the wrong position; barriers of coal covenanted to be left for the protection of a royalty have been unduly thinned; and trespass into adjoining properties has taken place, owing to the plans of workings being incorrect. Experience teaches that old plans, thirty years' old and upwards, should be regarded with suspicion. Too much reliance used to be placed on the magnetic needle, and too little attention paid to the variable declination of the magnetic meridian. Nowadays a colliery staff usually includes a competent surveyor, who devotes his time and attention to the important duties of surveying and planning, under the direction of the manager. At some collieries the manager does the surveying, and every colliery manager ought to be able to do it if need be. Indeed some knowledge of surveying is required in order to pass the examination for First-Class Certificates.

A scale which is often adopted for plans of underground workings is $\frac{1}{2500}$, as this enables objects on the surface to be marked on the plan from the maps of the Ordnance Surveys, which are always accepted as correct. Sometimes the workings are plotted on these maps. Two chains per inch is also a favourite scale for these plans, and being a larger scale than the former, shows the workings more clearly. It is a good practice to mark on the plan in coloured letters, at stated distances, the level in feet, taking the bottom of the shaft as a datum line; and also to state the thickness or section of the seam. The main roads are often indicated by being coloured blue, and the return airways by light red. It is well to keep a survey plan, showing merely the line of each survey with the date. This may be useful to prove the date of the workings subsequently, for instance in the event of questions arising as to damage to the surface. The main roads, and what may be called the framework of the plan, should be surveyed with a theodolite, or a fast needle compass, but the needle being much more expeditious, may often be used, with proper care and precautions, for filling in the details between these main lines.

A useful form of plan, which is sometimes kept, may be called a "Projected Workings" plan. On it are marked the outlines of all the royalties included in the "take" of the colliery, the lines of faults, dykes, or other geological disturbances, so far as they are known, or may be reasonably assumed, and the workings up to date. On this plan the manager sketches the projected workings of the mine for the guidance of himself and his under-officials. When a group of adjoining collieries are supervised from one office, it is sometimes desirable to show all the workings on one plan at a very reduced scale. For this purpose the small Ordnance scale of 6 inches to the mile is often adopted.

Besides surveying, "levellings" have frequently to be made underground, for such purposes as to determine the thickness of top or bottom stone requiring to be removed to give the desired gradient on haulage roads; or to decide how water may be best removed from dip workings, whether by cutting water levels, or by a siphon; or if a pump is necessary, to determine the position of the pump. Continuous sections of levellings of the main roads from the shaft to the far end are useful, and should be kept for reference. Surveying and levelling are important features in colliery working.

CHAPTER V.

SUPERINTENDENCE OF LABOUR AT A COLLIERY.

THE **Overman** (or Oversman) at moderate-sized collieries usually fills also the position of Under-manager, which was created by the Coal Mines Regulation Act, 1887. On him largely depends the satisfactory working and good discipline of the colliery. Just as the sergeants have been rightly called the backbone of the British army, so the overmen may be said to be the backbone of colliery underground management. The position is as a rule well filled by men who have worked their way up through every grade of pit work. They are thus practically versed in the work which they superintend.

At some collieries the overman does a large amount of writing or office work, in connection with the making out of the wage bills and pay notes. At the larger collieries, where the wage bills are correspondingly bigger, the tendency is to employ the overman's energies entirely in the pit work, the office work being done by clerks. Something may be said in favour of the former arrangement. When an overman calculates the wages of each underground workman, and makes out the wage bill, and also the pay note book, showing the off-takes, and each man's net wages, he is likely to have a more intimate knowledge of what each man is doing, and can do, than when this work is left to clerks. On the other hand, in the latter case, the overman is more free to devote both his mind and his time to pit work. A form of daily report made by him is appended.

The **Back-Overman** * has responsible charge of the mine underground in the back shift in the absence of the overman. He

* Back-overman is a North country term for the day-shift overman.

COLLIERY.

OVERMAN'S DAILY REPORT.

Dated this *day of* 192

Time.	Barometer.	Thermometer.	Water Gauge.	
....	....	....	....	Bank
....	....	....	....	Underground

1. State what Districts of the Pit you examined to-day, and in what state you found the ventilation	....
2. Have you examined the air-courses, stoppings, air-crossings, and working places in the Mine, and in what state of repair and condition did you find them?	....
3. Is there a sufficient quantity of timber and other material in the Mine, and sent to the places where needed? ...	....
4. Have you consulted with the Back - Overman, Deputies, Master Wasteman, and Master Shifter on the state of the Mine and other matters connected therewith?	....
5. Have you examined the Deputies' Report Books, and are their Reports properly entered therein?	....
6. Have you met with any Gas; if so, where, and what steps have you taken to remove it?	....
7. General Remarks and Signature of Person making Report ...	....

Signed,

visits daily, as far as practicable, those parts of the mine which have not been visited by the overman, the object being that every working place should be visited daily by one of them. On coming to bank after his shift, he confers with the overman, master shifter, and deputies on the state of the mine. He assists the overman in the measuring of the yard work, and, at some collieries, in the making out of the wage bills. The report made by him may be in the following form (p. 75).

Deputies or Deputy-Overmen.—Each district,* or "flat," is in charge of a deputy, under the direction of the overman or back-overman. The deputy is the competent person required by the Coal Mines Act, 1911, who examines the roads and working places before the hewers arrive, fencing off any dangerous place, and making a report of his examination. A simple plan is to provide signal boards, having printed on one side, "Workings all right, workmen can go inbye," and on the other, "No one to go beyond this point," with spaces left for the deputy to affix his signature in chalk. This board is hung at the station, and is signed by the deputy each morning after his examination before the fore-shift hewers come inbye. It may be used as a danger signal, or to let the men know that all is right. It does not supersede the written report required by the Act, a suitable form of which is appended (p. 76).

After examining the workings, the deputy meets his men at the appointed station (usually the putters' flat, see Plate V.), where a wooden chest (deputies' kist) is kept for holding the deputies' tools, and having examined their lamps, and satisfied himself that all is safe, he sets them "inbye."

Since 1st January 1913 deputies have been required to possess certificates of their ability to make accurate tests for inflammable gas; to measure the quantity of air in an air-current; and that their hearing is such as to enable them to carry out their duties efficiently. Their duties are defined in the General Regulations of 1913, Clauses 49 to 62.

The deputies often stay to draw timber in "broken" places,

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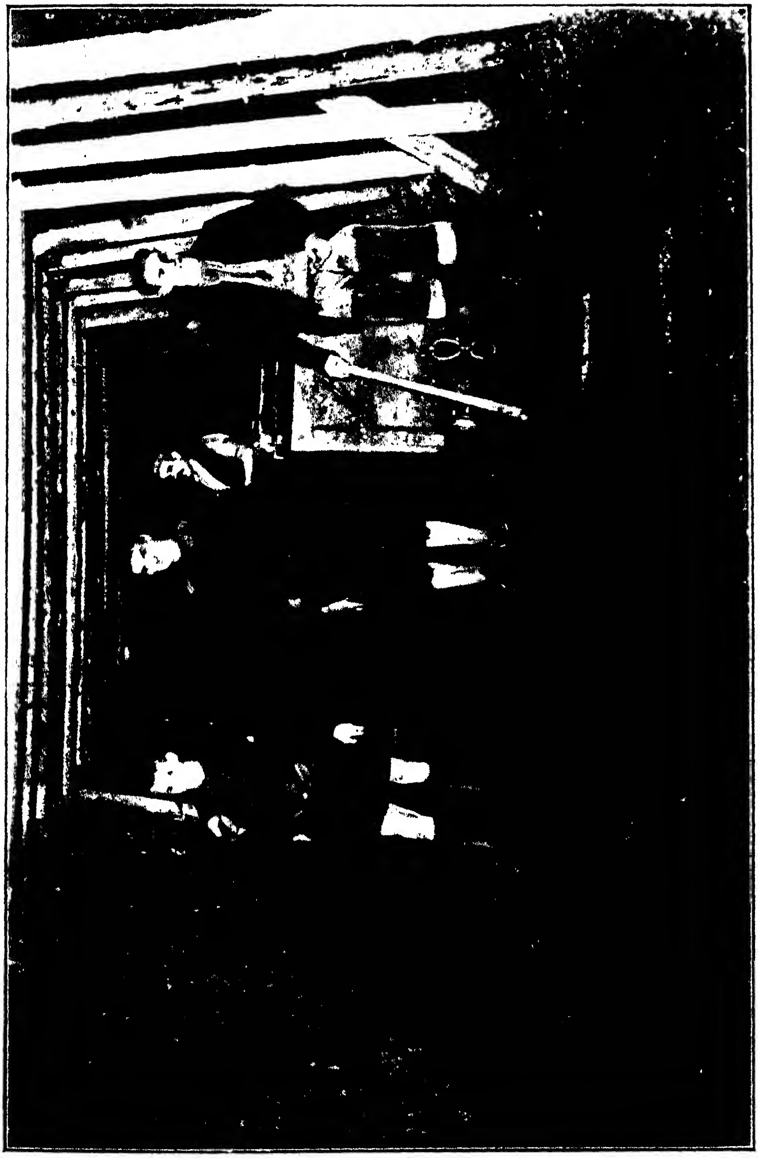
* In Scotland "Section" is the term in use to describe district.

† From a carefully kept account at a large colliery having fiery seams, it was found that 27 per cent. of the deputies' time was employed in making the preliminary inspection of the workings required by the Mines Act, and in examining the men's safety-lamps.



A Putters' Flat, with Back-shift Hewers going inbye, and a Deputy in the background.

[*To face page* 74.

COLLIERY.

BACK-OVERMAN'S DAILY REPORT.

Dated this *day of* 192

Time.	Barometer.	Thermometer.	Water Gauge.	
....	....	....	....	Bank
....	....	....	....	Underground

1. State what District of the Pit you examined to-day, and in what state you found the ventilation	....
2. Have you conferred with the Overman and Deputies as to the state of the Mine under your charge?	....
3. Have you seen all the workmen and boys under your charge safely out of the Mine? ...	....
4. Have you examined the Main Air-Currents, and what state are they in?	....
5. Have you visited the working places where the Overman has not been, and are they all clean and in proper working state?	....
6. Have you examined the Deputies' Report Books, and are their Reports properly entered therein?	....
7. Have you met with any Gas; if so, where, and what steps have you taken to remove it? ...	....
8. General Remarks and Signature of Person making Report ...	....

Signed,

REPORT OF INSPECTION BY FIREMAN, EXAMINER OR DEPUTY.

Date *Mine* *District* *Seam* *Shift*

Strike out words in italics for report of inspection during shift.

I hereby certify that I have inspected every part of the mine situated beyond the Station, and in which workmen are to work or pass during the shift, *and all working places in which work is temporarily stopped within any ventilating district in which the men have to work*, and that the following is a full and accurate report of the condition of the district as ascertained by me during my inspection :—

Noxious or inflammable gases ...	....
	....
	....
	....
State of ventilation	....
	....
Condition of roof and sides	....
	....
	....
Supply of timber—	....
(*a*) Working places	....
	....
(*b*) Pass-byes, sidings, &c. ...	....
	....
Other matters affecting safety, and	....
remarks	....

To be filled in for inspection *during* shift only.

Number of men under my charge during the shift, as checked by me

To be filled in for inspection *before* shift only.

Examination { Commenced / Completed

Time of commencement of work in the shift

Signed *Fireman, Examiner or Deputy.*

Date

Countersigned { *Under Manager.* *Date* / *Manager.* *Date*

COLLIERY.

MASTER SHIFTER'S DAILY REPORT, 192

1. Have you examined and locked all Lamps of Workmen under your charge?	
2. Have you allowed any Naked Lights to be used except in the Waggon Ways on the out-bye side of Caution Boards?...	
3. Are all the Tramways and Waggon Ways under your charge secure?	
4. Have you examined all Loftings up to the inbye end of Stations, and are they all right?	
5. Are there sufficient Man-holes for places of Refuge on all the Main Roads to the inbye end of Stations, and are they clean and in a proper state? ...	
6. Have you examined the Main Air-Currents, and what state are they in?	
7. Have you met with any Gas; if so, where, and what steps have you taken to remove it? ...	
8. General Remarks and Signature of Person making Report ...	

Signed,

MASTER WASTEMAN'S DAILY REPORT, 192

1. Are the Air-Courses such as to provide an adequate quantity of air to keep all the working places free from all noxious Gases?	....
2. Have you travelled the Main Air Returns, and kept all doors between the Intake and Return Air-Currents securely locked?	....
3. Are the Furnaces and Boiler Drifts clean, and have you travelled and examined the Airways at the sides of these Drifts?	....
4. Are the Furnaces all right and in good working order?	....
5. Are the Workmen's Lamps examined properly by you, or an authorised person, and securely locked?	....
6. Have you examined all Stoppings, Air-Crossings, and Doors, and are they all in good repair, &c.?	....
7. Have you examined the Main Intake and Return Air-Courses and Goaf Edges, and what state are they in?	....
8. Have you met with any Gas; if so, where, and what steps have been taken to remove it?	....
9. General Remarks and Signature of Person making Report ...	....

Signed,

A Deputy Drawing Timber near the Fallen Goaf.

[*To face page* 78.

which have been driven as far as required. This is the most dangerous of all pit work, and requires special care and experience. Plate VI. is a photograph of a deputy engaged in this work. See also Plate VII.

The **Master Shifter** has responsible control underground in his shift in the absence of the overmen. He keeps an account of the shifts worked by his men. He writes a daily report (see form subjoined), and confers daily with the overmen.

The **Master Wasteman** * has the charge of the airways, especially of the return airways, and of the men working in them, of whose time he keeps account. His responsibility is considerable in fiery collieries with long return airways, especially where the roof is difficult to maintain, but there are some collieries where such an official is not required. He also makes a daily report (see form subjoined).

The **Engineer,** or **Foreman Enginewright,** has charge of the joiners, fitters, smiths, masons, enginemen, and other mechanics, for each department of whom there is usually a foreman, who acts under the directions of the engineer. He has responsible charge of the engines, boilers, ropes, and all machinery. Sometimes he keeps an account of all materials received, and in what department used, acting as storekeeper.

The General Regulations of 1913 under the Coal Mines Act, 1911, enact that where electrical apparatus is in use, an electrician shall be appointed in writing by the manager to supervise the apparatus ; and that the electrician shall keep at the mine a log-book made up of daily log-sheets kept in the form prescribed by the Secretary of State. A copy of the form is shown on p. 359.

A large number of report books and registers are required by the Coal Mines Act, 1911. Specimens of a good many of these forms are given in Appendix.

Heapkeeper or **Keeker.**†—The men and boys engaged in screening and cleaning the coals, and putting them into waggons, are under the charge of this official, who is responsible to the

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* This is a North country term. In some other mining districts the duties of a master wasteman are performed by the overman.

† "Keeker" is a North country term for what might be termed a surface foreman.

COLLIERY.

Heapkeeper's Daily Report.

1. State the quality of Coals Screened	....
2. State the Condition of Screens and Heapstead	....
3. State any Accidents or Stops, and Cause at Bank	....
4. Are the Tubs well cleaned inside and out?	....
5. Make any other remarks necessary	....

Dated this *day of* 192

Signed,

manager for seeing that this work is properly done. He makes daily reports on some such form as that given here, which of course is varied to suit the particular conditions of a colliery.

In some cases the heapkeeper keeps an account of the timber and rails sent down the pit, and an account of all goods received by rail, stating the number of truck, descriptions of goods, from whom, when arrived, and when unloaded—in which case he may be said to act as traffic manager as well as heapkeeper.

In regard to electrical plant, which of late years has been increasingly applied to colliery work, there is a wide field for the adoption of a suitably organised scheme to secure from any given plant the highest degree of efficiency and reliability. Such a system has recently been devised by Mr A. H. Human, the equipment for which is manufactured by Manifoldia Limited of West Bromwich, and has been applied to various factories and collieries in the United Kingdom. The system is such that it enables the engineer to keep in constant touch with the supervision and upkeep of the motors, switchgear, fuse-boxes, and sundry apparatus forming the installation of the works or colliery, and at the same time provides a visual record of the essential maintenance and operation costs. By a simple means of centralisation of the information obtained from inspection, all faults, failures, repairs, and alterations are brought automatically to the attention of the manager. Every individual item of equipment being labelled and indexed and having its own report space in the final chart, on reaching the manager he is enabled to sum up at any time the state of his plant.

CHAPTER VI.

ARRANGEMENT OF LABOUR AND SYSTEM OF WAGES.

SOME knowledge of the stirring events which have happened during recent years in the coal industry is required in order to understand properly its present position and the existing agreement under which wages are now regulated. During the six years succeeding the outbreak of the Great War (1915-20) money wages rose continuously. Some idea of the extent of the rise may be gathered from evidence given before the Coal Industry Commission of 1919, that the average annual earnings of all colliery workers, men, women, and boys, were in the year 1913 £82, and in the September quarter of 1918 at the rate of £169. Further increases were given subsequently. In 1920 the average wage of all workers in the coal-mining industry, men, women, and boys, on the basis of five days a week and seven hours a day, before the strike in October of that year, was 82s. 7d. a week. This gives a rate of £214 a year. (See Statement by Mr Bridgeman (then Secretary of Mines) in House of Commons in October 1920.)

The Government controlled the industry from 1st March 1917 until 31st March 1921. It was due to labour troubles in the South Wales coalfield that the Government was driven into undertaking the financial control of the industry.

In 1919 (26th February) a Commission with Mr Justice Sankey as Chairman was appointed to " inquire into the position of and conditions prevailing in the coal industry."

Three conflicting reports—by different members of the Commission—were issued on 20th March 1919, and on 20th June 1919 four further separate reports.

The chief practical outcome of this Commission was a reduction of the hours of work underground from eight to seven. This was accompanied by a substantial increase in wages.

It is worth noting that an increase in wages, combined with a reduction in hours, has a cumulative effect in adding to the cost of production. Thus, assuming a man is getting 10s. for eight hours' work—or 1s. 3d. an hour—an increase of 20 per cent., combined with a reduction of hours to seven, gives 12s. for seven hours' work—or 1s. 8½d. an hour—an increase of 5½d. an hour, or 36 per cent. And in return for this increased expenditure there is a smaller output of coal.

Nationalisation.—The main objective of the men who have controlled the action of the Miners' Federation during recent years has been the Nationalisation or Socialisation of the industry. This implies the elimination of the employer and the destruction of private enterprise.*

Repeated demands on the part of the Miners' Federation led to a three weeks' strike in October-November 1920, and finally to thirteen weeks' stoppage in April-June 1921.

By the end of 1920 our export trade was rapidly disappearing, owing mainly to the high prices we had to charge in order to cover our cost of production. The same coal that was selling for 16s. 6d. per ton for home consumption actually reached 150s. a ton for export. Each month showed heavy and increasing loss, and the Government hastened to cut the loss by decontrolling the industry on 31st March 1921. For the month of March 1921 the accounts published by the Coal Controller showed a loss for the whole country of 6s. 10.55d. per ton. The total cost of production was 38s. 11.66d. per ton, of which sum wages accounted for 27s. 9.61d. The corresponding figures for 1917, when Government took control, were wages 10s. 6d. per ton, and total cost 14s. 0.14d. During the last three months of Government control, there was a loss amounting, according to the official returns of the Mines Department, to £14,684,936. From a state of prosperity in 1917 the industry had fallen to a state of semi-bankruptcy in 1921. It would be a mistake, however, to attribute this collapse to Government control. The causes were numerous and world-wide.

Since 1921 there has been a marked recovery. The extent of this recovery was well summed up by the Rt. Hon. W. C. Bridgeman (the late Secretary for Mines), when speaking at the dinner of the Mining Institutions, at the Guildhall, London, on 16th November 1922, when the Prince of Wales was present: "At

* See proposed scheme of Nationalisation brought before Sankey Commission by miners' representatives, and the "Nationalisation of Mines and Minerals Bill," introduced into Parliament March 1923.

the present moment, if they compared to-day with March of last year, which was the period of the last month of Government control, they would find that the output had increased from 4,300,000 tons a week to 5,400,000 tons a week. The days worked per week had gone up from four and three-quarters to five and a half. The cost per ton had gone down from 40s. 1d. to under 17s., and the exports had gone up during the quarter from 5.4 million tons to 18.3 million tons. The mining industry had made a greater effort than any other to meet the difficulties with which this country was surrounded."

National Pool.—After the strike of 1920 the objective of the miners' representatives had got narrowed down to a national pool of wages and profits.

This means, with respect to profits, that the resources of prosperous collieries which should be used for their profitable development would be squandered on maintaining unprofitable collieries which had better be closed ; and with respect to wages, that the miners in districts earning high wages would surrender some of their earnings to subsidise the wage fund of poorer districts. This demand was rejected unanimously by the colliery owners as economically unsound and impracticable. For a long time the miners' representatives refused to confer with the owners unless this demand was acceded. The result was a deadlock, and the thirteen weeks' stoppage of 1921. The cost of the stoppage to the collieries is given by the Mines Department as £10,413,650.

Mr Frank Hodges, the Secretary, at a conference of the Federation in June 1920, declared: "We are going to create a first-class economic crisis which will reduce the nation to chaos."

Fortunately the British public refused to be stampeded into chaos.

But the damages were heavy.

To quote Mr Hodges again: "The Miners' Federation is saved, but the loss to our people is beyond recovery."

The President of the Federation, Mr Herbert Smith, has summed up the price paid as "the poverty and starvation of their members and the misery of millions of their fellow-countrymen."

And the overburdened taxpayer has had to pay £41,350,000 * in order to keep the industry on its legs !

* See reply of Secretary of Mines to question in House of Commons, 12th December 1922.

PLATE VII.

A Hewer "Kirving" in a Thin Seam, and a Deputy Setting Timber.

National Settlement.—The settlement of 1st July 1921, which terminated the dispute, is the greatest experiment in profit-sharing which has yet been tried on a national scale in a big industry.

Under it wages are regulated, not as hitherto in accordance with the selling price of coal, but in proportion to the difference between the selling price and the cost of production.

The relative shares of capital and labour are fixed at 83* per cent. to labour and 17 per cent. to capital. Out of every shilling of proceeds † the miner gets 9.96d., say 10d. Also he is guaranteed a minimum wage.‡ The 17 per cent. apportioned to profits was fixed at that figure, because over the period of fifteen years from 1899 to 1914 inclusive, the profits per ton averaged 17 per cent. of the wages per ton.

Minimum Wage.—Up to the end of December 1922 the South Wales owners had made good this minimum wage out of their share of the profits, to the extent of £3,338,400, which is irrecoverable by them.

The President of the South Wales Institute of Engineers, in his address delivered at their annual meeting, held on 26th January 1923, stated that "according to monthly ascertainments for that district, under the terms of the National Agreement, the owners had sacrificed £3,057,000 from November 1921 to November 1922, without any possibility of recovery, in order to bring wages up to the minimum." §

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* Since the above was written these percentages have been altered to the further advantage of the miners, the Standard Profits being reduced to 15 per cent. of the cost of the Standard Wages. See Appendix I., Copy of Revised Agreement of June 1924.

† These "proceeds" being the sum left after deducting costs of production other than wages, such as timber, stores and materials, administrative expenses, &c., see page 89.

‡ *N.B.*—This has nothing to do with the minimum wage under the Minimum Wage Act of 1912.

§ The following extract from the *Newcastle Daily Journal* of 24th May 1923 is instructive with regard to the practical working of the Agreement, and the losses that are borne by the owners:—

"It is sometimes argued by opponents of the Wages Agreement that there are enormous arrears of standard profits which have to be made up under the Agreement out of any future surplus, and that in consequence the wages in certain districts cannot possibly rise above the minimum for an indefinite period.

For the year 1922 the financial result for the whole country to Labour and to Capital was as follows :—

Wages	£129,550,476	92.6 per Cent.
Gross profits	10,356,760	7.4
	£139,907,236	100.0

From these gross profits there must be deducted—in order to arrive at the net divisible profits—interest on Loan Capital, Income Tax, Corporation Profits Tax, and allowance for Redemption of Capital.

"In no district did profits receive the agreed share of the 'net proceeds,' and in some districts the 'net proceeds' had to be largely supplemented in order to meet the cost of wages alone." *

"The actual recoverable deficits in standard profits as at 28th February 1923 are as follows :—

		No. of Men employed, Dec. 1922.
Kent	£72,766	1,381
Newbury	27,268	approx. 500
Bristol	15,737	2,028
Cumberland	263,344	9,873
South Staffs.	113,547	7,109
North Wales	8,800	15,067

"In all other districts, including Lancashire and Cheshire, where the deficit at the end of October 1922 was £168,123, any previously existing deficit has now been wiped out.

"The total number of men now employed in the mines is 1,162,754, so that approximately 1,126,000 are entirely unaffected by these deficits.

"There is also an impression that the whole of the extra 20 per cent. on standard wages, which makes up the minimum wage, can be recovered by the owners out of any future surplus if it has been given up by them out of their standard profits during any period. This is not so. The following example will serve to make the position clear :—

"Imagine the standard wages to amount to £100, and working costs, other than wages, to £30. In this case standard profits would amount to £17, making a total of £147 for the three items included under standard costs.

"If, however, the proceeds of the sale of coal amount to £140 there is a deficit of £7. But this is only on paper ; the real position is worse. For wages must get a minimum of 20 per cent. above standard, and the owners must, therefore, actually pay out £150 (£120 in wages and £30 in costs other than wages), leaving them with no standard profits and £10 out of pocket.

"Should there at any future time be a surplus of £50 the owners are entitled to apply £7 of it towards wiping out that deficit that they previously made good, leaving £43 to be divided between themselves and the workmen. But they are not allowed to recover the other £3 that they were actually out of pocket, or the £17 that they should have got as standard profits.

"The Wages Agreement is a Profit-Sharing Agreement in which the workmen share the profits, if any, and the owners bear the losses when they occur."

* Second Annual Report of the Secretary for Mines for year ended 31st December 1922.

The National settlement provides (see Appendix) that "The standard wages shall be the district basis rates existing on 31st March 1921, plus the district percentages payable in July 1914 (or the equivalents in any district in which there has been a subsequent merging into new standards), plus, in the case of pieceworkers, the percentage additions which were made consequent upon the reduction of hours from eight to seven." And "In no district shall wages be paid at lower rates than standard wages plus 20 per cent. thereof."

For the purposes of this settlement the whole country is divided into thirteen districts, and there are Boards, consisting of equal numbers of persons, representing owners and workmen in each district (see Terms of Settlement in Appendix).

In the Northumberland district this standard or minimum level below which wages cannot fall, was in June 1922 80 per cent. above the basis rates, whereas in July 1914 it was only 25 per cent. above. Over the whole country standard wages were in June 1922 43 per cent. above the pre-war level of 1914. There has been a tendency in some quarters to confuse "standard" wages with pre-war wages, which is altogether misleading.

Other privileges which the miner has now in comparison with the pre-war period are seven hours of work instead of eight. Pieceworkers get an extra 14.2 per cent. to compensate for the shorter time, and datal hands get the same wage for seven hours' work as they did for eight. The rates of wages per hour are much higher in 1922 than they were in 1914.

Under the National Agreement each individual owner or colliery company keeps its own profit or loss, but the wage fund of each district depends on the profit or loss of all the collieries in the district.

Three items have to be determined for each district, viz. :—

(1) The cost of the standard wages.

(2) The costs of production other than wages.

(3) Standard profits equivalent to 17* per cent. of the standard wages.

Of any surplus that remains after deducting these three items, 83* per cent., say $\frac{5}{6}$ths, is added to the wage fund of the district.

These sums are determined by independent accountants appointed by each side.

The method is shown in the following Joint Report of

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* See Footnote on p. 85.

the Accountants acting for Durham Coalowners' Association and Durham Miners' Association for the month of November 1921 :—

ACCOUNTANTS' REPORT DETERMINING WAGES.

Joint Report of Price, Waterhouse & Co., chartered accountants, acting for Durham Coalowners' Association, and Edward Sparks & Son, chartered accountants, acting for Durham Miners' Association.

We have to report that the returns (T.S. 1 and T.S. 2) for the month of September 1921 have been submitted to us in respect of all the collieries coming under the Durham Coalowners' Association, and we have prepared an aggregation of the results shown by the returns, which will be verified in due course as may be considered necessary by joint test audits of the owners' books.

We find on the basis of these returns that the wages payable for the month of November 1921, ascertained in accordance with the National Settlement dated 1st July 1921, are :—

The district basis rate at 31st March 1921 ..	100 per cent.
The district percentage payable in July 1914 ..	57.50 ,,
The 83 per cent. of surplus proceeds expressed as a percentage upon the basis rate	85.39 ,,
Making an addition to the basis rate (viz., 100 per cent.) of	142.89 per cent.

Details of the calculation of this percentage are shown on the Schedule attached hereto.

(Signed) PRICE, WATERHOUSE & CO.
,, EDWARD SPARKS & SON.

NEWCASTLE-UPON-TYNE,
28th October 1921.

Schedule referred to in Accountants' Joint Report, dated 28th October 1921 :—

Calculation re *wages payable during November* 1921, *based on the ascertained results of September* 1921.

Wages paid by owners in September other than flat rate and the 20 per cent. additions, *i.e.*, basis wages plus the March 1921 percentage = 107½ per cent.	207.50	£1,443,043
March 1921 percentage	107.50	747,601
Basis wages	100.00	£695,442
July 1914 percentage	57.50	399,879
Standard wages	157.50	£1,095,321
20 per cent. thereon	31.50	
Minimum (under Clause 8 of the Terms of the Settlement)	189.00	

Calculation of Divisible Surplus.

Proceeds	£2,874,652
Less costs of production other than wages ..	877,651
	£1,997,001
Less standard wages as above	1,095,321
	£901,680
Less standard profits (17 per cent. of standard wages)	186,205
Surplus for division	£715,475
83 per cent. of which is applicable to wages ..	£593,844

Equal to a percentage upon the above basis wages of 85.39 per cent.

Percentages Above Standard Rates.—The following table gives the percentages above standard rates in the different districts which were paid in May 1922 :—

	At May 1922, per cent.			Percentages Paid at End of 1913 on same Standard.
Scotland	110.00	above standard of	1888	87.5
Northumberland ..	88.4	,, ,,	1879	52.5
Durham	90.26	,, ,,	,,	60.0
Yorkshire, &c. ..	79.71	,, ,,	1911	
Lancashire, &c. ..	42.00	,, ,,	,,	
North Wales	32.00	,, ,,	,,	
So. Staffs. and Salop ..	32.00	,, ,,	,,	
Kent	28.00	,, ,,	,,	
Cumberland	30.00	,, ,,	1915	
South Wales	28.00	,, ,,	,,	
Bristol	21.99	,, ,,	1917	
Radstock	48.04	,, ,,	1918	
Forest of Dean ..	62.00	,, ,,	1919	

These percentages vary month by month according to the ascertainment of the accountants of the results of the preceding period. Thus the percentages paid in May depend upon the results obtained in March.*

For instance the ascertainment for August 1922 in Durham

* In January 1923 the National Wages Board for the Coal Industry agreed that the following periods should be taken for the ascertainment of wages in the coalfields for the next four months :—

"The months of November and December to determine the wages of March and April, and the months of January and February to fix the wages of May and June."

showed a fall from 90.62 per cent. to 62.09. Wages, however, were paid on the agreed minimum basis of 89 per cent. This fall of 28.53 per cent. was due to a drop of about half a million tons in the output as compared with the previous period, and a decrease in the selling price of 9.51d. per ton, from 17s. 1.5d. to 16s. 3.64d.

Wages in 1922 Compared with Pre-War Wages.—In the Table the percentages paid at end of 1913 are given for Scotland, Northumberland, and Durham. The comparison with 1922 shows that the wages paid now are substantially higher than they were at the end of 1913. In the other districts the standard rates have been changed since 1913, so that the comparison cannot be given. Up to September 1917 the dates and amounts of increases in wages varied in the different districts.

It was stated in the House of Commons by Mr Bridgeman, the Secretary of the Mines Department, that the average weekly earnings of all persons (men and boys) employed in the coal-mining industry in April 1922 (making allowance for the Easter holidays) was approximately 51s. According to information supplied to the Coal Industry Commission of 1919, the corresponding figure for June 1914 was 30s. 6d.

Owing to the fact that the proceeds of the coal-mining industry largely depend on the competition of other coal-producing countries, coal miners have suffered a larger reduction in wages than work-people employed in some other industries, such as railwaymen, bricklayers, dock labourers, &c., whose wages are influenced directly by conditions at home and very slightly by foreign competition. On this point some comparative figures issued in September 1922 by the Central Council of Economic Information are instructive.

The average wages of all workpeople employed at collieries, based on a computation of 5⅓ shifts worked per week, were estimated to be * 44s. 10d. per week, as compared with 35s. 1d. before the war. This is an increase of 27½ per cent. But with respect to the "non-competitive" industries, taking into consideration the numbers of men employed and the reduction of working hours, the average increase over pre-war wages was estimated to be 91 per cent., more than three times as much as the percentage of increase which the miners are getting.

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* This estimate appears to be too low in view of Mr Bridgeman's statement quoted above, but the fact remains that foreign competition has lowered wages in those industries which are subject to it.

Subsistence Wage.—Clause 5 of the National Agreement provides that "if the rates of wages in any district do not provide a subsistence wage to low-paid day-wage workers, such additions in the form of allowances per shift worked shall be made to the daily wages of these workers, as in the opinion of the District Board, or, in the event of failure to agree by the parties, in the opinion of the Independent Chairman, may be necessary for the purpose."

The subsistence wage which was paid under this clause in May 1922 was in Scotland approximately 7s.; Northumberland, 6s. 9½d.; Durham, 6s. 8½d.; Cumberland, 6s. 10d.; Bristol, 6s. 6d. In addition to these money wages many miners get a house free of rent, or an allowance for house rent, and a supply of fire coal, either free or at a small price.

In Durham and Northumberland these two items are estimated to be worth 1s. 8d. per shift.

The Lancashire, Cheshire, and North Staffordshire Joint District Board referred this matter of a subsistence wage for the lower paid workers to the Independent Chairman, Judge Spencer Hogg. His award (August 1922) defines as "a low-paid day-wage worker" any one whose gross earnings fall below £2. 6s. 6d. a week, and fixes as maximum additional allowances that may be paid for each shift worked :—

1s. 0d. for workers of 21 and over.
9d. " " 18 and under 21.
6d. " " 16 " 18.

Principles of National Agreement.—Under this National Agreement profits are proportional to wages; they rise and fall together. The miner is informed of the cost of production and of the financial position of his industry. This was formerly a closed book to him.

It gives him a direct interest in lowering cost of production, which he can do most effectively by increasing his output.

It is satisfactory to note that since this Agreement came into operation there has been a distinct improvement in the output per man-shift.

Its great merit is that it stimulates the interest and the co-operation of the workers in the efficiency of their work.

Several of the miners' leaders have testified to its value.

Mr Straker, of the Northumberland District, a member of the Miners' Executive, has said: "To have these costs, together with the total output, placed before the men's side has enabled them to understand the position of the industry much better, which is probably in advance of any other industry in that respect"; and Mr Hodges has stated: "There is nothing wrong with the fundamental principles of the Agreement. They are better than any principles that have operated in any previous agreement."

In the prophetic words of the late Mr Emerson Bainbridge: "The true principle which may, perhaps, some day be evolved out of disaster and misfortune is the principle of co-operation —co-operation which will yield to capital a reasonable return commensurate with the risks and uncertainties of mining, and to the workman as large a proportion of the product of his industry as the condition of trade will afford." *

Days and Hours of Work.—Some knowledge of the daily routine of a colliery, of the different classes of labour employed there, and of the system of wages in vogue, is essential to a proper understanding of the subject of colliery working.

The useful work of a colliery—the best service it can render to the common weal—is the production of coal suitable for the market at as low a price as possible.

A considerable proportion of the cost consists of charges for rent and rates, health and unemployment insurance, salaries and royalties, maintenance of underground roads and railways, pumping of water, feeding of horses and ponies, ventilation, upkeep of machinery and buildings and plant of various kinds.

These charges go on whether coal is being raised or not. Evidently the larger the output over which these standing charges are spread, the lower will be the cost per unit of output, and the lower the price at which it can be supplied to the community.

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* *Fed. Inst. of Mining Engineers*, vol. x., p. 429 (1895).

When a colliery is standing idle,* these charges do not cease, though no coal is being got to meet them.

A reduction in the hours worked carries with it an increase in the cost per ton of these upstanding charges.

This needs to be kept in mind when considering the best arrangement of hours of work at a colliery.

The daily hours of work underground of each individual worker are now limited to seven by the Bill which came into force in July 1919.

This allows of three shifts in the twenty-four hours, with three hours to spare, and evidently the largest number of workers can be employed and the largest output can be secured by working three shifts.

At collieries which require a great deal of repairing work (*i.e.*, stone, shift, and waste work), it may not be practicable always to employ three shifts of coal-getters, but there are many collieries where a three-shift system will achieve best the desired object.

It is unfortunate, therefore, that the miners generally are opposed to this system.

The three-shift system was the subject of much contention and discussion in Northumberland and Durham when the Eight Hours Bill came into operation at the beginning of 1910—six months later than in the other mining districts.

It was adopted then at a considerable number of collieries, chiefly in Durham, and it is being carried on still under the Seven Hours Bill. A two-shift system is, however, the more usual practice. The arrangement of shifts of the different classes of labour varies a little at different pits, but the

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* The heavy loss to the labour and capital engaged in coal mining due to inactivity is not generally realised as it should be. Some idea of it may be gathered from the following figures (see "Idle-Day Costs in American Mines," by the late Francis S. Peabody, Chairman of Peabody Coal Co., Chicago. Paper read before the International Railway Fuel Association, Chicago). The figures are based on average results of all the bituminous mines in the United States during the five years 1917-21.

Out of a possible 300 working days per year, the average time worked was 200 days. Mr Peabody, guided by his experience as chairman of a company operating thirty-six mines, estimated the annual loss to capital arising from the 100 idle days at $123,912,000 (or roughly £25,000,000), and the loss to the 700,000 miners employed at $280,000,000 per annum (say £56,000,000).

following may be taken as a normal instance of the three-shift system.

Coal drawing starts at 6 A.M. and goes on for fifteen hours till 9 P.M.

The time-table of the shifts of different classes of labour is as follows :—

UNDERGROUND.

	First Shift.	Second Shift.	Third Shift.
Hewers	4 A.M. to 11 A.M.	10 A.M. to 4 P.M.	3 P.M. to 9 P.M.
Putters, drivers, and other lads	5 A.M. ,, 12 noon	9 A.M. ,, 4 P.M.	2 P.M. ,, 9 P.M.
Rolleywaymen ..	4 A.M. ,, 11 A.M.	9 A.M. ,, 4 P.M.	2 P.M. ,, 9 P.M.
Onsetters	5 A.M. ,, 12 noon	9 A.M. ,, 4 P.M.	4 P.M. ,, 11 P.M.
Deputies	2.30 A.M. ,, 9.30 A.M.	9 A.M. ,, 4 P.M.	3 P.M. ,, 10 P.M.
Stonemen and shifters	One shift, 9.45 P.M. to 4.45 A.M.		
SURFACE (EIGHT-HOUR SHIFTS).			
Banksmen ..	6 A.M. to 2 P.M.	2 P.M. to 10 P.M.	10 P.M. to 6 A.M.
Winding and fan enginemen, &c.	6 A.M. ,, 2 P.M.	2 P.M. ,, 10 P.M.	10 P.M. ,, 6 A.M.

On each alternate Saturday, known in the northern coalfield as "baff" Saturday, coal drawing starts usually an hour earlier, at 3 A.M.—at some pits two hours earlier, at 2 A.M.—but in both cases stops at noon, so as to allow the workers a full half-holiday. On this day there are two six-hour shifts for nearly all underground hands, the first being from 2 A.M. to 8 A.M., and the second from 6 A.M. to 12 noon.

The other Saturday (known as "pay" Saturday when pays were fortnightly) is a whole holiday.

Wages are now paid weekly, on the "baff" Saturday, and on the Friday of the alternate week, for work done in the preceding week. In the Midlands and most other districts it is customary to work a short day on both Saturdays.

On the two-shift system the time-table as arranged at some large collieries in Northumberland is as follows :—

Coal drawing, 3.40 A.M. to 5 P.M., 13 hours 20 minutes.

Underground—

	First Shift.	Second Shift.
Hewers	3.40 A.M. to 10.40 A.M.	10 A.M. to 5 P.M.
Putters, drivers, rolleywaymen, onsetters, and datal hands	3.33 A.M. „ 10.40 A.M.	9.53 A.M. „ 5 P.M.

	First Shift.	Second Shift.	Third Shift.
Deputies	12.30 A.M. to 7.30 A.M.	5 A.M. to 12 noon	10.15 A.M. to 5.15 P.M.

Chargemen	7 P.M. to 2.07 A.M.
Stonemen and shifters ..	8.15 P.M. to 3.22 A.M. On Friday nights they start one hour earlier.

Surface—

	First Shift.	Second Shift.
Banksmen and screeners ..	3.30 A.M. to 11.45 A.M.	8.45 A.M. to 5 P.M.

The times stated are those at which the shifts commence to descend and commence to ascend. It is agreed that coal drawing shall not begin until the fore-shift men and boys have gone down.

In Northumberland it is mutually agreed that on "baff" Saturdays all fore-shifts commence one hour earlier than on week-days, and the pits finish not later than 2 P.M.

At a large colliery in the Midlands, working on a two-shift system, the hours are: Coal drawing; 7 A.M. to 2 P.M., and a night-shift from 11 P.M to 6 A.M., making fourteen hours daily of coal drawing. These hours are also those of the two shifts of hewers. There is an afternoon shift of transport hands from 2.15 P.M. to 9.15 P.M. besides morning and night-shifts as above, making three shifts of transport hands.

Repairers (the stonemen and shifters of the northern coalfield) work one shift in the afternoon, 2.15 P.M. to 9.15 P.M. On Saturdays work ceases at 12.15 P.M.

In South Wales the men, as a body, will not agree, so far, to more than one shift of coal-getters in the twenty-four hours, which no doubt accounts *in part* for the high cost of production in that coalfield. It is a recognised custom, however, that in *winning places and headings* two shifts should be worked daily. The general arrangement at the large collieries is a morning shift of coal drawing with colliers getting and filling coal; an afternoon shift of repairers; and a night-shift of repairers, and of work in headings, when coal left from the morning shift is drawn, and also coal got in the headings during the night-shift.

In other districts also, at a good many collieries, there is a tub-loading shift, as it is sometimes termed, at nights. This means that some hewers go down at nights to fill into tubs coal that has been left lying over from the morning shift, and to work in winnings and headings, which need to be kept in advance.

In the Northern District the working places are divided by lot amongst the hewers every three months. The process of drawing lots is called "cavilling." Each pair of hewers are "cavilled" to a working place, where they must remain during the quarter year, unless they make a mutual arrangement with another pair to exchange places with them. There are recognised rules, determining what working place a hewer must take, when the place to which he was cavilled is worked out during the quarter.

An "average weight" is kept by the weighman of the tubs filled by each hewer, who is paid at the rate of the tonnage price in operation in his district, and all over-plus at the same rate. If his average is under standard weight, he suffers a corresponding reduction.

There may be, and usually are, several tonnage prices in the same seam, but, as a rule, one district has but one tonnage price if the same description of work is pursued throughout it. "Whole" or "first working" prices, where the bord-and-pillar method of working is practised, are naturally in advance of "broken" or "second working" (removal of pillars) prices—the coal being more easily won in the latter instance, owing to the weight of the superincumbent strata taking effect on the pillars. In most instances it is agreed between masters and men that "broken" prices cannot be enforced by the former until a stipulated area (say 1,200 square feet) of pillars has been extracted, nor shall any place be paid "broken" price unless within 60 yards of the goaf. The score price of a district may be determined somewhat after the following manner:—

(1) At a Durham colliery in the year 1877,* working the Low Main seam with a section of 3 feet 10 inches of clean coal, it was reckoned that in a 2-yard "place" an average hewer ought to "take off" per shift a 2 feet 6 inches "jud." The calculation

* It has been thought advisable to quote actual cases for all the examples, as being more reliable than figurative instances. These examples, though dating back to the earlier editions of this book, are still sufficient to show the method of calculating hewing prices, &c., whether by the score of tubs or by the ton. The prices and costs are those current in the Northern District some years prior to the war.

would then be: 6 feet multiplied by 2.5 feet multiplied by 3.83 feet = 57.45 cubic feet = 2.136 cubic yards; 18.83 cwt. (the weight of a cubic yard of coal) multiplied by 2.13 = 40.107 cwt.; 40.107 cwt. divided by 8 cwt. (the standard weight of a tub) = 5 tubs.

5 tubs at 14s. per score	3s. 4d.
Yard work at 1s. 10d. per yard, for 2 feet 6 inches ..	1s. 6d.
Per hewer per shift	4s. 10d.

The county average at this time was 4s. 8d.

(2) In a second instance, the thickness of seam was 3 feet 9 inches clean coal; length of jud, 3 feet; width of bord, 15 feet; 3 feet 9 inches × 3 feet × 15 feet = 6.25 cubic yards = 5.85 tons of coal. And the average weight of tubs drawn from the Low Main seam during the previous pay being 8.42 cwt., 5.85 ÷ 8.42 = 13.89, or nearly 14 tubs.

From daily observation it may be safely inferred that here the average hewer can easily hew and fill 7 tubs during his shift in the "whole" working, and allowing him 5s. for his day's work, the score price is fixed at 15s.

In order to induce men to put forth greater energy, and also the better to drive their places, a yard price is usually added in bord-and-pillar pits, the amount being dependent on the description of place driven—that is, on the width of the place and on the angle it makes with respect to the bordways cleat, or main cleavage planes of the coal. For instance, in the Low Main seam quoted above, the yard prices ranged thus:—

Winning headways ..	2 yards wide	1s. 8d. per yard.
" " ..	3 "	1s. 4d. "
Cross-cuts	3 "	1s. 6d. "
Walls (North and South)	2 "	1s. 6d. "
" "	3 "	1s. 2d. "
Bords (East and West)	2 "	1s. 4d. "
" "	3 "	0s. 8d. "
Taking off side coal		0s. 5d.
Skirtings, jenkins, and splitting pillars		0s. 5d.

Sometimes winnings are "let" *through* the colliery previously to the quarterly cavilling, when each "set" of men gives in its particular price, such yard price being over and above the actual score or tonnage price, which is paid as usual. Then there are such refinements and details as "bordways cross-cuts" and "headways cross-cuts," according as the cross-cut place approaches to true bordways or headways course respectively. Many other items have also to be considered by the colliery viewer in his daily routine in this department of his work—such as consideration for local hard coal, working wet, scalloping, for " hitches," " troubles," " balks," " ramble," and what not, for the determination and settlement of which no hard and fast rules can be stated ; the questions raised being such as need for their settlement only common sense joined to experience.

As regards the mode of paying for the taking down of the " ramble," or " following stone," in the seam already mentioned, the hewers, for taking down and casting this back, were paid 2d. per inch (in thickness) per score of tubs filled, when the ramble was over 9 inches thick, but when below this thickness they received no extra remuneration.

In the thinner seams, a very frequent system of tonnage payment is to regulate the price paid by the height of the seam—that is to say, the greater the thickness of the seam the less the price per ton, and *vice versâ*, the overman measuring the height in the working places every fortnight.

The course pursued with respect to under-filled and dirty tubs may be stated thus : If the banksman notices that a tub is not well filled, he may " set it " to the " weigh." The tub, if it proves to be under weight, is said to be " set out " by the banksman. Tubs thus set out suffer the recognised reduction ; but tubs under weight which are set out by the weighman are included in the average eight account, which, of course, they lower. As an example, the deductions on this account at a large colliery (the standard weight of a tub being 8 cwt.) were as follows :—

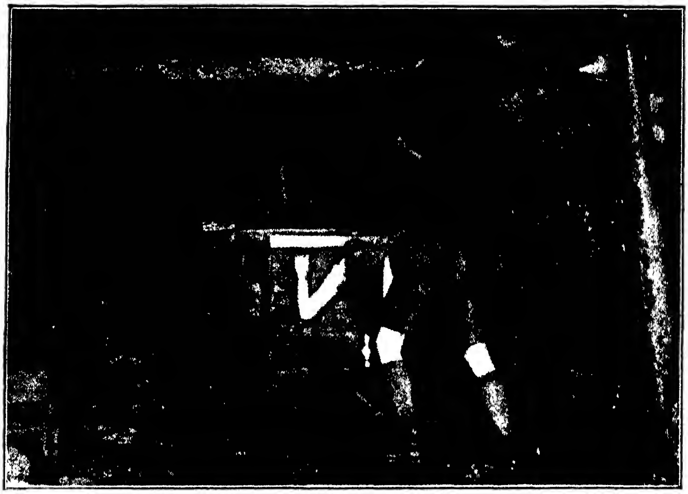
For Seam—

56 lbs. under weight in a tub of round coals 28 ,, ,, small ,,	amount to be deducted, 3d.

For . and Seams—

56 lbs. under weight in a tub of round coals 28 ,, ,, small ,,	amount to be deducted, 5d.

The quantity of stone, slate, band, or foul coal for which a tub could be " laid out," and the deductions made for the same, were at the colliery under consideration, 20 lbs., deduction 4d. ; 25 lbs., deduction 5d. ; 30 lbs., deduction 8d., except when the value of the tub was below 8d., when its full value was confiscated.



A Hand-Putter at Work.

A Stoneman at Work with a Hand-drilling Machine in the face of a Stone Drift.

[*To face page* 99.

The tons hewed per hewer per shift vary from about 2 tons in hard coal like the steam coal of Northumberland, to about 6 tons in soft coal like the coking and gas-coal seams of West Durham. The hewing prices per ton are fixed on the basis of the weight of coal an average hewer can get in his shift.

There is an average standard wage for hewers, agreed upon between the Owners' Association and the Miners' Union in each county. When the hewers' earnings at any colliery are at least 5 per cent. above or below this recognised county average, a readjustment of the prices paid for hewing can be obtained by either side. This is one of the rules of the Joint-Committee, consisting of representatives of the Owners and of the Miners, with an independent chairman, which exists for the sake of deciding questions about wages arising at individual collieries. (The larger questions affecting the whole county—such as general advances or reductions in wages—do not come within the jurisdiction of this Committee.)

We come now to the numerous and varied classes of men employed for "off-hand labour" who in many cases are (like the hewers) paid "by the piece."

Putters.—These are lads from sixteen to eighteen years of age, who convey the tubs—by the aid of ponies when the height of the road allows it—between the hewers' working places and the putters' "flat" or siding, where the tubs are made up into sets and taken away by the drivers. Sometimes men are employed for hand-putting. On Plate VIII. is a photograph of a hand-putter starting from the putters' flat with an empty tub.

The putters are paid according to the number of full tubs they "put" from the face to the flat. A price per score of tubs is fixed for the first 130 yards' distance in the case of pony-putters, and 80 yards in the case of hand-putters. For every additional 30 yards in the former case, and 20 yards in the latter, an additional price per score is paid. For example, at a certain colliery in Durham, for the first 130 yards, pony putting, 11¼d. per score of tubs of coal put is paid, and constitutes the standard price; for every successive 30 yards in distance, an additional penny per score is paid. Thus, presuming the average distance put at a flat amounts to 240 yards, $240 - 130 = 110$, and $110 \div 30 = 3$ and 20 over. Then, first, 130 at 11¼d. = 11¼d.; three, 30 at 1d. = 3d.; (over), 20 at 1d. = 1d.; total, 1s. 3¼d. This amount (1s. 3¼d.) will be the putting score price, or "rank," of the flat.

The distances from the putters' flat to the working places have therefore to be measured frequently. To avoid this trouble, sometimes a "standing rank" is fixed—that is, a price per score which does not vary, but which is estimated to be a fair average for the various distances "put" in the different districts of the pit. The method of keeping account of the putter's work is the same as for the hewers. Like the hewers each putter has a bundle of "tokens," bearing a distinctive mark or number, by which his tubs are known. He attaches one of these to every tub he puts, and when the tub comes to bank at the surface, this token, as well as the hewer's token, which is also attached to each tub, is taken off by a boy employed for the purpose, and hung up in the token cabin. Thus the weighman at bank knows, and keeps account of, the number of tubs put by each putter and filled by each hewer daily.

The putters change their flats, or districts, each quarter year, cavils being drawn for them at each quarterly cavilling. Every morning (or in some pits once a fortnight) the deputy in charge of the flat apportions the hewers amongst the putters, and determines by some simple method of drawing lots, which hewers each putter shall take.

Stonemen.—Other off-hand men who are often paid by the piece are stonemen. Their shift is seven hours from "bank to bank," and they go down at various times. Their work, consisting as it does in a very great degree, if not entirely, of opening out and development, constitutes one of the most important branches of the underground department. Plate VIII. shows a stoneman at work with a hand-drilling machine in the face of a stone drift. The payment of this kind of work is in many cases a matter of bargain, and in determining the price, many and various circumstances have to be taken into consideration.

For the sake of clearness, the several descriptions of stone-work may be considered under the heads of (i.) Canches; (ii.) Ridding; (iii.) Drifts; (iv.) Staples; and (v.) Miscellaneous Bargain Work.

(i.) CANCHES.—These may be of three kinds—top, bottom, or side. The construction of air crossings, in so far as the stone-work is concerned, may also be regarded as coming within this category.

Where the mode of calculation adopted is so much per inch in height of canch for a standard width of 6 feet, the following may be taken as average basis prices:—

Top coal	1¼d.	per inch.
Bottom coal	¾d.	„
Top stone, Blue shale (soft)	1½d.	„
„ „ (fairly soft)	1¾d.	„
„ „ (fairly strong) ...	2d.	„
Bottom stone (soft)	1½d.	„
„ „ (hard)	2d. to 2½d.	„
Top stone (post or sandstone) ...	2½d. to 3d.	„
Bottom stone (post)	2½d.	„

These prices are dependent upon the condition that explosives are used in working the stone. The matter will be better understood, if a few specific examples be given.

First Example.—New drift-way; taking off side for new landing:—

Dimensions. { Has to be finished 10 feet × 6 feet 6 inches = 65 square feet.
{ Is at present ... 8 feet × 6 feet 6 inches = 52 square feet.

2 feet × 6 feet 6 inches = 13 square feet.

$13 \times 3 \div 27 = 1.44$ cubic yards. Character of stone, shale, very broken and fairly soft, for which the price was 1¾d. per inch. This gives 2s. 7½d. per cubic yard, or 3s. 9½d. per lineal yard. Decided to pay 4s. upon a calculation made as follows:—

Thickness of canch = 2 feet = 24 inches; 24 inches at 1¾d. = 42d.

$$\frac{42 \times 6 \text{ feet } 6 \text{ inches (width of canch)}}{6} = 45\tfrac{1}{2}\text{d.} = 3\text{s. } 9\tfrac{1}{2}\text{d. per lineal yard.*}$$

A disadvantage which the men had to contend with in this instance was their having to "shoot" two sides (canches) instead of only one. At the same time, there were two advantages to put against this—namely, there was no "stowing" to do, and the owners supplied the explosives.

Second Example.—East incline, top canch: thickness of canch, 8 feet 6 inches, to run out to 4 feet, thus averaging 6 feet 3 inches. Character of stone, white sandstone. Consider as three canches thus:—

	£	s.	d.
First canch, 2 feet 3 inches at 2½d. per inch	0	7	10
Second canch, 2 feet at 2¾d. per inch	0	7	10
Third canch, 2 feet at 3d. „	0	8	6
Making, per lineal yard	1	4	2

* The standard width for all these inch prices is 6 feet: 3s. 9½d. ÷ 1.44 (cubical contents of canch) = 2s. 7½d. per cubic yard.

The width of canch was 9 feet at top and 8 feet at bottom. It was let at £1. 4s. 2d., less 10 per cent. for cost of explosives (gelignite and Settle's water cartridge), say, £1. 2s. per yard.

It will be noticed that the thick canch is divided into three, it being difficult to shoot down a canch of sandstone (post) much over 2 feet thick without waste of explosives, and at the expense of the regularity of the place. The first canch is always the easiest to shoot.

Third Example.—Slanting staple in east side Main Coal return, Low Main seam (December 1888). In this case, the staple had to be slanted, in order to enlarge the return, as an increased quantity of air was required (inbye) in some of the new districts then opening out; and it was desirable also that these districts should be

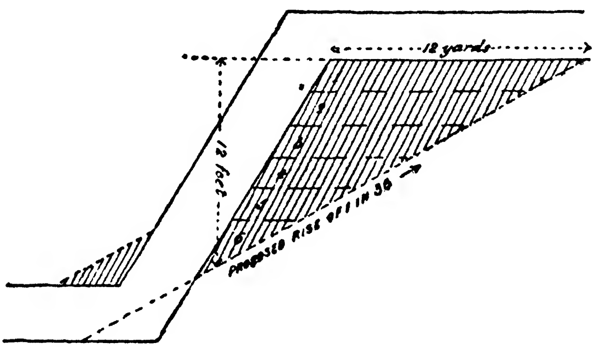


FIG. 1.—SKETCH ILLUSTRATING METHOD OF CALCULATING COST OF STONE WORK IN MAKING A SLANTING STAPLE.

provided with a better travelling road. The use of explosives (with Settle's water cartridge) was allowed, as there was no air from broken workings passing this part of the return. It was arranged to work continuously, with three shifts of two men each.

The mode of calculating the cost was as follows, there being six canches in all, each 2 feet thick and 6 feet wide (see Fig. 1):—

										£	s.	d.
First canch,	2 ft. thick and	12 yds. long,	at	2½d.	p. in.	= 5s. od.	per yd.	=		3	0	0
Second	,,	,,	10	,,	2¾d.	,,	= 5s. 6d.	,,	=	2	15	0
Third	,,	,,	8	,,	3d.	,,	= 6s. od.	,,	=	2	8	0
Fourth	,,	,,	6	,,	3¼d.	,,	= 6s. 6d.	,,	=	1	19	0
Fifth	,,	,,	4	,,	3½d.	,,	= 7s. od.	,,	=	1	8	0
Sixth	,,	,,	2	,,	3¾d.	,,	= 7s. 6d.	,,	=	0	15	0
										12	5	0

The total cost thus working out to £12. 5s., the men (contractors), in order to make fair wages, would have to finish the work well within a fortnight.

Fourth Example.—Taking up seggar, or fireclay, in Main Coal seam (September 1889). Paid at the rate of 2½d. per inch, the stratum being of a particularly hard gritty nature. In another seam, taking up fireclay was paid at the rate of 1½d. and 1d. per inch, usually the latter; but when the bed was only from 6 inches to 8 inches thick, at 1½d. Clearing away fallen stone or coal lying on top of the seggar was not included in the canch price, but was paid for extra, according to the extent.

An ordinary width of canches is, in main ways, 8 feet wide;* in branch ways, 7 feet wide. When shooting top or bottom canches, the width being decided, no extra width that the men

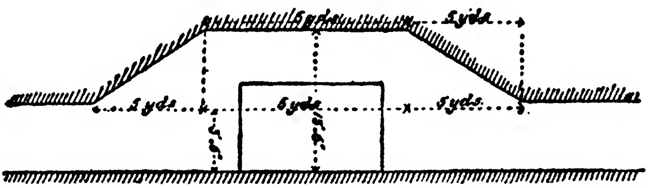


FIG. 2.—SKETCH ILLUSTRATING METHOD OF CALCULATING COST OF STONE WORK IN MAKING AN AIR-CROSSING.

may make, over and above this, is taken into consideration when measuring their work. The powder or other explosive will of course expend itself somewhat in the sides, but little extra work is entailed thereby in dressing back, stowing, &c.

Fifth Example.—Estimated cost of an air-crossing to be shot out in Low Main seam (1887), the dimensions being as follows (see Fig. 2):—

	Feet.	Inches.
Allowance for arching	1	0
Height of return air-way above arch	6	0
Height of in-take air-way beneath arch	6	6
Total height	13	6
Deduct height of seam...	3	6
Height of stone canch	10	0

* Assuming the main-and-tail rope system of haulage to be adopted. In the case of endless chain or rope being the system of haulage, the width of canches on main roads would be from 9 to 12 feet.

Amount of stone to be taken down, 10 feet × 8 feet × 30 feet = 2,400 cubic feet = 88.9 cubic yards, which at 6s. 9d. per cubic yard = £20 total cost. The following is the manner of calculating the preceding price:—

	Post Stone.
First 2 feet at 3d. per inch	72d.
Second " 3½d. "	84d.
Third " 4d. "	96d.
Fourth " 4½d. "	108d.
Fifth " 5d. "	120d.
	480d.

The place when finished to be 8 feet wide—say, 9 feet.

$$\frac{480\text{d.} \times 9 \text{ ft.}}{6 \text{ ft.}} = 720\text{d.} = £3 \text{ per lineal yard.}$$

$$£3 \times 10 \text{ yards} = £30 \div 88.9 = 6\text{s. } 9\text{d. per cubic yard.}$$

The inch prices must sometimes be altered to suit special circumstances, as in the following case:—

Sixth Example.—Air-crossing over barrier way in Low Main seam (June 1889). The return and in-take airways are "cross-cut on," as the pit-saying is, and as shown in Fig. 3. Now this work could not be let at the 3d. per inch basis price, although the stone was ordinary "post" (sandstone), as a difficulty was experienced in "tailing out" the canch, so ½d. per inch was added. There was, of course, more tailing out to do than if the air-crossing had been a rectangular one.

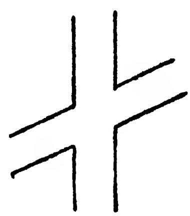


FIG. 3.

(ii.) RIDDING.—Actual examples again will best explain matters in this class of work.

First Example.—Enlarging gateways, drifts, &c., in Low Main seam (November 1887). This was paid at the rate of 3s. per cubic yard, putting and stowing being close at hand. All stone was wedged down, and no explosives were allowed to be used. Character of stone, shale and sandstone.

Second Example (February 1888).—Cleaning up and laying way for tubs, preparatory to commencing to take off pillars in Daleway seam. All along the headways the top coal was "up-standing," but a band of stone below had fallen, and was lying by the sides, where it had been placed by the hewer when working in the whole. There were 18 yards in the bord where the top coal had fallen (see Fig. 4).

As to headways. Averages measured from the *top of the seam*, in order to determine how much *must* have fallen, and taken every 10 yards. Average = 10 inches. 10 inches × 9 feet wide × 33 yards long, at $1\frac{1}{4}$d. per inch, 10 inches × $1\frac{1}{4}$d. × $\frac{9}{6}$ = 1s. 6d. per yard.

As to bords (107 yards). The thickness of fallen stone was greater here than along the headways, and in 18 yards of it the top coal had fallen. Regarding this as two canches, the calculation is—(*a*) 107 yards × 16 inches × 5 feet wide, 16 inches × $1\frac{1}{4}$d. × $\frac{5}{6}$ = 1s. 4d. per yard; and (*b*) 18 yards × 20 inches × 9 feet wide, 20 inches × $1\frac{1}{4}$d. × $\frac{9}{6}$ = 3s. $1\frac{1}{2}$d. per yard.

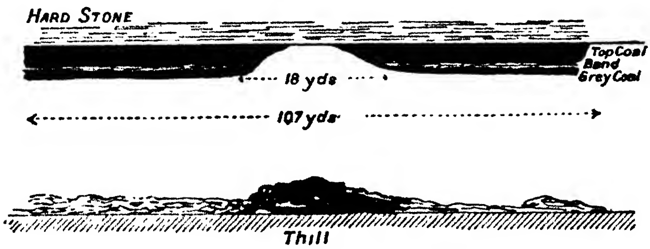


Fig. 4.

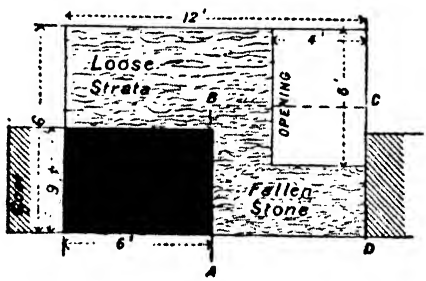


Fig. 5.

Sketches Illustrating Methods of Calculating Price for Ridding.

Third Example.—Putting across "bord rooms" was always paid at the rate of 5s. per lineal yard, *plus* the current county percentage above standard wage. This was the only bargain work that varied with the percentage advances and reductions.

Fourth Example (see Fig. 5).—Enlarging a return air-way, Main Coal seam (1887). The air-way to be made 12 feet wide by 9 feet high. The present dimensions are 4 feet wide by 6 feet high. The original road A B C D, owing to the falling of the stone, had got partially filled up and altered to the position indicated in Fig.

5. The coal was to be hewn out and paid for at the district score-price.

4.5 feet × 6 feet = 27 square feet of coal.
4 feet × 6 feet = 24 area of opening.

51

12 by 9 = 108 square feet sectional area of finished air-way. 108 − 51 = 57 square feet sectional area to be ridded.

57 square feet per lineal yard = 6 cubic yards.

The price paid was 1s. 1d. per cubic yard = 6s. 6d. per lineal yard.

(iii.) STONE-DRIFTS.—When contracting for the driving of stone-drifts—or, indeed, stone-work operations of any description—a formal agreement is often drawn up and signed by the two parties concerned. To quote from an actual instance:—

......................*COLLIERY*, 18th October 1887.

NEW STONE-DRIFT—MAIN COAL.

AN AGREEMENT between A. B. on behalf of the Coal Company Limited, the one party, and C. D., E. F., &c., the other party, relative to the driving of the above-named stone drift.

First Part.—The contractors agree to drive the stone-drift in a straight and uniform manner. It is to be finished 6 feet high by 6 feet wide, and to rise at the rate of ½ inch per yard. The stones to be filled into a tub, "put" to the siding. The men to set all timber and erect the brattice for the ventilation; and to keep the drift in a safe and workable condition to the satisfaction of the master shifter.

Second Part.—The owners agree to provide the explosives and blasting materials. Also to provide and sharpen all necessary gear. The timber and brattice to be taken to the drift way end at the owners' expense.

The rate of payment to be £1. 14s. per lineal yard. Six inches of coal or whinstone to break the bargain.

To be let for twenty (20) yards, but can be stopped at any time should the management deem it necessary.

Signed on behalf of the owners,

Manager.

Signed on behalf of the men,

} *Contractors.*

Witness to the above signatures..............................

In the above case the stone was sandstone and shale mixed, and the price per cubic yard was 8s. 6d. = per square foot 11.33d. Below is another form of specification, which has been used in "letting" stone-drifts to be driven by contract:—

COLLIERY.

SPECIFICATION AND DESCRIPTION OF A STONE DRIFT TO BE DRIVEN FROM THE SEAM TO THE SEAM IN THE PIT.

I. The drift to be driven 9 feet wide and 7 feet high, and to rise 4½ inches per yard, passing through all strata between the seam and the seam, an account of which is provided herewith.

II. The drift to be driven by the marks as directed by the manager of the colliery.

III. It is expected that the gradient will be uniform, but it may be necessary to vary it as circumstances arise.

IV. The contractors to find all gunpowder—or other explosives that may be used—candles and other stores; the owners to provide and sharpen the gear, including a drilling machine and drills.

V. The contractors to lay all plates, and to set any timber that may be necessary for their own safety; and to put in all air-tubes or ventilation brattice; the owners providing the same.

VI. The contractors to fill all stones, coals, and other material produced by the drift into tubs provided by the owners, who will also find the means for leading away the same. All coals to be filled free from stones or dirt.

VII. The drift to be driven and worked by not less than three men in the face at any one time.

VIII. The contractors to be paid once a fortnight on the usual and accustomed pay day within *five per cent.* of the sum earned, such five per cent. being retained in hand by the owners as a guarantee for the full and satisfactory performance of the work.

IX. The drift will be commenced within a few yards of the main east winning in the seam, and as there will be a tail end of top stone to shoot down before the drift is set in fast, it is agreed that the measurement for payment of contract price shall start at or be reckoned from the centre of this tail end. It is further agreed that as soon as the seam is touched the contract shall terminate.

X. The work to be performed in a workmanlike manner to the entire satisfaction of the manager of the colliery, upon whose certificate only the money will be paid.

XI. Written tenders to be handed in at this office on or before the day of 19 .

Signed

Colliery Manager.

COLLIERY OFFICE,
19

For stone-drifts, the following basis prices answer fairly well in the majority of cases. For sandstone: price 10s. to 11s. 6d.

per cubic yard in a *regular* stone-drift of 6 feet by 8 feet, or 5 feet by 8 feet or thereabouts. The price will be found to vary chiefly as the width of the drift; for the wider it is, the better the stone shoots. If the drift was wider than 8 feet, it would let for less than 10s. per cubic yard. For shale: price per cubic yard, 6s. to 7s. 6d. for the same sizes as the above.

If a drift is driven as an incline, not only are the difficulties of "putting" greater than if it was level, but the shooting of the stone is not so easily effected, as it is worked against the grain, as it were—that is to say, it is not parallel to the planes of bedding or stratification—unless, indeed, the strata are much inclined, which is rarely the case in the Northern coalfield. Furthermore, if, as sometimes happens, a thin bed of softer stone "puts in"—which is reckoned a godsend to the stone-man—an inclined drift does not long retain this advantage; hence allowances must be made in the bargain price when letting inclined drifts.

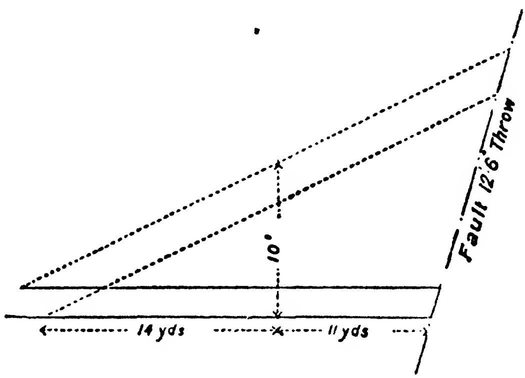


FIG. 6.

First Example.—Estimated cost of putting up an incline in east back headways for return air-way, as illustrated in Fig. 6. "Trouble" (fault) proved by a staple in the west back headways, and found to be a 12 foot 6 inch "riser." The incline to rise at 6 inches per yard. The first 14 yards will be shot "open-cast"—that is, as a canch, the thickness of the stone to be removed not being too great. (Beyond a certain thickness it is cheaper and better to "drift" in the "solid.")

Taking height of seam to be 3 feet, 14 yards at 6 inches per yard = 7 feet + 3 feet = 10 feet, ∴ canch averages 5 feet, width 8 feet. 5 feet at $3\frac{1}{2}$d. per inch, $5 \times 12 = 60$ inches at $3\frac{1}{2}$d. = 210d., which $\times \frac{8}{8}$ = £1. 3s. 4d. per yard. The price for the close drift 5

Stonemen at work with Machine Rock Drills driven by Compressed Air.

[To face page 108.

feet high by 8 feet wide, at a basis price of 13s. 7d. per cubic yard = £3 per lineal yard.

14 yards at £1. 3s. 4d. =	£17, about
11 yards at £3. 0s. 0d. =	33
Making	£50 cost of putting up incline.

Second Example (December 1889).—A short stone-drift to be driven through a "balk," let for 10 yards. The section of the "place" was as follows :—

	Ft.	In.
Shale	1	6
Coal	1	6
Seggar (fireclay)	1	0
	4	0

There was a good "parting" at both the top and the bottom of the drift, the size of which was 6 feet by 5 feet. The price paid was 6s. per cubic yard—say £1 per lineal yard. The men (who were barely up to the average in skill or strength) made 4s. 9d. a shift.

Of eighteen actual instances of stone-drifts driven at different collieries within the ten to twenty years preceding the war, the price per lineal yard has varied from £1. 10s. for a level drift 5 feet wide and 5 feet high, to £8. 10s. for a drift 16 feet high and 16 feet wide, falling 1 in 3. The latter was in South Wales. The strata driven through consisted chiefly of sand and gravel. The price includes payment for setting heavy timber.

1s. to 1s. 6d. per square foot area of section for ordinary coal measure stone is a rate recognised by many.

In driving long drifts through hard stone, considerable economy may be effected by the use of machine rock drills operated by compressed air or by electricity. Plate IX. illustrates a case in point. The drift was 11 feet wide by 6 feet 6 inches high, and was driven a distance of about a mile. Two of Cranston's machine rock drills were used, actuated by compressed air at a pressure of 55 lbs. per square inch. This is a percussion drill, making at normal speed 300 blows a minute, the cutting tool being attached to the piston rod, and moving with the same reciprocating motion. The cylinder is made of gun metal, and is 3½ inches diameter by 5½ inches stroke. The forward feed motion, necessary to keep the machine up to its work as the hole is drilled, and the rotating movement required to be imparted to the cutting tool, to hinder it striking the same place successively, are both communicated by hand through the screw and handle grasped by the men, as seen in Plate IX. These movements may thus be varied at will to suit the varying nature and hardness of the stone, and the mechanism is such that the two movements may be given independently of each other, that is, the machine may be moved forward without rotating the drill, and *vice versâ*. The mechanism is strong and simple, and the machine seldom goes wrong or needs repairs. In hard sandstone, holes 2 inches diameter were drilled by this machine 6 feet deep within half an hour, and the average rate of progress of the drift was 45 feet a fortnight, work being continuous with two men at a time following each other in eight-hour shifts. In softer stone (blue metal and post girdles) the progress has been as much as 25 yards in the fortnight. The bargain price paid in hard sandstone was £2 per yard, the workmen finding themselves explosives (compressed powder and gelignite). In softer stone it was 35s. a yard.

(iv.) SINKING STAPLES.—Two examples will suffice.

First Example.—Estimated cost of sinking staple down dip "trouble," to prove the seam (November 1888). Sinking on the slope of the "leader" causes more difficulty than sinking perpendicularly, and as the trouble in this case "haded" very much, it was difficult to cast back the *débris*. The amount of throw of fault was 25 feet; the dimensions of staple, 6 feet by 6 feet.

The ordinary rate of payment would have been 7s. 6d. per cubic yard (= £1. 10s. per running yard), but owing to difficulties introduced by the sloping of the staple, an additional 6d. per cubic yard was paid. The price was therefore £1. 16s. per lineal yard. The character of stone was as follows:—First 2 feet, seggar, or fireclay; next 4 feet, shale; and the remainder, sandstone; but to put against this there was the soft "leader" stone, in which the staple was partially sunk.

Second Example.—The sinking of a staple from the Maudlin to the Hutton seam, for purposes of ventilation (April 1889). This staple was 13 feet 6 inches in diameter, the stone being principally hard shale with some sandstone. No water was given off. The stowage was close to hand, and the *débris* was filled into a kibble, drawn up by a small double-cylindered engine. The price paid per fathom was £11. 6s. = 7s. 2d. per cubic yard. There were six men at the bottom of the staple. Besides sinking the staple, they put in all brattice, and stowed the *débris*.

(v.) MISCELLANEOUS BARGAIN WORK.—The prices actually paid at a large colliery in the county of Durham are given in the following instances :—

(1.) *Drawing chocks in broken or longwall:* 5d. per chock ; or if done by the shift, 3s. 10d. per shift.

(2.) *Putting through "bord" or "wall-rooms"* (old roads filled up with fallen stone): 5s. per lineal yard, *plus* current county percentage above standard wage.

(3.) *Pillaring in longwall*, which consisted of building pillars 6 feet (and in some instances 8 feet) thick, of refuse stone alongside the gate-ways and cross gate-ways through the goaf. This work was performed by back-bye men,* who were paid on the score of coal drawn out of the particular district where the modified form of longwall was in vogue. Thus, in a particular case: "Pay ending Saturday, 23rd April 1887. 80 score 7 tubs were drawn out of the sixth north way. To J—— C—— & Partners, 80 score 7 tubs at 3s. per score = £12. 1s."

Taking another instance of the same mode of payment, two men will put in 5 yards in two shifts, that is, it will take four men one shift to build 5 yards. $8 \times 3.5 \times 15 = 420$ cubic feet $\div 27 = 15.5$ cubic yards. This at, say, 1s. 6d. per cubic yard $= 23.25$ shillings $\div 4 =$ 5s. 9d. per man per shift.

Again, suppose the walling to be 7 feet thick throughout the gate-ways and the cross gate-ways, and cross pillars to be built every 2½ yards, the pillaring to average about 3 feet 6 inches in height. The men to cut the bottom the full width of the gate-ways and cross gate-ways (that is, to take up what is left by the hewers, who merely cut sufficient bottom stone for tramway width), and to stow the same in the juds. The amount per yard to be paid will be on the following bases—namely, so much per cubic yard for the pillaring, and so much per inch for the canch.

(4.) *Setting timber balks* (long timber about 8 inches square).—This is often paid at so much per balk. If set with props, say 8 feet apart, 1s. 6d. per balk ; but if set into the side of way, then 2s. per balk.

(5.) *Underground mason work.*—With arching 9 inches thick, 5 feet wide, and 6 feet high, inside, the following rates of payment were observed in a recent instance:—One mason, at 7s. per yard (he

---

* Men who do not work in the face.

had to pay a labourer out of this); one stoneman (whose duty it was to square back the sides, &c.), 8s. per yard: the cost per lineal yard being thus 15s., not taking into account the cost of "putting" the bricks and lime.

The following prices were paid in a 6-foot seam. It should be noted that rubble-built stoppings cost more than brick stoppings:—

Brick stopping,	9	inches thick,	at 0s. 9d.	per square yard.
"	12	"	at 1s. 0d.	"
"	15	"	at 1s. 3d.	"
"	18	"	at 1s. 4d.	"

Knocking out a stopping, and building up a door in place of it, would be paid according to the area of door put in (that is, area taken out), and at the same rate as building stoppings. Plastering stoppings was paid at the rate of 1¾d. per square yard.

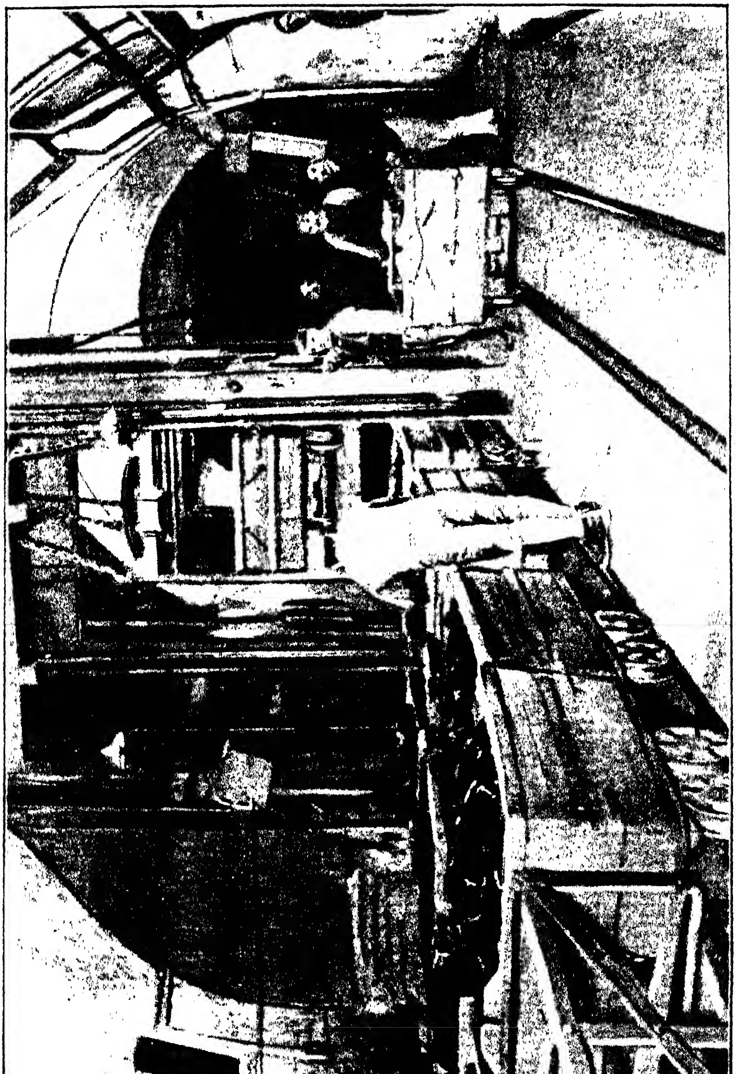
In arching, if the distance between the crown of the arch and the roof was under 1 foot, the masons received no payment for stowing; but if the distance exceeded this amount, they were paid at the rate of 1d. per inch for a width of 6 feet (as in canches), or 1s. per cubic yard. Masons in all cases stowed the spaces behind the arching and level with the crown of the arch free of payment. Masons paid their own labourers. When building *pillars* above arching, masons were often paid at the rate of 1s. 6d. per cubic yard.

As to "putting" stones, one rule is to pay so much per foot of canch per yard of putting after the first 150 yards, this price being usually ½d. per foot per yard. For example, canch 1 foot thick, and with a distance on measuring day of 160 yards, the amount payable over and above the canch price would be 5d.

Datallers.—Under this term are included the various workmen—numbering roughly about one-half of the working miners—who are employed, in addition to the hewers, putters, and stonemen, and who as a rule are paid not by the piece, but by a datal wage.

Shifters are a class of men who do the necessary *repairing and preparatory work* at nights, when the pit is not drawing coals—such as ridding falls of stone and setting timber, to make the pit ready for the following day. When working full time they get short shifts of six hours, at the week end, for which they are paid the same wage as usual.

PLATE X.



Onsetters at work.

[To face page 112.

A Rolleywayman Boring a Sleeper, and Fore-shift Hewers on their way outbye to the Shaft.

[*To face page* 113.

Wastemen do work similar to that of the shifters, but their work is confined to the return airways. They remove stone which has fallen, and see that the roof is properly supported, and that these return air-roads are kept open and of ample size. They are generally old men. Hewers who are too old to continue at that work often become wastemen.

Banksmen and onsetters, instead of a datal wage, are frequently paid a rate per score of coals drawn up the shaft, and thus it becomes their interest to keep the work going, and avoid any stoppages. The banksmen are stationed at the landing of the cage on the surface, and their work consists in "uncaging" the tubs—that is, taking the full tubs out of the cage, and conveying them to the screens (where this is not done by mechanical power), putting the empty tubs into the cage, and giving the necessary signals to the engineman and to the onsetters. The latter, the onsetters, do similar work at the bottom of the shaft. Plate X. shows onsetters at work. The electric light is now frequently used for lighting the bottom of shafts, and the incandescent lamps covered by reflectors are visible in the photograph.

Rolleywaymen, whose duty it is to keep the way right on the main roads, and expedite the conveyance of the tubs along them, are also frequently paid by the score of coals drawn, but more often they are paid a datal wage. They are also the platelayers of the pit, and this part of their work is usually paid by the piece, say 1⅞d. per yard for laying new way, and 1d. per yard for taking up the old way. Plate XI. shows a rolleywayman boring a hole in a sleeper for the pin fastening the rail chair, and a group of fore-shift hewers coming outbye to the shaft at the end of their shift, about 11 A.M. The *locale* is a self-acting inclined plane, and the rope and a roller are visible.

There are other classes of underground off-hand labour, varying according to the circumstances of each colliery, such as *Horse-keepers, Enginemen, Water-leaders, Incline and Engine-plane Attendants, Switchkeepers, Couplers, and Trappers*, all of whom are paid a datal wage.

According to the Coal Mines Act, 1911, boys under fourteen years of age may not be employed below ground. No girl or woman of any age may be employed below ground. The Act contains several sections dealing in detail with the employment of boys, girls, and women in mines above and below ground.

The cost of labour per ton of coals drawn will increase as the proportion of off-hand men and boys employed increases, other things being equal.

CHAPTER VII.

WAGES BILLS AND COST SHEETS.

THE procedure in making up the weekly pay bills—which in a large colliery office, concerned it may be with several pits, will in some cases run into thousands of pounds—varies somewhat in details, according to the particular circumstances of individual collieries, and to the differing methods in minor matters preferred by individual managers; but in its main features the general practice is pretty uniform. Of course, in the larger collieries employing a large and varied staff, a more elaborate system is necessary than the comparatively simple procedure which suffices for a small colliery. In the present chapter a general view is given of what is necessary to be done, and examples are furnished of the various forms of pay bills, returns of produce and cost, and the like documents, required to be used in some shape or other in every well-organised colliery.

The most important of the wage bills is known as the *Overman's Bill*, or Underground Bill, which includes the wages of all underground workmen. It is necessarily an elaborate document. Several large sheets are devoted to a detailed account of the hewers' work, and give the names of each pair or set of hewers, the number of tons filled by them, and the amount of money due at the agreed price per ton; also, the yard work and consideration money, and the total gross amount due to each pair or set of men. From this gross amount various off-takes, as stated on the bill, are deducted. House rent, Minimum compensation, and Health and Unemployment Insurances are shown in separate columns.

A form of so much of the underground bill as relates to the hewers is given in Form A, Plate XII.; and the headings of the portion of the same bill relating to the putters, in Form B, in the same Plate. Under these headings are stated the number of tubs put by each putter, the prices per score of tubs, and the amounts due.

The wages of the datal hands are stated on other sheets, under the various heads of overmanship, deputies, rolleyway, drivers, trappers, engine-plane, braking inclines, horsekeepers, stonemen, and shifters, &c., of which Form C, Plate XII., will serve as an example. It refers to drivers.

Another page is occupied by an abstract account in which the totals already shown are brought forward and added together (see Plate XIII.). The total thus obtained, if it includes the stone and shift work bill, is the amount spent during the week on labour in getting the coal and bringing it to bank. If the total of the wage bills for surface labour are added to the underground bill, the grand total will show the cost of all labour for "getting" the coal, and putting it into waggons at the colliery. An abstract of charges for surface labour is given in Plate XIV. Plate XV. shows the labour costs into trucks. The quantity of coals drawn each day from the different royalties (that is, the separate areas belonging to different owners to whom royalties for coal worked are payable) into which the workings extend, is also shown, these particulars having to be duly recorded for the making up of the accounts of rents payable to the several owners of the coal properties over which the seams being worked extend (see Plate XVI.).

The cost per ton of coals drawn, the average wages of the hewers and of the putters, the number of horses and ponies at work, and other information are stated on Plate XVII. Separate sheets are required for account of overtime, and of minimum wage (see Plates XVIII. and XIX.).

An abstract of all the wage bills and other charges is given in some such form as Plate XX.

A **Pay Note Book** is usually kept, into which are entered every pay week the names of the workmen employed; their total earnings; the off-takes, under various heads—as, for example, pick-sharpener, priest,* laid-out, set-out, firecoal, water, doctor,

* Roman Catholics are found in considerable numbers in mining communities, many of them being Irishmen, and often first-rate workmen; and it is a common practice for them to arrange for the dues to their priest being handed direct to the priest in a lump sum by the colliery officials on the occasion of each pay.

Form C.

Plate XIIa.

Drivers.		Age.	Total Shifts and Rates.		Add R°/o Deduct °/o			Deductions and Off-takes															Total.		Nett Wages.			House Rent.		Minimum Compensation.			Employer's Insurance.				No. of Check.
																																	Health.		Unemployment.		
Names.	Districts.				£	s.	d.	Fire Coal.	Dr.	Dr.	Dr.	Joint Off-takes.	P. R. Fund.	Water.	Nurse.	Reading Room.	Priest.	Bands.			Health Insce.	Unempl. Insce.	s.	d.	£	s.	d.	s.	d.	£	s.	d.	s.	d.	s.	d.	
	Brought forward																																				

[*To face page* 115, *after* Forms A *and* B.

No. *PAY ending* 19 *PIT* *SEAM* *COLLIERY.*

ABSTRACT ACCOUNT OF OVERMAN'S PAY BILL.

ABSTRACT OF HEWING.

	xx.	T.	s/d.	£	s.	D.	£	s.	D.	£	s.	D.	£	s.	D.
To Hewing in the Whole Mine															
" " "															
" " "															
" " "															
" " "															
" " "															
" Hewing in the Broken or Longwall															
" " "															
" " "															
" " "															
" " "															
" " "															
" " "															
" " "															
" " "															
" " "															
" " "															
" " "															
" " "															
Total															
" Bad Coal, &c.															
" "															
" "															
" "															
" "															
" "															
" "															
" "															
" "															
Total															
" Overplus Weight															
Proof of Total A															
" Consideration, Juds, &c., brought forward Total B															
" Narrow Work, " " Total C															
Total £															
" Percentage															
Hewers' Gross Wages, Proof of Total D £															
Deduct Off-takes A															
Total Amount, Hewers' Nett Wages £															
Deduct Off-takes B															
Proof of Total F															
Carried forward															

ABSTRACT OF OFF-HAND WORK, &c.

	Over-man's Totals. £	s.	D.	Off-takes A. £	s.	D.	To be Billed. £	s.	D.	£	s.	D.	Off-takes B. £	s.	D.	To be Paid. £	s.	D.	£	s.	D.	HOUSE RENT. £	s.	D.
Hewing brought forward																								
To Putting																								
" Horse Driving																								
" Water Leading																								
" Timber Leading																								
" Overman and Back Overman																								
" Rolleyway Men																								
" Onsetters																								
" Banksmen																								
" Deputies																								
" Trapping																								
" Braking																								
" Station-keeping																								
" Furnacemen																								
" Boys at Inclines																								
" Horse-keeping																								
" Switch-keeping																								
" Lamp-keeping																								
" Smart Money																								
" Calling																								
Totals																								
Amount of Bill																								
Total Amount of House Rent																								

PROOF OF OFF-TAKES B.	£	s.	D.
Water Company			
Doctor			
Priest			
Permanent Fund			
Accident Fund			
Smith			
Tokens			
Glasses			
Advanced			
Total			

	£	s.	D.	£	s.	D.
Received from other Agents { Per Engineer						
Received from other Agents { ,, Master Shifter						
Add Off-takes B						
Less—Pick Money, Passed to Smith's Bill						
Amount to be Paid						
Amount of Bill as above						

Signed *Manager.*

Undermanager.

COLLIERY.

No...............*Pay*, 192 .

From the.............................*day of*...192 , *to and with the*...............................*day of*...192 .

AN ACCOUNT OF GENERAL SURFACE LABOUR, INCLUDING FARM WORK.

ABSTRACT OF CHARGES.

	WAGES.	DEDUCTIONS.			WAGES.	OFF-TAKES.														NETT WAGES.	GOVERNMENT WAGE.	WAR WAGE.	HOUSE RENTS.	EMPLOYERS' INSURANCE.	
		Fire Coal		Total.		Dr.	Dr.	Sick Funds.	P.R. Fund.	Priest.	Water.	Nurse.	Reading Room.	Band.	House Rents.	Health Insce.	Unempl. Insce.		Total.					Health.	Unempl.
	£ s. d.	s. d.	s. d.	£ s. d.	£ s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	s. d.	s. d.
Screening																									
Winding Engines																									
Fan Engine																									
Locomotives																									
Pumping Engine																									
Electric Engine																									
Sawmill																									
Joiners and Shaft Work																									
Blacksmiths and Fitters																									
Railways																									
Masons																									
Labouring																									
Casting and Filling Coal																									
Carting																									
Traction Engine																									
Farm																									
TOTAL																									

EXAMINED:—

		Nett Wages £ s. d.
Dr.	brought down	
Dr.	"	
Sick Funds	"	
P.R. Fund	"	
Priest	"	
Water	"	
Nurse	"	
Reading Room	"	
Band	"	
House Rent	"	
Health Insurance	"	
Unemployment Insurance	"	
Government Wage	"	
War Wage	"	
House Rents	"	
Employers' Health Insurance	"	
Employers' Unemployment Insurance	"	
TOTAL AMOUNT TO PAY		£

[*After* PLATE XIII.

PLATE XV.

COLLIERY.

LABOUR COSTS INTO TRUCKS. No............ PAY...192

DAYS WORKED.	BASIS. s.	d.	WAGES. £	s.	d.	COST. s.	d.
Hewing							
Yard Work							
Putting							
Overmen and Deputies							
Engine Plane, &c.							
Drivers							
Water Leaders							
Inclines and Rolleyways							
Horsekeeping							
Onsetting							
Banking Out							
Smart Money							
Hauling Engines							
Sundries							
Bargain Work							
Shift Work							
Waste Work							
Total Underground							
Screening							
Pumping Engines							
Electric Engines							
Winding Engines							
Fan and Shop Engines							
Locomotives							
Joiners and Shaft Work							
Smiths and Fitters							
Masons							
Carting							
Labourers							
Railways							
Casting and Filling							
Total Surface							
Gross Cost							
Subsistence							
Minimum Compensation							
Health and Unemployment Insurance							

% WORKINGS.	T.	C.	%
Coal Whole			
Broken			
Longwall			
Clay			

Seams.

Queen			
Top			
Main			
Bottom			
Givens			

	T.	C.	%	%
Best				
Unscreened				
Small				
Screened Splints				
Unscreened Splints				
Splint Small				
Waled Out				
Brasses				
Waste				
Actual Best				
Actual Small				

HEWERS.
No. on Books
Shifts Worked
Shifts Lost
Total

PUTTERS.

Averages.

		Wage.	Tons.
HEWERS	Drift		
Shaft			
Pit			
FILLERS	Drift		
Shaft			
Pit			
Putters			
		%	%

Hewers off work. Ill
Idle

Putters off work. Ill
Idle

Timber Consumed.

PROPS. 3′	3½′	4′	4½′	5′	5½′	6′	6½′	Total.	Tons. P. Prop.	BALKS. Split.	Whole.	Planks.	

[*After* PLATE XIV.

COLLIERY.

No...................*Pay,* 192 .

From the......................*day of*...192 , *to and with the*......................*day of*..192

AN ACCOUNT OF COALS WORKED OUT OF THE VARIOUS ROYALTIES.

WORKINGS.

	DRAWINGS.											ROYALTY.												ROYALTY.												ROYALTY.										ROYALTY.			
												Coals.										Fire-clay.		Coals.										Fire-clay.		Coals.								Fire-clay.		Coals.		Fire-clay.	
	Coals.				Laid Out.	Stones.		Fireclay.				Seam.		Seam.		Seam.		Seam.		Seam.				Seam.		Seam.		Seam.		Seam.		Seam.				Seam.		Seam.		Seam.		Seam.				Seam.			
	XX.	T.	XX.	T.	TBS.	XX.	T.	XX.	T.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.
Monday																																																	
Tuesday																																																	
Wednesday																																																	
Thursday																																																	
Friday																																																	
Monday																																																	
Tuesday																																																	
Wednesday																																																	
Thursday																																																	
Friday																																																	
Saturday																																																	
Total																																																	

AVERAGES, &c.

	Top Seam.	Main Seam.	Queen Seam.	Bottom Seam.	Wonder Seam.	Totals and General Av'rages.
No. of Days Worked -						
,, Hewers on Books -						
,, Shifts Worked -						
,, Hewers off Work -						
,, Putters ,,						
Hewers' Average Wage -						
Deputies ,, ,, -						
Putters' ,, ,, -						
Tons per Hewer per Shift -						
Average Weight per Tub -						
,, Tare - - -						
Horses at Work - -						
13 Hand Ponies at Work -						
Putting ,,						
Horses off Work - -						
13 Hand Ponies off Work -						
Putting - - - - -						

COMPARATIVE COST PER TON FOR UNDERGROUND LABOUR AND SCREENING.

	Last Pay Cost ℔ Ton.		This Pay.				
			Amount.			Cost ℔ Ton.	
	s.	d.	£	s.	d.	s.	d.
Overmen's Bills - - -							
Waste Work - - -							
Bargain ,, - - -							
Shift ,, - - - -							
Screening ,, - - - -							
Labour as per Surface Bill *Less*—Screening, Traction Engine, and Farms							
TOTAL - - -							

[*After* PLATE XVI.

OVERTIME ACCOUNT for No.................Pay ending.................................192......

NAME.	Occupation.	Sunday.	Surface. $1\frac{1}{2}$ hrs.	Surface. $1\frac{1}{3}$ hrs.	Underground. $1\frac{1}{2}$ hrs.	Underground. $1\frac{1}{3}$ hrs.	Rate.	Wages.	War Wage, &c.	TOTAL.	NAME.	Occupation.	Sunday.	Surface. $1\frac{1}{2}$ hrs.	Surface. $1\frac{1}{3}$ hrs.	Underground. $1\frac{1}{2}$ hrs.	Underground. $1\frac{1}{3}$ hrs.	Rate.	Wages.	War Wage, &c.	TOTAL.

MINIMUM WAGE ACCOUNT. **COLLIERY.**

No................*Pay* ....192.....

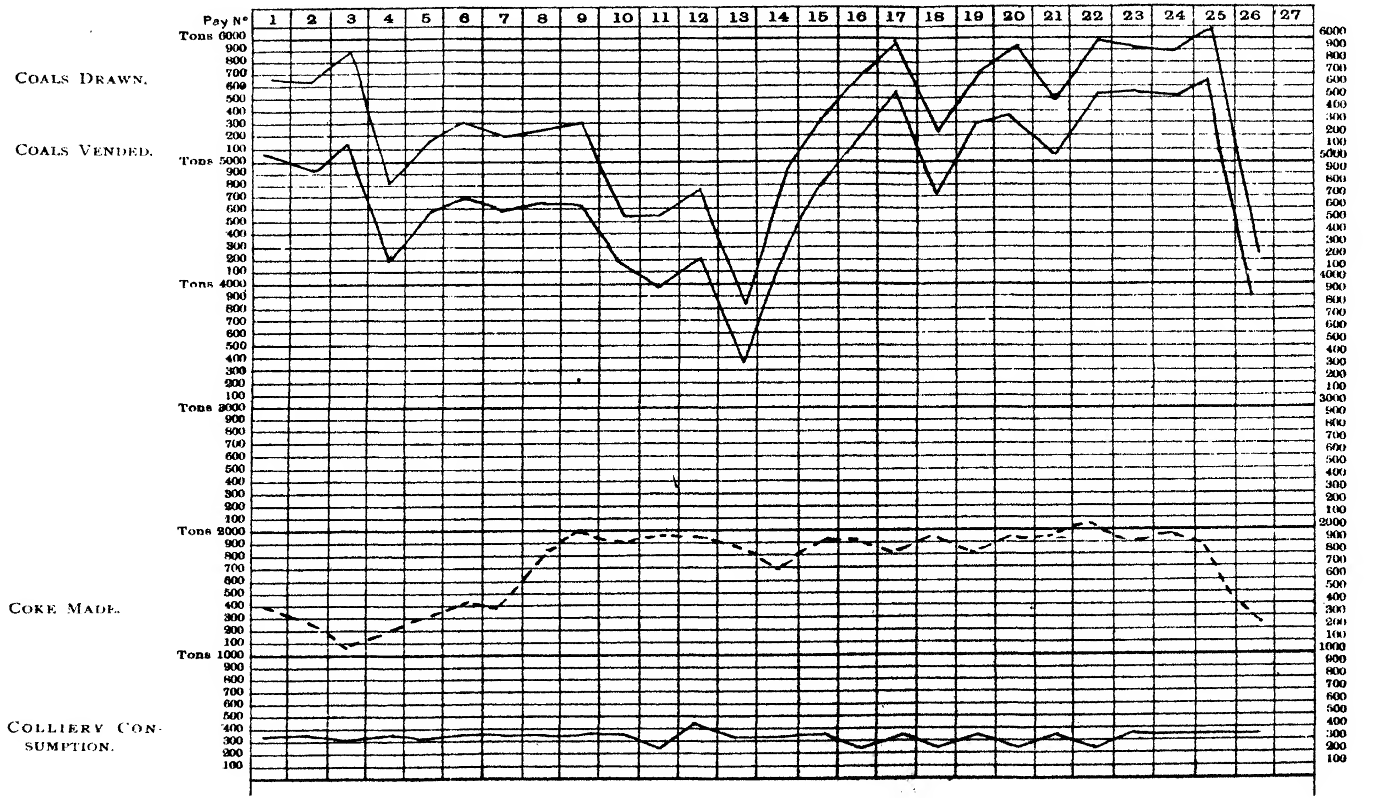
Token.	NAME.	Shifts.				Earnings.	Average per Shift.	Add Minimum per Shift.	Amount to Pay.	
		Total Each.	Idle.	Sick.	To Pay.					

[*After* Plate XVIII.

Form J.

Graphical Statement of Coals Produced and Disposed of Pay by Pay.

Plate XXa.

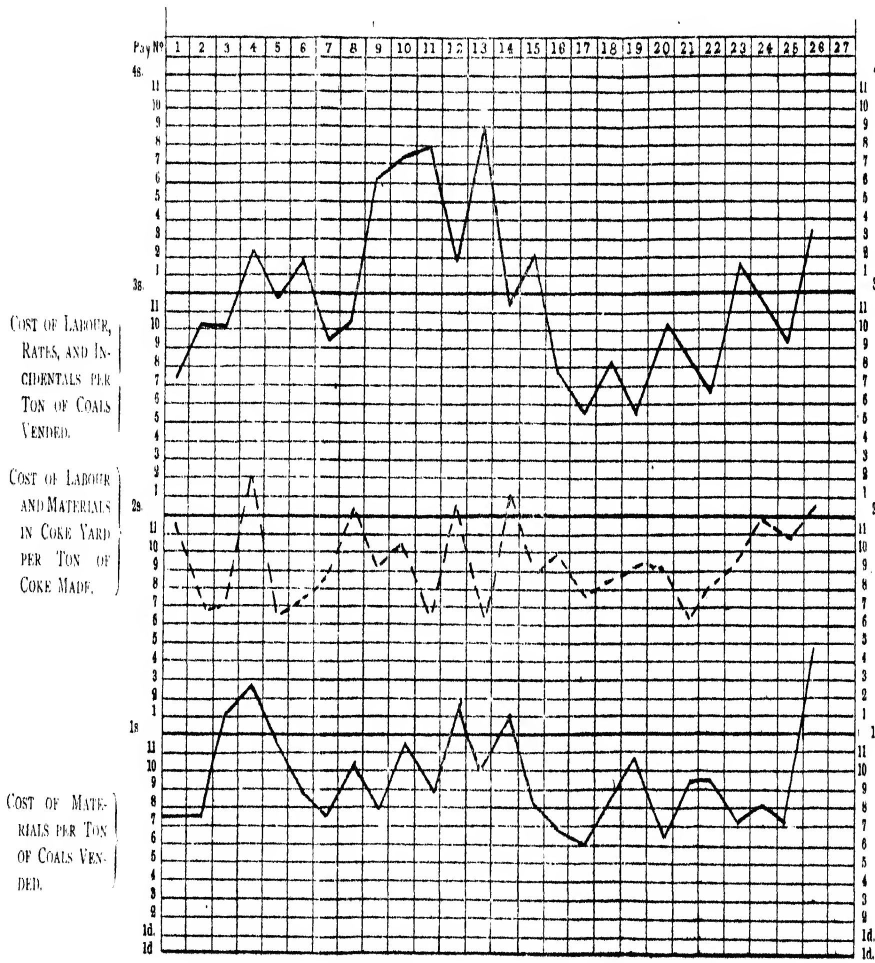


[To face page 117.

PLATE XXB.

FORM K.

GRAPHICAL STATEMENT OF VARIATIONS IN COSTS FROM PAY TO PAY.



[After FORM]

miners' permanent relief fund—these items varying at different collieries and with different men; and the net wages, payable direct to the miner, remaining after these deductions.* For instances of the particulars required, see Plate XIII., already referred to on the preceding page.

Each set or pair of hewers receives on Thursday (at some collieries on Wednesday)—that day being known as "reckoning day"—a *Pay Note* giving the above-mentioned particulars in their case, with the number of shifts worked. A note in the subjoined form is used for this purpose (Form, p. 119). The men come to the overman's office for the note, and can then ask any questions about it, and satisfy themselves that it is correct. At the pay, the pay note book is referred to as each man comes for his money, and the name of the individual to whom the money is handed is written against the amount in the book.

Income Tax cards (see Form, p. 120) also are now required. These are made up weekly, and the particulars are sent to the Income Tax office twice a year.

The card shown is for a hewer, and columns are provided to show what he has spent on explosives and on pick-sharpening. These expenses are deducted from the sum assessable to Income Tax.

Other cards without these columns are provided for "datal hands," who have no expenses of this kind in connection with their work.

The engineers' and heapkeepers' wage bills, the overman's, the "shift," "waste," and other bills are ready to be examined and checked on the Monday and Tuesday of each week; and on these days a manager's time is generally occupied for the most part in examining and passing the wage bills.

To show the rise and fall of costs at a glance, graphical methods are most effective. Forms J and K will serve as an illustration of diagrams suitable for this purpose. In one of these, Form J, the varying quantities of coal brought to the surface each fortnight, the quantities sold, and the amounts consumed at the colliery in raising steam and in supplying the workmen with fire coal, are shown, as also are the tons of coke made each pay. In the other, Form K, the varying cost of pro-

* Now that wages are paid every week, some of the off-takes are deducted weekly and some fortnightly. This is shown on the Pay Note.

ducing this coal and coke, both for labour and materials employed, is shown in like fashion.

These diagrams illustrate the well-known fact that, roughly speaking, the cost of working varies inversely as the output—that is, if the output of coal is reduced, the cost per ton of getting that reduced quantity will be increased. As the line showing the output rises, the line showing the cost falls. This is due to the fact already mentioned that there are a large number of charges which continue the same or nearly so, however the output of coal may vary. The water must be pumped, the ventilation must be maintained, the winding engines must be in readiness, the horses and ponies must be fed, the underground roads must be kept good, and a considerable number of men must be employed, even though little or no coal is being got. There are, no doubt, some collieries which may be left almost to themselves without taking harm, but these are quite exceptional. Returns made in this form are, of course, not in substitution of statistical returns in the form of pay and cost sheets, but are made up from these latter to illustrate the course of things over a given period.

Some additional forms are also given—namely, Form O and Form P, p. 121—which have been found suitable in different cases for returns of production, costs, &c., per fortnight or per week. They will sufficiently explain themselves.

It need hardly be said that discretion will have to be used in adapting the examples of forms given in this chapter to the actual circumstances of each colliery for which they are required, with due regard to the fullness of detail desired in each particular case. But in any case the system adopted should be such as to enable the colliery manager to grasp for himself, and make plain for others, the true facts of each week's working—as regards the amount of coal got, financial results, the cost of its production, &c.—and such as to show readily any waste or extravagance which may occur in any department of labour or in the consumption of materials.

COLLIERY **HEWERS' PAY NOTE.**

No. *Shifts*

Dr. *COLLIERIES LTD.* *Cr.*

*Fire Coal...	...	3d.			
*Laid out ...	...	4½d.			
†Dr M. ...	...	1/6			
†Dr S. ...	...	1/6			
†Dr W. ...	...	1/6			
†P.R. Fund	1/4	} 2/10			
†Pick-sharper	2d.				
†Weighman	1/-				
†Aged Miners	½d.				
†Infirmary	2d.				
†Dr Barnado H.	½d.				
†Ambulance	1d.				
†Priest ...	...	...			
†Water ...	...	...			
†Nurse ...	...	...			
†Reading Room ...		...			
†Powder ...	...	...			
†Band ...	...	...			
*Health Insurance		5d.			
*Unemployment ...		9d.			
*Levy ...	...	...			
Balance to Pay ...		...			
TOTAL ...		£			

	Tons					
Hewing ...		@				
,, ...		@				
,, ...		@				
Band ...		@				
Wet ...		@	½d.			
Ramble ...		@	½d.			
Juds ...		@				
Consideration ...			...			
Yard Work		@				
,, ...		@				
,, ...		@				
,, ...		@				
,, ...		@				
,, ...		@				
,, ...		@				
,, ...		@				
TOTAL ...			£			
Clay ...		...	...			
Minimum Compensation						
House Rent ...			...			
TOTAL ...			£			

* Weekly. † Fortnightly.

....

Colliery

No.	NAME.	AMOUNT.		

I authorise }
to receive above wages.

Signature of Receiver

INCOME TAX CARD.

COLLIERIES *No.*

Name *Occupation*

Address

1st Quarter, April to July 1922.					3rd Quarter, Oct. 1922 to Jan. 1923.				
Pay.	Gross Earnings.		Exp.*	P.P.†	Pay.	Gross Earnings.		Exp.	P.P.
7B					20B				
8A					21A				
8B					21B				
9A					22A				
9B					22B				
10A					23A				
10B					23B				
11A					24A				
11B					24B				
12A					25A				
12B					25B				
13A					26A				
13B					26B				
	£					£			

2nd Quarter, July to Oct. 1922.					4th Quarter, Jan. to April 1923.				
14A					1A				
14B					1B				
15A					2A				
15B					2B				
16A					3A				
16B					3B				
17A					4A				
17B					4B				
18A					5A				
18B					5B				
19A					6A				
19B					6B				
20A					7A				
	£					£			

Gross Earnings, Four Quarters, £ : :

* Explosive. † Pick-sharper.

PLATE XXc.

FORM O.

COLLIERY. WEEKLY COSTS, &c.

PAY WEEK *ending*..19......

Tons Drawn.	Days Pit Worked.	Number of Men and Boys Employed Underground.				No. of Colliers' Shifts off Work.	No. of Men and Boys Employed Aboveground.	Ponies Underground.		Props and Bars.		Ventilation.					
		Colliers.	Others.	Boys under 16.	Total			At Work.	Off Work.	Sent in.	Sent out.	Intake.	Return.	Water Gauge.	Barometer.	Thermometer	Revols. of Fan.

UNDERGROUND LABOUR.	£	s	D.	Cost per Ton.	ABOVEGROUND LABOUR.	£	s.	D.	Cost per Ton.
Coal-getting - - - - -					Banksmen - - - - - -				
Colliers' Bye-work - - - -					Screeners - - - - - -				
Strait Work - - - - - -					Enginemen - - - - - -				
Putters - - - - - - -					Firemen - - - - - -				
Bye-work - - - - - - -					Carpenters - - - - -				
Deputies - - - - - - -					Blacksmiths - - - - - -				
Waggon-way Men - - -					Sawyers - - - - - -				
Engine-plane Lads - - - -					Masons - - - - - - -				
Hauling Enginemen, Firemen, Pumps, &c.					Shunters - - - - - -				
Water Leading - - - - -					Slack Elevator - - - - - -				
Waste Work - - - - - -					Carters - - - - - - -				
Horsekeeper - - - - - -					Pony Drivers - - - - -				
Hanging-on - - - - - -					Platelayers - - - - - -				
Lamp-man - - - - - -					Labourers - - - - - -				
Putters' Bye-work - - - - -					Weighmen - - - - - -				
Engine-plane Extensions - - -					Clerks - - - - - - -				
Omissions - - - - - -					Gasmen - - - - - -				
					Enginewright - - - - -				
					Omissions - - - - - -				
Colliers' Average Earnings per Shift -									
No. of Tons got per Colliers' Shift Worked									
" " Prop or Bar Used -									
					Underground Labour - - -				
					Aboveground Labour - - -				
					Total Labour - - -				

[*To face page* 121.

FORM P.

	COLLIERY.			Cost per Ton.		Formerly.			Cost per Ton.		Total this Year.			Cost per Ton.		Cost per Ton last Year.		Cost corresponding Pay last Year.	
				Workings.	Saleable.				Workings.	Saleable.				Workings.	Saleable.	Workings.	Saleable.	Workings.	Saleable.
	£	s.	d.	s/d	s/d	£	s.	d	s/d	s/d	£	s.	d.	s/d	s/d	s/d	s/d	s/d	s/d
SEAM: Pit Bill ..																			
SEAM: Shift & Bargain																			
SEAM: Waste																			
SEAM: Shaft																			
SEAM: Screening ..																			
SEAM: Total ..																			
SEAM: New Work ..																			
SEAM: Total ..																			
SEAM: Corresponding Pay of last year																			
Enginemen ..																			
Enginewrights ..																			
Joiners, Sawyers, &c.																			
Waggonwrights ..																			
Joiners at Tubs .																			
Smiths .. .																			
Smiths at Tubs .																			
Masons, Surface																			
Do. Underground																			
Carting and Labouring																			
Branches & Falling																			
Coke Ovens ..																			
Stables & Granary																			
Nailor																			
Storehouse ..																			
Railway																			
Staiths																			
Brickmaking ..																			
Quarry																			
Gratuities and Pensions																			
Repairing Houses																			
Sundries																			
Salaries																			
New Houses ..																			
New Work ..																			
Total ..																			
Total Labour ..																			
Total Material ..																			
Total Labour and Material																			
Total in 19 Labour																			
Total in 19 Material																			
GRAND TOTAL in 19																			

CHAPTER VIII.

TOOLS AND APPLIANCES USED IN COAL-GETTING.

THE pick and the shovel are still the indispensable tools of the miner, as they have been for a good many hundred years.

Picks are now made of cast steel, and are lighter and more durable than the old iron ones. Coal-hewers' picks vary in weight from 1½ to 3½ lbs., the pick in most ordinary use being 2½ lbs. The lighter picks are used for "nicking," and for the farthest under part of the undercutting or kirving; the heavier picks for breaking down the top coal. A hewer has generally three or four picks with him during his shift. In a soft seam he will not blunt more than one, but in hard coal it may be three or four.* A good pick-sharpener is a valuable workman at a colliery. In Durham and Northumberland each hewer pays a fixed sum—usually 2d. or 3d. a fortnight (see Hewers' Pay Note)—to the pick-sharpener, and the owners of the colliery pay him a wage per shift besides.

Fig. 7 shows the ordinary form of coal-miner's pick and shaft. The shaft is fitted with a steel head, A, slightly tapered, and so made (as shown in the sketch) that it can be sprung out by driving a wooden wedge into the end of the shaft, and can be thus adjusted to fit slightly varying sizes of pick eyes. The pick is fastened tightly on to the shaft by striking the end of the shaft against the ground a few times, and is similarly loosened by striking the other end. Hickory is now generally used for shafts. It is more durable and heavier than ash. A pick shaft of the dimensions shown in Fig. 7 weighs 2½ lbs. Fig. 8 shows an ordinary coal-

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* The life of a pick is of course determined chiefly by the nature of the coal or other strata which it is used to hew. Coal containing lumps of iron pyrites, locally termed "brasses," is very detrimental to the duration of picks, and when hewing in such coal, a hewer will probably use several picks in the course of his shift. On an average taken over a large number (1,000) hewers, the addition of one pick and two pick shafts per annum were found to keep up the number required per hewer.

hewer's shovel, made of hammered steel from $\frac{1}{8}$ inch to $\frac{3}{16}$ inch thick. With its ash shaft it weighs 8 lbs. Besides his picks and shovel, a hewer's ordinary working gear includes a mall or hammer and a wedge, and where shot-firing is allowed, a drilling machine, or a set of hand drills, and a beater or stemmer, a scraper, and a pricker. Where safety fuses are used, or electric wires for shot-firing, a pricker is not required. Hand-drilling machines weighing about 50 lbs—such as that shown in Fig. 14

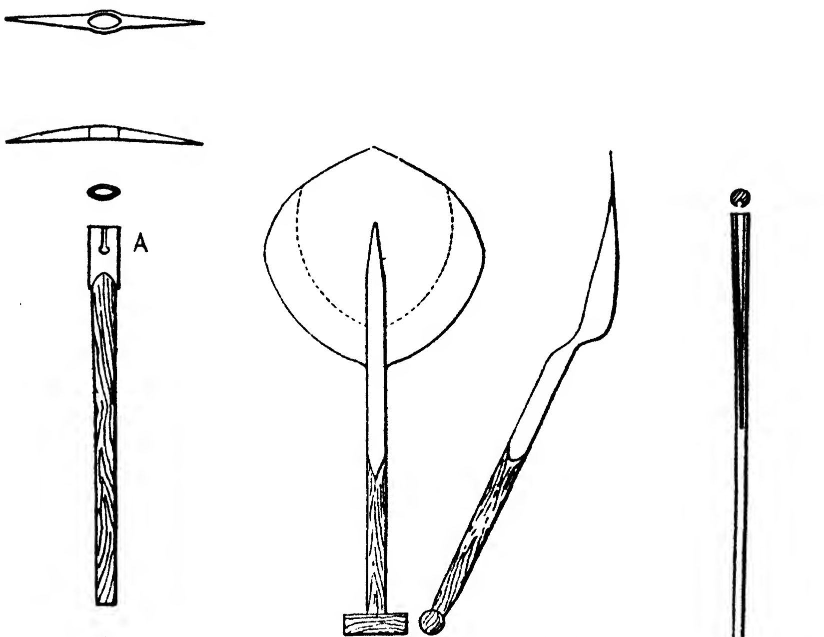

FIG. 7.—PICK AND SHAFT. FIG. 8.—HEWER'S COAL SHOVEL. FIG. 9.—STEMMER.

MINERS' TOOLS. Scale = One-sixteenth.

(see p. 125), and also in Plate VIII. (see p. 99)—may be purchased for £2 or thereabouts.

In Durham and Northumberland the hewers provide their own picks and drilling gear, and the owners supply the shovel, mall, and wedge, and also a wooden stool, or "cracket," for the hewer to sit upon when working. (In Plate VII., and also in Plate XXV., the hewer's pick, shovel, and cracket are visible.) The Explosives in Coal Mines Order, 1913, lays it down, as regards explosives below ground, that "in the process of charging or stemming for blasting, no iron or steel scraper, charger, tamping rod, or stemmer shall be taken into or used in the mine; and only clay or other non-inflammable substances shall be used for stemming." In accordance with this requirement, the necessary tools are usually made of an alloy of copper. In the illustrations, Fig. 9 shows a stemmer; Fig. 10 a scraper; and Fig. 11 a pricker. A mall made of 2-inch square iron with steel facings, weighing with its shaft $7\frac{1}{2}$ lbs., is shown in Fig. 12. An iron wedge for breaking down coal is shown in Fig. 13; its weight is 5 lbs.

A safe substitute for powder in breaking down coal and stone

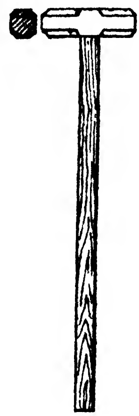

FIG. 12.—MALL.

FIG. 10.—SCRAPER FIG. 11.—PRICKER. FIG. 13.—WEDGE.

MINERS' TOOLS. Scale = One-sixteenth.

has long been a great want in coal mining. Many efforts have been made to supply it, by various mechanical contrivances, by the use of lime cartridges (steam, as the expansive or exploding force, being generated by the application of water to the lime), and more recently by the invention of explosive compounds of such a chemical composition that they generate little flame during combustion by detonation.

One of the earliest mechanical contrivances was the stub-and-feather, which consists of a steel wedge or "stub" driven in between two tapered pieces of steel termed "feathers," and placed in the drill hole, thick end foremost. Sometimes the feathers are simply curved pieces of steel with little or no taper. They are made curved in order that they may better fit into the bore-hole. The sizes of "stub-and-feather" wedges vary to suit circumstances, but a convenient length for wedging down coal is about 2 feet 6 inches.

Careful trials with the stub-and-feather in coal-getting were made at Elemore Colliery, Co. Durham, in 1877. These experiments proved that in pillar working and modified longwall in the Low Main seam—a seam of average hardness, 3 feet 6 inches in section—"juds" 5 to 6 yards in width, well kirved, could be brought down readily by the stub-and-feather when driven

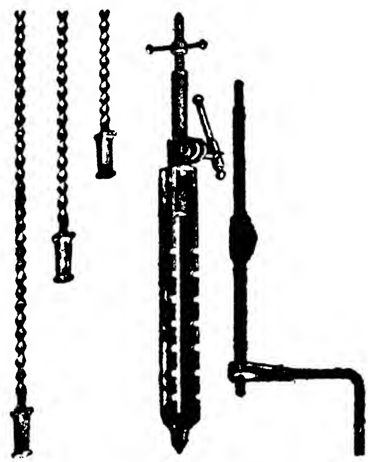

FIG. 14.—HAND-DRILLING MACHINE.

consecutively into three drill holes drilled at intervals across the face. Stone-drifts have been driven considerable distances by the aid of the stub-and-feather, where the risk of a gas explosion forbade the use of powder. For instance, at a colliery in County Durham, in the years 1881-82, a pair of stone-drifts were driven a distance of about 200 yards to win an area of coal, with the help of a MacDermott's drill and stub-and-feather wedge, no explosive being used. A series of holes 2 inches in diameter were first bored close together in a line across the face, at about one-third of the height from the bottom. The stone between the holes was then broken away by driving iron bars into the holes with malls, and a kirving was thus formed across the face. A couple of holes were then drilled, one in the right nook and the other in the left, at about two-thirds of the height from the floor, and the stone above the kirving broken down by driving the stub-and-feather into these holes. The area of drift was 5 feet by 4 feet, and it was driven at a bargain price of £3 a yard (= 1s. per cubic foot), all tools being provided by the employers. The rate of progress was very slow. Had powder been admissible, the work could have been done for, at most, one-fourth of this cost.

The stub-and-feather is rarely, if ever, used nowadays, but it embodies the elementary idea of several more recent mechanical contrivances for breaking down coal and stone. The same principle is carried a little further in the multiple-wedge of the Hardy Patent Pick Company, which admits of the insertion of a third wedge. In Jones and Bidder's machine, patented in 1868, a series of wedges (as required) were driven in between side pieces by a small hydraulic ram worked by a hand-pump.* In Burnett's roller-wedge, the friction is much reduced, and the efficiency correspondingly increased, by substituting rolling for sliding friction between the wedge and the side pieces. Mr Burnett also patented a new system of nicking, consisting of a series of drill holes, drilled in the coal at the side of the jud in a line deviating somewhat from the vertical. The Haswell mechanical coal-getter of Mr W. F. Hall has given good results in some seams.†

The hydraulic principle has been variously applied to the same end, as in the mining wedge introduced by Herr Walcher ‡ at some Austrian mines, and subsequently tried at Sandwell Park and other Staffordshire collieries; and in Mr W. S. Shreeve's patent hydraulic wedge, consisting of several hydraulic rams graduated in area, which was tried in the Wigan district. Hydraulic wedges involve, of course, the use of water and a hand-pump.

These several appliances, as well as others of a similar nature, all appear to have given more or less satisfactory results under certain circumstances, but no one of them has come into general application in any district, and their short-lived notoriety may be taken to signify that they have not fulfilled the requirements of practical work.

Machine Mining.—Coal-hewing is the department of coal-mining which has come most recently within the scope of

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* *N. of E. Min. Inst. Trans.*, vol. xix., p. 11. † *Ibid.*, vol. xxxiii.

‡ *Brit. Soc. Min. Stud.*, vol. x. Paper by H. W. Hughes.

mechanical aid, and it certainly presents great difficulties to the efficient operation of machines.

On the other hand, machine mining now offers wide opportunities for improved methods in the getting of coal and for increased production. As the late Inspector of Mines for the Northern Division remarked in a recent report :—

"The output per person is a clear indication that, unless some extraordinary change takes place in man power, mechanical aids to coal-getting will have to be more generally used if the other trades of the country which depend upon coal are to be carried on upon an economic basis."

Confined space, dirt and dust, dim light, violent and variable strains, and too often rough and ignorant handling, are conditions which test mechanical construction to the utmost.

For more than a century much persevering effort has been directed to the devising of mechanical means of relieving the strenuous labour of hand-hewing, and of thus reducing the cost of producing coal. So long ago as 1761 a machine for cutting coal was patented by Michael Menzies, an engineer of Newcastle-on-Tyne.

These early machines were driven by man or by horse power.* The introduction of compressed air about 1855, and of electricity as a motive power about 1884, are prominent landmarks in the path of progress.

But it is evidence of the many difficulties in the way that it is only within the last twenty years—the opening years of the twentieth century—that coal-getting by machines has been firmly established, and is making steady progress.

Much credit is due to the makers and users of these machines who have patiently garnered the fruits of experience, and by successive improvements have adapted them to the very trying conditions under which they have to work underground.

Supervision.—But the best machines are of little value without competent direction and control, and it is here that

* A horse-driven coal-cutter was used at the Waterloo Colliery, near Leeds, on a face 30 yards long. (See *M. and C. Machine Mining*, vol. i., p. 137.) In County Durham the familiar name for a coal-cutting machine was for a long time the "Iron Man."

The first patent for electrical coal-cutting was applied for in 1863, but seems to have been still-born. It was not till 1885 that an electrical coal-cutter—a bar machine with a 10 H.P. motor, patented by Messrs Bower & Blackburn —was used with some success in a colliery near Normanton (see Llewellyn B. Atkinson, *M. and C. Machine Mining*, vol. iii., p. 53).

present practice sometimes falls short of what is required to ensure successful results. The successful institution of machine mining at a colliery calls for the close and continued attention and forethought of the manager and his officials.

Three or four men (usually three) are required to go with each machine when at work. The selection of suitable men and their proper training are matters of the first importance. No one would set an untrained man to drive a winding engine or a locomotive, and to get good results with a coal-cutting machine the attendants must have training and experience. They should, in the first place, be good "pitmen," with experience at the coal face; and then well instructed in the mechanism and in the care and maintenance of the special machine of which they have charge, and trained to work together as a team, each man knowing his own particular work and doing it in unison with the others. It is generally best to select young men for special training. Some of the firms who make these machines offer facilities for the training of machine attendants.

A daily report of the performance of each machine should be kept, and a weekly cost sheet. The accompanying forms will serve as examples. This ensures attention to detail, and promotes adequate supervision.*

New arrangements of work and wages are required in the coal faces where the machines are to be used. All this needs careful consideration and supervision. The economical working of the machines is dependent on the getting and filling of the coal, and its rapid removal after it has been undercut. A cardinal factor in the economical operation of any machine is to keep it going at its full capacity.

The work should be arranged so that the face is undercut and the coal cleared away daily. The traffic must be regulated so that the output from each longwall face or district where machines are used is removed within the prescribed time. As a practical arrangement for achieving this object, the following instance deserves notice: "The night-shift fireman in every district counts every tub, both full and empty, and notes their positions. He then makes out a detailed account of them. This account he hands to the manager or under-manager in the morn-

* See *M. and C. Machine Mining*, vol. i., No. 3, p. 52, and No. 9, p. 193, and vol. ii., p. 203; see also "The Application of Costing to Coal-Cutting," by J. B. Mavor; *Proceedings National Association of Colliery Managers*, vol. xix., p. 180.

Coal-cutting Cost Sheet, Pence per Ton

Pay Ending.	Days Mine Worked.	Output. Tons.	Cutting.	Drilling and Raking-out.	Flitting Machines.	Laying Iron Pipes.	Total Labour.	Repairs Underground.	Repairs by Fitters.	Smith's and Pick Sharpening.	Total Repairs.	Explosives.	Lubricants.	Hose pipes.	Picks.	New Machine Parts.	Sundries.	Total Stores.	Total Cost.	Lineal Yards Cut, 5 ft. 9 in Deep.
Jan. 8	3	1,568½	1·53	1·16	·94	·13	3·76	·12	·25	·15	·52	·14	·18	—	—	—	·07	·39	4·67	579
,, 15	5	2,631½	1·61	·95	·07	·36	2·99	·02	·07	·19	·28	·10	·13	—	·22	—	·06	·51	3·78	964
,, 22	6	2,760½	1·43	·91	·50	·22	3·06	·09	·20	·13	·42	·16	·11	1·04	—	—	·16	1·47	4·95	1,017
,, 29	5	2,219	1·84	1·00	·08	·35	3·27	·02	—	·19	·21	·13	·15	—	·25	·34	·10	·97	4·45	908
Feb. 5	6	2,573	1·80	·89	·41	·21	3·31	·28	·23	·07	·58	·10	·11	—	·25	—	·11	·57	4·46	744
,, 12	5	2,090½	2·11	1·20	·61	·12	4·04	—	·10	·11	·21	·11	·11	—	—	—	·09	·31	4·58	952
,, 19	5	2,360½	1·79	·89	·39	·33	3·40	·08	·02	·19	·29	·16	·18	—	—	—	—	·34	4·03	874
,, 26	5	2,346½	1·86	·90	·23	·38	3·37	·06	·04	·13	·23	·13	·15	—	·24	—	·04	·56	3·96	947
Mar. 5	5	2,037	1·93	1·05	·52	·29	3·79	·04	·05	·18	·28	·12	·14	—	·24	—	·17	·67	4·74	908
,, 12	4	2,159	1·68	1·05	·52	·16	2·89	·11	·23	·18	·52	·12	·14	—	—	—	·14	·40	3·81	977
,, 19	4	1,754	1·89	1·19	·15	·23	3·46	·10	·23	·22	·55	·13	·18	·81	·36	·06	·10	1·66	5·67	706
,, 26	5	2,295½	1·53	·96	·70	·09	3·28	·12	·11	·20	·43	·17	·16	—	—	—	·06	·39	4·10	906
Apl. 2	4	2,123	2·01	1·13	·51	·20	3·85	·04	·09	·15	·28	·15	·15	—	·28	—	·06	·64	4·77	870

Annual Summary

Year																				
1910	206	98,708	1·79	1·26	·26	·24	3·55	·05	·14	·16	·35	·16	·13	·20	·15	·10	·16	·90	4·80	40,289
1911	229	112,921	1·55	1·06	·34	·28	3·23	·11	·18	·15	·44	·17	·15	·23	·14	·19	·12	1·00	4 67	45,308
1912	233	128,245	1·86	1·04	·39	·23	3 42	·14	·18	·16	·48	·18	14	·18	14	·23	·16	1·03	5·03	53,990

The above is a Reproduction of portion of a Cost Sheet compiled week by week, and a Summary of the results of each of three consecutive years' working.

ing. In these notes the manager has a complete record of every tub in the pit, empty or full, also their position—whether on the main haulage, auxiliary haulage, or at the conveyors. With this information he is able to direct and control the traffic, to prevent irregularities, and ensure an even distribution taking place." *

The rapid removal of the coal when filled may be much assisted in some cases by mechanical haulage carried right up to the face.

Advantages.—The desire to reduce the cost of coal-getting is, as a rule, the prevailing motive of a colliery manager in adopting coal-cutting machines, and their success is usually measured by the relative saving effected in comparison with hand-hewing. And no doubt this is a fair general test of their value. This saving is likely to be larger as the cost of labour is higher. In the U.S.A. very few machines are used in States where cheap negro labour is available, but, as every one knows, they are largely used in other States where the cost of labour is high.

But it should not be overlooked that there are other advantages than reduced cost of coal-getting, no less real, though they cannot be accurately expressed in figures.

Machine mining organised on a sufficient scale, and properly carried out, admits of (1) concentration of the workings or "Intensive Mining," as it is sometimes called ; a larger output from a given area ; fewer and shorter roads ; saving in "stone" work ; saving in rails and sleepers ; shorter haulage ; simpler ventilation ; facilitated supervision.

Of the improvement in ventilation which may be effected, the following remark, which occurs in an annual report of the Inspector of Mines of the Northern Division, the late Mr J. R. R. Wilson, may be cited as independent evidence :—

"Where it has been found expedient to adopt rotary coal-cutting machines or conveyors upon longwall faces, and therefore maintain a more or less straight line of face as opposed to the common form of stepped face, the ventilation has been much improved."

(2) A fuller control of the working faces in straightness of face, and regularity of advance, and in systematic timbering, tending to greater safety. It has been proved in some cases that the back timber can be more easily recovered from the goaves,

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* See Mr W. Carson, Newbattle collieries, N.B., *Proceedings National Association Colliery Managers*, vol. xvii. (1920), p. 246.

and that the cost of "stone packs" can be reduced, the falls of "top stone" being more regularly controlled than with hand-hewing, and that a saving in the cost of timber can be effected.

Mr Dyer Lewis, Inspector of the South Wales Division, in one of his annual reports, bears evidence to the improved conditions of roof control. "Machine mining makes for regular and straight lines of faces, and a more regular and efficient system of supporting the roofs and packing the gobs."

It is worthy of note that in Scotland, where a larger proportion of the output is got by machines than in any other district, the injuries from falls in the coal face per 1,000 workers underground are fewer than in any other district.

A coal seam should be worked so as to prevent any falls of roof in the working faces, and so as to utilise the pressure of the strata in the getting of the coal.

The variable factors in effecting these objects are:—

1. The building of paçk-walls and the stowing of the goaf behind the face.
2. The timbering of the face.
3. The direction in which the face is advancing in relation to the planes of cleavage in the coal seam and in the roof stone, and in relation to the rise and dip of the seam.
4. The depth of the holing.
5. The speed at which the face is moved forward.
6. The straightness of the face.*

The three last conditions can be altered and determined much more fully and exactly with the aid of machines than with hand-holing. This is one of the main advantages of the employment of mechanical coal-cutters, that they admit of a wider variation of these conditions, and of a more regular and exact system of working.

(3) With a deep undercut the coal can be got in some seams with little or no shot-firing, thus saving the cost of and the danger from explosives.

(4) The cut may be made next to or in the roof, or next to and in the floor, or in a "Band," as best suits the structure of the seam and the nature of the roof and floor. More "large" coal

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* Sometimes better control of the roof, and prevention of falls in the face, may be gained by keeping the line of the advancing face on a concave curve of large radius. Generally, however, a straight face is best.

Table showing Number of Coal-Cutting Machines and Face Conveyors in Use and the Coal got by them.

Year.	Number of Collieries where Machines are at Work.	Output per Machine.	Tons per Total Persons Employed Under-ground.	Number of Machines.	Worked by		*Mineral Obtained.	Total Output Coal.	Percentage of Total Output.	Number of Conveyors at Coal Face.
					Electricity.	Compressed Air.				
							Tons.	Tons.		
1902	166	8,615	278	483	149	334	4,161,202	227,095,042	1.8	...
1906	333	8,981	287	1,136	451	685	10,202,506	251,067,628	4.0	...
1907	390	8,625	287	1,493	643	850	12,877,244	267,830,962	4.8	100
1910	432	8,079	254	1,959	873	1,086	15,878,000	264,417,000	6.0	274
1911	471	8,693	257	2,146	997	1,149	18,667,000	271,878,000	6.8	326
1912	626	8,293	242	2,444	1,134	1,310	20,270,000	260,398,000	7.7	268
1913	676	8,494	259	2,897	1,307	1,590	24,609,958	287,411,000	8.5	377
1914	652	7,848	234	3,093	1,415	1,678	24,274,517	265,643,000	9.1	408
1915	638	7,934	265	3,089	1,449	1,640	24,510,124	253,206,081	9.6	424
1916	660	7,749	257	3,459	1,590	1,869	26,805,398	256,375,366	10.4	491
1917	678	7,422	243	3,799	1,739	2,060	28,196,486	248,473,119	11.3	603
1918	695	6,897	226	4,041	1,797	2,244	27,873,646	227,714,579	12.2	613
1919	729	6,265	193	4,482	1,950	2,532	28,081,017	229,743,128	12.2	712
1920	760	6,060	184	5,073	2,154	2,919	30,746,274	229,295,000	12.8	823
1921	776	4,413	179	5,259	2,257	3,002	23,207,924	163,251,181	14.2	818
1922	785	7,015	217	5,434	2,395	3,039	38,124,122	249,606,864	15.2	928

* Includes fireclay, ironstone, oil shale, and ganister.

N.B.—The figures for 1921 show both the increased number of machines in use, and also the heavy fall in output due to the combined effect of the three months' stoppage and the Seven Hours Act.

can be got, and in a cleaner condition. If large coal is reiqured from thin, hard seams, it is almost essential to use machines. In thick seams, too, where the cost of machine mining may be as high as or even higher than that of hand-hewing, the increased proportion of "large" coal obtained by the use of machines proves their worth.

Progress during Recent Years.—A valuable and exhaustive report upon mechanical coal-cutting was published by the North of England Institute of Mining and Mechanical Engineers in 1905. In the opening sentence of that report it is stated that "Mechanical coal-cutting in this country is as yet only emerging from the experimental stage. This is indicated by the fact that most of the machines now in use have been started within the last two or three years."

The steady increase in the number of machines, and in the number of collieries using them, which has been made since that date, in spite of the great upheaval of the war, is shown in the accompanying table (p. 131).

The numbers of different kinds of machines in use are given in the following Tables:—

TABLE SHOWING THE NUMBER OF DIFFERENT TYPES OF MACHINE AND THE COAL CUT BY THEM IN 1920 AND IN 1922.*

	Disc.	Bar.	Chain	Percussive.	Rotary Heading.	Total.
Number of machines	1,213	795	1,479	1,946	1	5,434 (1922)
	1,254	964	1,2·4	1,882	29	5,075
Tons cut (coal only)	12,408,615	6,811,173	14,125,689	4,788,525	120	38,124,122 (1922)
	11,092,063	5,022,606	10,086,229	3,972,343	20,965	30,194,206
Tons cut per machine	10,229	7,237	8,308	2,461	723	5,951
	8,845	8,567	9,551	2,110	120	7,015 (1922)

PROPORTIONATE NUMBER OF DIFFERENT TYPES OF MACHINE EXPRESSED IN PERCENTAGE.

	Disc.	Bar.	Chain.	Percussive.	Rotary Heading.	Per Cent.
	Per Cent.	Per Cent	Per Cent.	Per Cent.	Per Cent.	
1902	82	5	2	6	5	100
1913	42	19	8	30	1	100
1920	25	14	24	37	...	100
1922	22	15	27	36	...	100

* Since these Tables were in print the figures for 1922 have been published and added. They show substantial progress in the output per machine, and also the increasing use of the chain type of machine.

In 1920, 760 collieries, or more than one-quarter of the total number of collieries at work that year, were using machines. More than ten times as many machines were in use in 1920 as in 1902, and the percentage of the total output cut by machines had increased from 1.8 to 12.8 per cent. Scotland is leading the way in machine mining. Of the 2,154 electrically-driven machines that were at work in 1920, more than half—or 1,149—were in Scotland.

Taking the whole country, compressed air machines are in a considerable majority over the electrically driven. This is due to the number of percussive machines, and to the lack of a satisfactory machine of that type driven by electricity.

It is disappointing to note that during recent years, since 1913, there has been a steady fall, year by year, in the output per machine.

In 1920 there were 2,176 more coal-cutting machines at work than in 1913, but the output per machine was less by 2,434 tons. Per person employed in the whole industry there was also a drop in the total output during the same period, from 259 to 184 tons.*

The Seven Hours Act, which came into force on 14th July 1919, has caused loss of output and increase of cost.

At a colliery in Northumberland, where machine mining is carried out on a large scale, the result of this Act was a fall in output from 13.73 to 9.91 tons per filler per shift, and an increase of cost of 1s. 1d. per ton.†

But with regard to the production per machine it is necessary to take into account also the different types of machine. The tons cut by a disc or by a chain machine average more than four times as many as by a percussive machine. In 1920 there were at work 1,882 percussive machines, forming 37 per cent. of the total; 1,254 disc—25 per cent.; 1,214 chain—24 per cent.; 694 bar—14 per cent.; and 29 rotary headers.

The percussive machines formed 37 per cent. of the total number, but they yielded only 13 per cent. of the total output cut by machines.

Evidently, as the number of percussive machines, which yield the lowest output, increases in proportion to the number of the other types—the disc, the chain, and the bar—which yield a much larger output, the average output per machine over the whole will be less.

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* In 1922 the total output per person employed had risen to 217 tons.

† See *Trans. Inst. Mining Eng.*, vol. lxii., p. 266, Mr Richard Summerbell.

Taking the period 1913-20, the number of percussive machines increased from 30 to 37 per cent. of the total number of machines. But this comparatively small increase certainly cannot account for the whole of the tremendous drop of 2,434 tons in the output per machine during this seven years. It is probably due partly to the increased number of thin and hard coal seams that are being worked; partly to legislation, *e.g.*, the Minimum Wage Act and the Seven Hours Act; and partly to the very high wages that prevailed during the years 1916 to 1921.

In considering the different types of machine, the outstanding fact is the rapid rise of the chain type.

In 1902 there were only ten of these machines in use; in 1913 the number was 250; in 1920 it had grown to 1,214; and in 1922 to 1,479.

Each type of machine has its special sphere of usefulness in the varying conditions of underground work.

In 1902 the disc formed 82 per cent. of all the machines in use; it was soon followed by the chain.

Chain.—The first chain machines were not strong enough, but the difficulties of construction have now been overcome, and its rapid rise proves that it is giving good results in practical work.

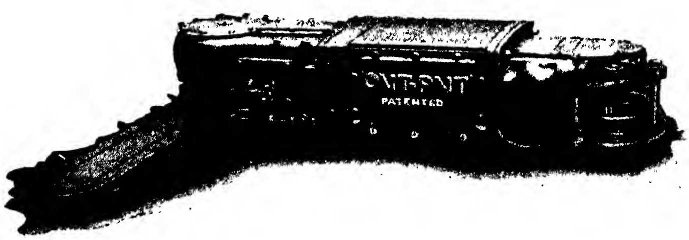

FIG. 15.

On the face of it an endless chain is a handier and lighter and simpler vehicle for carrying the cutters than a disc or a bar. In the chain machine the only moving parts which are exposed to falling material are the cutters, and as the "jib" or "banjo" carrying the chain is only about 2 feet in width, the overhanging roof can be supported by the insertion of "sprags" within this near distance of the solid coal. Thus the chain machine is well adapted to working under a weak roof (see Fig. 15).

It brings out the "debris" from the line of cut well, and thus saves the labour of clearing out this material with a shovel, and

PLATE XXII.

Messrs Clarke & Steavenson's Coal-Cutter at Lidgett Colliery, near Barnsley, in process of "Flitting."

This was the first disc coal-cutter adapted to be driven by electrical power.

[*To face page* 134.

Fig. 16.—Diamond Disc Machine.

also saves the waste of power due to the "churning" of this material when left in the cutting.

For work under a weak roof and in tender coal the chain machine stands first. The "banjo" can be slewed round horizontally through an arc of 180°, either by hand or by the power of the machine. Thus it cuts itself into the coal face under its own power. Gear wheels are adapted for two haulage speeds, a faster one for "flitting," *i.e.*, moving the machine from one working place to another along the roads of the mine, and a slower for cutting into and along a coal face. For hauling it along the face a very strong short-link chain is now provided in place of the rope which was used formerly.

Disc.—For exerting power at the cutters there is no better mechanical contrivance than a circular disc carrying the cutters at its circumference. Longer and stronger cutters can be used than with a chain or a bar. For cutting in hard material, at an even level, to a depth of not more than about 4 feet 6 inches and under a strong roof, the disc machine has no equal (see Fig. 16).

Under a weak roof falls are liable to "chock" the rotating disc and injure the machine, and supports for the roof cannot be inserted within the space occupied by the diameter of the disc.

A disc machine cannot cut itself into the face, and it is necessary to provide "rooms" or "stables" in advance at each end of the face.

Bar.—In the bar machine the cutting action is different from that of the disc and the chain (see Fig. 17).

FIG. 17.—BAR MACHINE.

The cutting teeth on the rotating bar move spirally across the line of cut, not in a horizontal plane, as with the disc and chain, and the speed of the teeth is much faster. There is a tendency to grind up or "churn" the cuttings, and the cutting action is less powerful than that of the disc and the chain. The bar is tapered down towards the point, and makes a thicker cut, and removes more material than the other two. This is sometimes an advantage in cutting out a "band" of "dirt." A bar cannot be jammed by falling material, as happens sometimes to a disc or chain, and the bar machine is free from this liability to shocks and strains. The setting of the cutters is simpler; the bar is easily swung in or out of the cut; it is better kept at one level, the tendency to rise or fall being corrected by means of screws; it cuts in either direction; no "stables" are required; it cuts itself into the face and completes the cut right to the end of the face; "sprags" can be inserted close to the line of cut for support of the overhanging roof; it is the most suitable machine for overcutting and for deep cutting. A depth of 9 feet has been undercut by it. It is the most versatile machine, having given good results under a great variety of working conditions.

Some instances may be mentioned. It has been used in a seam only 14 inches thick, where "the machine man pressed his feet against the machine and allowed it to push him along whilst lying almost on his back." Again, in heavy gradients of 30° to 60°, cutting up and down a longwall face. These heavy gradients have the good property that the fallen coal is rapidly cleared by sliding down the floor to the trams standing on the level; the holings from the cut clear themselves; shovelling is saved; output is increased; fewer gateways are required, and the coal is got at a lower cost. Chain machines are used also on these steep gradients.

The bar machine has been used for undercutting to a depth of 4 feet in fallen goaf, containing props and chocks, underlying a seam of coal. The props were sawn through, and when chocks were encountered the machine was raised a little to cut partly in the coal above. This can be done readily with the aid of the elevating jack screws with which this machine is fitted.

Where a seam is much cut up by small faults, the bar has special advantages in comparison with a disc or chain.

Bar machines driven by three-phase electrical current are now made, which stand only 13⅜ inches high, are 6 feet 8 inches long, and weigh 25 cwt.

Recent Improvements.—Valuable improvements have been made within recent years in the construction of coal-cutting machines, not the least being the standardisation of the various parts, so that these parts are readily interchangeable. Machines are now available with which either a bar or a chain may be used, as best suited to varying conditions underground. Again, an electric motor may be interchanged for an air turbine. The reciprocating air cylinders of former years are now giving place to the more compact and efficient turbine. The motors, whether three-phase electric, or direct-current electric, or air turbine, occupy the same position and the same space in the machine, and are interchangeable.

Work in Headings.—Another useful development is the application of bar and chain machines to work in narrow headings. This was considered previously to be almost a monopoly of percussive machines (with the exception of some American headers). Owing to their lighter weight, their portability, and the fact that they occupy less room, the percussive machines certainly have the advantage in "flitting" from place to place and for work in heavily timbered places. They are also simpler in construction and lower in first cost. On the other hand, they are costly consumers of power, and give relatively poor results in output.

By shortening its length by 2 to 3 feet, mounting it permanently on its own sledge,* and re-designing the haulage gear to give a speed for "flitting" of 50 feet per minute under its own power, Messrs Mavor & Coulson Ltd. were the first to adapt the bar machine to use in narrow headings.

It is claimed that one of these bar headers cutting to a depth of 6 feet, and attended by two men and a lad, will give an output equal to four percussive headers attended each by one man and a lad, or four men and four lads in all. With the latter, too, there are the drawbacks that the cuttings need to be raked out, and a supporting column has to be set up and fixed between roof and floor. The bar and chain machines may now be used from the start at the shaft bottom in forming the shaft pillars, and afterwards in the longwall faces. In bord-and-pillar working also they are employed with advantage both in narrow work and in pillar working.

The following example shows what can be done in headings in a normal shift with a bar machine driven by three-phase electricity carrying a 6-foot cutter bar:—

The seam is 2 feet 11 inches thick with a "rock" roof and "seggar" floor, worked on the "bord-and-pillar" method, at a colliery in the North of England (see Fig. 18).

Three men are attached to the machine, who all have been trained at the colliery, and have worked together as a team for three months. The width of the headings is 18 feet.

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* Messrs Mavor & Coulson make also a flitting truck for their "Universal" machine, which has been carefully designed to save time and trouble in the arduous operation of flitting.

PARTICULARS.

Length of shift, 6 hours 50 minutes.	Travelling time, 1 hour 10 minutes.	Time at face, 5 hours 40 minutes.
Preparing to start, 20 minutes.	Meal time, 20 minutes.	Changing picks, 20 minutes.
Number of places cut, seven	Average width of places, 18 feet.	Average depth of cut, 5 feet 9 inches.
Total cutting time, 1 hour 51 minutes.	Average cutting time per place, 16 minutes.	Area undercut 720 square feet.
Total flitting time, 2 hours 49 minutes.	Average distance flitted, 41 yards.	Average time per flit, 24 minutes.
Average time per place, cutting and flitting only, 40 minutes.	Average time per place, all in 49 minutes.	Total distance flitted, 288 yards.

These seven headings yield an average output of 8 tons per filler per shift. In a shift of 6 hours 50 minutes an area of 720 square feet is undercut in seven places, involving the flitting of the machine over a distance of 288 yards in a 3-foot seam. A flitting truck was not found necessary in this instance. (See *M. and C. Machine Mining*, vol. i., p. 130.) *

* As showing similar work done by a percussive machine, the following record performance by the "Hardiax" coal-cutter is instructive :—

The following is a report of the cutting by a "Hardiax" coal-cutter on 15th April 1923, at a Durham colliery, which has been communicated to us by the Hardy Patent Pick Co. Ltd.

The operator descended at 11.15 P.M. and ascended at 5.15 A.M., making a shift of six hours from bank to bank.

The schedule of work was then :—

Commenced cutting bord No. 1, 11.30 P.M., finished 12 P.M.; width, 12 feet; depth cu 5 feet; cutting time, 25 minutes.

Commenced cutting bord No. 2, 12.10 P.M.; finished 12.40 P.M.; width, 12 feet; depth cut, 5 feet; cutting time, 25 minutes.

Commenced cutting bord No. 3, 12.50 P.M.; finished, 1.20 P.M.; width 12 feet; depth cut, 5 feet; cutting time, 25 minutes.

Commenced cutting bord No. 4, 1.30 A.M.; finished, 2 A.M.; width, 12 feet; depth cut, 5 feet; cutting time, 25 minutes.

Commenced cutting bord No. 5, 2.10 A.M.; finished, 2.35 A.M.; width, 12 feet; depth cut, 5 feet; cutting time, 20 minutes.

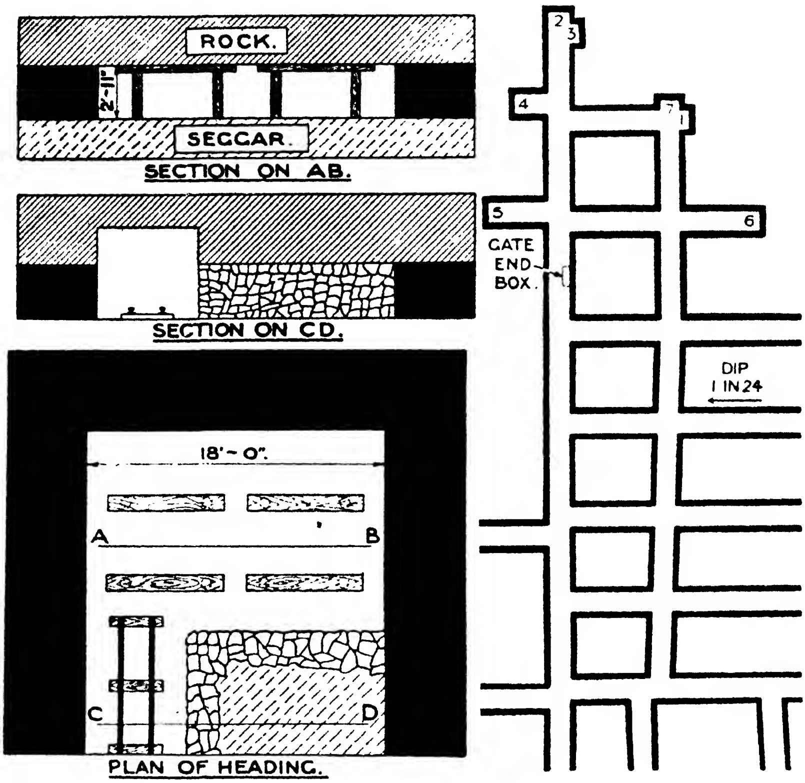


FIG. 18.—THE NUMBERS SHOW THE ORDER IN WHICH THE PLACES WERE CUT, SO AS TO MINIMISE THE FLITTING DISTANCES.

Commenced cutting bord No. 6, 2.45 A.M.; finished, 3.20 A.M.; width, 12 feet; depth cut, 4 feet 6 inches; cutting time, 30 minutes.

Commenced cutting bord No. 7, 3.30 A.M.; finished, 4.15 A.M.; width, 15 feet; depth cut, 5 feet; cutting time, 35 minutes.

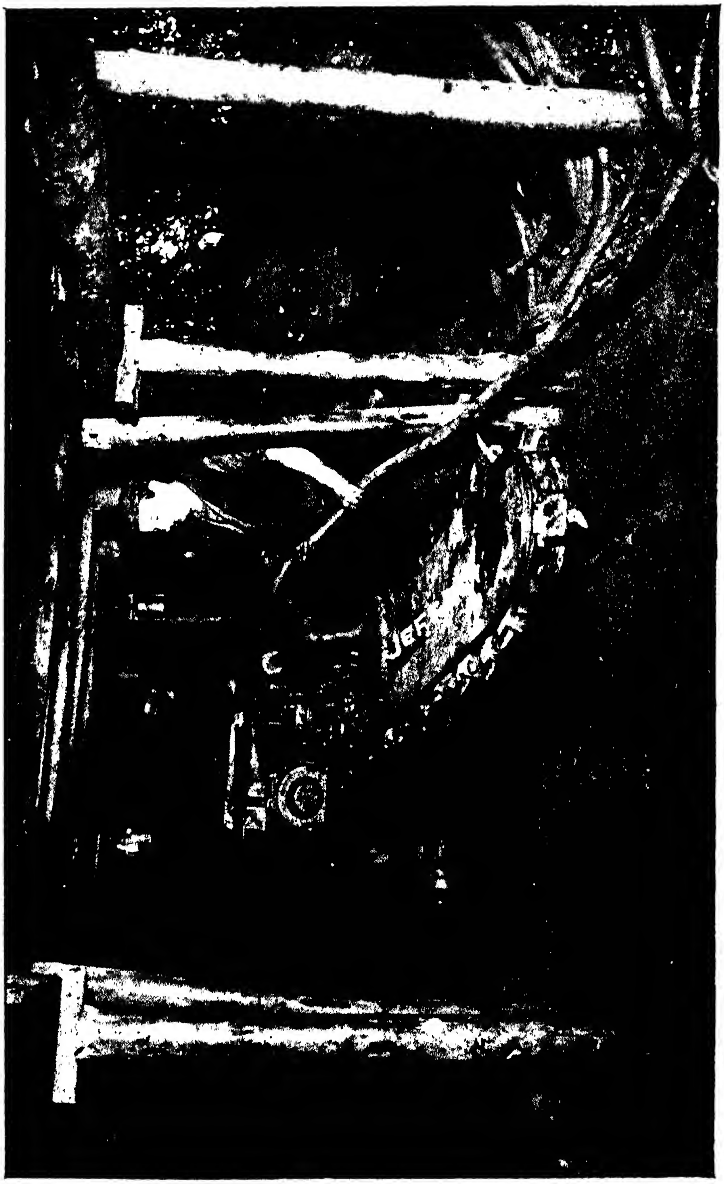
Commenced cutting bord No. 8, 4.25 A.M.; finished, 5 A.M.; width, 14 feet; depth cut, 5 feet; cutting time, 30 minutes.

Analysing the foregoing, the following may be deduced:—

Average cutting speed over full six-hour shift, bank to bank, 83 square feet per hour; average cutting speed in all eight places, 139 square feet per hour; maximum cutting speed (12 feet by 5 feet in 20 minutes), 180 square feet per hour; total, eight bords containing 499 square feet in 6 hours, bank to bank.

The distance between the pillars, as shown in the plan, was 44 yards. Places Nos. 1 to 7 were cut with one machine in one district, and place No. 8 is in a separate district, and was cut with another machine after place No. 7 had been cut.

The holing was done in a dirt band 6 inches thick in the middle of a seam, the upper portion of which was 26 inches thick and the lower 24 inches thick.



Photograph taken at *Seghill Colliery, Northumberland, 12th December 1923.*

A Combination Longwall-Arcwall Coal-Cutter flitting from one leading to another under its own powers.

[*To face page* 141.

Wide Headings.—In thin seams exploration work, or the winning-out of the seam, may be effected most economically by wide headings, or semi-longwall—*i.e.*, places of a sufficient width to allow of the making of two or three permanent parallel roads. With the aid of a machine the cost of driving these wide headings and making the roads may be covered by the value of the coal obtained from them. With hand-hewing this is impracticable,

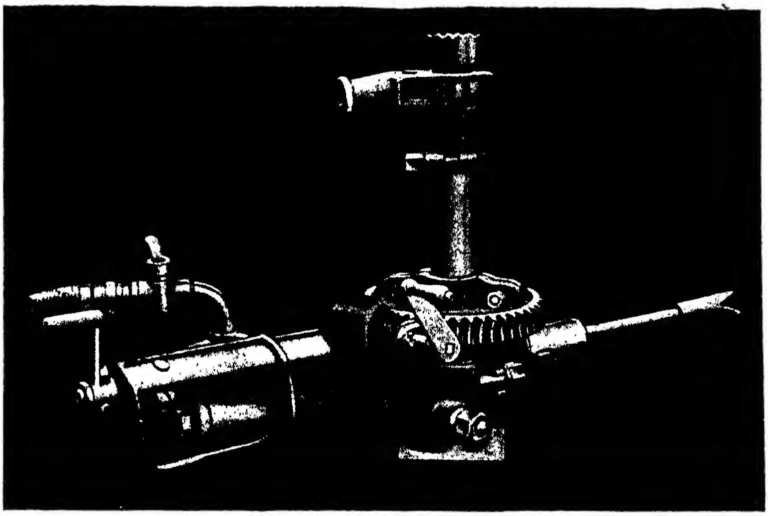


FIG. 19.—THE "HARDIAX" PERCUSSIVE COAL-CUTTING MACHINE.

the output being so much smaller and progress so much slower.*

Jeffrey Arcwall Machine. — For combined applicability to undercutting narrow places and longwall faces the Jeffrey Arcwall machine deserves attention (see Plate XXIII.). It is a

* In *M. and C. Machine Mining* for November 1922 an instance is recorded of linking together two adjacent collieries by wide winnings driven by machine in a hard coal seam about 2 feet thick with water raining down from the roof all the way. The distance between the shafts was 732 yards. Winnings 40 yards wide were driven from each shaft, and connection was made in about a year. The machines used were electrically-driven Universal bar machines. They undercut to a depth of about 4 feet in fireclay below the seam.

"The average output per man was approximately 2½ tons. The percentage of large coal was 65 per cent., and the output in quantity and quality amply covered the total cost of the winning."

recent development of the Jeffrey header, which was fully described in the earliest edition of this book (published in 1896). As now constructed it is a chain machine, adapted for use both in narrow headings, from 6 to 15 feet in width, and in longwall faces. For narrow work it is mounted on a wheeled tram to run on rails, and is moved from place to place by its own mechanism, like a locomotive. Substantial rails, well laid, are required.

When needed for longwall work, the tram and the haulage gear for "flitting" are taken off the machine. It is adapted to cut in the floor or in the roof, or at any level in the seam. It is widely used in British collieries in seams ranging in thickness from 2 feet upwards, and on gradients up to 1 in 6.

At a colliery in Co. Durham, one of these machines in charge of the colliery workmen recently cut twenty headings, each 15 feet wide, to a depth of 5 to 6 feet, and flitted a distance of over 900 yards in five and a half hours, the men's time from bank to bank being seven hours.

Cutters.—It is well to remember that it is at the cutters that the power of all these machines is rendered effective, and if any of the cutters are blunt or short or misshapen, the useful performance will be handicapped in proportion to these defects. The time spent in changing defective cutters is not wasted.

The resharpening and setting up of these cutter bits is no easy matter for a colliery blacksmith. A machine for this purpose and for making new "bits" has been put on the market by the Sullivan Machinery Co. (see Fig. 20).*

It is claimed that with it as many as six to sixteen picks or "bits" can be resharpened per minute, and four to eight new picks made per minute, and it turns them out exactly uniform in length and point and shape. A machine of this type will soon repay its first cost in reduced cost of power and of repairs at the cutting machines and in increased output of coal.

With percussive machines no less than with longwall machines it is vastly important to keep the cutter bits of the right shape and length. The penetration of a well-formed bit into coal at each blow of a percussive machine will be two or three times as far as the penetration of a blunt or badly formed bit, and the speed of cutting and the useful result will be in proportion. And also

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* See *Colliery Guardian*, 10th February 1922.

with a badly formed bit each blow causes greater shock and strain on the machine.*

The Hardy Patent Pick Co. Ltd. supply a machine (known as the "Bizzibob") especially designed for making new bits and for sharpening blunt bits for percussive machines and hammer drills.†

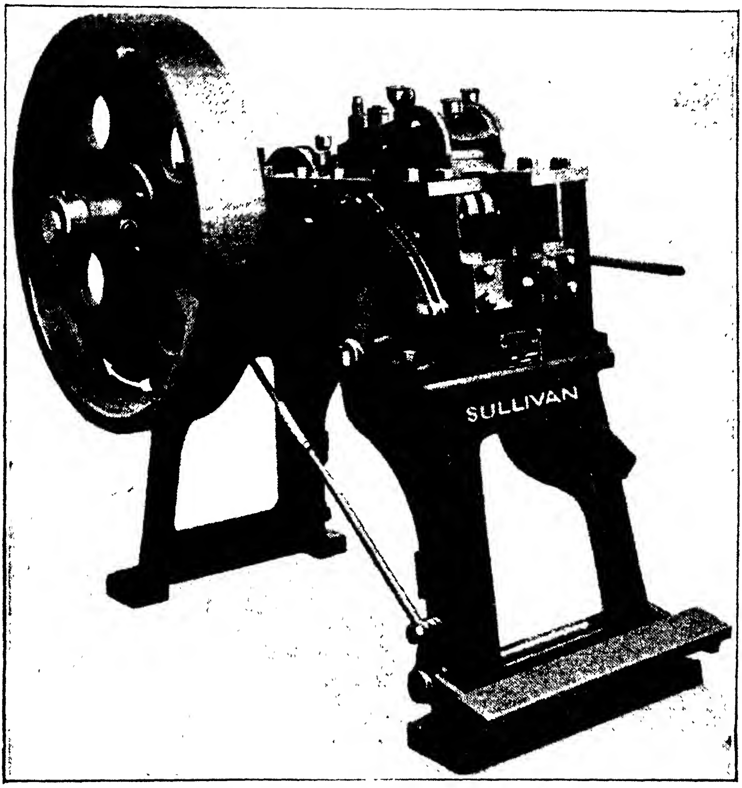

FIG. 20.—SULLIVAN CUTTER-BIT SHARPENER.

Some Points Worth Noting.—In order to achieve good results in machine mining it is essential to keep the cutter bits in good order.

Neglect to change the picks sufficiently often; neglect to clean out the cuttings; forcing the pace unduly beyond the capacity

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* See Mr J. Drinnan, Discussion "Coal-Cutting Limitations," Institute Mining Engineers, February 1922, vol. lxiii., p. 88.

† See *Iron and Coal Trades' Review*, 10th November 1922.

of the machine ; neglect to oil the machine properly ; and to keep dirt out of the bearings ; these are some of the mistakes which lead to failure and damage.

The work entails very heavy mechanical vibration on the machines, and they need frequent overhaul and adequate maintenance in order to give good results. " A stitch in time saves nine."

It is a good practice to thoroughly examine underground each machine every week, and to completely overhaul them on the surface every six months.

Another important matter is the organisation of a proper system of regular supply of the materials daily required for the machines, *e.g.*, oil and cutter picks, so that there may be no delay in getting them when required.

The machinemen should be provided with a suitable chest where they can keep all the tools and accessories which they require.*

Power.—With regard to the motive power, the cost of compressed air is on an average about three times as much as the cost of electricity.

But compressed air is safe in gassy seams, and is a valuable aid to the ventilation, especially in narrow headings. An adequate supply of air meters and pressure gauges to allow of an accurate record of the quantity and pressure of air used, is necessary for its economical operation.

The following figures may serve to give some idea of the consumption of air by coal-cutting machines and how much it varies.† The tests were made on four machines, three of the chain type and one bar, two of them fitted with reciprocating engines and two with turbines, all in the same seam.

The method of testing was to run each machine over a measured distance of 10 yards, the consumption of air (measured by a " Sentinel " meter valve), and the pressure and the temperature being taken at each yard cut, and averaged over the whole. The air was compressed at the surface to a pressure of 60 lbs. per

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* For drawings of such a chest, see *M. and C. Machine Mining*, vol. i., No. 11, June 1922.

† See *Proceedings National Association of Colliery Managers*, vol. xvii. (1920), p. 310, S. Barber.

square inch, and the machines were approximately 1 mile distant from the pit bottom. The air pressure at the machines varied during the tests from a minimum of 41 lbs. to a maximum of 53 lbs. per square inch, the average of ten tests being 49 lbs. The consumption of free air per square yard cut ranged from 566 to 3,679 cubic feet. The former result was got with a turbine-driven machine, which was new six months previously, and the latter with a machine driven by a reciprocating engine, having four 8-inch cylinders. The average consumption of the ten tests was 1,629 cubic feet per square yard cut.

These figures indicate the wide scope there is for economy in the consumption of power of air-driven machines.*

Taking the value of the compressed air at 2d. per 1,000 cubic feet of free air, the cost of it per square yard cut ranged from 1.13d. to 7.35d., the average being 3.25d.

Of the 5,073 machines which were in use in the year 1920, more than half (57 per cent.) of them were driven by air. But the electrically-driven machines, which formed 43 per cent. of the total number in use, accounted for more than half (59 per cent.) of the total coal cut.

A large majority of the disc, bar, and chain machines, which yield the largest output, are driven by electricity.

With direct current the usual tension runs from 500 to 550 volts, and with alternating current 440 to 650 volts and 50 cycles.

An adequate supply of power is essential to efficiency, and this remark is especially applicable when compressed air is the power.

Many efforts have been made, and are being made, to produce a satisfactory machine of light weight, driven by electricity, to do the same work as the compressed air percussive machines.

The Hardy-Bedford Electric Heading Machine.—Recently there have been good reports of such a machine, made by the Hardy Patent Pick Co. Ltd., known as the "Hardy-Bedford" (see Fig. 21). It has been in practical use for over

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* The following figures of air consumption have been published more recently (see *National Association of Colliery Managers, North Staffordshire Branch*, 12th March 1923, Mr H. Mason). It was a bar machine cutting to a depth of 4 feet 6 inches in a "soft dirt" 10 inches thick. With air at 30 lbs. pressure, the consumption was 640 cubic feet per square yard cut, and this was reduced to 480 cubic feet per square yard cut, with air at 40 lbs. pressure. The economy of the higher pressure is evident.

three years, undercutting in fireclay under a coal seam at collieries near Huddersfield, and it is now working satisfactorily also at Durham collieries. It cuts by rotary action, cutter-picks of special design being fitted into the cutter bar, which is rotated at a speed of about 350 revolutions per minute. The power unit is a $1\frac{1}{2}$ H.P. alternating current motor. A compressed air percussive machine doing the same work requires 25 B.H.P. to drive it. Like the percussive machines this new machine is fixed in position by attachment to a column provided with jack screw and toothed head and foot. By means of a worm handle it is moved radially round the column, longer cutter bars being used to square up the corners of the cut. With one setting of

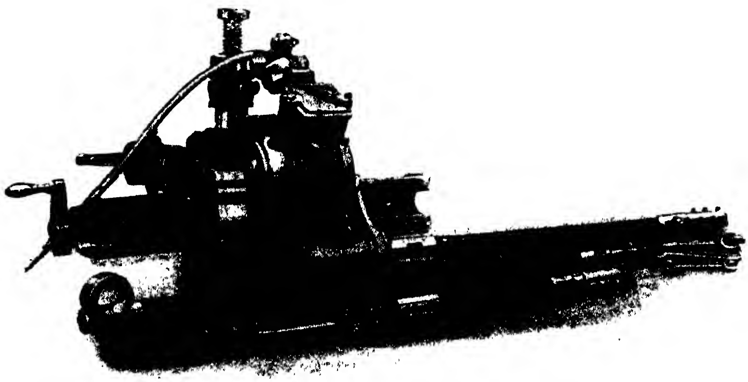


FIG. 21.—"HARDY-BEDFORD" ELECTRICAL COAL-CUTTING MACHINE, BY THE HARDY PATENT PICK COMPANY LIMITED.

the column a place 12 to 15 feet in width can be cut to a depth of 4 feet 6 inches. The height of the cut is about $3\frac{1}{2}$ inches.

In actual work the speed of cutting has often exceeded 100 square feet per hour.

Its weight is about the same as the air-driven percussive machines.

Percussive Machines.—Machines of the percussive or reciprocating type, though they fall short of the rotary machines in production of coal, yet have, as already mentioned, special advantages in their lighter weight, easier portability, and lower cost. There is a wide sphere of usefulness for them in the operations of coal-getting. The weight of a percussive machine with a 5-foot column runs about 550 lbs., whereas an average rotary machine weighs about 2 tons.

The percussive machines are adapted not only to "holing" in a horizontal plane, but also to shearing vertically. In a longwall face, undercut by a rotary machine, the coal in hard seams may be got down more easily, and shot-firing may be saved, by "shearing" the face at regular intervals with a percussive machine.

"Siskol" Percussive Machine.—These machines come in usefully for driving the advance "headings" or "stables" which

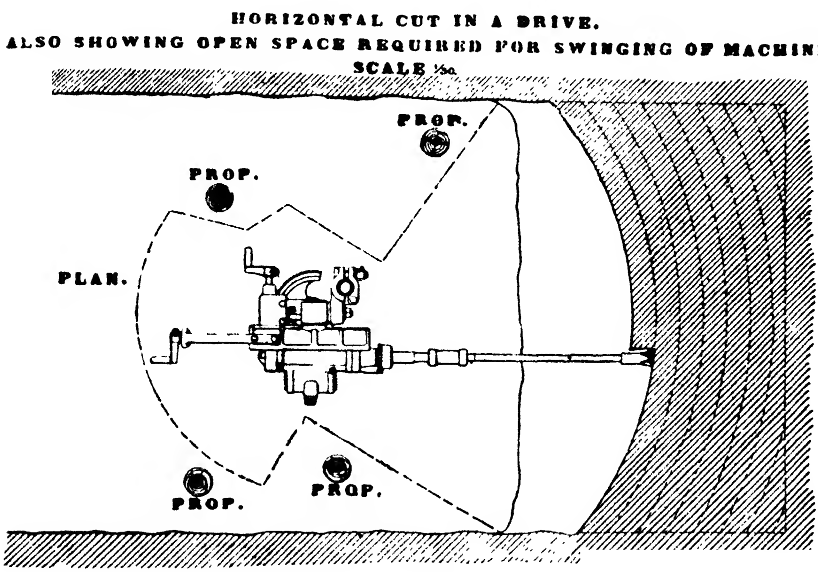


FIG. 22.—THE CHAMPION OR SISKOL COAL-CUTTER.

are often required at each end of a longwall face, though it is better to do without these headings if possible. They are employed in stonework in removing stone "canches" to make height, as well as in coal-getting; *e.g.*, in giving evidence before the Royal Commission on Mines, Mr F. A. Gray, H.M. Inspector of Mines for the Cardiff district, stated, "They could do their 'ripping' entirely with the 'Champion' channelling machine" (now known as the "Siskol"), "which would bore the hole and drive the wedge in. That was done at the Great Western collieries now, when there was not a shot fired in the three steam-coal pits."

The standard "Siskol" drill has a cylinder 3½ inches in diameter, and is designed for air pressures ranging from 50 to 80 lbs. per square inch. Five extension rods are provided, 20, 40, 60, 80, and 100 inches long. With one setting of the column it can cut a place up to 22 feet in width, the longer rods being used to square up the corners. A usual depth of undercut is 4 feet 6 inches. Fig. 22 shows the radial action of the machine and the open space required for swinging it. It can be used in seams from 18 inches and upwards in thickness.

Special tests of the air consumption at 65 lbs. pressure per square inch gave 116 cubic feet of free air per minute.

A special type is made, fitted to a wheeled carriage, and having a hinged column which can be lowered into a horizontal position for "flitting" in low places.*

Another excellent machine of the same fixed-column type is the "Hardiax" made by the Hardy Patent Pick Co. Ltd., Sheffield. A large number of them are in use with satisfactory results (see Fig. 19).

These machines are used in longwall working on the "step" system, as well as in bord-and-pillar working.

Different Types of Percussive Machines.—Of the existing percussive machines which are in use in coal mines there are three general types :—

(1) A machine attached to a fixed column round which it is moved radially, as just described

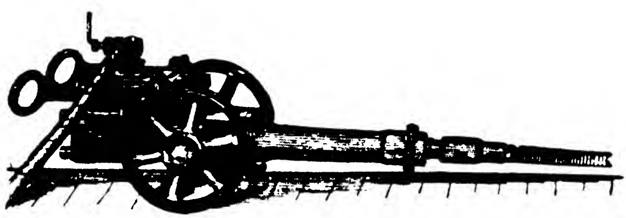


FIG. 23.—INGERSOLL-SERGEANT COAL-CUTTER.

* Quite recently (1923) the Siskol machine has been adapted for breaking up a coal seam after it has been "holed," so as to avoid shot-firing. The ordinary five-pronged cutting bit is exchanged for a pick with a single point. The pick can be directed to any point in the coal face, and by striking a few blows with it, the overhanging coal is broken up into lumps. Good results have been obtained with it in this way at the Clipstone Colliery of the Bolsover Colliery Co. Ltd.

(2) A machine directed and controlled almost entirely by hand, *e.g.*, the Ingersoll-Sergeant (see Fig. 23). This is mounted on wheels and set on a wide wooden board sloping towards the coal face. With it the workman makes a "kirving," like that of the hand-hewer, higher in front and tapering to the back. Though this machine has the merit of allowing great freedom of control to the man holding it, yet this entails the drawback of a considerable jarring action which he has to withstand; and it is not suited to places less than 3 feet 6 inches in height, nor to rise headings, nor to "holing" in a band at some height in a seam.

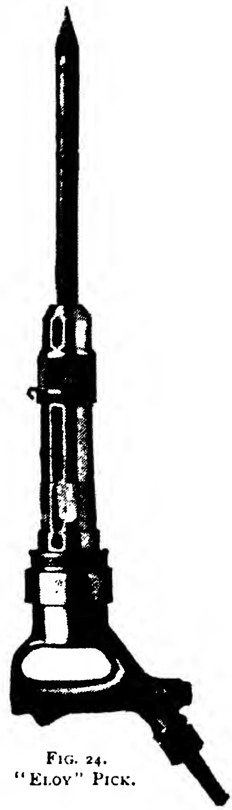


Fig. 24.
"Eloy" Pick.

(3) Hammer picks, weighing for coal work 16 or 17 lbs., which a man holds in his hands, their length being about 17 inches. Large numbers of them are in use, and they enable the coal-hewer to increase his production considerably. They are most effective in hard seams. One of the best of these hammer picks is the "Eloy," made by Messrs Reavell & Co. at Ipswich for the Reavell-Mossay Pneumatic Tool Co. Ltd. (see Fig. 24). Previous to its introduction to English collieries, it had been fully proved in Belgium, where it is known as the Liégeois. More than 6,000 of them are in use at Belgian collieries, and the number is rapidly increasing. The construction of this pneumatic pick does credit to its designers and makers. Its special feature is a light sleeve valve which is placed in the axis of the cylinder in an easily detachable head, and which controls the distribution of the compressed air. The admission ports are always closed before the exhaust ports are opened. Working at full speed, it makes 1,200 blows a minute. It works efficiently with air at a pressure which may vary from 60 to 80 lbs. per square inch. It stops automatically directly the workman ceases pressing on it. This is due to the action of the sleeve valve, and is independent of the trigger valve in the handle of the tool, which controls the admission of air. It cannot, therefore, run light, which is the cause of so much strain and wasteful consumption of air with some hammer drills.

An average size for coal working has a piston $1\frac{3}{16}$ inch in diameter and stroke $4\frac{1}{2}$ inches, and weighs $17\frac{1}{2}$ lbs.

It claims a low air consumption of about 30 cubic feet of free air per minute for continuous working. The frequent operation of the automatic cut-off causes the average consumption to be reduced to about 15 cubic feet of free air per minute under ordinary working conditions.

Conveyors.—The successful operation of coal-cutting machines requires the rapid and regular clearing away of the undercut

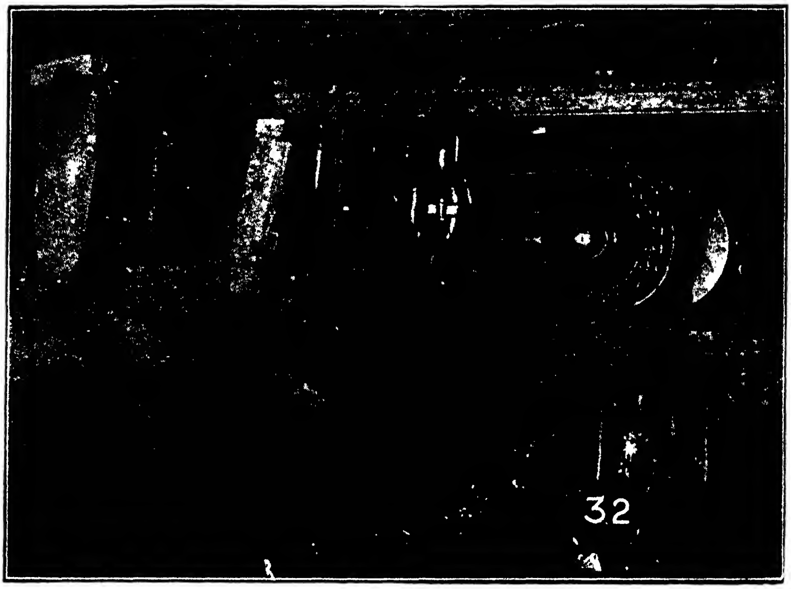


FIG. 25.—BLACKETT'S CONVEYOR. (Photograph showing the delivery end.)

coal. In thin seams worked by longwall there is not height for the coal-tub to be taken along the face. Therefore, when the coal is filled by hand, gateways or roads into the face must be made at frequent intervals of not more than about 10 yards, to facilitate the labour of filling the coal from the face into the tub standing on the gateway. And as the making and maintaining of gateways is a costly item in longwall working, the fewer there are the better.

This has led to the introduction of mechanical conveyors running parallel to the face; the fillers shovel the coal on to the conveyor behind them, which carries it along the face a distance of, say, 50 to 100 yards, and delivers it into the tub standing on the roadway, or on to a gate-end loader (see Fig. 26).

In comparison with coal-cutters conveyors are a novelty, but their value was speedily recognised. Colonel W. C. Blackett was a pioneer in this improvement, and designed a trough scraper conveyor, which was doing good work in Durham collieries in 1903 and is still in general use.

In 1907 one hundred coal face conveyors were in use in Great Britain, and in 1922 the number had increased to 928 (see Table, p. 131).

They are used with advantage not only in thin seams but in seams up to 6 feet in thickness, and not only in conjunction with coal-cutters, but also with hand-hewing.

Fig. 25 is a photograph of the delivery end of a Blackett

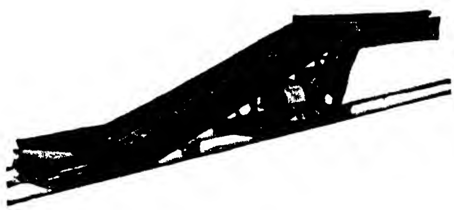


Fig. 26.—Gate-End Loader.

conveyor. An endless chain of special design moves along a steel trough, the chain drum being driven through gearing off an electric motor or compressed air engine. The space occupied by the conveyor is about 10 inches high above the floor by 19 inches wide, and in length they are usually made to serve a face of 90 yards. The hewer fills his coal into the trough immediately behind him, and it is carried by the chain to the end of the face, where it falls off the conveyor into the tub standing on the going road to receive it. A large quantity of coal can thus be rapidly filled and sent away. Fewer roads are required, and much costly stonework is thus saved.

The chief difficulty is the moving forward of the conveyor as the face advances. The troughs allow of considerable bending, and are light and can be easily moved forward. But all the timber in the way needs to be removed and reset ; and the support of the roof in the face presents a different problem from that usual, because there are no pack walls in the goaf behind.

In thin seams where the roof falls readily in the goaf, or bends down soon so as to make it solid, and where the face can be maintained without much timber, the conditions are favourable to a conveyor, and great economy may be secured by it. The labour of filling coal on to a conveyor is much less than that of filling it into tubs.

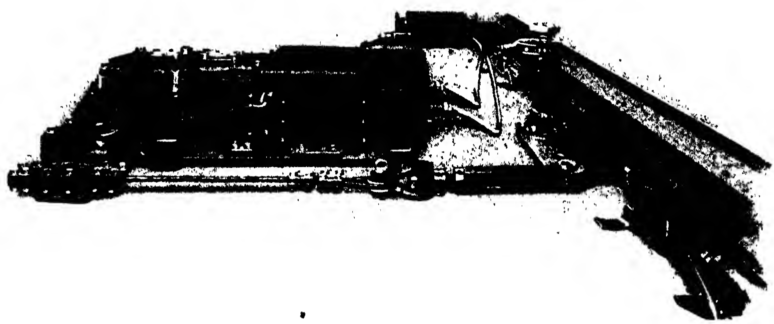


FIG. 27.—"SHAKER CONVEYOR," MADE BY THE DIAMOND COAL-CUTTER CO.

Besides the scraper conveyor there are two other types of continuous discharging conveyors now in general use, viz., the shaker or jigging conveyor, and the band conveyor.

In all three types a trough is an essential part of the apparatus, but in the band and scraper conveyors, besides the trough, there

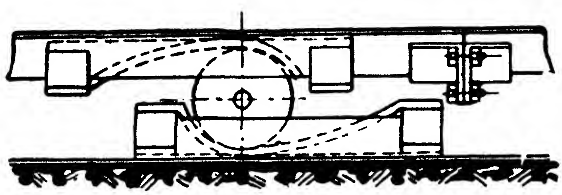
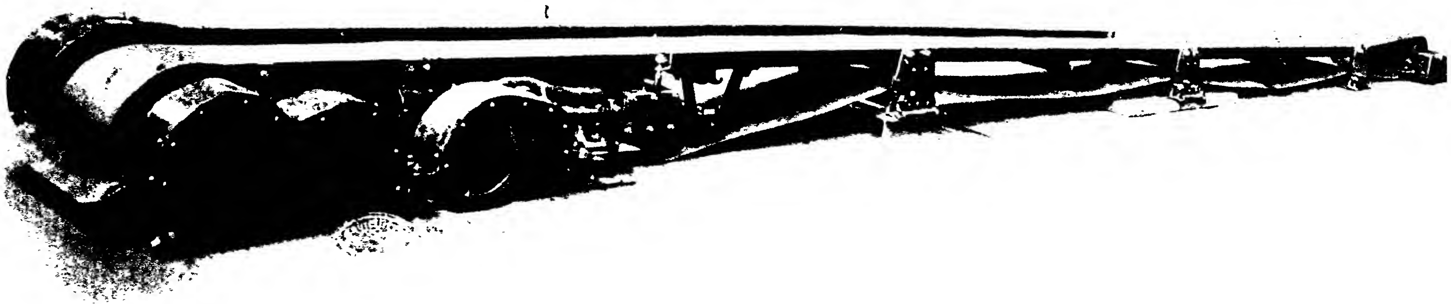


FIG. 28.—ADVANTAGES OF THE CURVED ROLLER PATH ON THE PATENT ROLLER CONVEYOR.

is required in the one case an endless band, and in the other some form of scraper, the trough being stationary, and the coal conveyed along it by the moving band or by the scraper.

In the shaker (see Fig. 27) the movement is given to the trough —a to-and-fro movement of 6 to 12 inches—the length being varied to suit the gradient and the description of the coal. The shaker conveyor is the simplest in construction, and with dry coal of suitable size it is effective on the level, or downhill, or even at



Band Conveyor.

a slightly ascending gradient. Small coal or wet coal has more frictional resistance and is more difficult to move.

The jigging movement is given to the trough by the aid of rollers moving on curved paths.

Fig. 28 shows the construction as made by the Mining Appliances Company of Sheffield. The rollers are two solid iron wheels fastened to a steel axle. The steel frame forming the upper roller path is attached to one end of each trough. The conveyor is driven by a single-acting motor, the reverse stroke being made under the influence of its own velocity. The makers supply a single-acting compressed air motor, specially designed for the purpose, which works with efficiency and economy; or an electric motor may be used, if preferred. Fig. 29 shows the patent lugs for connecting the troughs, so designed that the connection is quickly made, and the bolts and the nuts remain in the connections, and cannot be lost. This conveyor is adapted to working over an uneven floor, and in a face which deviates somewhat from a straight line.*

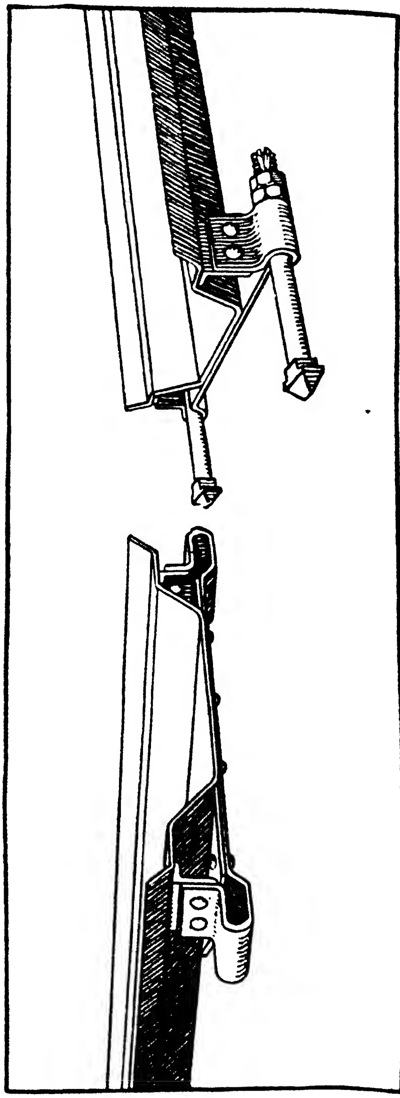


Fig. 29.—Showing Method of Connecting Troughs in a Shaker Conveyor.

A band conveyor made by Mr Richard Sutcliffe, Horbury, near

* The Meco Co., of Sheffield, make a band conveyor with important improvements, recently introduced, which allow of its being rapidly moved forward in a longwall face.

Wakefield, is made of solid woven cotton and nailed on its edges by a patented process to prevent abrasion. It works with very little noise, and does not break or injure the coal in any way. It will convey material against the gradient up to an angle of about 20° with the horizontal.

The object of these conveyors is to remove a large quantity of coal as rapidly as possible, or at any rate within the fillers' shift. Evidently the supply of trams at the delivery end must be continuous, and so arranged that there is no stoppage in loading them.

For this purpose there should be double railway and an empty tram always ready to take the place of the tram which is being filled.

Sometimes a conveyor is used in the gate road as well as in the face, the face conveyor delivering on to the gate-road conveyor, and the coal is thus conveyed to the tram on the main haulage road, where there is more room than in the gate road.

A useful contrivance for promoting continuous loading is the gate-end loader, made by Messrs Mavor & Coulson Ltd., shown in Fig. 26.

This receives the coal from the face conveyor at a height of about 11 inches from the floor, and raises it by means of an endless scraper chain to a sufficient height for discharging into trams. The length of the projecting jib permits an empty tram to be shunted under it behind the tram being loaded. The whole machine is mounted on wheels to suit the gauge of the tram rails, and can be moved easily by a couple of men.

Where a face conveyor discharges into a tram standing on the gate road, it is necessary to make height by taking up the bottom stone, and also generally to keep the gate road in advance of the face. With the gate-end loader this is unnecessary, height being made by taking down the top stone, which is often preferable to ripping the floor; nor need the gate road be driven in advance of the face. A considerable saving may be thus effected. The cost of cutting the floor is sometimes twice as much as the cost of cutting the roof, and the cost of driving a heading in advance of the face is saved also.

Besides these trough conveyors another method of mechanical conveyance along the face of a thin seam is the use of low trams specially constructed to suit the height and conditions of the seam. By means of an endless rope haulage these small trams are pulled to and fro along the face, and are made to discharge their contents through bottom sliding doors into the ordinary big tram standing in the gate road.

Conveyors may be used sometimes with great advantage in seams which, owing to their peculiar structure, are not suitable for cutting by machine.

This is so in many of the seams of the South Wales coalfield.

With hand-hewing, conveyors may be usefully applied to a saving of cost of making and maintaining roads ; a saving of " stone " work in making height in the faces ; less shot-firing ; more room in the goaf for stowing ; simpler ventilation ; and a more rapid advance of the face. Their successful application calls for much initiative and skill and foresight on the part of the officials in overcoming difficulties by resourceful methods.

Practical Results Obtained with a Machine in Bord-and-Pillar Working.—As an example of the results in output, cost, and wages, which were obtained by the use of a coal-cutter in bord-and-pillar working in a thin hard seam at a Durham colliery, the following is instructive.*

The section of the seam was :—

	Ft. Ins.		Ft. Ins.		Ft. Ins.
Splint coal	0 8		...		...
Band	...		0 1		...
Coal	1 $6\frac{1}{2}$		...		...
	2 $2\frac{1}{2}$	+	0 1	=	2 $3\frac{1}{2}$

The coals above and below the band are filled separately, and the band is picked out and cast back.

Above the seam is a " following " stone about 2 inches thick, which always falls with the coal and has to be picked out also.

The machine used was a Mavor & Coulson " Universal " bar machine, height 2 feet 2 inches, width 2 feet 6 inches, length 9 feet, weight 2 tons 6 cwt., driven by three-phase alternating current of 650 volts and 40 cycles. The length of bar used was 6 feet. The places undercut by it were 16 to 18 feet in width, and the yield of coal per place cut was 7 to 8 tons.

Three places were cut on an average each seven hours' shift. For " flitting " from place to place the machine was carried on

* See *Proceedings National Association of Colliery Managers*, May 1922, " Coal-Cutting by Electricity at Greenside Colliery," by William Rochester.

a sledge of special design, which answered the purpose admirably. The machine supplied the hauling power, working through a rope.

The average distance that the machine had to be moved from place to place was 61 yards. This was abnormally far owing to some places being drowned out by water.

A fair allowance for time taken in flitting was found to be 2 yards per minute. The average time occupied in undercutting a place 18 feet wide was 20 minutes.

The consumption of power averaged 6.3 Board of Trade Units per place cut, including the flitting; 4.5 units being consumed in cutting, and 1.8 units in flitting.

During the quarter year ended 31st March 1921, comprising seventy-two working days, 2,379 tons 16 cwt. were produced, at a cost of 5s. 0.82d. per ton. This cost was made up as follows:—

	Per Ton. s.	Per Ton. d.	s.	d.
Filling	2	5.48		
Cutting	1	4.51		
Drilling	0	3.24		
Cleaning	0	2.40		
Mechanics repairing machines ...	0	0.66		
Electricians	0	1.15		
Renewals to machine	0	2.01		
Oils and stores	0	0.55		
Explosives	0	1.17		
			4	9.17
Electrical power at 0.723d. per B.T.U.		0.65		
Depreciation (say)		3.00		
			0	3.65
			5	0.82

All the labour was paid by the "piece," the rates and the earnings per shift being as follows:—

	Average Earnings per Shift. s.	d.
Fillers, 10½d. per ton plus 12½ per cent. ...	11	10.3
Cutters, 6½d. per square yard plus 12½ per cent.	12	10.8
Cleaners, 1d. per square yard plus 12½ per cent. } Drillers, 5d. per hole 4 feet 6 inches long plus 12½ per cent.	9	9.2

In getting down the undercut coal the usual practice was to drill two holes, one at each side of the place.

The labour was arranged in the following shifts :—

Cutters	4 P.M. to 11 P.M.
,, ...	10 P.M. to 5 A.M.
Drillers and cleaners	2.30 A.M. to 9.30 A.M.
Fillers and putters	9 A.M. to 4 P.M.
Stonemen	8 P.M. to 3 A.M.
,, ...	2.30 A.M. to 9.30 A.M.

Thirty inches of bottom stone were taken up to make height for the tubs.

The production of coal per man per shift was approximately : fillers, 5 tons ; fillers, cutters, and cleaners, 2.70 tons ; fillers, cutters, cleaners, mechanics, and electricians, 2.55 tons.

A similar seam in the same neighbourhood is being worked on the bord-and-pillar method by hand-hewing at a cost of 5s. 1.7d. per ton, but the output per hewer per shift is only 2.12 tons, and the average earnings 10s. 11d.

With the machine higher wages were earned, though the cost per ton was a little less. The output per person employed per shift, and the output from a given area of workings, were increased, and transit charges were reduced.

This example shows that machines of this type may be used with advantage in bord-and-pillar working as well as in longwall.

As an important aid to attaining the main object of producing marketable coal at a saleable price, the use of machines at the coal face demands the serious attention of all colliery managers.

CHAPTER IX.

DIFFERENT SYSTEMS OF WORKING—SOME COMMON CHARACTERISTICS.

Commencement of Operations at the Seam.—The shafts having been sunk to the seam of coal which it is intended to work, it becomes the duty of the colliery manager to consider on what principle, or by what mode, it will be most desirable to exploit and develop the available coal.

One of the first, if not the first thing that will claim his attention after connecting the shafts by an underground passage, will be the area of coal required to be left to support the shafts and buildings around them on the surface, and the number and direction of the narrow places to be driven for the purpose of "winning" the coal.

In coming to a conclusion on this matter he must be guided by a variety of circumstances, prominent among which are the amount and direction of the inclination of the seam, the direction of the cleavage of the coal, the position and extent of any known faults or "troubles," dykes, and nip-outs. The situation of the different royalties, if the development of more than one is contemplated, is also a matter for initial consideration, so as to allow of there being as few instrokes as possible.

The main roads (*a*) should be as central as possible for the whole area—*i.e.*, should win as much coal as possible; (*b*) should drain water from as large a proportion of the total area as possible; (*c*) the gradient should be in favour of the full load coming "outbye" to the shaft; (*d*) any water met with should flow naturally to the shaft; (*e*) the roads should pass through as few different properties as possible; (*f*) they should encounter as few faults as possible; (*g*) they should be driven as cheaply as possible.

A correct estimate and thorough consideration of these matters are most important, and the decision on the several points thus arising must be guided by the balance of advantage. In practice the predominating guides are that the main road (winning) should be water-level—that is, should rise about 1 in 200—and should be straight, and where there is a pronounced gradient of seam, this decides its direction. On the *inclination of the seam* will largely depend the mode of haulage to be adopted—whether self-acting inclines can be utilised to the saving of much initial expenditure, and an ultimate lessened tonnage cost, or whether mechanical haulage is necessary. The inclination of the seam will also affect the manner in which the drainage of the mine must be carried out —whether an engine for draining workings to the deep is necessary,

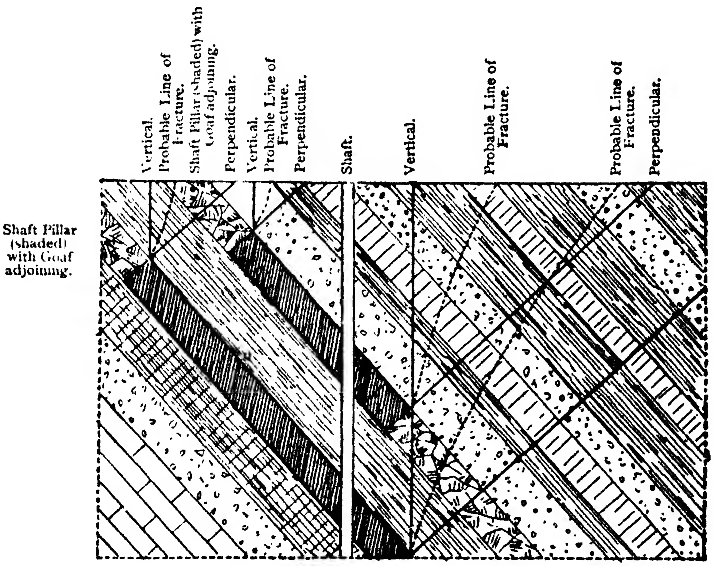


FIG. 30.—SECTION SHOWING COAL LEFT TO SUPPORT SHAFT IN AN INCLINED SEAM.

or whether the mine can be drained by gravitation. The ventilation also will to some extent be governed by the inclination, more especially if the seam makes much gas. These points—as well, possibly, as others of material importance which are peculiar to the locality where the coal tract to be operated upon is situated —will arise for consideration and decision.

The gradient of the strata, when considerable, must also be taken into account in deciding the size of the shaft pillars, and their position relatively to the shaft, a larger area of coal being required on the rise than on the dip side. This is due to the fact that the fracture of strata by subsidence does not take place along vertical lines, but in a direction somewhere between the vertical and the perpendicular to the planes of bedding (except in abnormal circumstances, such as the occurrence of big faults or of running strata, such as sand or gravel).* In the annexed illustration (Fig. 30), the dotted lines show the probable planes of fracture, which are curved and lie somewhere between the vertical and the perpendicular to the planes of bedding at the limits of the excavation. If the shaft be a shallow one, it will of course admit of smaller shaft pillars being left than in a deeper one, but in no case should they be under 40 yards square. An important point also is the nature of the floor of the seam: where it is soft and heaves readily, pillars must be left larger than otherwise would be necessary. The size of pillars cannot be calculated with scientific and mathematical accuracy, as many of the factors cannot be determined exactly, and experience is therefore the main guide towards the determination of the extent of coal to be so left.

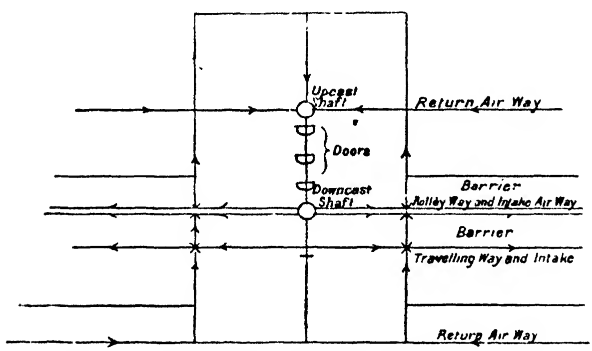


FIG. 31.—PLAN OF SHAFT PILLARS. Scale, 1 in. = 200 yds.

Under ordinary conditions the following rule may be taken as a fairly reliable guide to the sizes of shaft pillars required for various depths, not exceeding 200 fathoms or thereabouts: Taking a minimum size of 40 yards square at a depth of 60 fathoms from the surface, add 10 yards for every additional 20 fathoms in depth. Some colliery managers, however, do not deem quite such a large margin to be necessary, but lay out their shaft pillars on the principle that the size should be a quarter of the depth from the surface in yards square. But between these two rules it will be seen that there is not much to choose, the difference, whatever the depth, amounting only to 10 yards in the size of pillars. In Fig. 31 are represented the shaft pillars and winning places in a seam situate at a depth of 180 fathoms from the surface.

The area of coal to be left to support the shaft in level seams is

* German experience goes to show that the extent of the "draw," *i.e.*, the distance between the perpendicular and the line of fracture, is greatest when thick sandstone beds exist between the seams of coal and the surface.

perhaps best expressed as a radius round the shaft as centre. For instance, at the deep winning of the Barnsley bed in Yorkshire by the Cadeby Main shafts, 750 yards deep, a radius of 300 * yards of coal round the shaft was left, and beyond that the whole of the coal was taken away by longwall work. The seam is 10 feet 3 inches thick. Again, a sinking in South Wales in 1912 was 433 yards in depth, and a radius of 100 † yards round the shaft was left.

In another case—a modern colliery in the Midlands—the shaft is 600 yards in depth, and the shaft "pillar" is 600 yards in diameter. The effect of subsidence was evident 2 feet beyond the top of the shaft.

"The practice until lately at many collieries in Silesia was so to determine the size of the shaft pillar that the angle contained by two lines drawn, one from the shaft bottom to the edge of the pillar, and the other from the edge of the pillar to the top of the shaft, was 78°. But in the case of very deep mines a lesser angle is now being adopted." ‡

In the case of mines liable to spontaneous combustion, *e.g.*, Staffordshire and South Yorkshire—it is essential that not only the roads piercing the shaft pillar should be as few as possible, but that they should be as far apart as possible so as to preclude the creation of breaks in the coal. Consequently in some cases the main roads are driven for some distance either above or below the coal seam—that is, up to the point where the coal is to be taken away by longwall working. In any event it is highly desirable in cases where the coal is worked by the longwall method that the packing against the shaft-pillar edge should be as close and tight as possible, as leakage of air along the margin of the pillar is a fruitful source of spontaneous combustion.

It is an open question, especially in those cases where there is danger from spontaneous combustion, whether shaft pillars should be left. In some Continental coal mines they have of late been dispensed with. In 1912 the late Mr W. H. Pickering in collaboration with his son, Mr Basil H. Pickering, brought the question prominently before the mining engineering profession by reading a paper entitled "Why Leave Shaft Pillars," which may be studied

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* A circle 600 yards in diameter = 262,744 square yards, ¼ of 750 yards = 188, which squared = 35,344 square yards.

† A circle 200 yards in diameter = 31,416 square yards, ¼ of 433 = 108, which squared = 11,664 square yards.

The pressure of the superincumbent strata seems to increase more rapidly at greater depths. Hence a rule applicable to shallow depths does not apply to greater depths.

‡ "Modern Practice in Mining," by Sir R. Redmayne, vol. iii., p. 10.

with advantage by colliery managers.* The writers came to the conclusion that in many cases it is possible to extract the whole or part of the coal from the shaft pillars, and so obtain a large output within a few weeks of the seam being reached. But prior to this Mr Charles Snow had carried out the removal of the shaft pillar at South Kirkby colliery in Yorkshire by gradually working it off, and substituting for the coal ordinary packing, the course adopted being the building of the usual pack and tightly stowing the spaces between them.† The position cannot be better summed up than in the words of the late Mr C. E. Rhodes, "there is no intermediate course between taking the coal out from the shaft-bottom; or leaving a very large shaft pillar, and then taking all the coal out beyond it." ‡

A recognised rule for deep shafts is that the shaft pillar should be equal in radius to half the depth of the shafts.

For instance, at Frickley colliery in South Yorkshire the shafts are 664 yards deep to the Barnsley bed, and the shaft pillar was made 700 yards square. In order to avoid crushing of the coal at the edge of the shaft pillar, and the consequent danger of heating and fire which might thus arise, the headings were driven 80 to 100 yards farther, before being connected. By this means the first break of roof and the first subsidence was got at some distance from the pillar edge.§

Surface Subsidence.—The damage caused to land and buildings by subsidence of the surface is a serious result of colliery working, which gives rise to much litigation, and is to many collieries a considerable item of cost.

Decisions about it are based still on approximate rules drawn from varied experience rather than from scientific deduction.

The surface subsidence is not confined to the area of worked-out coal. There is a lateral as well as a vertical movement of the strata. The crucial question that usually arises for decision is the amount of "draw." How far over the solid unworked coal will the subsidence extend?

Present opinion on the extent of draw is somewhat as follows.‖

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* See *Trans. Inst. M E.*, vol. xliii., pp. 428-435.

† "The Removal of a Shaft Pillar at South Kirkby Colliery," by Charles Snow, *Trans. Inst. M.E.*, vol. xlvi., pp. 8-12.

‡ Presidential Address, p. 449, vol. xxxv., *Trans. Inst. M.E.*

§ See "Methods of Working the Barnsley Seam of the South Yorkshire Coalfield," by H. Rhodes and M. Rhodes, *Trans. Inst. Mining Engineers*, vol. lxiii., p. 412.

‖ See "The Theory of Subsidences," by Prof. Henry Louis, *Trans. Inst. Mining Engineers*, vol. lxiv., Nov. 1922.

In ordinary coal measure strata lying practically horizontal, the angle of draw is between 5° and 15°, being lower as the proportion of sandstone is greater, and higher as shale predominates.

In "secondary" strata, *e.g.*, the liassic rocks overlying the Cleveland ironstone (chiefly limestone and shales), it is about 25°.

In "recent" superficial formations, *e.g.*, boulder clay, it varies widely from 20° to 35°.

The Coal Conservation Committee in their final report expressed the opinion that, to ensure the safety of railways and surface erections, coal should be left equal to one half of the depth of the workings below the surface level of the land at the place. This is an angle of draw of 26 degrees 35 minutes, which is likely to be on the safe side in most cases.

Strata when broken being more bulky and occupying more space than when solid, the depth of the surface subsidence is always less than the thickness of the bed removed. In a good many instances it appears to be about 60 per cent. of the thickness of the seam.*

Principal Methods of Working.—The two principal systems of working a seam to "get" the coal are those known briefly as (I.) Bord and Pillar, and (II.) Longwall. In the former, narrow places are first driven in the seam so as to form pillars, which are subsequently removed: in the latter, the whole of the seam is removed in a long "face," the roof behind being allowed to fall, or the excavation filled with *débris*. These are the two leading systems, and all other modes of working may be said to be modifications of one or the other.

The conditions favourable to bord-and-pillar working are as follows: (1) If the roof contains water; (2) if much gas issues from the coal; (3) if there are many important buildings or reservoirs on the surface; (4) if the workings are beneath the sea; (5) if there is difficulty in obtaining sufficient material to pack the goaf; (6) if the top stone is of a loose nature and likely to fall in the working face; (7) if there are many "faults."

The conditions favourable to longwall may be stated thus: (1) A seam free from faults; (2) a thin seam; (3) a seam of hard coal, difficult to hew; (4) a seam with a suitable roof, that bends, but does not easily break; (5) a seam with a "dirt" parting—*i.e.*, a band of soft stone; (6) a seam where either fireclay or ironstone is worked contemporaneously with the coal.

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* In this connection the depth from the surface, the nature of the strata, the packing of the goaf, all have an important bearing.

Such are the conditions usually given. It is seldom that a *single fact* determines the manner of working, but rather a series of general conditions point to the right conclusion. For instance, it is mentioned above that a thin seam, other conditions being favourable, can be most satisfactorily worked by longwall. Undoubtedly this is so, but at the same time a thick seam—even when free from band—can often be worked to best advantage by this mode, as will be shown later on. Again, much depends on the custom of the district, the *genius loci*, the adaptability of labour, &c.—considerations in dealing with which only knowledge and experience avail.

Under the longwall system there is less waste of coal, less timber is consumed in supporting the roof, and there is less narrow work (see Chapter XII.), and, if the seam is not naturally a very tender one, a higher percentage of "round" coal, amounting perhaps to as much as 14 per cent., is obtained than by bord and pillar. A larger proportion of the entire seam also—namely, from 10 to 25 per cent. more coal per acre—is obtainable by longwall than by bord and pillar. Longwall is the most suitable system for working seams at great depths, where the pressure of the superincumbent strata is serious, because this pressure is thrown on to the goaf, which is carefully packed with stone to support it, whereas in bord and pillar the pressure has to be carried by the coal pillars, which are thus crushed,

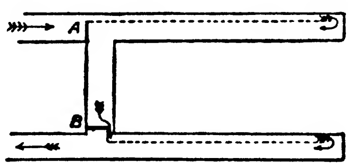

FIG. 32.—BRATTICING OF A PAIR OF WINNING PLACES.

with the result that the quality of the coal is deteriorated. Amongst other things in its favour, longwall costs less for timber, and there is less danger from falls of stone; it causes less damage to the surface, as the subsidence is more regular; it affords greater facilities for holing or kirving being done in "dirt," either below or above the seam; the number of off-hand men, relatively to the coal-hewers, is less than in bord and pillar. To put against this, however, is the increased cost of shift and stone work under the longwall method, entailed by the necessity of removing the top or bottom stone, as the case may be, in thin seams, to allow for tub and travelling height, and by the building of pillaring and the stowing of *débris*.

Comparison of Labour Required.—The relative proportion between the principal classes of underground labour employed in the two methods is indicated by the following figures:—

	* Bord and Pillar.	† Longwall.
Number of hewers to one deputy	11	19
" " " shifter or stoneman	2.5	1.81
" " " putter	5	11.0

Ventilation of Drifts.—In seams generating gas, all roads in process of being driven should be divided by a partition, which may be formed of brick, wood, or canvas brattice, so as to form a separate inlet and outlet for the passage of air to and from the face.

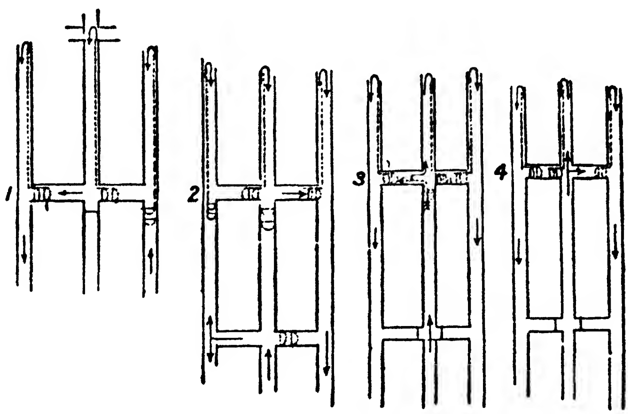

FIG. 33. FIG. 34. FIG. 35. FIG. 36.

PLANS SHOWING VENTILATION OF THREE WINNING PLACES.

The same end may be gained by wooden or metal tubes fixed along one side of the "place." The brattice should be carried to within about 6 feet of the face, and the intake air conducted up the narrow side,‡ as shown in accompanying Fig. 32, canvas doors or flaps being attached to the outer end of the bratticing, as at A and B.

* These figures are calculated on eight collieries in the North of England working bord and pillar, over a total number of 945 hewers, the average tons hewed per man per shift being about 4.7. Instances of longwall have occurred where the number of stonemen and shifters has been greater than the number of coal-hewers.

† Calculated over four collieries in the North of England working exclusively longwall, the total number of hewers being 1,200. The tons hewed per hewer per shift were 2¾, 70 per cent. of the output being "round" coal.

‡ It is a matter of dispute, whether, conducting the intake air up the narrow side, or up the wide side of the brattice, gives the better result in ventilating the face of a drift.

The face ventilation of three parallel drifts or winning headways is somewhat more complicated. The air may be conducted round the face according to four different modes—namely (1) when either the first or third place is the intake, Fig. 33; (2) when the middle place is the intake, Fig. 34; (3) when the middle place is the intake, Fig. 35 (another method); or (4) when the middle place is the intake, and the air is conducted up the *wide* side of the brattice in the intake or middle place, Fig. 36.

Peculiar cases sometimes occur. In driving a winning place in the Low Main seam at Killingworth colliery, the face was ventilated by means of a canvas brattice partition in the ordinary way. A blower of gas was tapped at the "leader" of a rise fault on the *intake* side of the brattice, and for some days gas came out at a steady pressure with considerable noise. To prevent this gas from being carried by the air current into the face upon the men at work, it was necessary to alter the bratticing. This was done in

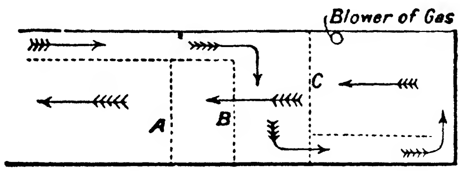

FIG. 37.—SPECIAL CASE OF FACE-BRATTICING IN THE PRESENCE OF A BLOWER OF GAS.

the way illustrated in Fig. 37. On the outbye side of the blower, the intake air was carried across to the other side of the place, and an air-crossing was formed of wooden deals to allow the return air to pass out over the top of the intake air. Owing to the rise fault, there was plenty of height. A, B, and C denote three canvas brattice doors hung from planks fixed across the place at a height of 6 feet above the floor. The double doors, A and B, prevented the intake air from escaping outbye when crossing over. Upon the planks was laid an air-tight partition of wooden deals. The arrows show the course of the air. Plate XXIV. shows a canvas flap or brattice door, with a deputy on his rounds coming through it.

When a single place is being driven—as is often the case in approaching old workings known to contain a considerable quantity of water at a high pressure, the exact position of which it is necessary to locate, and possibly to drain off the water by means of such a heading or drift—it becomes necessary to erect a more substantial

A Deputy on his rounds coming through a Canvas Brattice Door.

[*To face page* 166.

and air-tight division than can be effected by canvas or wood, in which case a brick wall is usually built. Subjoined are the details of an actual case in point. The length of the brattice was 200 yards, and cross pillars were built every 9 feet, making sixty-seven pillars in all. The average height of the brattice was 7 feet 1½ inches.

WORK AND MATERIAL REQUIRED—

Area, exclusive of pillaring	455	square yards.
Area of pillars	20	"
Total area	475	"
Bricks to a square yard of 4½-inch walling ...	42	
Number of bricks in walling	19,110	
" " in pillaring	560	
Total number of bricks in brattice ...	19,670	

* COST OF MATERIAL—

	£	s.	d.
19,670 bricks at 21s.* per 1,000	£20	13	0
1 load of sand and lime will build 50 square yards of 4½-inch work. Therefore 10 loads at 3s. 10d. per load	1	13	4
	£22	6	4

* COST OF LABOUR—

	£	s.	d.
475 square yards of brick walling at 6d. per square yard	£11	18	0
Leading bricks and lime, 16 shifts at 2s. 1d. per shift	1	13	4
	£13	11	4
Total cost (about 1s. 6d. per square yard) ...	£35	17	8

Wood brattice can be made very air-tight when built of planks 3 inches thick with slivered joints—oak slivers 2 inches by ¾-inch—and the ends of the planks fastened into stringing planks 3 inches by 9 inches grooved about 1 inch deep to receive them. The weakest places are where the brattice joins the roof and floor, as these are seldom smooth or level, and lime plaster is useful for covering up the little spaces that may occur.

* The actual cost to the colliery of making these bricks was about 10s. per 1,000, the above being the market price. All the items of cost given in this statement are based on prices ruling about 1895. The costs would now be of course very much greater.

The difficulty of making an air-tight connection next the roof and floor is one point of inferiority as compared with air boxes or tubes. The latter also occupy less space, and can be more readily put in or taken away. Their sectional area is often from 100 to

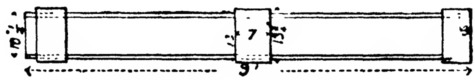

FIG. 38.—AIR-BOX. Scale, ¼ in. = 1 in.

200 square inches. When made of wood, they are rectangular in section. Fig. 38 represents the usual description of box. The cost of making a 9 feet length of air-box of ¾-inch deals, 20 inches square inside, would be as follows :—

	s.	d.
7 yards of deal at 8d. per yard	4	8
15 square feet of deal at 10s. 6d. per 100 square feet	1	7
4 lbs. of nails at 2s. per stone	0	8
Labour—¾ day at 3s. 8d. per diem	2	9
* Cost of one length	9	8

Cost per yard = 9s. 8d. ÷ 3 = 3s. 2⅔d.

Air-tubes are somewhat more costly. At the time that the above calculation was made the cost per yard of round steel air-tubes 15 inches diameter was 3s. 4d. The boxes or tubes may be laid either on the thill by the coal side, or (better still) carried along the side (some thickness of stone being left for their support) nearer the roof, as shown in Fig. 39.

One great advantage which boxes and tubes have over wood or canvas bratticing is that a small ventilating fan, to be driven by hand, can be readily attached to them if more air is required. On the other hand, there is increased friction of air owing to their smaller area, so that possibly what is gained in diminished leakage is more than lost in increased friction. They are particularly suitable when proving "troubles" by following the "leader," when the floor of the excavation is irregular, and bratticing could not be efficiently adopted.

Air-Crossings and Stoppings.—Since the splitting of air in the ventilation of colliery workings was introduced, the subject of air-crossings has claimed attention from colliery managers, and even at the present time a diversity of opinion exists as to which

* These items of cost are based on rates ruling about 1895, and the cost would consequently be much greater at the present time.

Fig. 39.—Air-Tubes carried round a corner, and ventilating a Single Heading.

[*To face page* 168.

type is best calculated to meet the requirements of any particular mine.

As a rule, after a colliery explosion of any magnitude the air-crossings and stoppings within the sphere of the explosion are either completely blown out, or are so seriously damaged as to render them quite useless in the work of restoration of the ventilation. It is a moot point, and one which has given rise to much discussion, whether air-crossings should be so strongly constructed as to effectually resist the explosive impact, or whether they should be so erected as to merely answer the purposes of the normal ventilation, and give way when subjected to the application of any abnormal force.

It is maintained by those who advocate the former view, that in the work of restoration it is most desirable that the rescue parties should be enabled to explore the workings and relieve the sufferers as early as possible—before, in fact, after-damp may have had time to take fatal effect; for it is generally acknowledged that fatalities due to colliery explosions are more largely caused by this deadly mixture than by explosive violence. If, then, the air-crossings and stoppings are only indifferently strong, they are sure to be so damaged as to be of little or no use in the work of re-establishing the ventilation.

Those, however, who support the second view, contend that the object to be secured is the limitation of the explosive force, and as in most modern colliery disasters the explosive current has traversed the haulage roads (which are in nearly every instance the intakes also), they argue that by constructing intensely strong air-crossings and stoppings, the mechanical violence of the explosion is prohibited from finding its quickest outlet by passing into the returns and thence to the upcast shaft—short circuiting in fact—in place of which it is confined to the intakes, and must traverse the greater part, if not all, of the workings, gathering intensity as it sweeps along the haulage roads from the coal dust which is often so plentiful in these galleries.

But cases could be quoted to show that even where the crossings and stoppings have been blown out, the explosion has continued its course along the intake. The course and extent of the explosion would seem to be mainly dependent on the presence of coal dust and gas.

Coal mines which are dry and dusty are now, however, required by law to be rendered safe by the admixture with the coal dust of inert stone dust.

That air-crossings and stoppings have to be very strong indeed to successfully resist the force generated by a colliery explosion has been instanced in more than one case. At Elemore colliery, in the county of Durham, which "fired" in December 1886, the brick stoppings, and in several instances the arched brick air-crossings, were completely blown out. Mr Thomas Lishman, the late able general manager of the Hetton collieries (including Elemore), was of the opinion that "all main air-crossings in close proximity to the

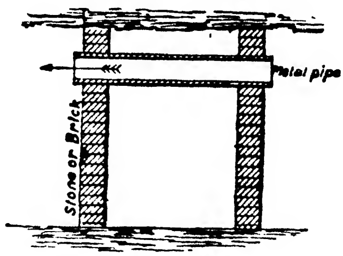

FIG. 40.—PIPE AIR-CROSSING.

shafts, where there are usually a considerable number in all mines of any magnitude, should be inserted in the strongest possible way, so that in the event of an explosion, the ventilation to the different districts which usually diverge from the main lines beyond such crossings, may be more readily restored." This expression of opinion deserves the careful consideration of the managers of extensive and

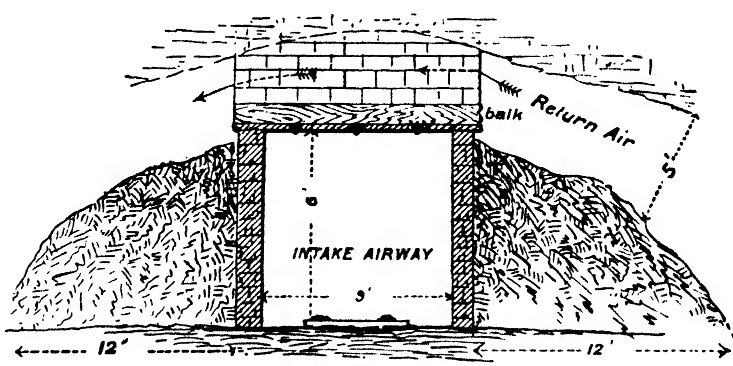

FIG. 41.—WOOD-TOPPED AIR-CROSSING IN SECTION.

fiery mines; but under ordinary conditions the wood-topped air-crossing and the common brick stopping, well plastered with lime meet the requirements of the case.

There are several kinds of air-crossings in use, each of which has its peculiar fitness and special merits. The chief types may be stated as follows:—(1) Metal pipe crossing; (2) Wood-topped crossing; (3) Flat-topped hinged-door crossing; (4) Single-brick arched crossing; (5) Double-brick inverted arch crossing; (6) Air-crossing cut out of the solid strata.

(1.) The pipe crossing, which is shown in Fig. 40, is only to be regarded as a temporary arrangement, and merely for conveying small volumes of air.

(2.) The wood-topped crossing (Figs. 41 and 42), which is perhaps the type most frequently adopted, consists of strong redwood deals, 3 inches by 11 inches, supported on side retaining walls of 9-inch brick, or of stone masonry, at the back of which the *débris* from the space excavated to form the air-crossing is heaped. The deals forming the top are clinched tight together by iron clamps, as shown in Fig. 42. Sometimes "slithering laths" are dovetailed between the deals, which ensures still greater air-tightness.

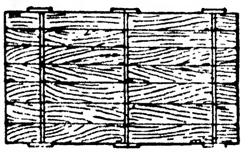

FIG. 42.—PLAN OF TOP OF WOOD-TOPPED AIR-CROSSING.

The cost of inserting such a "crossing" will be approximately in accordance with the following actual instance:—

COST OF AIR-CROSSING.*

WASTEMEN—	Shifts.	£ s. a.	Labour. £ s. d.	Materials. £ s. d.
Preparing for blasting ...	6	0 3 3	0 19 6	...
Blasting	15	0 3 3	2 8 3	...
Ridding and pillaring ...	40	0 3 3	6 10 0	...
Putting and stowing ...	30	0 3 0	4 10 0	...
Preparing for side-walls, putting in back-walls, and stowing	17	0 3 3	2 15 3	...
Putting on timber ...	6	0 3 3	0 19 6	...
Assisting masons with bricks and lime	6	0 3 3	0 19 6	...
			19 2 0	

MASONS—	Shifts.	£ s. d.	Labour. £ s. d.		
Building walls	10	0 3 8	1 16 8		
Labourers ...	6	0 3 0	0 18 0		
				2 14 8	...
Carry forward			...	21 16 8	...

* The figures are those ruling about 1895.

				Labour.			Materials.		
	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward	...			21	16	8	...		
MATERIALS—									
2 balks Dantzic pine, 15 feet × 9 inches × 9 inches each, 17 cubic feet	0	0	10	...			0	14	2
11 pieces 11 inches × 3 inches red deal, each 15 feet long, 165 lineal feet	0	0	$2\frac{15}{16}$	...			2	0	5
20 pieces $7\frac{1}{2}$ inches × 3 inches × $\frac{1}{2}$ inch laths, 150 lineal feet	0	0	$0\frac{1}{4}$	...			0	3	2
40 spar nails (10 lbs.) and 3 lbs. small nails, 13 lbs.	0	0	$1\frac{1}{2}$	...			0	1	8
2 pair of iron clamps 1 cwt. at 1s. ...	...			...			0	1	0
Labour screwing	...			0	3	0	...		
4,650 bricks at 13s. per 1,000 ...	...			...			3	0	6
Lime at 5s. per 1,000	...			...			1	3	3
Powder, 43 lbs. of compressed cartridges at 34s. per 100 lbs. ...	...			...			0	14	8
							7	18	10
							21	19	8
Total cost of labour and material							29	18	6

(3.) The only difference between the hinged-door crossing and that described above is that the wooden top is made in two halves, being two doors working on hinges and opening

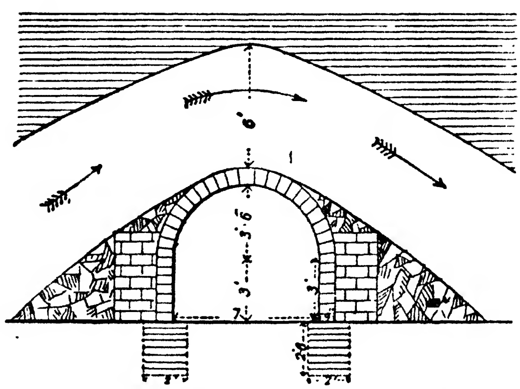

FIG. 43.—BRICK-ARCH AIR-CROSSING, IN SECTION.

upwards, and so arranged that in no case will they *remain* open, but upon the removal of the opening force acting from beneath, they fall to again and close tight. The object which it is sought to arrive at by this device has already been alluded to, namely, the creation of an escape exit for the violence induced by a colliery explosion.

(4.) The single brick arched air-crossing is a type in common use, and is fairly strong and air-tight, and where the top or side stone is of a short or broken nature, it is a desirable form of crossing to adopt. It is of course somewhat more costly to erect than the flat-topped wooden air-crossing, but where the stone is of the indifferent character here indicated it would prove the more durable, and hence in the long run the cheaper of the two.

The accompanying sketch, Figs. 43 and 44, represent an actual instance. Special foundations 2 feet 6 inches deep, consisting of well-packed rubble stone covered with a coating of cement at the floor level, were laid, on which to build the brick-work, as there was no hard stone above this depth. Strengthening walls, O, O, O, were

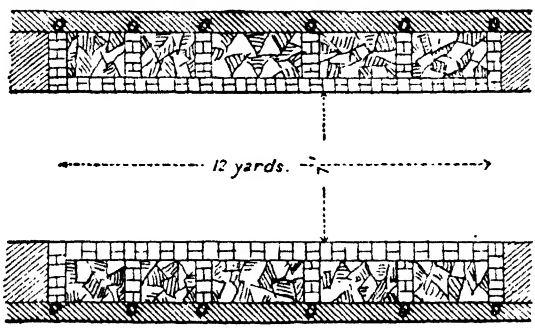

Fig. 44.—Brick-Arch Air-Crossing, in Plan.

built at intervals of about 2 yards, and the spaces between well packed with stone. The top of the arch was coated with cement, as water dripped from the stone above.

(5.) The inverted brick arched crossing is perhaps the strongest form of crossing that is constructed by artificial means. It is the ordinary brick arched crossing with an inverted arch placed in the return airway over the crown of the intake arch, so that the crowns of the two arches meet, the interstices so formed being filled in with solid masonry. Besides being capable of resisting very considerable explosive force, it is a serviceable form of crossing in cases where uneasy strata have to be dealt with. Instances have occurred, however, where even this form of air-crossing has not been strong enough to resist the upward pressure of the floor, and has required renewal after a few months.

(6.) The solid air-crossing, which is the strongest and most costly of the various types enumerated, is made by driving a stone-drift for a return airway over the top of the intake, and leaving several feet of solid strata between.

Figs. 45 and 46 represent a plan and section of a form of air-crossing in use at Celynen colliery, in South Wales, the peculiarity

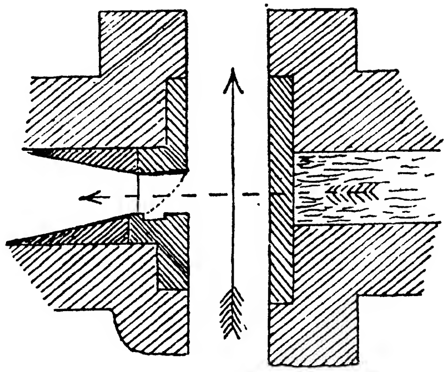

FIG. 45.—SPECIAL FORM OF AIR-CROSSING, IN PLAN.

being a door in the side, which enables the mine official to pass direct from the main intake into the main return airway at the crossing.

In all cases where stoppings are located on the outbye side of the "regulator"—"main stoppings," as they are termed—they should be built of solid masonry, either of brick or of stone, and in addition

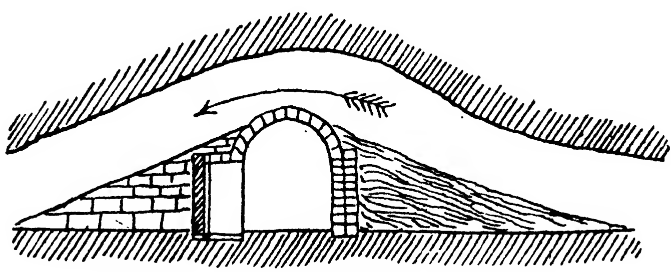

FIG. 46.—SPECIAL FORM OF AIR-CROSSING, IN SECTION.

be well plastered over with lime to prevent the air scaling.* They may be strengthened by stowing the bord or stenton *behind* with stone and rubbish; but the side facing the intake should always be visible for inspection and kept quite clear of rubbish.

* The leakages which occur in the volume of an air current during its passage from the downcast shaft to the working face are often surprisingly large, amounting sometimes to 84 per cent. of the entire volume (see "Notes on a Ventilating Current," by Henry Palmer, *Brit. Soc. Min. Stud.*, vol. xi., p. 46). The state of the stoppings greatly affects this.

Requirements as to Stoppings.—The Coal Mines Act of 1911 has been passed since the foregoing was written, and by General Regulation 91 (*a*) it is required that all stoppings between main intake and main return airways shall either be constructed of tight stone, dirt, sand, or rubbish packing at least 5 yards thick; or of tight stone, dirt, sand, or rubbish packing at least 3 yards thick; and in the latter case have the end of the packing nearest the intake airway faced with a wall of masonry, brickwork, or concrete not less than 9 inches thick, the face of which shall be covered with a coating of mortar so as to prevent leakage of air. The space between the face of the stopping and the roadway has to be kept clear.

These requirements do not, however, apply to mines under the Coal Mines Act in which coal is not worked, *e.g.*, oil shale mines, mines of stratified ironstone, or clay or ganister mines, nor to any coal mine in South Staffordshire liable to spontaneous combustion.

CHAPTER X.

WORKING BY BORD AND PILLAR.

"BORD and pillar," "Bord and wall," "Stoop and room"—or by whatever other local designation the system may be known—is the oldest system of working coal on record, as will have been inferred from the opening chapter of this volume. The object originally aimed at was the extraction of as much coal as possible in a single working, without allowing the roof to fall. The advance from this point to the leaving of larger pillars, with a view to subsequent extraction—the improvements in working and ventilation generally—and, in fact, the evolution of the whole system up to its present pitch of efficiency—have been fully dealt with in the opening chapter, and we now pass on to a consideration of the practical details of the system, as at present carried out.

The bord and pillar system took its rise in the Northern coal-field (Northumberland and Durham), and is still the prevailing method of working there. The account of it now to be given is, therefore, not inappropriately derived (for the main part) from experience in that district.

Winning Places and Main Roads.—We have already referred to the formation of the shaft pillars, and this work being completed, the colliery manager's next duty is to set away "winning places" or exploring roads which will in all probability be the main roads of the pit, both as regards haulage and ventilation, so long as the seam shall continue to be worked. The necessity, therefore, of driving these roads in such directions, and in such manner, as will best secure the advantageous working of the seam (see page 160), need hardly be emphasised. If possible (though local circumstances, such as position of royalties, &c., may prevent it) these roads should be projected from both sides of the drawing pits, so that any stoppage on one of the roads will not entail an entire cessation of the drawing of coals.

Plate XXV.

Face of a Winning Headways, showing an abnormal thickening of a Thin Seam.

[To face page 176.

In connection with the number and position of the main roads, reference should be made to certain requirements contained in the Coal Mines Act of 1911. It is enjoined by this Act that in respect of all coal mines opened after the commencement of that Act there shall be two main intakes of such size and maintained in such condition as to afford a ready means of ingress to and egress from the workings, and that only one of such roads shall be used for the haulage of coal. But in certain circumstances, and under certain conditions, defined by General Regulations, exemption from the requirement is permitted in respect of some mines. See General Regulations, Section 42 (1) of the Act.

In the working of these "places"—which in most cases should be three in number, parallel to each other—many irregularities may be encountered—such as, in miners' phraseology, rise or dip troubles or faults, swellies, nip-outs or wash-outs,* which of course considerably impede the prosecution of the work of laying-out the mine.

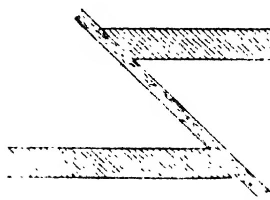

FIG. 47.—SECTION SHOWING REVERSED FAULT.

Plate XXV. is a reproduction of a photograph which was taken in the face of a winning headways driven in the Brockwell seam at a Durham colliery. The normal thickness of the seam is 3 feet, but this photograph shows an abnormal thickening of it, the whole height here being 11 feet, about 2 feet of which is stone. Water was raining down from the roof, and to the right of the view may be seen a screen or "picture" put up to keep the water from falling on to the hewer. Plate VIII., showing a stoneman at work, was taken in the face of the same winning a few yards farther on, when the coal seam had disappeared altogether, and progress had to be made through stone. Not infrequently a seam thickens considerably in the neighbourhood of a "nip-out," as was here the case.

These two plates illustrate some of the vagaries and irregularities which are often encountered in driving winning places. The winnings of the coal, however, will not be deviated from their

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* For meaning of these terms, see GLOSSARY.

predetermined course, unless, indeed, such a disastrous circumstance as a complete "wash-out" of such considerable extent as not to warrant the cost of stone-drifting through it, or a very large fault, or general thinning out of the seam, or other equally fatal deterioration, be encountered. Irregularities of gradient are subsequently removed, as the "face" working advances, by following up with "top" or "bottom" stone "canches"; and thus such gradients are formed as are best suited to the mode of haulage it is deemed advisable to introduce.

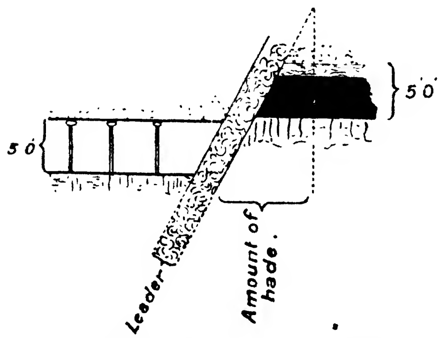

FIG. 48.—SECTION EXPLANATORY OF A FAULT.

Allusion has been made to the meeting with faults when driving these main levels. It is important, when such are encountered, that their character should be known—whether upthrows or downthrows, or (as is rarely the case) "reversed" faults (see Fig. 47). As a rule the direction of the "leader," or wall of soft stone or clay filling in the space between the opposing face of the dislocation and the coal seam (see Fig. 48), determines this point; for if a fault *lies to* at the "thill" or floor (that is, forms an obtuse angle with the floor), and *back at* the roof (making an acute angle with the roof), it is concluded to be an "upthrow"; and so *vice versâ*. Faults are seldom vertical. If a fault is encountered having a perpendicular face, the usual mode of procedure is to drive a short drift across the leader, when, with a knowledge of the strata lying above and below the seam, the position of the coal may often be rightly judged; or if not, then, when *quite* clear of the leader, a bore-hole may be put up or down to locate the position of the seam.

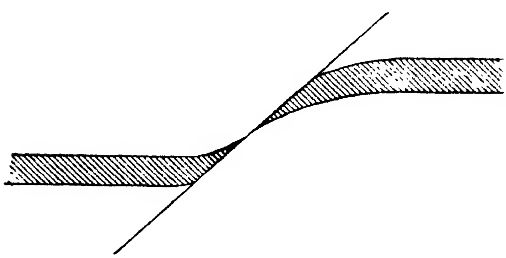
FIG. 49.—A FORM OF FAULT.

It frequently happens that the ends of the faulted seam are curved, as shown in Fig. 49, which fact often affords useful information as to the presence and direction of a fault. Pieces of coal are sometimes found drawn up or down into the intermediate strata of the leader, showing the track or course of the dislocation. "Faults" are the principal cause of stone-drifting in coal-mining, and reference may here be made to questions which commonly arise as to the probable length of such drifts.

(1.) Suppose the perpendicular depth between two parallel seams, which are dipping at the rate of 1 in 18, to be 20 yards, and it is desired to pass from the upper to the lower by means of a level

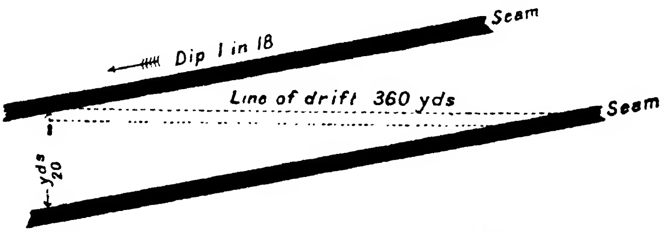

FIG. 50.—DRIFTING BETWEEN INCLINED SEAMS.

drift (Fig. 50); it is required to know the length of the drift to be driven from the one to the other. For every *horizontal* length of 18 yards, the lower seam rises 1 yard: hence the drift will be 20 yards × 18 yards = 360 yards in length before it touches the seam.

(2.) Suppose that a 20-feet dip fault be encountered when driving the main levels, say, in the coal (see Fig. 51), and the inclination of the seam be the same at both sides of the fault—viz., 1 in 18—and it be desired to pass by means of a horizontal drift from the one side to the other. The length of the drift will be 20 feet

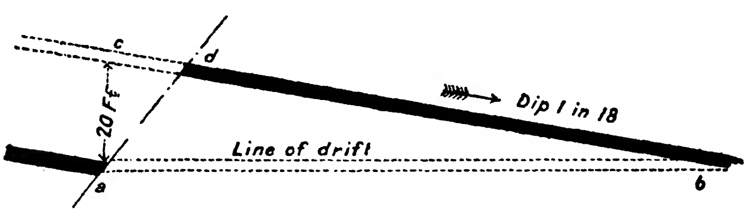

FIG. 51.—DRIFTING THROUGH A FAULT.

× 18 feet = 360 feet. To calculate the distance from the point *c* at which it will be necessary to set away a drift *in the seam*, we may proceed thus:—

$$ab = 18 \times 20 = 360 \text{ feet.}$$

$$cb^2 = ac^2 + ab^2$$

$$= 20^2 + 360^2 \text{ and } cb = 360.5 \text{ feet.}$$

(3.) If the seam in the last instance be taken as level at both sides of the fault (Fig. 52), the length and gradient of the drift would be determined thus:—Supposing the distance from the "staple" to the point at which the drift is to be set away is 300 yards, and the staple 20 yards deep: then

$$ab = \sqrt{20^2 + 300^2} = 300.7 \text{ yards} = \text{length of drift.}$$

$$\frac{300}{20} = 1 \text{ in } 15 \text{ is the gradient of the drift.}$$

It is obvious that in the case of a large upthrow or downthrow fault it is necessary to drift through the stone to reach the seam. This work is carried out by the "stonemen," who enter the place when evacuated by the hewers, by whom work of this kind is not usually undertaken. As a rule the stone work is done by contract (see Chapter VI.).

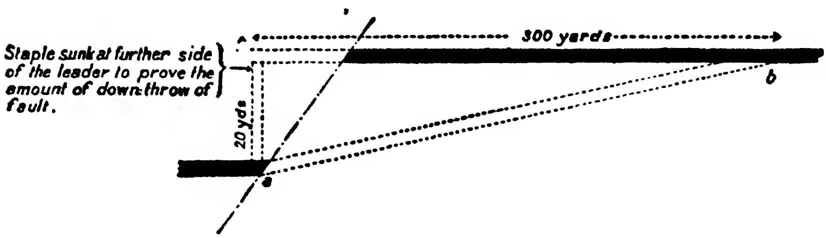

FIG. 52.—DRIFTING THROUGH A FAULT.

The size of the drift will be the same as that of the winning—namely, such as will meet the requirements of haulage and ventilation. The "back" or return-air places need not necessarily be drifted, as a staple will suffice, either inclined or perpendicular (see pages 102 and 110). Of course if four places are being driven, and the system of haulage is such as to make a separate travelling road a desideratum, a second drift will have to be driven for the passage of men and horses. An inclination of 1 in 4 (9 inches per yard) will be found to be about the steepest gradient at which such a road should be driven.

The *gradient* of the main road is a very important point, as may be easily imagined. Presumably that gradient will be the best where the amount of work performed by the horse or machine in drawing the *full* load out is equal to that expended in taking the *empty* load in. This will be found on calculation to be a rise *from* the shaft of about 1 in 120, if the co-efficient of friction of coal-tubs on rails be taken at $\frac{1}{60}$.*

The accuracy of the gradient is assured by the men and officials constantly checking it by means of a levelling lath or tee-bob,

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* The formula for calculating this is as follows :—

$$G = \frac{L - E}{L + E} \times F$$

Where G = gradient (which is a whole number: *e.g.*, G = 10 for a gradient of 1 in 10).
F = fraction representing friction (co-efficient of friction).
L = total load = tubs + coals.
E = weight of empty tubs.

Thus, if we have a weight of, say, 15 cwt. on an incline of 1 in 120 fall towards the shaft, the forces acting on this load are :—

(1.) *Gravity* = a force of $\frac{1}{120}$th of 15 cwt., or $\frac{1}{8}$ cwt., tending to *pull* the load down towards the shaft.

(2.) *Friction* = a force of $\frac{1}{60}$th of 15 cwt., or $\frac{1}{4}$ cwt., acting as a *retarding* agent.

Therefore there is a *minus* force—regarding the shaft direction as *positive*—of $\frac{1}{8} - \frac{1}{4}$ or $\frac{1}{8}$ cwt., *i.e.*, a force of $\frac{1}{8}$ cwt. against movement down the incline.

Again—considering the problem as of an empty and full "set" on an inclined plane, which is of such an inclination that the two "sets" are just balanced.

Then the full load (divided by the gradient), less the fraction for friction, *will equal* the empty load (divided by the gradient) plus the fraction for friction.

Hence we arrive at the following equation, and finally the formula, for discovering the best gradient for a haulage load :—

$$\frac{L}{G} \text{ (acting downhill)} - FL \text{ (acting against movement downhill)}$$

$$= \frac{E}{G} + FE$$

$$\therefore \text{ transposing } \frac{L}{G} - \frac{E}{G} = FL + FE$$

$$\text{and } \frac{1}{G}(L - E) = F(L + E).$$

$$\text{Dividing by } L - E \text{ we have } \frac{1}{G} = \frac{F(L+E)}{L-E}$$

$$\text{and inverting } G = \frac{L-E}{F(L+E)}$$

constructed to suit the gradient determined upon. Fig. 53 represents a levelling lath, and Fig. 54 a tee-bob, made for a rise of 1 in 12.

The *direction* of the main roads is a matter of equal moment to that of the gradient, and having been carefully determined beforehand, should in course of fulfilment be constantly checked by the surveyor by means of the compass or theodolite. The usual

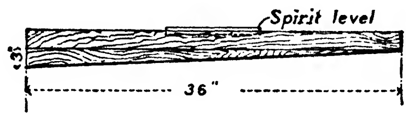


FIG. 53.—LEVELLING LATH.

method pursued is to fix in line with each other in the axis of the "drift"—that is, in the course at which the drift has to be driven—two or three vertical strings or plumb-lines suspended from the roof, a few yards distant the one from the other, and at a sufficient distance back from the face to ensure their not being deranged by the blasting operations. Standing at the farther outbye plumb-line, and sighting it in line with the others, this line may be prolonged into the working face, and a chalk mark made on the roof to guide

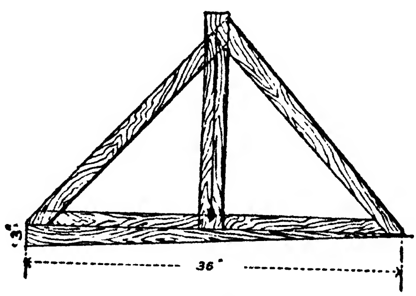


FIG. 54.—TEE-BOB.

the men who are driving the road. By this means the direction in which the "place" is going may be checked at any time. Whenever it is deemed desirable to shift the plumbs farther inbye, their relative positions should be redetermined by means of the compass or theodolite. These plumbs—or rather the points from which the strings are hung—should be fixed near one side of the road, rather than in its centre. If the road is driven crooked, a sight along the plumb-lines, when hanging near one side, will strike one side of the road and soon show the deviation.

Curved Roads.—This mode of procedure with respect to driving straight roads is simple and easily understood, but when it is necessary or desirable to drive a road on a curve—as for instance at the point of junction of a branch road with a main road (especially where the mode of haulage is main and tail rope, and the radius of curves is important), it is somewhat more complicated. Supposing it is desired to drive a curve of say 70 yards radius between the points A and B for an engine way. First determine

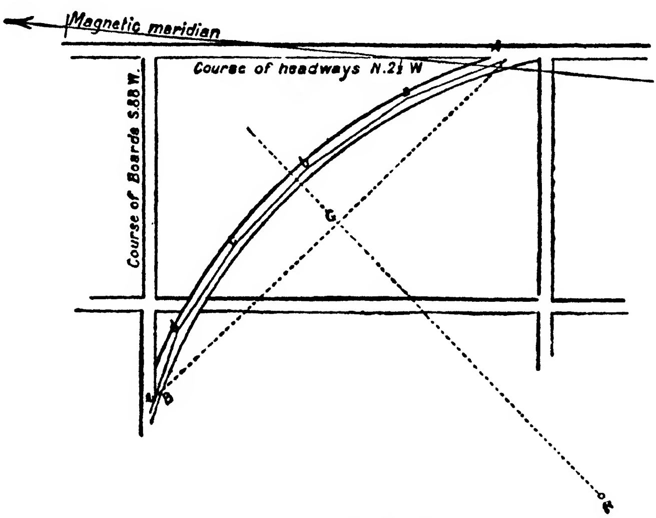


FIG. 55.—MODE OF LAYING-OUT UNDERGROUND CURVED ROAD.

the *magnetic* bearings of the two roads, then plot these as shown in the sketch (Fig. 55). Join A B by a straight line and bisect the same; and with radius (70 yards) describe the arc as shown. Draw the lines A*a*, *ab*, *bc*, *cd*, *de*, making them as equal as possible. Having done this, determine the course of these lines, as it is by these courses that the curve will have to be driven. As there will necessarily be a corner or "knob end" where a course terminates and another one commences, these are afterwards trimmed off by the hewer. Care must be taken to keep the marks in the centre of the place, otherwise the curve when complete will not be a true segment of a circle.

A curve may also be driven by means of plumb-lines. Suppose that it be desired to connect the two roads A B, C D (Fig. 56), by a road on a curve of 1 chain radius. To find the required offset in inches, divide the square of the distance between the plumb lines in inches by the radius of the curve in inches. Assuming that 11 feet is the distance between the plumb-lines, then

$$\frac{(11 \text{ feet} \times 12)^2}{792} = 22 \text{ inches.}$$

As each length of 11 feet is driven, the back plumb-line must be moved 22 inches at right angles to the previous line, and the line

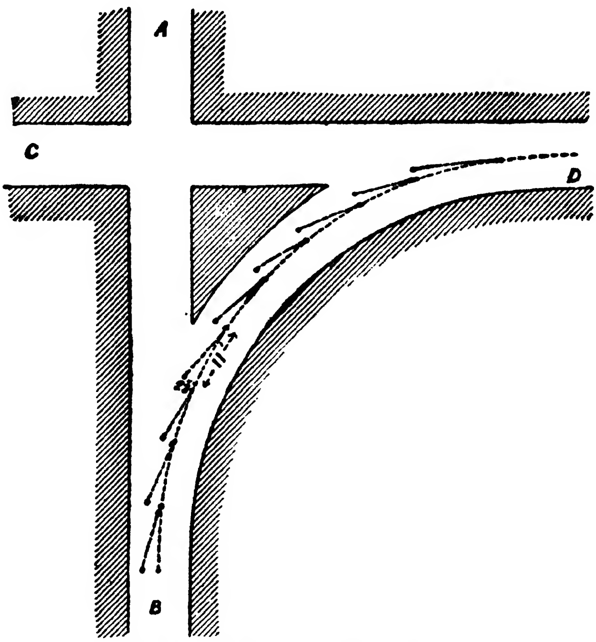
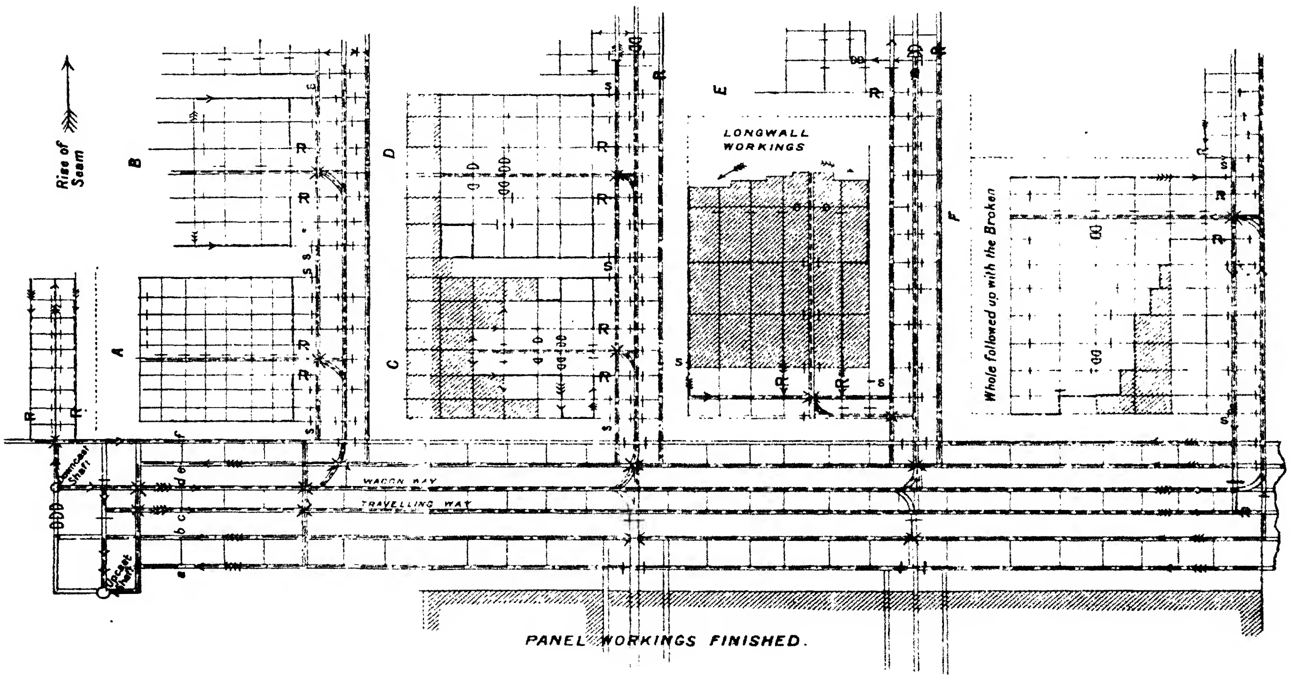


FIG. 56.—MODE OF LAYING-OUT UNDERGROUND CURVED ROAD.

between the two plumbs then gives the direction for the succeeding 11 feet of road.

The winning places having been driven a sufficient distance to allow of the fuller working of the seam, it becomes necessary to consider the manner in which the districts must be laid out, the size of the pillars, and the accompanying details. At the present day, when competition is so keen, and the most careful economy has to be practised in even the smallest items, the question of "produce"



Sketch Plan of a Mine worked on the Panel System.

REFERENCES.—Intake airways, - - - - ; Return airways, —— · —— · ——; Shaded part, goaf; Air-crossing shown thus, X; Regulators, R; Stoppings, - Doors, D; Arrows denote direction of air-current; Scale of air shown thus, 8.

or yield of round coal is one of vital importance. It is, therefore, necessary, before laying out districts of pillar workings, to carefully consider all the varying peculiarities of the seam, and to leave such pillars as, being adapted for removal with safety to workmen, will also yield a good percentage of round coal, and can be economically worked. The authors do not pretend, nor indeed do they think it possible, to lay down any hard and fast lines as to how this system of working should be carried out in all cases, as the circumstances at various collieries are so many and diverse as to necessitate the adoption of different methods both in the laying out of pillar workings and in their removal. Before they proceed to enumerate and describe in detail some of the methods that have come under their actual observation, a brief general description of the system of working may be given.

Panels.—In Plate XXVI. the main winnings are represented by *a*, *b*, *c*, *d*, *e*, *f*, and the districts, or "panels," by the letters A, B, C, D, &c. As already stated, the honour is due to Mr Buddle of having been the first to lay out workings on the panel system, and to demonstrate its practical advantages. The panel system * is briefly this:—The pit is divided into districts of varying area—30 acres or more—separated from each other by barriers of solid coal, generally from 30 to 60 yards wide, which, when the district or districts are being brought back in the broken, are removed in the manner to be described further on. The advantages derived from the introduction of this improvement in the bord and pillar system of working, such as the separate

* In connection with panel working, an interesting point was raised in the case *Wales* v. *Thomas* (High Court of Justice, Queen's Bench Division, 6th November 1885), respecting the meaning of the expression "out of the mine *or part of the mine*" in the Mines Regulation Act of 1872, and involving the question in what circumstances shots may be fired. "Timid people," said Mr Justice Day in his summing up, "are invariably getting into difficulties which other people avoid, and that is constantly the result of using words out of abundance of caution: you raise doubts and difficulties which would otherwise never have arisen at all. Having provided that 'part of a mine' having a separate system of ventilation shall be a 'mine' for the purposes of the Act, it was, no doubt, quite unnecessary to say that persons shall be "out of the mine or out of the part of the mine' where gunpowder is used." *Part* is equivalent to *panel*, which under the Act of 1872 could be regarded as a mine; where not divided into panels, then the men would have to be out of the pit proper when shots were fired, *part* in this case being used as in common parlance, whereas a panel has a separate intake and return airway of its own, and is to all intents and purposes a separate mine.

ventilation of each district, localisation of creep, and in some cases the force of explosions,* &c., have been already noticed (see Chapter I.).

Size and Shape of Pillars.—As in the case of shaft pillars, so also with ordinary pillars, the question of size is most important, but this has to be considered in connection with the manner of working them, no less than with the depth of the seam from the surface. When, for instance, the "whole" is followed up closely by the "broken," a smaller size will suffice than when the pillars have to stand some time before removal.

The dead load or statical pressure is sometimes asserted to increase directly as the depth of the seam from the surface, and to be the product of the depth into the average density of the overlying beds. A cubic foot of sandstone weighs roughly 150 lbs., of shale 160 lbs., of coal 82 lbs. As the strata of the Northern coal-field consist of frequent alternations of these, usually in the proportion of 20 sandstone and 12 shale to 1 coal, the average weight may be taken at 144 lbs. per cubic foot, or at the rate of 1 lb. per square inch for each foot in depth from the surface. The crushing strain of coal has been roughly estimated to be from 2,000 to 4,000 lbs. per square inch. Therefore at a depth of 2,000 to 4,000 feet the statical pressure on a coal seam is equal to its cohesive strength.

It is very doubtful, however, whether the actual top pressure on a seam is directly proportional to the depth. Certainly in practice it is often easier—that is, it requires less timbering, &c.—to support the roof of a mine in a seam 150 fathoms deep than in one 30 or 40 fathoms deep. Much depends on the nature of the strata for 2 or 3 fathoms immediately above the seam. From the numerous instances hereinafter mentioned (see Chapter XI.), it may be gathered that in actual practice, the size of pillars is certainly not proportional to their depth. In deeper mines, 700 and 800 yards, much difficulty has been experienced from the heavy pressure, which in some instances has crushed brick arching, 3 to 4 feet thick.† The pressure seems to be *relatively* greater at greater depths

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* In some of the heavy colliery explosions of modern times, however, in which coal dust has played such an important part, the explosive force has been generated or propelled along the main roads of the mine irrespective of districts. The panel system, therefore, does not in such cases appear to have much localising influence.

† See *Fed. Inst. Trans. of Mining Engineers*, vol. viii., p. 410, paper on the South Staffordshire Coal-Field, by F. G. Meachem.

than in shallower mines. Thus the late Mr Forster Brown stated "that in South Wales, where there was a great pressure at 2,200 feet, at half that depth there was not a corresponding pressure." At great depths the difficulties of pillar working will much increase.

It has been stated as a general rule that at the depth of 50 to 100 fathoms from the surface, pillars should be 30 by 40 yards; from 100 to 150 fathoms, 40 by 50 yards; and from 150 to 200 fathoms, 40 by 60 yards, or 50 by 50, and so on.

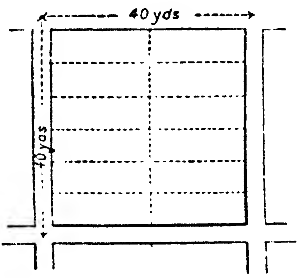

FIG. 57.—PLAN OF A SQUARE PILLAR.

The shape of the pillar is also important. A square pillar is probably the best support for the top pressure, but as a matter of fact pillars are oftener made oblong, as being easier to work off in the second working, the "juds" (as the successive slices whereby the pillar is removed are termed) not having to reach so far as in

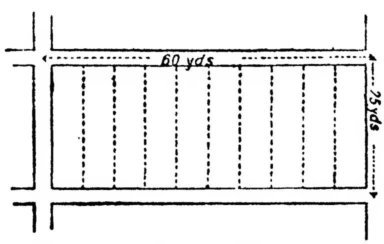

FIG. 58.—PLAN OF AN OBLONG PILLAR.

the instance of a square pillar, or where it is necessary to "jud" from one side of the pillar only. See annexed illustrations, Figs. 57 and 58.

The size of a pillar should be such as to prevent any general movement of strata, either in the whole working, or at the face in the broken working. When pillars are left too small, the well-known results termed "creep" and "thrust" ensue, as already described (page 7).

The relative proportions of coal wrought by the first and second workings—that is, by "whole" and "broken"—is of course determinable by the proportionate areas of excavation (bords and walls) and pillars. To give an instance (see Fig. 59). The bords are driven 6 yards wide, and are 50 yards long, centre to centre. The walls are 3 yards wide, and 30 yards long, centre to centre. The pillars are said to be 30 × 50, centre to centre, but the actual area of

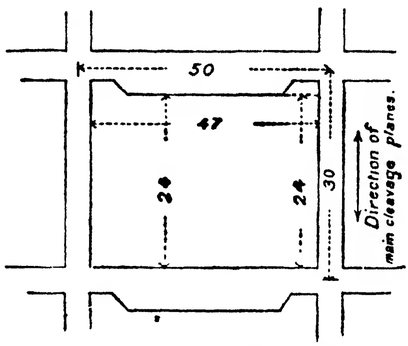

FIG. 59.—SKETCH ILLUSTRATING PROPORTION OF COAL LEFT IN PILLAR (Dimensions stated in yards).

coal left is equal in area to 24 × 47 = 1128 square yards. Therefore there is excavated in the first working an area equivalent to 372 square yards, or 24.8 per cent. of the coal is worked in the "whole." In this calculation no allowance has been made for turning the bord away narrow, as is often done, the first and last two yards of the

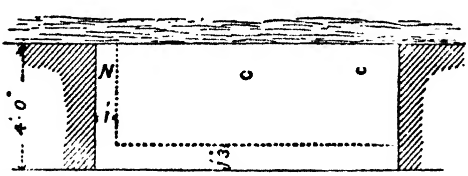

FIG. 60.—SKETCH SHOWING POSITION OF KIRVING, NICKING, AND SHOT-HOLES.

bord being 3 yards wide instead of 6 yards. This leaves more support for the roof where the two roads cross. If great accuracy is desired, this would have to be taken into account in the calculation.

The manner of working the coal at the face, as pursued by the coal-hewers, claims some attention. Where the seam is a soft one, and round coal is not particularly wanted—as, for instance, where it is made into coke, or used for making gas—the coal will be hewn down in such manner as suggests itself to the hewer as best fitted to secure merely the largest possible quantity. If, however, the seam is a hard one, or large (that is " round ") coals are wanted, as is the case with steam and household coal seams, certain modes have to be adopted by the hewer in order to work his place to the best advantage, and at the same time produce the highest possible

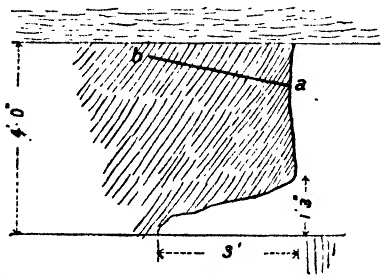

FIG. 61.—SECTION OF A "PLACE" SHOWING POSITION OF SHOT-HOLE, AND KIRVING.

percentage of round coals. He will, therefore, undercut, or, as it is locally called, " kirve " or " hole " the seam across the full width of the place (bord, or wall, as the case may be). This excavation should not exceed about 15 inches in height at the face, tailing out to nothing, and running generally about 3 feet into the seam.

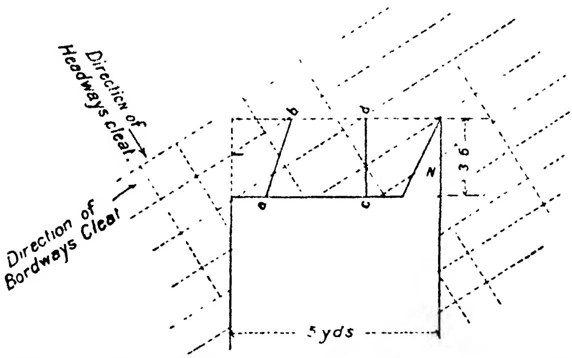

FIG. 62.—SKETCH SHOWING POSITION OF SHOT-HOLES AND NICKING IN A CROSS-CUT.

This process is known as " kirving a jud," and is preparatory to bringing down the coal by shot-firing or by wedging. In order to loosen the overhanging coal at one side, and also to save shattering effects on the coal where the shot is fired, the " place " is " nicked " up one side (N, Fig. 60), the shot being placed at the other side. The kirving and shot-hole are shown in section in Fig. 61.* Fig. 62

* It is worthy of note that under the Explosives in Coal Mines Order of 1st September 1913 " no shot shall be fired in coal unless the coal has been

represents a "cross-cut," with one set of dotted lines showing the bordways "cleat," while the other dotted lines at right angles to the bordways show the headways "cleat." Where these cleavage planes or other "backs" or "partings" in the seam run more or less diagonally across the "place," the nicking (N, Fig. 62) should be at that side of the place which forms an acute angle with these "backs," and the shot at the other side. The force of the shot is exerted along these lines, and therefore when they are running into the seam from the shot-hole, more coal is likely to be brought down.

Shot-Firing.*—The process of charging and firing a shot in coal—in those mines where the use of gunpowder is admissible—is briefly this : A hole is bored, about an inch in diameter, and of the same depth as the kirving ; the *débris* is cleaned out with the scraper (see Fig. 10) ; the cartridge or cartridges of explosive are put into the back of the hole ; the pricker (see Fig. 11) is inserted, and the hole is then "stemmed" round the pricker with the "beater" (see Fig. 9) to the out-end of the hole. The "stemming" or "tamping" material is usually either soft clay or seggar (fireclay) crushed up into a more or less powdery condition, for no inflammable substance (*e.g.*, small coal or coal dust) is permissible for stemming, and the stemming has to be provided by the owner, agent, or manager of the mine (*Explosives in Coal Mines Order*, 2 (*b*)). When the hole has been stemmed, the pricker is withdrawn, and a squib or fuse is then inserted in the hole made by the pricker. The deputy or hewer then very carefully examines the "place" and parts contiguous to it, and if he discovers no gas, he unscrews his lamp, sets fire to the squib or fuse, again screws his lamp, and adjourns to a place of safety until the shot explodes.

Squibs are not so much in use as formerly for firing shots owing to the fact that the use of safety lamps has become so much more extended. For it is only in those mines in which the use of safety lamps is not required by the Coal Mines Act, and where the

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holed to a depth greater than the depth of the shot-hole," a provision which is not applicable to an anthracite mine or any mine which may be exempted by the Divisional Inspector on the ground that, by reason of the character of the coal or the inclination of the seam, holing would be impracticable or dangerous.

* The regulations as to the use of explosives in coal mines are contained in the Explosives in Coal Mines Order of 1913, which mining students should study in detail.

mine or part of the mine is not dry or dusty that squibs may be used. The old-fashioned straw (or "kitty" of the northern miner) is a thing of the past, the nature of the present-day squib being specified in the fifth schedule of the Explosives Order.

In so far as the use of explosives is concerned, the mines under the Coal Mines Act of 1911 are divisible into two classes, viz., (1) mines generally, and (2) those in which special provisions are operative. Under the latter are included all coal mines in which inflammable gas has been found within the previous three months in such quantity as to be indicative of danger, or coal mines which are not naturally wet throughout. In regard to the latter class the regulations are particularly stringent, and no explosive other than a permitted explosive, as defined in Orders, may be used or taken into the seam or seams in which the gas has been found, or any shaft or drift communicating therewith, or any dry and dusty part of the mine or shaft or drift communicating therewith.

Furthermore, all shots have to be fired by a competent person appointed in writing by the manager, and such person must not be one whose wages depend on the amount of mineral to be gotten, and he must have obtained a shot-firer's certificate. The shot-firer has to keep a daily written record of the number of shots fired by him, and the number of cartridges in each shot. Every shot has to be charged and stemmed under his supervision, and no shot shall be fired except by means of an efficient magneto-electrical apparatus so enclosed as to afford reasonable security against the ignition of inflammable gas.

In the main haulage roads and main intake airways or any place immediately contiguous thereto, unless naturally wet throughout, no shot shall be fired without the special permission in writing of the manager or under-manager, and only then when the workmen have been removed from the seam in which the shot is to be fired, and from all seams communicating with the shaft on the same level, except the men engaged in firing the shot, and, in addition, such other persons (the number of whom is specified and is determinable by the number of persons employed in the mine) as are necessarily employed in attending to the ventilating furnaces, steam boilers, engines, machinery, winding or ventilating apparatus, signals, or horses, or in inspecting the mine. There is one further important exception, viz., in respect of those mines in which mechanical haulage is used for hauling mineral from the face, and the movement of the strata renders it necessary to maintain the height of the roads by ripping, in which case the provision as to the removal of the workmen does not apply to those men who are so employed within a distance of the face as may be fixed by the manager with the approval of the Inspector of the Division.

These are some of the more important of the regulations in regard to shot-firing, but all the regulations are of importance; and it is more than probable that the comparative freedom of late years from the great explosions which characterised the coal-mining industry in the past is in large measure due to these and the regulations as to rendering the coal-dust in mines innocuous.

Miss-Fires.—Under the Explosives in Coal Mines Order of 1913, "No explosive shall be forcibly pressed into a hole, and when a hole has been charged, the explosive shall not be unrammed nor shall any part of the stemming be removed nor shall the detonator leads be pulled out," and "before any shot is charged, the direction of the hole shall, where possible, be distinctly marked on the roof or other convenient place"—a very necessary precaution as, in the case of a miss-fire, it is then possible to avoid drilling into the charge when boring a second shot hole.

The precautions which must be taken, which are contained in Clause 3 of the Explosives in Coal Mines Order, may be quoted *in extenso*:—

"If a shot misses fire:—

"(*a*) The person firing the shot shall not approach or allow any one to approach the shot hole until an interval has elapsed of not less than ten minutes in the case of shots fired by electricity or by a squib, and not less than an hour in the case of shots fired by other means.

"(*b*) If he has occasion to leave the place, he shall fence off the place before leaving, and attach to each fence a danger board indicating the presence of a miss-fired shot.

"(*c*) A second charge shall not be placed in the same hole.

"(*d*) If the shot was fired electrically he shall, before approaching the shot hole, disconnect the cable and the removable handle from the firing apparatus, and shall examine the cable and connections for any defect.

"(*e*) Except where the miss-fire is due to a faulty cable or a faulty connection, and the shot is fired as soon as practicable after the defect is remedied, another shot shall be fired in a fresh hole, which shall be drilled not less than 12 inches away from the hole in which the shot has missed fire and shall, as far as practicable, be parallel with it.

"(*f*) If the miss-fired shot contained a detonator, the person firing the second shot shall, before doing so, attach a string to the electric leads or the fuse of the miss-fired shot, and secure it by attaching it to the cable or to a prop or otherwise.

"(*g*) After the second shot has been fired no person shall work in the place until the person firing the shot or an official of the mine has made a careful search for the detonator and charge of the miss-fired shot. If the detonator and charge are not found the stone or mineral shall be loaded under the supervision of the person firing the shot or an official, and sent to the surface in a specially marked tub. The search for the detonator and charge, and the loading of any stone or mineral which may contain a detonator, shall be carried out as far as possible without the use of tools.

"(*h*) Should the miss-fired shot not be dislodged by the second shot, further holes must be drilled, and the same precautions taken as aforesaid.

"(*i*) The person or persons firing the shots shall report the circumstances to the manager or under-manager without delay, and the number of cartridges, if any, which have not been found, and hand to him the detonator and charge, if found."

The requirements as to the non-removal of the stemming and the pulling out of detonator leads and of all of the requirements contained in Clause 3 of the Order, which we have quoted in full, do not apply in cases where an exemption has been obtained from the Secretary of State on the ground that an appliance is used which enables the detonator to be removed with safety after the shot has been charged. In this respect exemptions have been granted in respect of shots which are fired with the use of the apparatus known as (1) the "P.P." apparatus, and (2) the "Adder" apparatus, for a description of which see Appendix III.

Shot-firing is still the chief cause of explosions, as the recent (1922) examples in Cumberland (Haig Pit, Whitehaven, and St Helen's, Workington) and Scotland (Plean Colliery) have shown. It is the ignorance or carelessness of the shot-firer that is generally at fault.

For every shot fired there are three points to be considered—(1) the placing of the shot; (2) the quantity of explosive to be used; (3) the stemming of the shot.

To be able to decide rightly on these points a man needs training and experience.

The training and the selection of suitable men as shot-firers is an important duty of the colliery manager.

It is a useful practice to use numbered detonators, and to keep a record of their issue, so that every shot fired can be traced to the shot-firer. This tends to make him more careful in the exercise of his duty, knowing that he can be brought to book for a miss-fire or accident.

Sump and Back End.—Whilst dealing with the details of face work, mention may be made of a method known locally in the North as "Sump and Back End." In driving places "on end," or "headways way," both in the whole or broken, after kirving across half the place, and nicking up one side, a hole is drilled about the centre of the place, and a shot fired, which brings down that "sump," as it is called. The hewer then frequently proceeds to take out a similar sump in the same half of the place, thus leaving a "back end," which may be kirved bordways, and brought

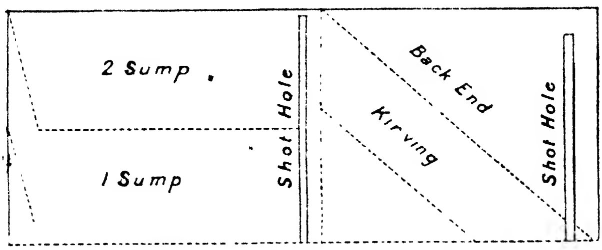


FIG. 63.—SKETCH ILLUSTRATING "SUMP AND BACK END."

down altogether by one shot in the right or left "nook" as the case may be (see Fig. 63). In wide places driven "on face," or bordways way, in a similar seam, frequently no nicking is done, but the hewer kirves the place for its whole width, and fires two shots—one in the left nook and the other in the centre—to bring down half the width of coal, and two more shots for the other half.

In working some of the coking coal seams of West Durham in the "whole," in the wide bords the kirving is sometimes made 5 feet in, and the first hole for the "breaking-up" shot is drilled to about this depth—"shooting fast" being allowed and there being no nicking, as round coal is not especially wanted. The diameter of such a shot-hole is usually about 1 inch, but the drills vary from $\frac{3}{4}$ inch to 2 inches. Sometimes as much as 32 inches of powder = about 1 lb. will be fired in this shot; but a more usual quantity is 20 inches = about $\frac{2}{3}$ lb. The back-end shot is lighter. The length of shot-holes, and the amount of explosive used, vary according to the nature of the seam, the work required to be done, and the size of coal wanted Eight oz. of powder is perhaps an average charge.

Ventilation in Panel Working.—There are several ways of ventilating panels when "going in the whole," and those most frequently adopted may be briefly described :—

(1.) *Where the workings are not subject to much gas*—that is, in pits which cannot be termed fiery—the air-current is directed as shown in Fig. 64.

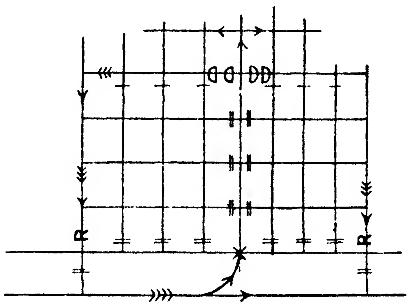


FIG. 64.—PLAN OF VENTILATION IN PANEL (NON-GASSY).

(2.) *Where the seam generates gas* to such an extent that it is frequently detected by the lamp in the workings—in other words, in mines which are classed as fiery—the mode of ventilation shown in the next diagram, Fig. 65, is usually pursued. In this case, the return air is caused to pass through a regulator fixed in the place

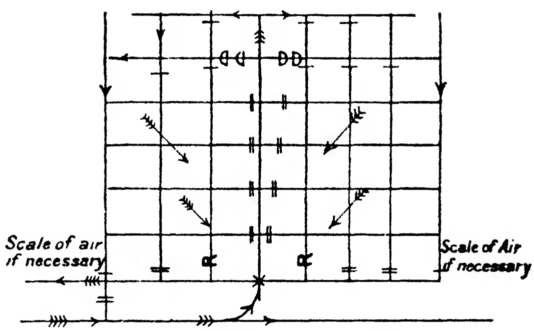


FIG. 65.—PLAN OF VENTILATION IN PANEL (GASSY).

next to, and parallel to, the haulage road, so that the air has to pass through all the old workings before it reaches the regulator and makes its exit into the main return.

(3.) *Where the pit, or part of the pit, is very fiery*, and subject to "blowers" of gas—which may continue to give off large volumes at a high pressure for a considerable time, sometimes not diminishing for years—the system of "shething" or coursing the air to and fro along the passages (as shown in Fig. 66) is adopted.

The air is said to be "shethed," or coursed, "one and one," or "two and two," when it is carried along the top end of a row of pillars and back along the bottom (Fig. 66) of the same row, or along the top of one row and back again along the bottom end of a second

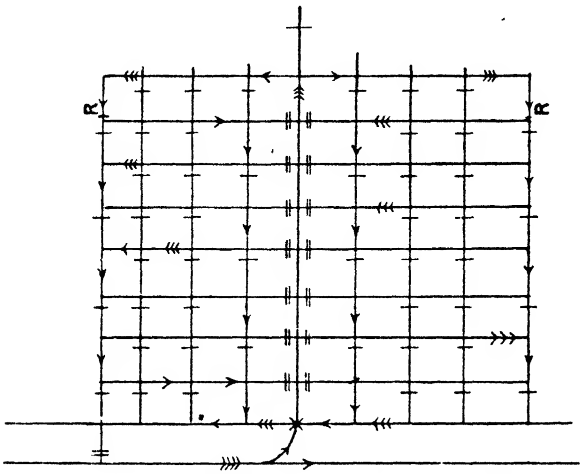


FIG. 66.—PLAN OF VENTILATION IN PANEL (VERY FIERY).

row of pillars (as in Fig. 67), respectively. Where the seam in work is exceptionally fiery, it may be necessary, or at any rate desirable, to course the air "one and one," but it will be seldom that such a condition of mine will exist as to render this impera-

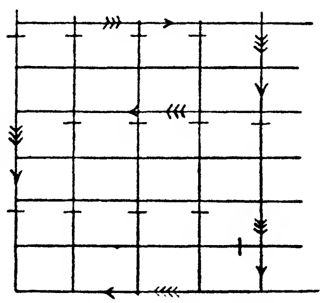


FIG. 67.—PLAN OF VENTILATION IN PANEL (VERY FIERY: COURSING AIR TWO AND TWO).

tive, and usually in fiery mines it will suffice to course the air every three or four pillars.

A Practical Example.—Where the bords and walls soon become filled with fallen stone, or where districts are subject to creep and thrust, and it is therefore desirable to work out the coal as soon as possible, the pillars are removed soon after they have

been formed—or, as the expression is, "the whole is followed up by the broken." This manner of working is shown in the accompanying diagram, Plate XXVII. The broken is aired with the current from the whole workings, and the scale on the doors *a a*. The sketch represents varied circumstances which are encountered in bord and pillar workings, as indeed in other methods also, and which tax the judgment and the ingenuity of the colliery manager. The information which it is intended to convey may be conveniently expressed in the form of question and answer, the question being of a type commonly occurring in the examinations for colliery managers' first-class certificates.

Given, then, that the seam is 4 feet thick, and free from intervening bands; that the roof and thill are fairly good, requiring only ordinary timbering; that the position of old goaves, and the issue of gas, are as shown on the plan. Mark on the plan the position of the landings and putters' "flats," and state the volume of air required in each split, denoting the air currents by arrows, brick stoppings by double lines, brattice stoppings by single lines, doors thus, D; scales thus, S; regulators thus, R; and air-crossings by an X. State also the number of hewers per shift, the tons per hewer per day, and the number of deputies required, the hewing price per ton being 1s.

The answers will be as follows, and as shown on Plate XXVII. Amount of air in splits :—

	4,000	cubic feet	per min.
	6,000	"	"
	5,000	"	"
	2,000	"	"
	1,000	"	"
Total ...	18,000		

Number of hewers per shift, 30; total number, 60; average hewers' wage per shift, 5s., to earn which the average tons per hewer per shift must be 5, and the tons per day 300; number of deputies, 3 per shift = 6 total.

In connection with the mode of working "following up the whole with the broken," attention should be given to the necessity of keeping an airway, of such dimensions as will permit it to be easily travelled by the officials, from the last working place in the whole to the commencement of the broken, and from the last broken working to the main return airway for the district.

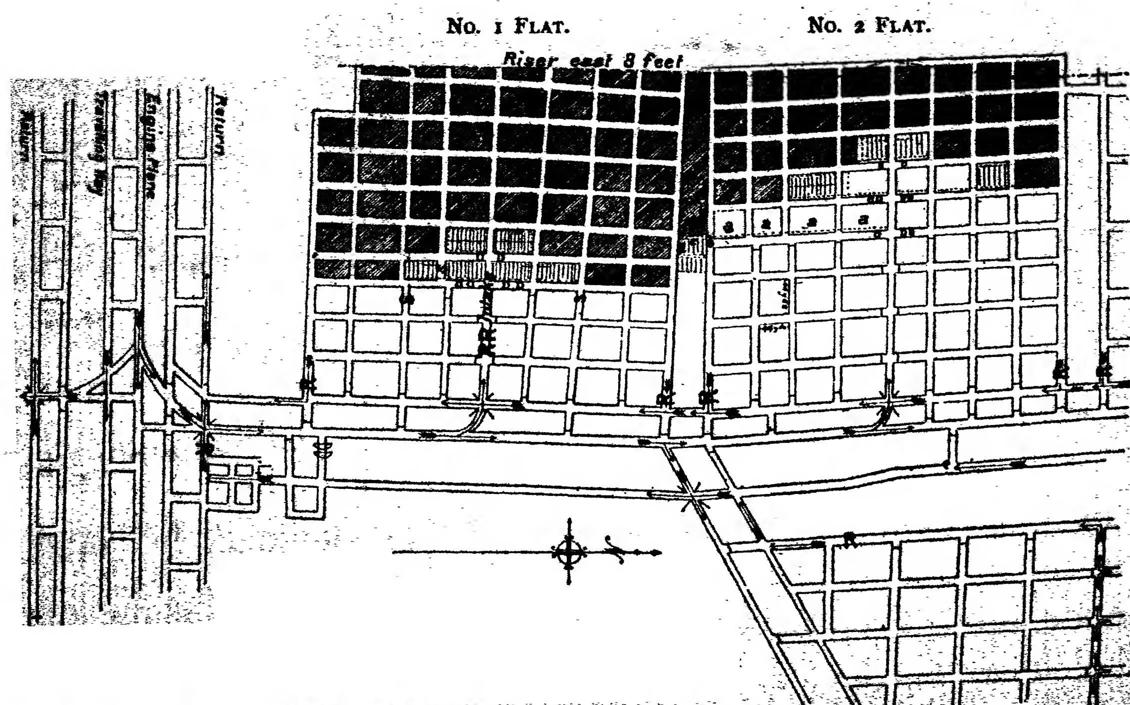
Stoppings.—The bord-end stoppings are usually made of wood brattice. They keep the air on to the face. The permanent main stoppings alongside the rolleyway, and the "regulator" stoppings—or the stoppings which direct the air on to the regulator, and which are in a line with it, and are moved forward when it is advanced—are best constructed of stone or bricks, well plastered over with hair and lime to make them air-tight (see page 175).

The Position of the Regulator is an important factor in the practical ventilation of colliery workings. As a general rule, in panel workings such as we have described, it should be as near the face as is conveniently practicable, as by so placing it the air pressure on the haulage road (intake) stoppings is greater than if the regulator were placed on the outbye side of these stoppings. For the same reason it is desirable to have the return airways skirting the haulage (intake) road on either side, one pillar distant, so that any gas issuing from the old workings may pass into these airways and be swept away by the return air into the main returns, and that there may be no risk of gas leaking through the stoppings on to the intake airway. A "scale," if any, is usually placed in the furthermost corner of the panel next the main return, so as to act as a drain or gas-tap to the old workings.

Fire-damp being lighter than air, it naturally rises to the highest workings of a district. In mines subject to much gas, this is often a source of considerable inconvenience, especially if other circumstances are such as to necessitate the workings being driven to the dip. In such instances it is often found desirable to have a gas-tap (Plate XXVI., page 185)—that is, an outlet—at the highest possible point of the workings; and if these are coming back in the broken, this passage should be kept open up to, and for some distance into, the old workings, so as to act as a relief to the pressure of gas accumulating in them. This mode of drawing off the gas is known as "ascensional" ventilation.

Plate XXVIII. represents a set of two panels, both in course of being brought back in the broken. The diagram is taken from an actual colliery plan of a Durham mine, with the addition that the skirtings, juds, &c., are shown in detail.

When working in the whole, the air was conducted along the face by means of wood brattice, which was fixed by the deputies to the props. Sometimes a row of props had to be set specially for the brattice. It ought to be kept within a few yards of the face, and the joints in fiery pits should be well pointed with lime, or



Plan of Broken Workings, Bord and Pillar System.

REFERENCES.—Shaded part, goaf; Air-crossing shown thus, X; Regulators, R; Doors, D; Stoppings, —; Air-Scales, S; Arrows denote direction of air-currents.

" cleaded " with strips of wood, as it is astonishing what a quantity of air may be lost and never reach the face when this is not carefully done. A place fouled with gas may sometimes be cleared by merely pointing the brattice and making it air-tight. Another matter requiring attention is the canvas doors at the place ends, which force the air up the brattice.

The workings shown in Plate XXVIII. were in a seam of which the following was a section :—

	Feet.	Inches.	
Top coal	1	6	Unworked, being inferior coal.
Good coal	3	6	Worked ; but running through the middle is a band of grey coal 5 inches thick, together with a band of stone 1 inch thick, which were cast back.
" Slippery " band, on which the men kirved	0	1	Picked out and cast back
Good coal, which was taken up after the main or middle part of the seam was wrought ...	0	6	Worked.
Bottom or steam coal ...	1	0	Worked.
Total thickness of seam	6	7	

The seam dipped 1 in 18 to the east, and was, at the shaft, 147 fathoms from the surface. The roof was generally of soft sandstone, but the top coal, being left, formed a fair support when working in the whole. The thill was a bed of sandstone similar in quality to that forming the roof. The pillars were made 44 × 44 yards, centre and centre. The character of the coal, when " going in the whole," was decidedly strong, a feature characteristic of the seam in question.

When a " flat," or " panel," had reached the determined distance, broken working was commenced at the two extremities, the pillars being removed on some regular plan, and a proper (diagonal) line of advance kept, so that no pillar, or portion of a pillar, was left surrounded with goaf. Neglect of this precaution would have caused some of the coal to be crushed and lost. As all bords and walls had fallen, the pillars were skirted along the bottom end for a " going headways," and the pillars either judded to the rise the full breadth—40 yards—the last jud being shortened by a lift driven so far along the top end of the pillar ; or the pillar was jenkined up one side, skirted along the top end, and juds driven half-way down, the other half of the pillar being taken off by judding from the bottom end.

In order to work the barrier, a skirting (*a*) was driven south along the bottom end of the row of pillars next to be worked until it reached the barrier, and so served in the future as a place from which juds might be driven; the barrier was then jenkined (*b*) down by the side, and a narrow place (*c*) driven into the solid through the barrier (provided it was of convenient width: if it was too wide, it was worked from both districts), and juds (*d*) turned away to the east and west--those going westward holing into the barrier goaf, and those turned away to the east being driven the required distance, whatever it might be.

In working in the broken—where the roof was composed of soft shale, and apt to " come on " or " weight," however well timbered the place might be—when a pillar had been removed by judding, excepting the last jud, it was not unusual, especially when the pillar happens to be the one next to the waggon way, to take off this last 5 yards, or the width of a jud, by a series of headways lifts, that is, places about 5 yards wide driven in a headways direction in a pillar from the waggon way—for if it were attempted to take it off by a bordways jud, it would most certainly have broken down.

When a jud did fall, the method usually adopted of again reaching the face was seldom that of ridding out the fallen jud, as the cost of so doing would have far exceeded that of the lost timber and rails. It would be " dead work," no coals being obtained in the operation, besides the loss caused by having to send out stones in the tubs, instead of coals, if the stones could not be stowed in the workings. But a narrow place was turned away, and the fallen jud skirted or jenkined, as the case might be, " loose at an end," until the termination of the fallen jud was reached, when a " siding-over " was driven 5 yards across the face, and the jud continued.

The following is a list of the yard prices paid at this pit (1890):—

WHOLE WORK.

				s.	*d.*
Winning headways	2	yards wide	... ...	1	10 per yard.
Walls, N. & S.	2	"	... ...	1	9 "
Winning headways	3	"	... ...	1	3 "
Walls, N. & S.	3	"	... ...	0	6 "
Bords	2	"	... ...	1	4 "
Do.	3	"	... ...	0	10 "
Boring...	...	...	... ...	0	10 for 10 yards.

BROKEN WORKING.

				s.	*d.*	
Half-pillar walls	2 yards wide		... ...	0	11	per yard.
Do. do.	3 ,,		... ...	0	7	,,
Skirtings	2 ,,	"loose at an end"		0	7	,,
Jenkins	2 ,,	"fast at both sides"		0	9	,,
Do. ...	...	"loose at an end"		0	7	,,
Removing stooks	... ...	...	...	0	10	per stook.

The score price for hewing in the whole was 12s. 6d. for 21 tubs of 11 cwt. each = 13d. per ton. The broken price was 9s. 5d. = $9\frac{3}{4}$d. per ton.

In working the barrier dividing the two districts, a communication was effected between them, so that the question arose—Which way would the return air of either district take? Would it pull from the first to the second, or *vice versâ*? If no definite precautions were taken to keep it in one direction, it might, if there were heavy falls, or obstructions of any kind, in the returns of No. 1 flat, pull from this district to No. 2 district, carrying the gas with it from the goaf edge if there were a low barometer, and so foul all the workings in No. 2 flat which it passed. In order to avoid this, the following steps were devised, which may be followed with advantage in similar cases: Two* regulating doors, R R, were put in the intake of No. 1 flat, the area of which let us suppose to be 7 square feet each, the regulator in the north side return being 10 square feet area, so as not to materially check the efflux of the return air. The regulating doors on the intake of No. 1 district acted as a check on the air passing through the apertures at a high velocity, and against a corresponding resistance, but in the north side return there was less resistance and an easy road. Now, as there was no obstruction offered to the intake air of No. 2 district, there would be a considerable volume passing in it, more than in No. 1 flat; and as the regulator in the north return of No. 1 was capable of passing a much greater volume of air than would be supplied to it from No. 1 alone, a portion of the air from No. 2 would pass through the barrier, and down the north side return of No. 1, through the regulator there and into the main return, and might always be depended upon keeping to this road.

In fixing the regulators in No. 1 intake, the better way would be to make a separate place for them from off the waggon way, as

* Two, because when one is open for the passage of men or tubs, the second still acts as a check.

represented at R R in Fig. 68, so that they might be clear of the constant traffic of the waggon way, on which two "fast" doors, D D, would have to be fixed.

Old Manner of Winning and Working Pillars.—We are often inclined, in considering the mining methods adopted by our forefathers, to blame them for their shortsightedness in working on what seem to us such wasteful and ruinous systems; but when we bear in mind what were the actual conditions of the primitive state of coal-mining, including the want of any form of safety-lamp, the impossibility of securing good ventilation with the simple appliances and limited experience then available, and the like hindrances, we are bound to admit that they did fairly well in the circumstances.

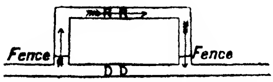
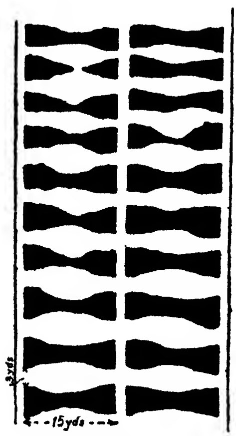


FIG. 68.—MODE OF REGULATING INTAKE AIR.

Figs. 69 and 70 illustrate some of the early methods of laying



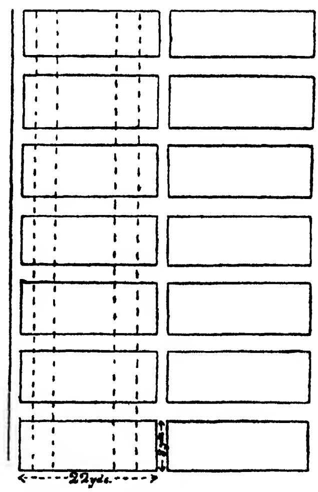


FIG. 69. FIG. 70.

DIAGRAMS ILLUSTRATING OLD PILLARS.

out pillars. The pillars were left very small, in order that as large a percentage of coal as possible might be obtained in winning out the pillars, which were then abandoned. The pillars were 15 yards long; the walls 2 yards wide; the bords being turned away out of the headways 3 yards wide, and gradually widened out until at the middle of the pillar, where the coal left between was very thin—in fact the bords often holed into each other (see Fig. 69). The bords were then narrowed in as they approached the wall, and holed 3 yards wide as at the other end, and so protected the headways course. In some cases the pillars were 20 yards long, and 5 or 6 yards wide, and driven straight. The pillars so formed were abandoned, an enormous quantity of coal, amounting sometimes to 35 per cent., being thus sacrificed. Sometimes a system of reducing the pillars was adopted, and in cases where pillars had been left 12 by 9 yards and 22 by 8 yards, or in some other sufficiently large dimensions, they are known to have been partially removed by driving a wide place through the middle of the pillars, or by driving a place at the top and bottom (see Fig. 70).

As already explained in Chapter I., when pits got deeper

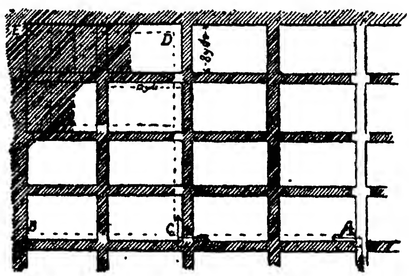


FIG. 71.—METHOD OF REMOVING OLD PILLARS.

this mode of working could not be carried on to any great extent without producing the serious consequences of creep or thrust. These were very frequent and disastrous in their results at the commencement of the present century, whole tracts of coal being entirely lost. As time progressed, however, and a greater amount of knowledge was gained through experience, mines were laid out and worked differently.

In a district which had been worked in the whole many years ago, the pillars had been left 12 yards long and 8 yards wide, in a seam lying at a depth of 300 yards from the surface, and dipping 1 in 18, with a thickness of 4 feet 3 inches. The thill was seggar (fireclay), and the roof was composed of 2 feet of soft blue stone (shale), above which was a hard " grey metal " (arenaceous shale). When removing the pillars in this district the coal was most expensive and difficult to work, the roadways requiring constant lowering, and the coal was very much broken. Various methods were tried in working off the pillars with more or less success; but as it was found most economical to have only a few hewers in the district, and to keep open at one time as few roadways as possible (the headways and bords which had been driven respectively 2 yards and 5 yards wide, were all close fallen), the following was found to be the most satisfactory method of procedure. As shown in the illustration (Fig. 71), a skirting, A B, 2 yards wide, was driven from the rolleyway at four pillars or so back from the face to the far side of the panel, and about two pillars from the far side, a jenkin, C D, 2 yards wide, was driven to the goaf. A skirting, D E, 3 yards wide, was then driven along the goaf side to the far end of the second pillar, and juds were then commenced. The adjacent pillar was then skirted along the other end, thus leaving a larger distance between the skirtings, and so two pillars were brought back together. For timbering ordinary props were used, which were drawn out when each jud holed.

CHAPTER XI.

REMOVAL OF PILLARS AT DIFFERENT DEPTHS.

I. At Shallow Depths (not more than 300 yards from the Surface).—In working the Low Main seam at Seaton Burn colliery, Northumberland, where the average thickness of the seam was about 4 feet, and the depth 120 yards, the pillars were made 30 × 16 yards,

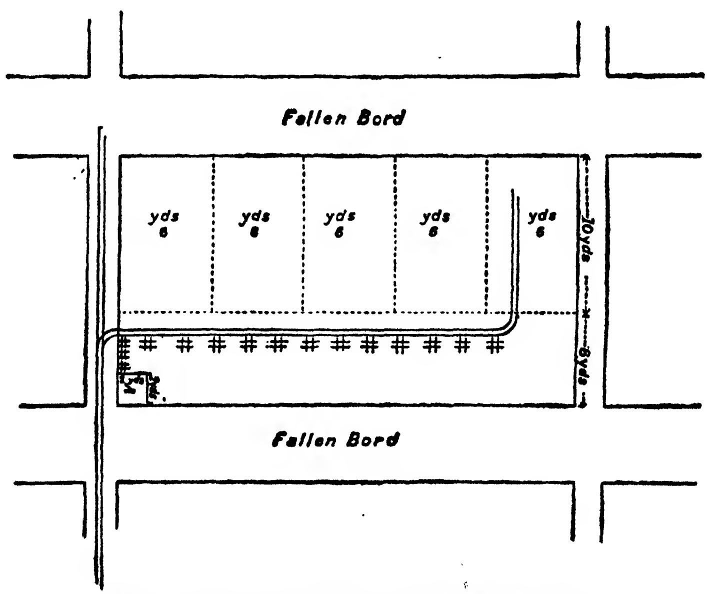


FIG. 72.—METHOD OF WORKING PILLARS AT SEATON BURN.

and were worked off as shown on the annexed sketch (Fig. 72). A way 6 yards wide was driven by the side of the old bord, which was usually filled with fallen stone. A "stook," 2 yards square, A, was left at the turning away next the headways. The rails were laid next the coal side, and chocks built on the other side of the rails at intervals of about 3 feet. When this road had been driven to the far end of the pillar, a "lift," 6 yards wide, was turned away next to and driven parallel with the headways. It was found that the coal yielded a larger produce of round when worked in a headways direction or "on end." Five of these 6-yard lifts completed the extraction of the pillar.

Fig. 73 shows a system followed at Marley Hill colliery, West Durham district, in removing pillars in the Busty Bank seam, which is 144 yards deep at the shaft, and averages in section 5 feet, including two stone bands, 4 inches and 1½ inches thick, about the middle of the seam. The pillars were 50 yards bord by 20 yards wall. They were split by a siding-over or half-pillar wall, C D, driven through the middle, and were worked off in bordways lifts, 5 yards wide, right and left from the split wall and from each headways course.

The same system was followed at Byermoor colliery in the West Durham district, in working pillars 50 × 33 yards, centre and

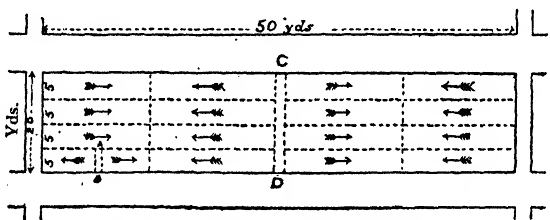


FIG. 73.—METHOD OF WORKING PILLARS AT MARLEY HILL.

centre, in the Busty, which here varies in thickness from 4 feet 6 inches to 9 feet, including a band of fireclay. The seam is 130 yards deep at the shaft.

This system was also followed at the Towneley colliery, Emma pit, North-west Durham, in removing pillars 20 yards square, in the Brockwell seam. Its depth is 168 yards, with section as follows :—

	Ft.	In.	Ft.	In.
Coal	0	2½	...	
Band	...		0	1½
Coal	2	6½	...	
	2	9 +	0	1½ = 2 feet 10½ inches.

In this case it was not necessary to split the pillar by a half-pillar wall, but the lifts could be carried up half the length of the pillar, or 10 yards. Sometimes in getting the last lift the roof would not stand if the lift were driven 10 yards up from the headways, and therefore a short jenkin was driven through the middle of it, as shown at A B in Fig. 73. Sometimes stooks, 2 yards square, were left at the turning away of each lift, being worked off when the lift was done. When the old headways was "close fallen," it was necessary to drive a skirting by its side.

At Towneley the square-shaped pillar was preferred, but there were some, 30 yards by 12 yards, also in the Brockwell seam, which were worked as shown in Fig. 74. The pillar was divided into four by three sidings-over from the old bord, and removed in lifts, 6 yards wide, in the order of the numbers on sketch, and in the direction of the arrows. An objection to this method was the large quantity of narrow work to be paid for.

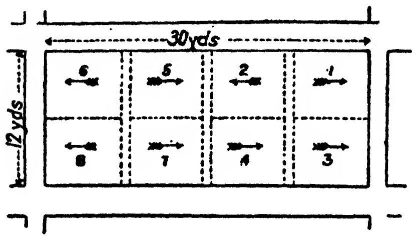


Fig. 74.—Method of Working Pillars at Towneley.

At Old Pontop, near Annfield Plain, West Durham distri
e Main Coal was worked at a depth of 148 yards. Its secti
is :—

	Ft.	In.	Ft.	In.
Coal	2	11	...	
Band	...		0	2
Coal	1	4	...	
	4	3 +	0	2 = 4 feet 5 inches.

The pillars were made 30 yards square. The top stone was (in local phraseology) "blue metal with post girdles," that is, shale and sandstone intermixed. The old bords were generally fallen. A jenkin (O P, Fig. 75) was set away 6 yards from the edge of the pillar, and was driven from 8 to 9 feet wide for a distance of 24 yards. A siding-over was then made to the left to the old bord, and the piece of coal marked A, on Fig. 75, was "lifted off" to the headways. The lift B was then commenced, and worked as far as the roof would permit. No. 2 jenkin was then driven, and the lifts removed as before. This left 12 yards of coal. No. 3 jenkin was driven up the centre of this 12 yards a distance of 24 yards, sidings-over right and left were then made, and the full width of face, 12 yards, E, was lifted off to the headways. The remaining blocks, F, F, were brought back together. Originally these pillars were worked by driving one jenkin up the centre for 24 yards, siding-over right and left and taking the end off, and then bringing back the two wings

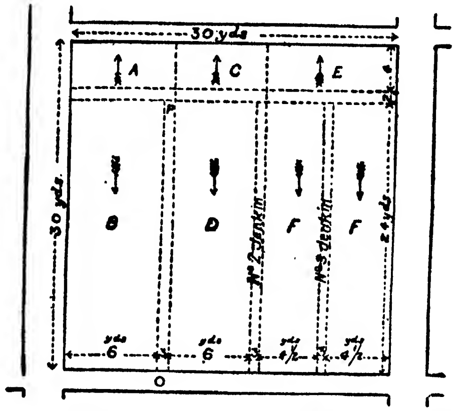


FIG. 75.—METHOD OF WORKING PILLARS AT OLD PONTOP.

together. This was abandoned on account of the expense of timbering, though the coal was successfully got; and the later method, as above described, was adopted in preference.

The following plan was adopted at Killingworth colliery,

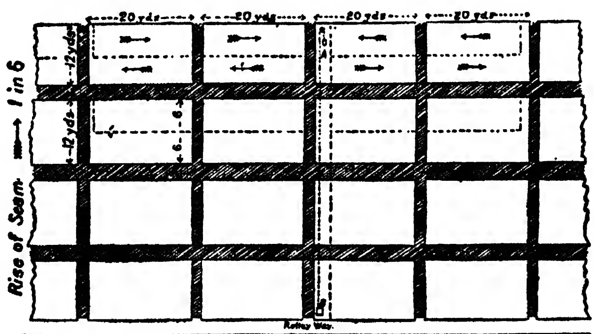


FIG. 76.—METHOD OF WORKING PILLARS AT KILLINGWORTH.

Northumberland, in working a district of pillars in the High Main seam, where it lay at a considerable inclination—about 1 in 6. The seam is 226 yards deep at the shaft, and was in this district 6 to 8 feet in section of excellent coal, being the same seam as that which used to be worked at the old Wallsend colliery, on the bank of the Tyne, and of the quality which has made Wallsend so famous amongst house coals in the London market. The pillars were 20 yards bord by 12 yards wall. The old bords and headways were generally fallen. Fig. 76 shows the method of working, the arrows denoting the direction in which the lifts were worked. A skirting, A B, was driven by the side of the old headways up the rise of the seam (leaving a thin shell of coal on here and there, sufficient to prevent the fallen stone from running in), to the extremity of the area to be worked. This skirting was well timbered, and laid with double way to be used as a "dilly." (A dilly is the local term for a self-acting incline worked with a light chain running round a small sheave, which is tethered by a short length of strong chain to a stout prop placed at the top of the incline. This sheave can be readily moved, so that there is little difficulty in lengthening or shortening the incline. Formerly a hemp rope and a counterbalance weight were used, but a chain in place of the hemp rope, and a full tub in place of the weight, are a decided improvement. It is usually run with one full and one empty tub at a time, and the lad at the top controls the speed by placing an iron "sprag" between the spokes of the sheave.) The dilly having been made, places were turned away, and driven 6 yards wide in the farthest up pillar, right and left from the dilly. These places were continued through two or sometimes three pillars, and then the remaining 6 yards were brought back towards the dilly. As a rule a dilly was made next every fourth headways course, and 16 pillars worked to each.

At another part of the High Main seam workings at Killingworth colliery, some 2 miles distant from the former, the seam was lying nearly level, and the section was:—

	Ft.	In.	Ft.	In.
Top coal	0	6	...	
Stone	...		0	1
Bottom coal	4	5	...	
	4	11 +	0	1 = 5 ft.

The top stone was very bad, being loose and rubbly, with no sound parting for some way up. The pillars were made 30 yards bord by 18 yards wall (see Fig. 77). A skirting having been made by the side of the headways, two jenkins, each 5 yards wide (A and B, in Fig. 77), were set away, and driven simultaneously up the full length of the pillar. The more quickly a pillar can be removed the better, especially when the top stone is troublesome. The farthest inbye of the two jenkins was then "drawn"—that is, the rails, and as much of the timber as possible, were removed—and allowed to fall, thus relieving the pressure, the other jenkin being kept open to form the road out for the rest of the pillar. This was, if possible, brought back in one lift to the headways. As a rule, however, the top stone was too bad to admit of this being done, and in this case a lift, C, would be taken 10 yards up, or as far as the stone would allow, and then D would be worked off. A siding-over, O P, would then be made about the middle of the remaining block of coal in order to shorten the length of lifts, and these would be got in the direction shown by the arrows, E and F being first removed, and then G and H.

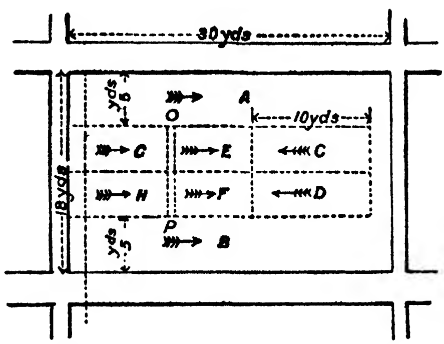


FIG. 77.—ANOTHER METHOD OF WORKING PILLARS AT KILLINGWORTH.

A large area of the High Main seam in the neighbourhood of the Ninety-fathom * dyke, towards which the seam dipped heavily, was successfully and economically worked as follows:—Headways were driven up the full rise of the seam, at intervals of 33 yards apart, to the extremity of the district, a length of about 250 yards. Holings between them were made every 50 yards. After the headways had been driven to the extremity the pillars were brought back, being worked in bordways lifts right and left from each headways course, and driven half way up the pillar. The headways were driven "under the top," and used as self-acting inclines.

* One of the principal geological dislocations of the coalfield—a down-throw north—often much exceeding 180 yards, and running from the sea-coast at Cullercoats westward by Gosforth and Denton to Greenside and Whittonstall.

A similar plan was very successfully carried out in working the Main Coal seam at Houghton colliery, County Durham. The section of seam averaged 7 feet of coal. A large area of it was laid out in blocks 100 × 80 yards, by narrow places, 2 yards wide, driven to the boundary, with holings between them for ventilation at intervals of 100 yards. The seam made a good deal of gas, and the narrow places were bratticed by a plank brattice well pointed with lime. The boundary having been reached, the blocks of coal were worked back in one face bordways on the longwall principle, three rows of props being kept next the face. The working cost of underground labour and screening was below 2s. a ton.

A seam of tender coal known as the Three Quarter—2 feet 2 inches in thickness, at a depth of 70 yards, with a hard roof and floor—was worked as follows: The pillars were made 24 yards

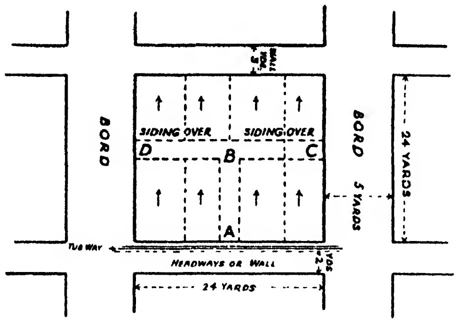


FIG. 78.—METHOD OF WORKING PILLARS AT GARESFIELD.

square, and the first working followed up closely by their removal. The headways were driven 3 yards wide, in order to make room for the stowing of the bottom stone, which was taken up for a width of 1 yard to make height for the "way," the remaining 2 yards being filled with the bottom stone. In working the pillar, a jenkin (A B, see Fig. 78) was driven half-way down the centre of the pillar, and sidings-over, B C and B D, were driven to the bord at each side, and the coal taken out in lifts as is usual in this district. The "way" on the headways was thus utilised in working the pillar, and no ridding of fallen stone was required in order to get at the pillar. The hewing price in the whole was 1s. 2d. a ton, which included the cost of taking up bottom stone to make height for the tub; in the broken it was 1s. 1d. a ton.

II. At Depths from 300 to 600 yards from Surface.—At

Castle Eden colliery (now closed), in the East Coast district of the county of Durham, pillars 33 yards by 22 yards, in the Low Main seam, were worked on the method of bordways lifts. The seam was 3 feet in section where thus worked, though it was much thicker than this in other districts of the colliery. The roof was a strong "post" or sandstone, which stood well. Depth, 300 yards. The two first lifts in the pillar were made 8 yards wide, leaving 6 yards for the last one, and they were carried up the half pillar or 16½ yards. The way was laid up the middle of each lift, chocks being built on each side at intervals of 3 feet apart. These were subsequently removed without much difficulty, as the top stone

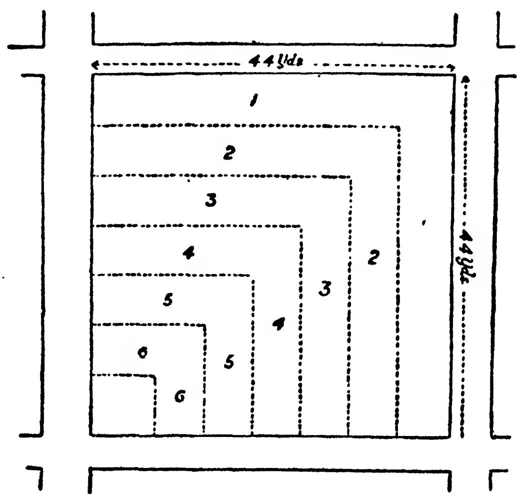


FIG. 79.—METHOD OF WORKING PILLARS AT MURTON.

frequently did not fall for some time after they had been drawn. Sometimes these pillars were worked by driving a jenkin by the side of the old bord where it was fallen, and removing the remainder of the pillar in headways lifts, as little or no difference was found in working them, whether this way or bordways.

The plan of bordways lifts was adopted at Silksworth colliery (East Coast district, Co. Durham) in working the Maudlin and Hutton seams; the former lying at a depth of 536 yards at the shaft, 5 feet 9 inches in section, and the latter at 580 yards, 4 feet 6 inches in section.

Fig. 79 shows a method followed at Murton colliery, in the same district, in working pillars 44 yards square in the Hutton seam.

Depth at the shaft 490 yards, with a section of good coal 3 feet 10 inches, and bottom coal 10 inches, which is removed to make height. Bordways and headways lifts were driven simultaneously. No narow work was required, and the square shape of the pillar —the best shape for resisting pressure—was retained, whilst it was being reduced in size.

The following example is taken from the Main Coal seam at Eppleton colliery, in the county of Durham, lying at a depth of 346 yards from the surface at the shaft, and having the following section:—

	Ft.	In.	Ft.	In.
Top coal unworked	...		1	6
Good coal worked	4	4	...	
Bottom coal „	0	9	...	
	5	1 +	1	6=6 ft. 7 in.

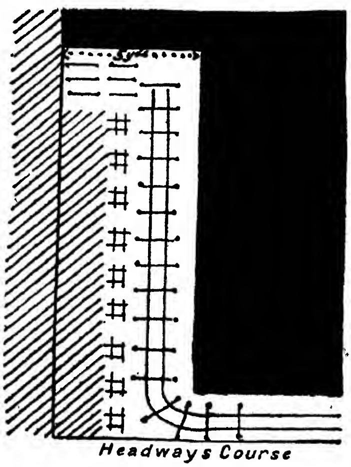


FIG. 80.—THE TIMBERING OF A JUD.

The pillars had been laid out 44 by 33 yards, centre and centre, the headways driven 2 yards and the bords 5 yards wide. It was not found necessary to skirt the headways, as there was only the top coal fallen, the roof being a strong grey metal (arenaceous shale), and the thill also strong. The wide bords, however, fell, so that these were jenkined (loose) for a going bord, the headways being ridded out. The juds were driven to the rise the width of the pillar from out of each headways, the timbering being carried out as shown in Fig. 80. The juds were driven 5 yards wide, and chocks built with oak logs, 22 by 4 inches, were set 6 feet from the coal side, and 4 feet 6 inches apart The mainway was timbered where necessary with props and planks, as shown in the sketch; the space between the chocks and the loose side of the jud was also timbered with props and planks, but these were drawn out every night, three rows being always left next the face, and the roof allowed to fall behind them.

This system was adopted wherever possible, as a great saving in timber was the result, the props being recovered and not stand-

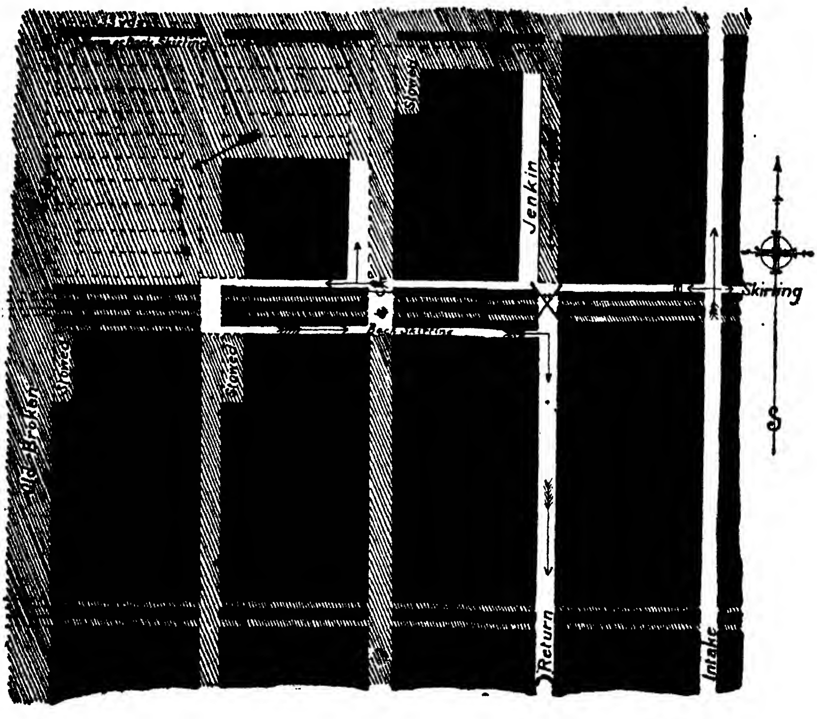


Fig. 81.—Method of Working Pillars in the Hutton Seam at Eppleton.
Scale, ½ inch = 1 chain.

ing until broken, or stowed up, as is often the case. The chocks were drawn when the jud holed—that is, was driven its full distance. The pillars were of good size for satisfactory working, yielding a good percentage of round coal—viz., about 60 per cent. The timbering was carried out by deputies, who built the chocks and altered any timber which was set by the hewer if required. In the absence of the deputies, the hewer himself set it if wanted. The back timber, or timber between the chocks and the loose side of the jud, was drawn by two timber drawers, who were sent into each pit at night for the purpose, and who drew all the "broken" districts in the pit.

The seam from which the two following examples are taken was the Hutton, an average section at the pit under consideration being—

	Ft.	In.
Good coal	3	0
Bottom coal	0	3
Splint coal	0	3
Total	3	6

The roof consisted of shale, varying up to 4 feet in thickness, and above this was a bed of strong white sandstone. The thill was a bed of seggar or fireclay, about 21 inches thick, of excellent quality for manufacture. The seam at the shaft is 346 yards from the surface, and dips east at the rate of about 1 in 20, and at the district from which the first example is taken the depth would be about 450 yards.

As shown in Fig. 81, the pillars were 66 yards by 33 yards from centre to centre, and the longer length (66 yards) being in the headways direction—that is, north and south, contrary to the usual way. The walls (north and south) were driven 5 yards wide, and the bords (east and west) 3 yards wide. The ordinary method was thus exactly reversed. The roof in this part of the pit was very bad, and when working in the whole it was exceedingly difficult to keep it supported with timber until the holings were made. When a holing had been effected, it was found much cheaper to draw the timber all out and allow the roof to fall freely, and then drive another "fast" place alongside, leaving 6 feet of coal next to the drawn-out place. This second place was driven 2 yards wide.

When this district was "going in the whole," it was at the same time "followed up with the broken" on the west side. This is designated the "Old Broken" on the plan, Fig. 82, to distinguish it from the new goaf.

The method of working off the pillars was this: A skirting (see Figs. 81 and 82) was turned off the waggon way, and was driven (fast) alongside the old walls to the south of the row of pillars, four in number, to be removed. This skirting was driven 2 yards wide, and about 6 feet of coal was left between it and the old walls. Jenkins 5 yards in width were driven from out of the skirting up by the side of the old bords, the remaining portion of the pillar being "judded" off to the west. In order to secure the proper ventilation of the workings, a back or return skirting was driven 2 yards in width, communications (or "stentons") being made between it and the intake skirting. In driving this skirting the bottom had to be taken up, and "places," 5 yards in width, were driven from the

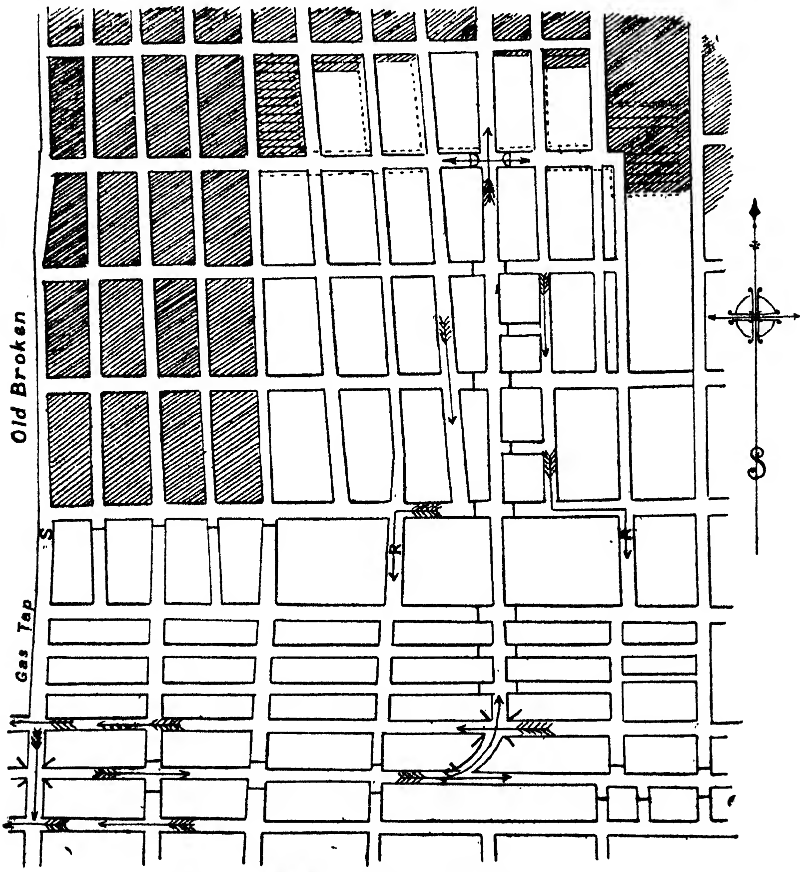


FIG. 82.—GENERAL PLAN SHOWING BROKEN WORKINGS.

References.—Shaded part represents goaf; Air-crossing shown thus, ↘↙↗↖; Regulators, R; Doors, D; Stoppings, —; Air-scale, S; Arrows denote direction of Air-currents.

skirting into the solid, for the stowage of the seggar taken up by the bottom cutters to make height. Sometimes when the roof stood badly, a second jenkin was driven, the first was drawn out and allowed to fall, relieving the pressure on the second. The juds were driven for 27 yards or so to the west, the original breadth of the pillars being 33 yards; but 6 yards must be deducted for the breadth of the jenkin. The last three juds or so were shortened by means of a headways lift driven up the west side of the pillar. All lifts and juds were driven 5 yards wide, and no stooks were left, owing to the difficulty experienced in working them off when the jud is drawn.

As regards the ventilation of the workings—which was very important, as the seam gave off much gas—it will be best to give two examples: one to demonstrate the manner in which the air was conducted before the completion of driving of the back and other skirting, and the other to indicate the course of the air after these skirtings were driven.

Supposing, then, that the intake skirting has not as yet holed into the "old broken," but has only been driven three and a half pillars along, and several juds have been taken off the north end of the fourth pillar—that is, the pillar next to the "old broken"—and that the back skirting has also not yet holed into the goaf; the air would, in this case, be forced along the intake skirting and up the jenkins ventilating the juds, and thence into the goaf, travelling along the last or old back skirting, which will not yet have fallen close, and will pass down the return bord over the intake skirting, at which place a temporary wood crossing is built, and into the main return. But if, on the other hand, the skirtings have holed into the "old broken," the air will pass along the intake skirting, up the jenkins (ventilating the juds), along the edge of the goaf, and down by the side of the "old broken" into the back skirting, and thence into the main return of the district.

As already stated, opposite every jenkin there was a communication between the two skirtings, through which the air was prevented from passing by brattice stoppings, with manholes covered with canvas flaps. So that later on, when the pillars were worked off so far, these in succession formed a road for the return air into the back skirting.

This system of pillar working and of ventilation was found necessary, owing to the quantity of gas evolved from the goaf, and owing also to the effects of creep and bad roof. As it was, there was a considerable amount of "lowering" necessary, owing to the constant lifting of the bottom. Before the flat was ventilated as described above, the gas used to be frequently detected on the tramway, and in considerable volume too.

Fig. 83 represents the barrier workings in this district, or rather the working of the barrier which separates this district from the adjoining one. The operations may be thus described. A fast skirting (*a*) was driven from the tramway towards that portion of the barrier which it was desired to remove. On reaching the barrier a " fast " skirting (*b*) was driven north and south for about 30 yards each way. From the north end of the skirting a " fast " jenkin (*c*) was driven east by the edge of the barrier goaf—that is, that portion of the barrier already worked. From the south end of the skirting another place (*d*) was similarly driven through the solid

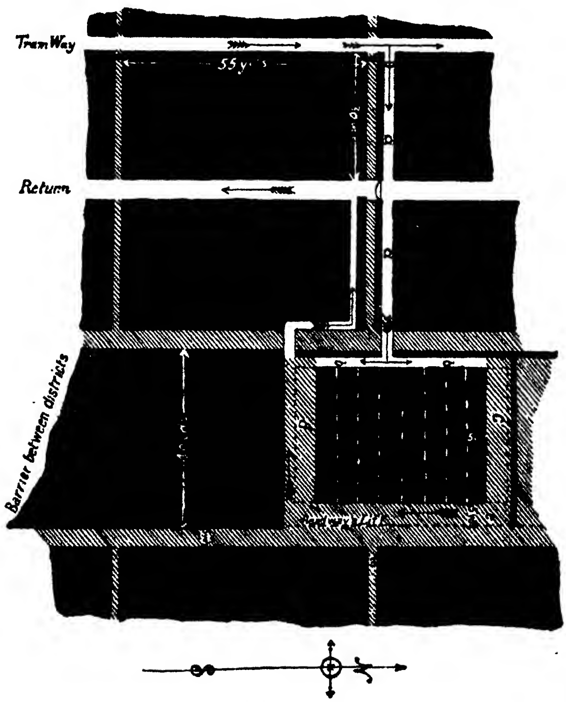


FIG. 83.—BARRIER WORKING IN THE HUTTON SEAM AT EPPLETON COLLIERY.
Scale, ½ inch = 1 chain.

coal. From the far ends of both these places so driven, a lift (*e*) was turned away, and driven 5 yards wide. These lifts holed half-way, and formed a road for the air, the timber being drawn out as soon as a holing had been effected. The rest of the coal was taken out by juds, as shown in the illustration. It will be also observed, on referring to Fig. 83, that there was a back skirting driven from the main return (east side of district), and communicating with a jenkin driven loose by the side of the old headways bord. The use of this back skirting has been already described. The dimensions of the various roads, pillars, &c., are shown in the illustration. The remarks as to the necessity of the above mode of working off the barrier, which were made at the close of the description of the removal of the pillars in this district, are applicable here also.

The total quantity of coals produced per annum in the whole of the district referred to averaged about 10,712 tons, the percentage of round coal being 47.38. This was a fair result for the Hutton seam in that part of the Northern coalfield. Subjoined are the costs per ton for the various kinds of labour and other outgoings (December 1885):—

	s.	*d.*	
Hewing 10,712 tons of coal	1	5.23	per ton.
Deputy work	0	3.45	,,
Ridding	0	1.71	,,
(Ridders and chockmen draw all juds.)			
Bottom cutting	0	2.74	,,
Timber	0	2.61	,,
Cost per ton	2	3.74	,,

The number of cubic feet of air entering the district per minute was about 6,600.

Fig. 84 represents in detail the manner in which large pillars, 66 x 44 yards in the Main Coal, were extracted when the character of the roof of the seam did not allow of much length of jud being driven. The pillars might have been worked off by headways lifts being driven the full width; but the quality of the coal so produced would have been inferior to that produced by working bordways way. The pillars were skirted along the bottom end, and the pillar to be worked jenkined up its full length, and a skirting driven along its top end, the pillar being judded from this skirting for a distance of about 22 yards. The two last juds were driven up instead of down, a narrow place being set into the solid about 20 yards from the top end of the pillar, and driven 10 yards—the width of the two juds. A skirting was driven (loose) alongside the fallen juds, and the same course of operations pursued until the pillar was entirely removed. All jenkins and skirtings were, of course, driven narrow. The Main Coal in this district was the same, or nearly the same, in section as that given at p. 213. The top coal was not worked, but allowed to stand in order to form a roof, the stone above being, as already stated, of a very broken nature.

Recapitulation.—To sum up the question of working-off pillars, it may be said that the system most in favour, and most generally adopted, is that of bordways lifts (right and left from every headways course driven half-way up the pillar), or where the pillars are long (that is, 40 or 50 yards), by first driving a "half-pillar wall" across the middle of the pillar, and carrying the bordways lifts right and left from this as well as from the headways courses. It has been objected to this course that it requires a large consumption of timber, the time occupied in removing each lift being considerable;

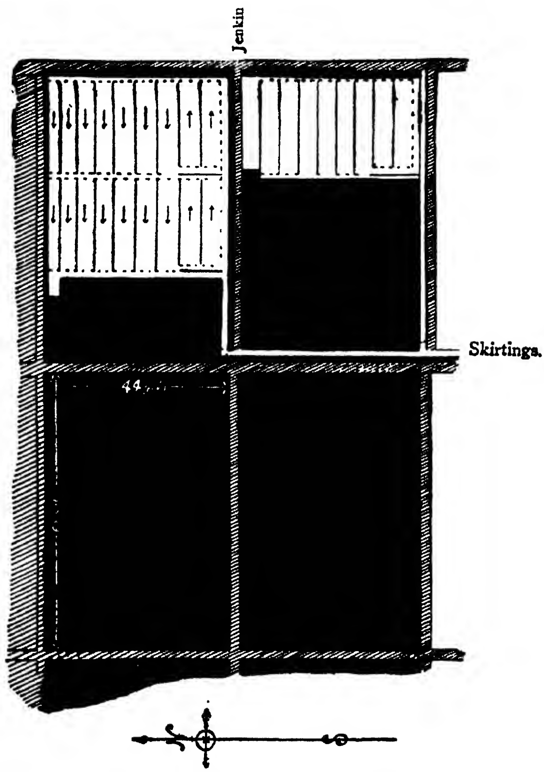


FIG. 84.—METHOD OF WORKING LARGE PILLARS IN THE MAIN COAL SEAM AT EPPLETON COLLIERY. Scale, ½ inch = 1 chain.

but if experience may be taken as a guide the very general adoption of the system seems to prove its advantage in practice.

The guiding principles to be observed in pillar working are:—

(1.) That the pillars should be of such a size as to prevent any general movement of the strata, whether of the nature of creep or of thrust, either during the whole working, or at the face during the working of the pillars.

(2.) As has been already pointed out (page 199), a regular line of advance should be maintained in working the broken, its direction being governed by the course of the coal facings and of the lines of fracture in the top stone. In many cases a line forming an angle of 45°, or thereabouts, with the headways courses is found to answer best. When a few pillars are allowed to fall behind, so as to become nearly surrounded with goaf, the coal becomes crushed, and it may be found impossible to work them. Much good coal has been lost in this way.

(3.) As soon as commenced, the more quickly a pillar can be worked off, the better.

(4.) Narrow work should be avoided as much as possible.

(5.) The system of working should allow, if possible, of most of the timber being drawn, so that it can be used again.

The following extract, from a report by the late Messrs Nicholas Wood and George Hunter, dated 8th July 1840, relative to pillar working at Thornley colliery, in South-east Durham, may be interesting:—They were asked what they considered "the best method of working pillars in the Five-quarter seam with reference to (*a*) the expense, (*b*) the production of the greatest quantity of round coals, and (*c*) the security of the mine both with regard to water and inflammable gas." The Five-quarter seam lies at a depth of 168 yards, and above it, and next the surface, are 64 yards of magnesian limestone and sand of the Permian formation, containing large feeders of water. Their reply was: "We consider the best method of working the existing pillars with reference to the expense, and also to the production of the greatest quantity of round coals, to be to take the narrow bords [size of pillars not given—probably narrow] as mothergates (rolleyways), and to drive headways 2 yards wide across the walls at intervals of every three pillars apart, thus leaving a pillar-and-a-half of coal on each side to be taken to each headways. Then to drive a jenkin 2 yards wide, wherever practicable, on the one side of the wall or pillar, and where not so, up the middle of the wall, working the remaining part of the pillar back towards the headways in the usual manner, or in that manner which, by experience, shall be found most advantageous. This plan of working the pillars will, we apprehend, have the effect of bringing down the sand-feeders of water—at least we are of opinion that such an event must be calculated upon and provided for; but as we consider that the best mode of working the whole mine involved this effect, it did not appear to us necessary to provide against it in determining the best method of working existing pillars. With respect to the security of the mine as regards inflammable gas, the mode of working which we have recommended will afford adequate means of ventilation, so far as practicable in pillar working; but the practicability or propriety of working the coal with candles or lamps can only be determined by experience."

Another question they were asked was: "Do you consider the present mode of working the Five-quarter seam the best and most economical method with reference to the future as well as the present cost; or what alterations and modifications do you recommend to be adopted?" They replied: "We do not consider the present mode of working the Five-quarter seam the best or most economical method, either with reference to the present or future cost. We think a simultaneous working of the whole coal and pillars the best and most economical mode, considering the nature of the roof and other circumstances regarding the seam; the working of the pillars to follow the working of the whole coal as nearly as possible, so that there may never be more than two headways in operation at once."

The system of following up the whole with the broken has much to recommend it. When the pillars can be removed before the walls have fallen, the expense of opening out afresh, ridding, setting timber, and laying way is saved. The workings, too, are concentrated, and the cost of putting and driving thereby reduced. There is less length of road to be examined and kept good, and less distance for the air to travel. On the other hand, in a seam which makes gas, the quantity of gas to be dealt with at one time will be increased by working the pillars immediately behind the whole, and if the top stone does not fall readily there will be the danger of having a large gasometer, close to the whole workings. Working away pillars may bring down a feeder of water, which may drown the whole workings if they are close at hand. Great pressure may also be thrown on the pillars which must be left to support the main roads, and these may be affected. When, however, the top stone falls readily, so as to speedily fill up the goaf, the best plan, certainly, appears to be to follow up the whole with the broken. Care should be taken that the goaf thus formed does not prevent the readiest access to districts to be worked in the future. The operations of some collieries are seriously hampered by the inconsiderate way in which goaf has been formed in the past.

It is usual in bord and pillar workings to make the bord longer than the wall, the walls being originally communications between the bords simply for the purpose of ventilation (see Chapter I.). The advantage of this is, however, doubtful. At some collieries the walls are made longer than the bords. For instance, at a colliery in West Durham the walls are driven 30 yards in length and the bords 20 yards, and the pillars are worked in bordways lifts driven 10 yards up at each side of every headways course, as shown in Fig. 85. It is claimed that the coal is thus worked more cheaply,

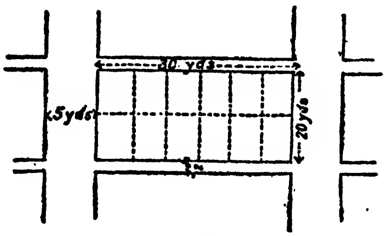


FIG. 85.

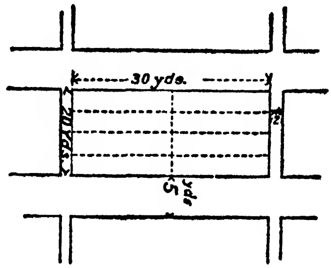


FIG. 86.

SKETCHES ILLUSTRATING THE RESULTS OF ALTERING THE RELATIVE LENGTHS OF BORDS AND WALLS.

because a larger proportion of it is got at broken price, and also the length of lifts in removing the pillars is only 10 yards; and the coal is, therefore, better got, and less timber is used than would be the case if the bords, and therefore the lifts, were longer. The following calculation makes this clear:—

FIG. 85.

Coal got in first or whole working.

Bord 22 yards × 5 yards = 110 square yards.
Wall 30 „ × 2 „ = 60 „

170 „

78 per cent. of the seam is put into pillars by this method.

FIG. 86.

Coal got in first working.

Bord 32 yards × 5 yards = 160 square yards.
Wall 20 „ × 2 „ = 40 „

200 „

75 per cent. of the seam is put into pillars.

Three per cent. more of the seam is got in pillars by the first of these two methods; but, on the other hand, there is in that method more yard price to pay, namely, 10 yards at (say) 1s. 4d. = 13s. 4d.

200 square yards − 170 square yards = 30 square yards; and estimating the seam to be 3 feet thick, and to weigh 19 cwt. per cubic yard, this gives 28 tons more coal got per pillar in the broken working by the first method than by the second: 28 tons at say 2d. per ton (assuming broken price to be 2d. per ton less than whole) = 4s. 8d.* There does not seem to be any saving in cost of working, assuming that the top stone is such as to allow the lifts to be driven up a distance of 15 yards. The shorter lift is certainly an advantage in favour of the first method.

A previous instance similar to this has been given on page 214 (Fig. 81), where, in working the Hutton seam at Hetton colliery, the places driven north and south (or walls) were made 66 yards long by 5 yards wide, and the places driven east and west (or bords) 33 yards long by 3 yards wide. Here the alteration in the widths of the places driven will affect the calculation in favour of the change.

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* The figures quoted in these calculations are, of course, pre-war.

CHAPTER XII.

WORKING BY LONGWALL.

LONGWALL is said to have been first practised in this country in Shropshire some three centuries ago, and to have been suggested by the method of working metalliferous lodes.

Mr G. C. Greenwell, the well-known author of a treatise on Coal-Mining, first published so long ago as 1852, pointed out in a paper "On the Working of Thin Seams of Coal, &c.," * which he read in the year 1856, that in some of the "more highly favoured coal districts of this county (Northumberland) seams of 2½ feet and more were considered unworkable to a profit, and were left untouched in consequence"; but he reminded his hearers that the day would come when "these seams will be of greater consequence than the thick ones": and it may be said, without fear of contradiction, that Mr Greenwell lived to see that day. That these thin, hard seams are now being worked to advantage, is largely due to the adoption of the longwall system of working and to the use of coal-cutting machines.

The longwall system proper is that practised in Derbyshire, Notts, Yorkshire, and the Midland coalfields generally, where, after pillars of coal have been left for the protection of the shafts, the whole of the seam is removed in every direction from the shafts, roads being kept through the goaf. Sometimes the roads are first driven in the coal to the boundary, and then the longwall face brought back towards the shaft. The drawback to this is that time and money are required for driving the narrow places, before any profitable output of coal can be secured. Under certain conditions, however, such as a liability to gob (or goaf) fires, this longwall "retreating," as it is sometimes called, well repays the preliminary outlay.

In ordinary longwall, the face may be carried forward in one long continuous line, sometimes a mile or more in length; or it may be "stepped," in widths of 10 to 40 yards or thereabouts, each width being 4 to 6 yards in advance of the adjacent one. The

* *Transactions of North of England Institute of Mining Engineers*, vol. iv., p. 193.

tub-way is sometimes laid along the face, and the tubs taken along the face to be filled with the fallen coal; or sometimes the coal is filled into the tub standing in the gateway. The practicability of this arrangement depends mainly on the thickness of the seam. The distance between the roads or gateways varies considerably, being from 10 to 100 yards, the narrower intervals being necessary in thin seams, where there is not height for the tub in the face, and where the coal must therefore be brought along the face to the tub in the gateway. By the use of mechanical conveyors the number of gateways may be much reduced.

In the Northern coalfield, besides true longwall, a modified system is sometimes practised—a combination of pillar working and longwall. Roads are driven in the coal, and subsequently maintained as gateways through the goaf, at intervals of 30 or 40 yards, and the coal between them is removed by "lifts" or "juds" driven about 6 to 12 yards wide to the right and left of each road, the lift being driven half the distance between the roads—that is, 15 or 20 yards, or otherwise, as the case may be. Sometimes these lifts are all driven in one direction the whole distance from one gateway to another.

In **Northumberland and Durham,** longwall working was first practised in the limestone coal seams of north Northumberland, and is now chiefly applied to the working of thin seams, where there is not height for the ordinary coal tub to be taken along the face. This necessitates—if mechanical conveyors are not adapted—that the gateways are made at such intervals, usually 10 or 12 yards, as will enable the hewers to fill their coals into the tub standing in the gateway; or else special tubs have to be made of such a height as to enable them to be taken along the face, which is not often done; or a small tram has to be used to bring the coals along the face to the gateway, where they are "teemed" into the tub. This last alternative has been tried in one or two instances, but abandoned. The two latter alternatives admit of longer intervals—30 or 40 yards —between the gateways, and a consequent saving of two-thirds or three-fourths of the stone-work. The arrangement, however, most generally adopted is to make the gateways at intervals of 10 yards, allowing two hewers in each shift to each gateway, with crossgates at intervals of 30 or 40 yards, packwalls 5 to 7 feet thick being built at each side of every gateway. It entails a large amount of stone-cutting and pillaring, and the extra cost of this as compared with bord-and-pillar working will, as a rule, counterbalance the reduction in the hewing price; but under favourable circumstances it gives a larger proportion of round coal, and has the balance of advantages in its favour.

The arrangement of labour is the same as that customary at collieries in the district. The hewer kirves, gets, and fills the coals into the tub, which the putter takes to the "flat." The stone-cutting and pillaring are done at nights by the stonemen and shifters. There are two shifts of hewers, the fore-shift coming to work usually about 4 A.M., followed by the back-shift about 10 A.M. They are paid according to the number of tons of coal which they send to bank, irrespective generally of whether it is small or round, though at some of the Northumberland collieries they are only paid on the round. During each shift every hewer is working for himself, his interest being to fill as many tubs as he can. He does not share with his neighbours, but generally, though not always, he shares with his marrow (or partner), who follows him in the succeeding shift. This system is probably not the best adapted to longwall working, to get the full benefits of which it is sometimes important that the face should be kept straight, should be carried forward as regularly as possible, and that the kirving should be continuous along a good length of face, before the coal is allowed to fall.

Recognising this truth, some managers have adopted the division of labour which is common in Derbyshire and elsewhere—namely, that of holers, getters, and fillers—thus dividing the hewers' work into three classes of labour.* As an instance of this, we may take a Durham colliery working (1894) at a depth of 184 yards, a seam of following section :—

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* The following regulations were drawn up for the guidance of the men working in the Harvey seam of a Durham colliery :—

"REGULATIONS TO BE OBSERVED IN WORKING THE LONGWALL, HARVEY SEAM.

"*Note.*—Men employed in Longwall are subject to the General and Special Rules in force on this Colliery.

"*The Holers* to kirve under the seam 3 feet 6 inches, or such distance beyond that as may be agreed upon from time to time. To cast back all band, &c., got in 'kirving,' into the goaf, and to keep it out in front of the timber and packs. To put in their own 'stays' where required. After finishing holing or kirving the prescribed distance, all band, stone, dirt, small or refuse coal to be cleared away along the face so that the coal will fall upon the clean thill.

"*The Getters* will take down at night the coal made ready during the day.

"*The Fillers* to stand eight hours bank to bank; to take down all loose coal, shaken by shots or wedges, along the face. Any extra work required will be paid for at the usual rates current on the colliery."

	Ft.	In.	Ft.	In.
Coal	2	9	...	
Stone band	...		0	$3\frac{3}{4}$
Coarse coal	...		0	5
	2	9 +	0	$8\frac{3}{4}$ = 3 ft. $5\frac{3}{4}$ in.

Gateways were made at intervals of 40 yards, and the face was kept straight. In a length of face of 120 yards, there were employed 11 holers, 1 getter, and 4 fillers. The holers were divided into two shifts, coming to work at the same hours as the ordinary hewers did. They "holed" in the coarse coal and band, casting it all back into the goaf, and put sprags in under the 2 feet 9 inches of good coal. The result was that 75 per cent. of the seam was got as round. They were paid 8d. to 11d. per yard, according to the nature of the coal. The getter came in with the back-shift, and stayed to fire the shots after the other men had ridden. He was paid 1d. per yard length of face of coal got. The fillers came down at 6 A.M., when the pit commenced to draw coals. They not only filled the coals, but also "put" them to the flat. They were paid by the score of tubs they filled, and an extra price of 3s. a score had to be paid for tramming along the face and filling into the tub at the top of the gateway. Owing to this extra cost, and also to the difficulty of bringing the large coal along the face, the big lumps having often to be broken, it was found after a trial that this method did not answer so well as where the gateways were made at intervals of 10 yards, and no way was required along the face; and this system was therefore adopted in preference, 2 feet of bottom stone being taken up in the gateways, and a stone pillar 4 to 5 feet wide built on either side; the cost of this work was about 6d. a ton on the coal got.

The same system of working and arrangement of labour was adopted at another Durham colliery in a seam 3 feet 2 inches in section, with a bad roof, consisting of a soft "following" stone several feet thick. A modified longwall had been tried—viz., making gateways 40 yards apart, and working the coal between in "lifts" 9 yards wide driven half the distance between the gateways right and left of them—but this did not answer where the top stone was very bad. A long straight face was therefore tried with gateways at intervals of 40 yards, and a way laid along the face for a small tram, in which the coal was brought to the gateway, and there "teemed" into the tub, and the holing, getting, and filling were done by different sets of men. In this case the holers were arranged in parties of three, who shared together, the price paid being 8½d. a yard for holing 3 feet 2 inches under, the height in front not to exceed 16 inches. There were two sets of three to each 40 yards. The getters were paid by the shift, 4s., and there was one of them in each shift. The fillers were paid according to the number of tubs filled, as before.

Here, too, it was found that tramming along the face did not answer, and that it was better to make gateways at shorter intervals so as to avoid it. The division of labour, however, is highly spoken of, and certainly seems better adapted to effective and continuous kirving, and to getting as much round coal as possible, than where one man is kirving, getting, and filling in 5 or 6 yards of face independently of what his neighbours are doing, his only interest being to fill as many tubs as he can for himself during the five or six hours he is in the face. There are no doubt advantages in division of labour, such as (i.) increase of dexterity in every particular workman, and (ii.) saving of the time which is commonly lost in passing from one kind of work to another. On the other hand (as pointed out long ago by that eminent authority, Adam Smith), something may be said—mainly, perhaps, from a humanitarian point of view—as to the benefits of variety of occupation. The change from kirving to drilling or wedging, and then filling, must be a relief to the workman, and perhaps he is able to do more work this way than when confined to one class of labour.

The modified system of longwall already mentioned is practised at a good many collieries in Durham and Northumberland. At a colliery in Northumberland this method was practised in the Low Main seam, at a depth of 120 yards, the section of the seam being:—

		Ft.	In.		Ft.	In.	
Coarse coal	...	...			0	5	
Stone band	...	...			0	2	
Good coal...	...	4	0		...		
		4	0	+	0	7	=4 ft. 7 in.

It was always worked below the band, which made a good parting to timber against, but fell freely after the timber was drawn. Headways were turned out of a narrow bord at intervals of 30 yards. After they had been driven 10 yards, lifts 8 yards wide were turned away to the right and left, and driven 15 yards up, or half the distance between the headways. Two hewers at a time worked in each lift. At first the way was laid down the centre of the lift, the roof being supported by props and chocks at each side, but after a time, to save timber, it was laid next the coal side, with a row of chocks on the other side. When the first lifts had been driven up a few yards, the headways or winning-place was widened out to 6 yards, and driven forward at this width, two hewers at a time being employed in it. Stone packs 7 feet wide were built at each side, leaving 6 feet space between them. With two lifts and the winning-place going, there were six hewers at work together in each gateway, and the tubs they filled were sufficient to occupy one putter in removing them to the flat. The arrangement is shown in Fig. 87.

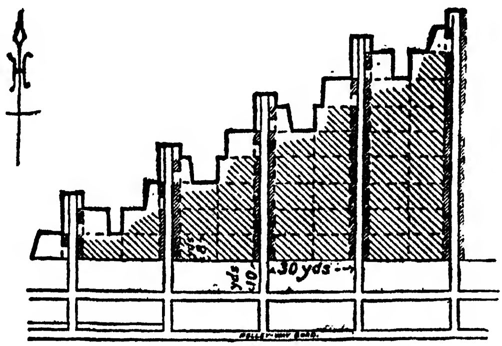


Fig. 87.—Modified Longwall Working.

At another colliery a seam 2 feet 3 inches in section, at a depth of 218 yards, was worked in a similar way, the gateways in this case being 40 yards apart, and the lifts 9 yards wide. Right and left hand lifts were not allowed to be going opposite to each other at the same time, as this would throw much extra pressure on the timber and packwalls. The top stone was a strong " post " (sandstone), and about 2 feet of bottom stone were taken up to make 4 feet height on the rail. Chocks were used in timbering the lifts, the cost of which came to about 3½d. a ton (1894).

Sometimes the lifts were driven the whole distance from one gateway to another, where the top stone was very strong. This was done in a seam 3 feet 4 inches thick, at a depth of 300 yards, with a hard sandstone roof, the distance between the gateways being 40 yards. Chocks were used for timbering, and were nearly all got out after a lift had been driven. The lifts were 8 to 12 yards wide. To make height in the gateways, 2 feet to 2 feet 6 inches of top stone was taken down, and 1 foot to 1 foot 6 inches of bottom stone. This allowed a margin for squeezing. The packs were built 12 feet wide. The output per hewer per shift was more than doubled, as compared with bord and pillar working, but eventually this way of working was abandoned on account of the expense of shooting down the hard top stone. The bottom stone was found to be too soft for packing, and it was necessary to "get" the hard top stone, which never fell of itself.

The following mode of working a seam at a large colliery in the county of Durham was in vogue some years ago (1886). The seam at the shaft was 347 yards from the surface, and had an inclination of 1 in 18, which, as the surface was fairly regular, and the district where the modified longwall working was being carried out was about a mile from the shaft and in the direction of the dip, would materially add to the thickness of the superincumbent strata at this point. The section of the seam averaged as follows :—

	Ft.	In.
Clean coal	3	0
Bottom coal	0	3
Splint	0	1 = 3 ft. 4 in.

The roof consisted of a panel of blue stone (shale) about 4 feet thick and of a somewhat broken nature, above which was a bed of strong white post (sandstone). The thill was seggar (or fireclay), about 2 feet in thickness. The gateways were 66 yards apart, and when these attained a length of 120 yards a cross gateway was put across the whole district. The coal was worked by bordways juds or lifts 6 yards wide, driven half-way across between the gateways, or a distance of 33 yards. The No. 1 gateway is farthest advanced, each succeeding gateway being one jud behind the other, so that a diagonal line of face is preserved, and, the coal being of a tender character, crushing is prevented. It was owing to the tenderness of the coal that the modified longwall was adopted in preference to the longwall system proper.

When it was desired to win out a jud, the gateway out of which it was to be turned was driven 6 yards farther in and 2 yards wide, the jud being turned away out of this: 10d. per yard over and above the score price was paid for this winning out. The coal was kirved the full width—6 yards—across the jud, and nicked up the fast side, and wedged down with steel wedges. In no case was blasting allowed, on account of the gassy nature of the seam. The bottom, which consisted of seggar, was taken up to make travelling height, by a special set of men termed "bottom cutters" (who did the work during the night), for a width of 3 feet, the greater portion of it being cast into the goaf, and only a small quantity sent to bank for brickmaking. The timbering in the juds was arranged as follows:—A row of chocks not less than 5 feet apart was placed along either side of the tramway, and wherever the stone was dangerous, props and planks were set across the tram road as well. Across the face were set three pair of gears, three deep, which of course were continually being advanced. A row of small props, supporting planks, were arranged along the "fast" side of the jud, about 1 foot 6 inches from the coal, in order to preserve an airway about the face, as illustrated in Fig. 88. The

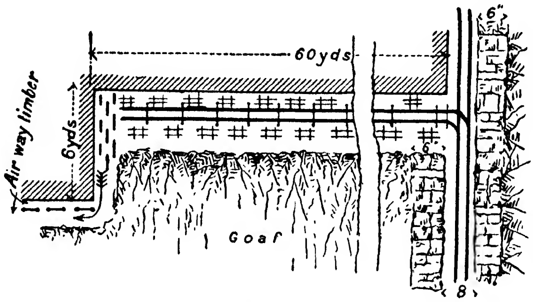


FIG. 88.—TIMBERING IN MODIFIED LONGWALL WORKING.

gateways were packed on either side; this pillaring being about 6 feet thick, and built with suitable stones taken out of the goaf. The gateways were 8 feet wide between packs.

The system was (1894) carried out on a large scale at another colliery in working a seam lying at a depth of 260 yards, and having this section:—

	Ft.	In.
Coal	1	7
Splint (picked out on the screens) ...	0	5
Coal	1	6
	3	6

The seam was very hard to hew—owing partly, perhaps, to another seam 20 yards below having been already worked—and it could not be successfully worked by bord and pillar.

At the same colliery, another seam, 328 yards deep, was similarly worked. Its section is:—

	Ft.	In.	Ft.	In.
Ramble or following stone ...	..		0	1½
Coal	2	6	...	
Fireclay band	...		1	0
Coal	1	4	...	
	3	10 +	1	1½=4 ft. 11½ in.

The band and ramble, which were thrown back, fill up the goaf, and the top stone—a " blue metal "—does not fall. Fig. 89 shows the

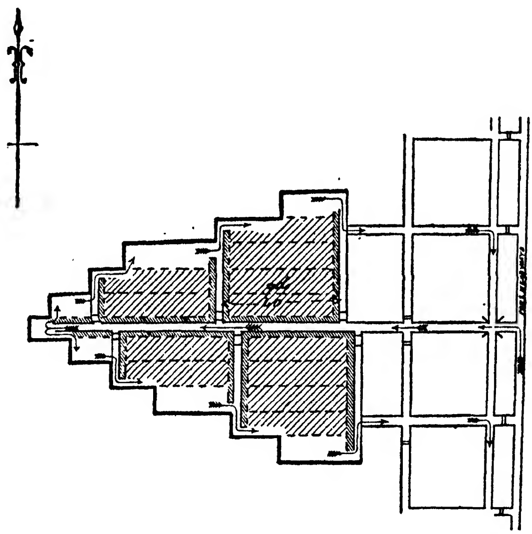


FIG. 89.—MODIFIED LONGWALL WORKING (ANOTHER INSTANCE).

plan of working. The gateways were made 40 yards apart, and the lifts, 8 yards wide, were carried the whole distance between the gateways, and were all driven in one direction—namely, towards the rise of the seam, which was westwards, or bordways. They were kept one behind the other, so as to make a stepped face. There were two hewers working at a time to each gateway. The way was laid down the centre of the lift. Chocks were used for timbering, and some stone packing was built on the " loose " side of the lift, next the goaf. Crossgates were made at intervals of 40 (or sometimes 60) yards, which allowed some of the other gateways to be done away with, and the rails to be taken up.

The air was taken round the face, as shown on the sketch. With bad top stones, this becomes a difficulty, and is an objection to the system.

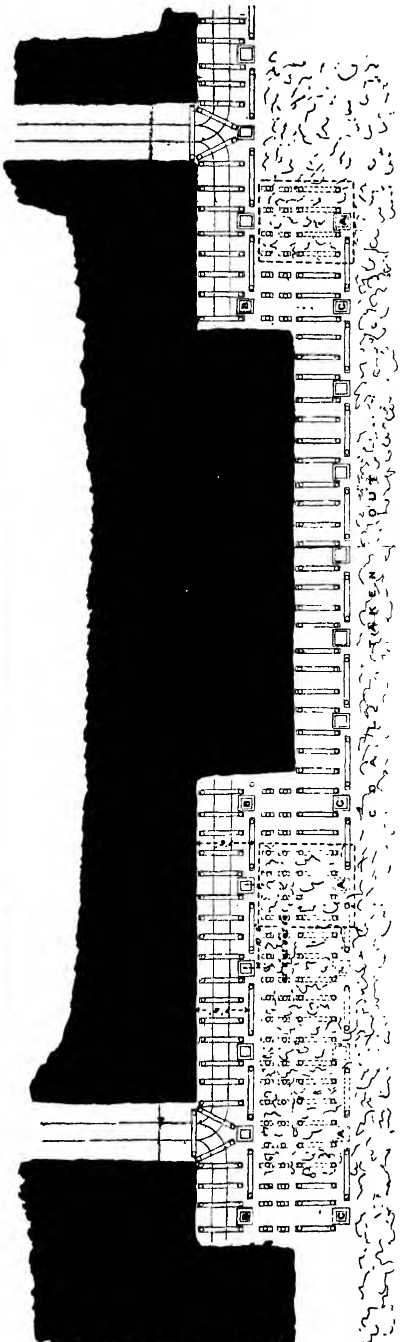
This method of working, however, gives many of the advantages of longwall, in the concentration of the workmen, the avoidance of narrow work, and the using of the top pressure to assist the getting of the coal; and it costs less for stone-cutting and pillaring than where roads have to be kept through the goaf every 10 yards.

Removal of Pillars by Longwall.—Sometimes pillars are worked out on the longwall principle, and an instance has been already given at p. 211. This was also done in a seam where the top stone was very hard and strong, and the thill soft, and the bords had crept close. The seam was at a depth of 170 yards from the surface, and in section was as follows :—

	Ft.	In.	Ft.	In	Ft.	In.
Ramble or following stone ...	...		...		0	9
Coal	1	2	...		...	
Seggar band	...		0	8	...	
Coal	2	7	...		...	
Coarse coal	0	4	...		...	
Splint	0	5	...		...	
	4	6 +	0	8 =	5	2

The pillars, which were 30 yards bord by 20 yards wall, were worked off in one face of 20 yards, carried the whole distance of 30 yards. Four hewers at one time were hewing in the face. Two ways were kept by chocks (which were always got out afterwards), and the remaining space was nearly filled with the seggar band and ramble thrown back. The men hewed as much as 6 tons a shift, and 1½d. a ton less was paid for hewing than in cases where, the roof not being good enough, the pillars had to be worked in lifts.

Plate XXIX. shows the "block" system of working by longwall as practised in a northern colliery. Mechanical conveyors were not used in this system which was being carried out in a seam —the Low Main—4 feet 6 inches in thickness. It consisted in the formation of large blocks of coal, much larger than the pillars



PLAN OF SYSTEMATIC TIMBERING IN THE LONGWALL BLOCK SYSTEM.

[To face page 235.

left in the bord-and-pillar method, and working them off by wide lifts.

The distance between the " pairs of gears " (barrow-way timber) was 2 feet 6 inches, and between the " chocks " 10 feet centre to centre, the chocks being always next to the " loose end " as at C, the second chock (A) back from the loose end being shifted up to the face, viz., to B. The " back timber," behind the chocks, were props and " headtrees " 2 feet 6 inches apart. The chock and timber round it were drawn out as soon as it was practicable to do so, *e.g.*, when chock A was shifted up to B, the timber around it, two rows on each side, was drawn to the extent indicated by the dotted line.

In Yorkshire and the Southern mining districts, thick as well as thin seams are worked by longwall, and there are various arrangements of labour. At a colliery near Leeds, the Haigh Moor seam lies at a depth of 112 yards, and its section is :—

	Ft.	In.		Ft.	In.	
Good coal	3	0		...		
Soft clay band	...			0	3	
Coal	1	9		...		
	4	9	+	0	3	= 5 ft.

It was worked (1896) as follows : The face was kept straight, and carried forward in a cross-cut (" half-end and bord ") direction. Gateways were made at intervals of 33 yards, packwalls 7 or 8 feet thick being built at each side, and also at intervals of 6 feet throughout the gob. The coal face between two gateways is called a " bank," and each bank was divided between two sets of men—three to each set—so that each set of three had 16½ yards of face to work. They kirved and got the coal ; filled it into tubs (the small over riddles of ⅞-inch mesh, what went through being left below) ; set the timber ; and stowed the loose stone in the gob behind. They were paid a fixed price per ton of coal they filled, each set of three sharing together. The kirving (or " bearing " as it is locally termed) was made in the band and inferior bottom coal, and was always made for the whole width of 16½ yards, sprags being put in 6 feet apart, before the coal was allowed to fall. It had then to be broken up. The men went down at 6 A.M., and their shift was eight hours.* In this district there was only one shift of hewers.

At this colliery the system of forewinning and working backwards was sometimes followed, narrow endings being first driven to the extremity of a district, and the coal brought back in one line. There seems to be no decided preference for one plan over the other, the extra cost of driving the "endings," and the larger proportion of small coal thus made, and the delay in getting a good quantity of coal, just about counterbalancing in this case the cost of making and keeping roads through the goaf.

At another colliery in the same district, the Beeston Bed—which is 4 feet thick, and lies 143 yards in depth—was worked on what is sometimes called the Derbyshire method. A pillar of coal 100 yards square was left round the two shafts; and beyond this the whole of the coal was being removed in every direction, all the roads being through goaf. Two feet of top stone—which was hard "bind" or argillaceous shale—was first taken down in the gateways, but usually 5 feet of stone had to be removed before the road could be considered permanent; or, in other words, every permanent road had to be cut afresh out of the stone. At each side of every gateway a packwall 9 feet thick was built, then 9 feet of gob, then a 6-feet pack, and so on. The leading places were going on face or bordways, and out of them, at every 30 yards, gateways were turned endways. Cross-gateways were made at intervals of about 300 yards, and at a course of 7 inches per yard from "face" or bordways, to cut off the gateways. Four men worked at each bank of 30 yards, and they kirved as well as got the coal, filled it into loose-ended tubs, the small coal over 1-inch riddles, built packwalls, and set timber, for 1s. 10d. a ton. When filling, a way was laid along the face of the bank, 2-feet gauge, and flatsheets were put down at the top of the gateway to enable the tub to be turned round readily.

The famous Barnsley Bed of South Yorkshire has been largely worked by longwall. In one instance it was 7 feet thick, lying at a depth of 279 yards. The banks were 30 yards, four colliers in each, and the face was "stepped," on account of fissures in the top stone.

At another Yorkshire colliery the same seam was worked at a depth of 450 yards, and is of the following section:—

* This will, of course, be seven hours now by reason of the amended Act of 1919.

	Ft.	In.	Ft.	In.	
Day bed	1	3	1	9	got in gob, but left on packs.
Dirt	0	6			
Softs	1	5	8	5	
Clay seam	1	4			
Hards	3	2			
Softs	0	7			
Slotting coal ...	1	11			
	10	2			

It lies at a gradient of about 1 in 10. The face was carried in a cross-cut direction, or "half-end and bord." The banks (or stalls) were 40 yards wide. In each of them five colliers were employed at a contract price of 1s. 4½d. per ton, for getting and filling the coal into tubs, timbering, building packs, and laying way. They engaged two fillers per shift. The output of coal from each bank averaged 20 tons a shift of eight hours. The gateways required no "ripping" or "stone-cutting" as a rule, but the stone fell in them, and was cleaned up by the night-men, and used for building the packs. The day bed formed the roof in the face; it was left above the packs, but was got in the gob between the packs. Three rows of props were kept in the face.

In the **Cannock Chase** district of **South Staffordshire,** the two principal seams—known as the Shallow and the Deep seams, 7 feet and 6 feet thick respectively—are got in very good condition by longwall working. The usual practice is to keep a straight face, and carry it in a cross-cut direction about "three-quarter end." Gateways are made 30 or 40 yards apart. The distance of coal face between two gateways is called a "stall," and is let to one or two stall-men or contractors, who are the most experienced of the colliers. They contract to get the coal (in the prescribed way as to holing, &c.), deliver it into tubs at the top of the gateway, set the timber, build the stone packing, and lay the rails, finding their own powder and candles—the owners finding timber and rails—for a price (about the year 1900) varying from 1s. 4d. to 1s. 6d. a ton on the coal got. They engage the holers and fillers and pay them their wages, and make about 5s. (1900) a shift for themselves. There is only one shift of coal-getters in the twenty-four hours. Before the recent change in hours of work they used to go down at 7.30 A.M. and ride at 4 P.M., the hours during which the pit drew coals. From 11.30 to 12, every one stopped work for breakfast. The rock-rippers and night-men went down about

10 P.M.: 20 tons per eight hours was considered a good output for a 40-yard stall, and in a stall of this width there will usually be six men employed. The holers are very skilful at their work, and one sees holing 6 feet in, and not more than 2 feet high in front. Where there is some soft stone just below the seam with a good parting from it, the holing is done in that, and the whole of the coal is got in good condition; but in some cases it is made in a soft carbonaceous shale or "ramble" above the seam. This is termed "bannocking"; but more powder being required, and more levering, to make the coal fall, it is only adopted where there is no suitable material for holing at the bottom of the seam. With the holing underneath, a few shots of powder fired, after the sprags have been withdrawn, bring down a very large fall of coal. The large lumps are filled into the tubs by hand, and the small is filled over riddles, what goes through being thrown back into the gob. The stone-work is done by separate contract. To get stone for the packwalls, small spaces called "wastes" are left in the gob, not far from the coal face, unsupported by timber or packing, where the stone falls freely.

At Cannock Wood colliery the Deep seam lies at a depth of 200 yards, and its average section is 6 feet 10 inches. In one district of the colliery it was worked under a very bad top stone, a jointy shale with no good parting for about 10 feet up. Bord and pillar was tried, but it was said to be impossible to keep the top stone up in the bords. It was, however, successfully worked by longwall, with a straight face, the stone packing being kept well up to the face, within 4 or 5 feet of it, and the gob made quite solid.

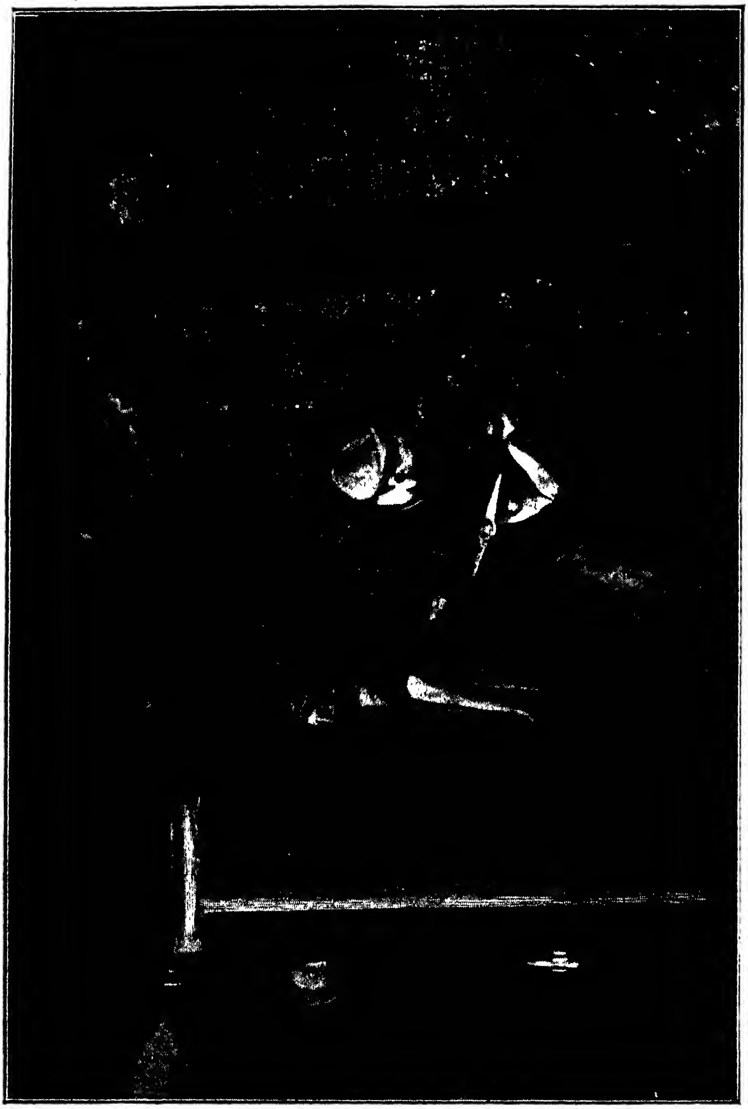
Thick Seam worked by Longwall.—It was mentioned on p 164 that thick seams could often be more profitably worked by the longwall method than by bord and pillar, and of this the following instance, taken from a Northumberland colliery, may be given.

The seam worked—the Main Coal—was of the following section:—

Top stone—thick panel of post.

	Ft.	In.	
Top coal	3	4½	
Band (seggar)	0	3	variable.
Bottom coal	2	8½	coarse.
	6	4	

PLATE XXX.



Hewers working at a Longwall Face in a Thick Seam.

[*To face page* 239.

Plate XXX. is a reproduction of a photograph taken in this longwall face, showing two hewers at work, and the overman leaning against a coal tub. The roof was a strong "framey" post (sandstone), and the thill was a "bastard seggar" or fireclay. The distance between the gateways was from 20 to 25 yards, the tramway being laid along the face, and moved forward as the face advanced. Although the seam was sufficiently thick to afford good travelling height, yet about 3 feet of the roof was shot down in the gateways every night, for the packing in the goaf, and this proved of further use later on when the "squeeze" commenced, which considerably reduced the travelling height in the gateways and cross-headings. The packing or pillaring was carried out in the following manner. The stone shot down after the back-

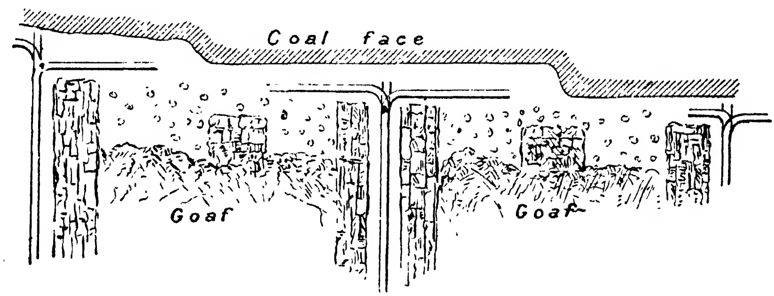


FIG. 90.—STONE PILLARING AND TIMBERING AT LONGWALL FACE.

shift hewers had left the pit was packed along the sides of the gateways to form a pillar 6 feet thick on either side, leaving the gateway 9 feet wide ; a chock was also built 6 feet square half-way between the gateways to act as a central support ; behind this stone chock the roof was allowed to subside, no timber (or as little as possible) being left in the goaf. Along the face, and on either side of the stone chock, props were placed as necessitated by the state of the roof—usually in rows three deep—which were advanced daily. The distance between the stone chocks was about 6 feet. It will be seen from Fig. 90 that the face was what is termed "hipped" or stepped—that is to say, an even or horizontal line of face was not preserved, but the first gateway was a yard or two in advance of the second, and so on—the amount of advancement being usually 2 yards—the reason for this being, that if an even line of face were kept, the line of roof fracture would be parallel to the face, and would in all probability extend right across the district, and it would be nearly impossible, with the limited packing, to support the roof. As it was, the breakage of timber was considerable, and the utmost promptitude had to be exercised in drawing it out and building the chocks.

The hewers "kirved" out the band in the winnings and shot up the bottom coal; they then shot down the top coal. At the longwall face, however, the pressure of the superincumbent strata upon the coal was sufficient usually to squeeze out the band, and the coal would hardly stand for kirving. It was desirable, therefore, that the face should be moved forward as fast as possible. The main advantage accruing from this mode of working was the greatly increased output per man, the average being 4.37 tons per shift.

Detailed description of the longwall system of working as practised in a **North of England colliery.***

The seam in question is a perfectly clean seam, free from stone bands and iron pyrites, and is worked for coal to be used for steam and house purposes, principally the former. Its average thickness is about 2 feet 7 inches, but it varies from 2 feet 1 inch to 3 feet 6 inches, and attains a greater section in "swellies." The floor is usually seggar (or fireclay), varying from 1 to 3 feet in thickness. The roof consists of sandstone (post), or shale (blue metal), with post girdles, or thick shale (blue metal). The synclinal axis of the Northumberland coalfield runs through the royalties in a north-easterly direction, the full rise being S.E. on its eastern side; whilst the measures in the western portion of the estate rise in a direction varying from S.W. to N.W. The average rate of inclination is about 2 inches per yard where the ground is not affected by faults, and the cleavage runs generally a little west of north.

The coal is worked outwards from the shaft to the boundary, all being taken out at the first working, except that which is left in pillars to protect the main rolleyways, and occasionally beneath buildings. By the terms of the lease, the coal has to be left under some buildings, but it has, in certain cases thus provided for, been removed, and in one case beneath a stream also, without any injurious effects, the thickness of cover being about 50 fathoms. On the plan shown in Plate XXXI. will be seen two

* For some of the particulars in this description the authors are indebted to Mr George Hurst, of Newcastle-on-Tyne, who has allowed them to make such use as they deemed advisable of his admirable paper on the subject (see *Journal, Brit. Soc. Mining Students*, vol. ix., p. 168).

buildings, beneath one of which a pillar has been left, whilst under the other the coal has been worked.*

The coal is won in the first place by driving a pair of (or sometimes three) winning headways or narrow bords, as the conditions of the district to be worked demand. These winnings usually consist of a fore and back place driven in the solid, for which the men are paid yard work in addition to tonnage price. The fore-place, being used as a rolleyway, is driven 12 feet wide and 6 feet high, and the back-place 9 feet wide. Usually, however, the back-place is made to "stow itself"—that is, it is driven of sufficient width to hold the stone which has to be shot down for pony height. This width varies from 12 to 18 feet, according to the height of the seam. Stentons, 14 to 15 yards long, are holed every 44 yards. Barriers of solid coal, 35 yards wide, are left on each side of the winning-places, the object being to protect the main roads, to lessen the cost of timbering, and to permit of the air being borne up for any distance without loss. Where no barriers of coal are left, it is impossible to prevent scale through the stone pillaring until this has been consolidated by the pressure, and all motion has ceased, which does not occur for a considerable period. Within 200 or 300 yards of the boundary no barriers or stenton coal are left, the fore and back places being then formed by driving one wide place, and building a stone pillar in the middle, with a tramway along each side.

The winning-places having reached a point sufficiently far from the shaft, the longwall is commenced. Suppose, then, that we have a pair of winning headways. A holing, driven 12 to 18 feet wide to "stow itself," is made through the barrier, and what is termed a "barrier place" is turned away, 5 to 10 yards wide, parallel to the headways (see Fig. 91). A stone pillar, 4 or 5 yards wide, is built against the barrier side in this road, the object of which is to prevent the roof breaking and coming down along the edge of the barrier when the coal has been removed at the other side by the

* It was found that, unless the coal left beneath buildings for their support was extensive, the effects of the workings in the vicinity of the pillar was considerable, and more marked than if the coal were evenly and entirely extracted. This, it was presumed, was due to the block of coal acting as a fulcrum to the leverage of the superincumbent strata. From extensive experience in this particular district, when calculating the area of coal to be left under buildings, it was found expedient to allow of a "draw" of one-fourth of the depth of the seam from the surface—not that the horizontal "draw" was quite so extensive as this, but that there might be a margin of safety.

longwall. As the barrier place proceeds, at every 11 yards a gateway, allotted to two men (one per shift), or to four men (two per shift) if pit room is scarce, is turned away bordways, or at right angles to the headways. By this arrangement each set of hewers has 11 yards of the face of the coal. The holings through the barriers are driven at intervals of 70 yards. Sometimes no barrier place is driven, but each set of men win out their own gateway in turn by working in a headways direction 11 yards, and then turning bordways. The former method is, however, considered the best. The seam being thin, 2 or 3 feet of the stone above the coal have to be shot down to make height for the putters and ponies. The stone is not taken down right across the place, but only a width of 3 or 4 yards to each 11 yards of the face, and a neat and substantial pillar, about 6 feet wide, is built on each side of the tramway, thus forming the gateway along which the coals are brought by the putters to the main road. The remainder of the stone shot down is stowed in the space or goaf between the gateways. One shot is generally sufficient to bring down all the 4 yards in each gateway.

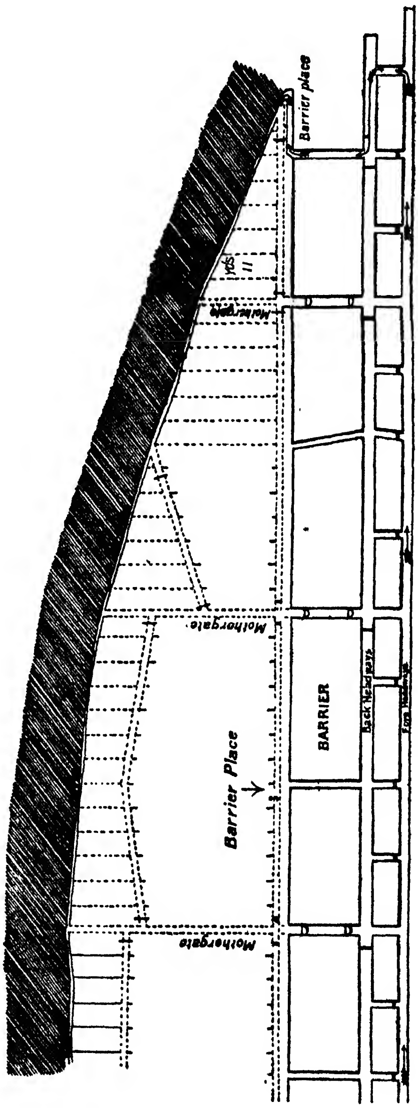


Fig. 91.—Plan showing Winning Headways. Scale, 4 chains to 1 inch.
References.—Brick Stoppings, ‡; Canvas Doors, |; Wooden Doors, D D.

The most effectual mode of pillaring which is in operation at the colliery under consideration—that which has been found to entail least "backbye" work—is illustrated in plan in Fig. 92, and in section across the gateway in Fig. 93. Having shot down the canch it is disposed of as follows:—The pillar *b d* is built and keyed into the "face" pillar (*a b*) of the previous night. Then a new face pillar, *c d*, is drawn across the face 4 to 6 feet from the last face pillar (sometimes called a "cross" pillar), the smaller and surplus stones are filled into the middle, and the side pillar, *a c*, is then built and keyed into the "face" or "cross" pillars, *a b*, and *c d*. The pillars—which are, of course, built of the largest and most suitable stones—are made 6 feet wide. The pillaring is usually kept 4 feet back from the face. If, when the hewer commences his work in the morning, he finds that the roof is only moderately strong, it will be necessary to have a prop or two and headtrees between the coal face and the pillaring, especially at the point A. These are drawn out as the pillaring and the face advance, with the exception of those at the side pillaring, which keep up the side stone; but as the pressure of the superincumbent

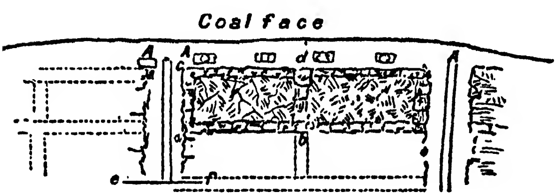


Fig. 92.—Plan of Pillaring on Longwall Face.

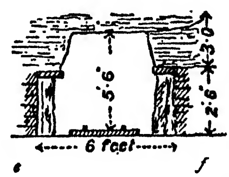


Fig. 93.—Cross-Section of Gateway.

strata—or "squeeze," as it is termed—comes on, these side props are pressed out. Gears are occasionally necessary across the gateways when the top stone is bad.

Usually thirteen gateways constitute a flat, the central one being called a "mothergate," as all the coals from the other gateways are brought on to it by means of cross-headings, and conveyed along it to the main rolleyway. A cross-heading, or cross-gateway, is a road made in the goaf, running across the gateways. The mothergate, and cross-headings, and gateways are illustrated in Fig. 94. A cross-heading being formed, the flat can be shifted inbye, and thus the "putting" distance will be reduced, and also the quantity of rails required.

There are three modes of making, or "putting over," cross-headings at this colliery. (i.) At one part of the colliery the stone immediately above the seam is a "panel" of very soft shale, of varying thickness, and mostly very wet, which renders it more difficult to keep up than it otherwise might be. This stone, therefore, falls away from the "post" panel above it, and makes it very difficult to keep the sides of the gateways in a proper state. Owing

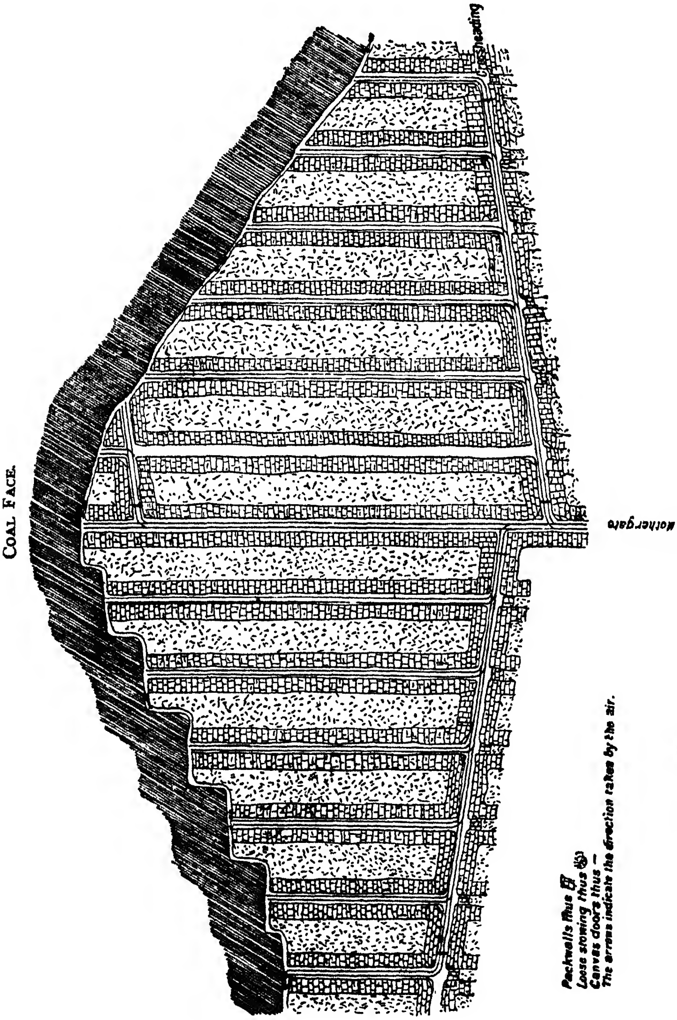


Fig. 94.—Drawing of Flat showing the Mothergate and Cross-Headings. Scale, 80 feet to 1 inch.

to the existence of these conditions of roof, the method adopted of putting over the cross-headings is as follows:—No side pillars are built *across* the gateways when the distance is reached at which the cross-heading will cut them off, the idea being to let the blue stone fall thoroughly, and the roof generally to settle, and then to rid through the closely fallen goaf. The worst of this mode is the high cost of ridding through the goaf, and the amount of "backbye" work which is entailed. (ii.) Another method is adopted where the stone is not so bad. When the gateways attain the distance at which the cross-heading will (when made) cut them off, side pillars are built across the gateway, so that when the cross-heading comes to be made there is an open road through the goaf, and it is merely requisite to shoot down the top stone between the gateways for height. (iii.) The best possible way, when practicable, of putting over cross-headings is to drive them in the coal as headways gateways, commencing from the mothergate (Fig. 95), which is driven in fast for a few yards for the purpose—4 yards or thereabouts.

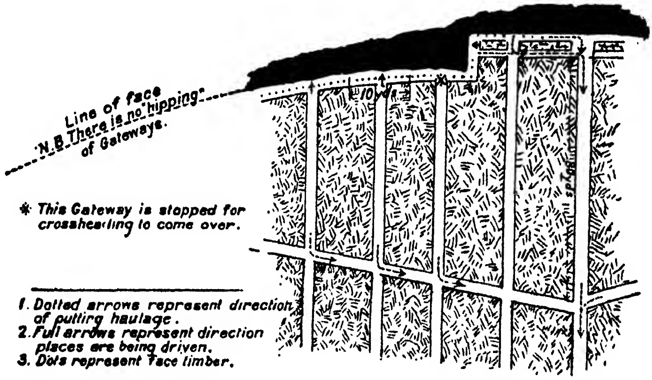


FIG. 95.—MODE OF FORMING CROSS-HEADINGS.

When a gateway is nearly up for the cross-heading, it is stopped about 10 yards short of its full distance (80 yards), this remaining 10 yards of coal being got by the cross-heading cutting it off.

Some of the advantages accruing to the last-mentioned method are:—(1) The saving in shooting of top canch; the stone being easier to shoot than in the two previously mentioned methods, owing to its not being "open," because in the former cases where subsidence has occasioned numerous cracks and crevices, a considerable part of the blasting force is uselessly expended in these interstices. (2) The saving in the *extent* of top to be shot down. In a district comprising, say, 17 gateways, experience shows that at least 5 gateways are in such a position that they can be stopped before attaining their full distance, the remaining 10 yards in each being got by the cross-heading, and as the canch is in no case shot flush up to the coal, there are, say, 7 yards of the canch less to shoot in every 80 yards of gateway, or 170 yards less of canch for every 80 yards the district advances.

Such of the old gateways behind the cross-headings as are not required for airways are stowed up. In this way we get cross-headings on each side of the mothergate, at intervals of from 60 to 100 yards. It will be seen from the illustration given in Fig. 94 that the cross-headings are not made at right angles to the mothergate, and that they are "off and on," as the saying is—that is, the right and left hand ones do not meet at a point on the mothergate. There are several reasons for their not being at right angles to the mothergates, of which the principal reason is that, the coal being worked to the rise, the tractive force in putting inbye and outbye is equalised. Another reason is, that the gateways are cut off one by one, and consequently the cross-heading is formed gradually, and there is not too large an amount of stone to shoot down at once. Again, by making the cross-headings "off and on," the use of double-turns in the tram-plates is avoided, and there is not so much liability of collisions between putters coming in opposite directions on to the mothergate.

In the gateways, from 2 to 3 feet of top stone are taken down, and in the main rolleyways and mothergates from 3 to 4 feet, according to the height of the seam and the partings in the stone. All the stone-work (shooting, loading, conveyance of stones by tub and pony, pillaring, &c.) is done by night-shift men, the hewers merely getting the coal and filling it into the tubs. A canch of 5 or 6 feet in length is left in the face of each gateway, and is supported by short props set by the deputies, the long timber in the gateways being put in by timbermen in the night-shift. A space of 3 or 4 feet is left between the face and the stone pillaring, which gives the men room to work in, and allows the air to pass directly along the face.

The roof does not break along the line of face, but droops gradually on to the stone pillaring, squeezing or compressing it finally into two-thirds of its original height. For this reason stone has usually to be taken down in the mothergate rolleyways two or three times; but when this degree of compression has been reached, no more motion takes place, and, as a rule, they remain permanently good, and require no more timbering or attention of any kind.

The hewers usually kirve about 3 feet deep into the bottom of the seam, and if necessary shoot their jud down, but generally the pressure is sufficient to bring it down. Where there is a sandstone (post) roof, the top part of the seam is frequently softer than the bottom, and is then preferred for kirving, it being in this case necessary to put a shot into the bottom of the coal.

A somewhat different mode of working is that with headways mothergates, shown in Fig. 96. In this system, a place 22 yards wide is driven with a packwall in the middle 7 or 8 yards wide, thus forming two mothergates, one for the right-hand and the other for the left-hand gateways. Openings are left through the packwall over 60 or 70 yards, as the place proceeds, for the passage of

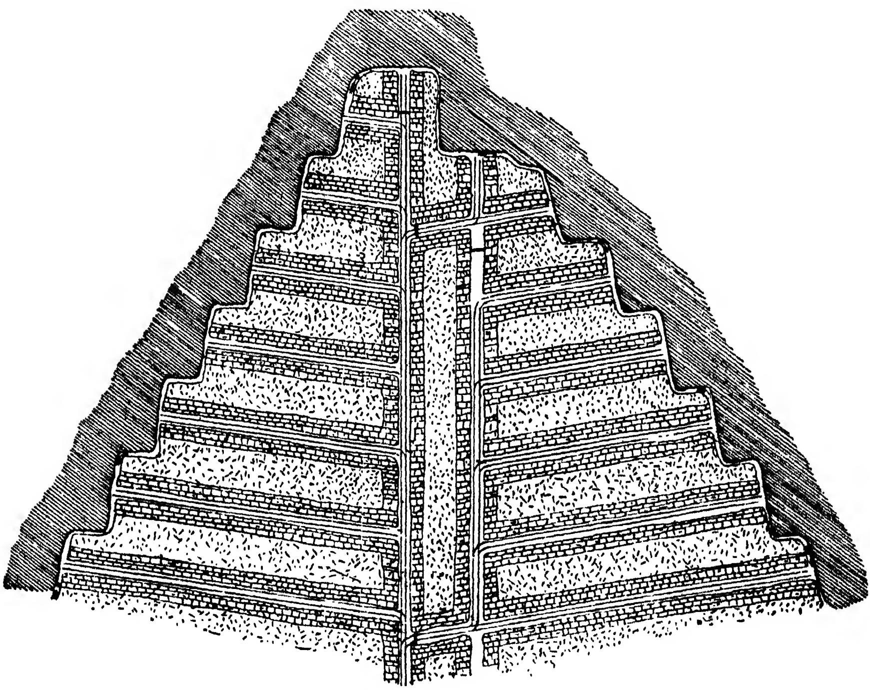


FIG. 96.—DRAWING OF A FLAT WITH HEADWAYS MOTHERGATES.
Scale, 80 feet to 1 inch. The shading shows the Coal Face.

the tubs. The men in these mothergates are paid yard work, and they may be considered as winning-places, the difference being that no barriers or stenton coal are left. The gateways out of these mothergates are formed every 11 yards, and are carried forward to a distance of 70 yards, when they will hole into the gateways of the adjoining flats. Only one of the mothergates is used as a rolleyway, the reason for having two being this: If there was only one, all the gateways right and left would have to be turned out of it, and consequently canvas doors would have to be put on all the gateways to bear the air up to the face, and there would be a serious loss from scale. These headways mothergates are not permanent roads, and in the course of time are cut off by a cross-cut from the main rolleyway, as shown at F in the illustration given in Plate XXXI.

This system is a convenient one under certain conditions, but does not seem to have any economical advantages over the other. Originally three headways mothergates were formed, as will be seen from the plan in Plate XXXI., as it was thought this number would be required to bear the air up properly, but two have been found quite sufficient for this purpose.

The mode of ventilation is very simple. The air from the downcast shaft is brought along the main rolleyways straight to the face, and after airing the men in the fore and back places, passes through the innermost barrier-holing on to the longwall face, along which it is carried, being borne up by wooden and canvas doors on the mothergates and cross-headings, as shown in Fig. 100, finally reaching the return, which will consist of old gateways and cross-headings left open through the goaf. The mothergates, gateways, and cross-headings are sufficiently ventilated by the scale through the canvas doors and pillaring. The air is split along the different main rolleyways, but there is not a separate split to each flat, the same split usually airing two or three.

The coal from the seam in question being used for steam and house purposes—principally the former—round coals are a desideratum, and in order to obtain as large a percentage of these as possible, the men are paid on the tonnage of round coals alone. The hewing price per ton is different at each pit, and varies inversely with the height of the seam. The following is the sliding scale which was operative at the time the above description was written, viz., in the year 1894 :—

	Ft.	In.			s.	d.	
Above	3	0 in thickness		...	2	0	per ton.
From 2 feet 10 inches to	3	0	,,	...	2	1	,,
At	2	10	,,	...	2	2	,,
At	2	9	,,	...	2	3½	,,
At	2	8	,,	...	2	5	,,

And one penny per ton increase for every inch the seam decreases in height from 2 feet 8 inches.

The vital points to be considered in longwall working are :—
(i.) The direction in which the face should be worked—whether

"on face" (bordways), or "on end" (headways), or "half-end and bord" (cross-cut). This varies in different mines, and depends on the vertical "slips" or "backs" or "partings" in the seam itself, and in the roof stone. The advancing line of face should form an angle with the direction of these "slips." The support of the roof in the working face, and the getting of the coal in good condition, are largely dependent on this. (ii.) Whether the face should be kept in one continuous line, or stepped. This too greatly affects the maintenance of the roof, and the size of coal got. Experience has proved that an alteration in this respect may sometimes be most beneficial. (iii.) The rate of advance of the face. Sometimes it pays to let the coal stand for a little while on the timber sprags or cockers, after holing, so that the superincumbent pressure may act upon it; and on the other hand, sometimes, the faster the face can be moved forward, the better. (iv.) The building of the packwalls, and the stowing of the goaf. The packs should be built as strongly as possible, and carried close against the roof, and kept well up to the face. Where the goaf can be stowed solidly, it is the safest plan. Care should be taken to leave no timber in the goaf. Attention to these points will often make all the difference between a profitable working of a seam and the reverse.

In concluding this general view of the subject of working by longwall, it is perhaps hardly necessary to remark that the system is carried out, as the above instances show, in seams varying much in section, in depth, and in the nature of the roof and floor. With a straight face, and with kirving properly done, it is undoubtedly the system best adapted to making the highest percentage of round coal,* and to getting the largest possible proportion of the entire

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* Upon this point, Mr Greenwell, from calculations made at Radstock (Somersetshire) in 1855, came to the conclusion that "a thin seam worked by board and pillar makes more small than a thick one"; "and," adds he, "it may be safely said that by the longwall mode as much round coal can be got out of a seam of coal 2 feet in thickness, as by the board and pillar method out of a seam 2 feet 9 inches, or possibly 3 feet." (See paper read before *North of England Institute of Mining Engineers*, vol. iv., p. 193.)

As to the relative liability to accidents, when both thin and thick seams are worked by longwall, Mr Greenwell maintains that "there is undoubtedly less liability to accident from fall of roof in a thin seam than in a thick one, when the quantity of coal worked is in proportion to the thickness of the two seams; otherwise, for the same quantity of coal, there is twice or thrice as much roof to work under in the former than in the latter instance, and consequently liability to accident must be greater."

The risk of accident in working by longwall is considerably less than by the seam. Where gateways have to be made 10 or 12 yards apart, and where the stone is hard and requires the use of explosives, the working cost is high, and it becomes a question whether the improvement in the vend compensates for the extra cost of working, as compared with bord and pillar.

When the roof of a seam consists of 5 or 6 feet of soft rubble—more of the nature of soil than stone—which falls in the face, and is of no use for building packs, it is doubtful whether longwall can be pursued with advantage. It has been tried under such circumstances, and abandoned. There are other conditions—such as frequency of faults, and the necessity of leaving a large proportion of the coal to support the surface—which are unfavourable to longwall; and at coking collieries, round coal is not particularly wanted.

The arrangements of labour to which reference has been made are:—(i.) Where each hewer works independently in 5 or 6 yards of face; (ii.) where there are three classes—holers, getters, and fillers; (iii.) where three or four men share together, and work amongst them a certain length of face, doing all the work that is required in the face; (iv.) where one man is responsible for a certain length of face—say 20 yards—and finds and pays the other labour required. The authors are not prepared to advocate any one of these systems in particular, in preference to another, as best for general adoption.

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bord and pillar system, for by the former method new and firm roof is constantly being exposed, the old roof to within a yard or two of the face being stowed up and pillared behind; whereas in bord and pillar the same roof is exposed (when working in the whole) for months, often for years. The great danger under the bord and pillar system of working is the drawing the timber out of old bords and walls, and when working off the pillars.

CHAPTER XIII.

STALL WORKING—DOUBLE AND SINGLE.

THIS system of working is native to South Wales, where it is still very generally adopted. Latterly, however, it has been giving place, to a large extent, to longwall in that district.

One of the first collieries in the North of England, if not the first, to try the double-stall method was Eppleton, belonging to the Hetton Coal Company. This was in 1885, when the system was tried in the Maudlin seam, owing to the unsatisfactory result of the bord and pillar method there, due to a very bad roof and thill. The seam was being worked entirely by bord and pillar before the double-stall method was tried, and in some parts of the pit, where the roof stands well and there is little or no lifting of the thill, bord and pillar is still being pursued. Owing to the loose, shaly character of the stone forming the roof of the seam in various districts of the pit, it was found very difficult to keep the roads in good condition: in fact, this could not be done on the old system without employing a considerable staff of shifters and wastemen, which, of course, contributed very materially to the cost of working. This being the case, it was determined to work the coal by that method which, whilst minimising the length of airway to be kept open, would at the same time not lessen, but rather tend to increase the produce for a given number of hewers, and be attended also with greater safety to the men generally.

The Maudlin seam, which lies at a depth of 308 yards from the surface at the shaft, and dips eastward at the average rate of about 1 in 14½, has the following section at a distance of 1,540 yards north-east of the shafts:—

		Ft.	In.	
2 ft. 7 in.	Top coal	0	11	Unmerchantable, therefore unworked.
	Stone	1	8	
Workable seam, 6 ft. 9½ in.	Good coal	1	7	
	Band of foul coal ...	0	3	This is not universal, being altogether absent in some places, and when present varies in thickness from 1 to 5 inches. It is cast back by the hewer, who is recompensed according to the thickness.
	Good coal	0	11½	
	Splint coal	0	3	
	Good coal	2	3	
	Stone band ...	0	6	Varies in thickness, in some places being absent altogether. Cast back by the hewer, who is paid according to the thickness.
	Bottom coal ...	1	0	Of variable thickness.
	Total height of seam	9	4½	

The stone between the seam proper and the top coal is generally "blue metal," but being of a soft shaly character, it forms an extremely bad roof. When working on the bord and pillar system, bore-holes were put up, about every 5 yards apart, through the stone band into the top coal to release the natural gas contained in these two beds, and so relieve the stone of some of the pressure. Although to some extent this acted beneficially, it was not found to be of much help in the long run. In parts of the seam the thill was very much subject to lifting—owing, it was thought, to the nearness of the Low Main seam, which in some places lies only a few feet below the Maudlin, the intervening strata being fireclay. This in itself is a strong reason for keeping open as few roads as possible.

The double-stall method was carried out as follows. A pair of narrow places, 8 yards apart, were turned away out of the headways course, and driven bordways way or " on face " for a distance of 10 yards. They were then connected by means of a narrow holing or " wall " driven parallel to the headways course, and so forming a " stook " or pillar of coal 8 yards by 10. The whole width of face—12 yards—was then carried forwards bordways way in the form of a " wide jud " or " stall." The distance which stalls were driven in the Maudlin seam at Eppleton averaged about 44 yards. In the middle portion of the stalls the timber was drawn out as the face advanced, and the roof allowed to fall. Two roads were kept, 2 yards wide, one on either side of the fallen stone, so that each road had a " fast " and " loose " side. The roof was supported by a row of chocks, set every 3 feet apart along the "loose" side of the road. Not less than three pairs of "gears" (props and planks) were kept across the face to protect the hewers. These were advanced every day, the stone falling behind them. The whole breadth of face was kirved across by the hewers and nicked up one side, and the coal brought down by driving steel wedges into the top of the seam. In no case whatever was powder allowed

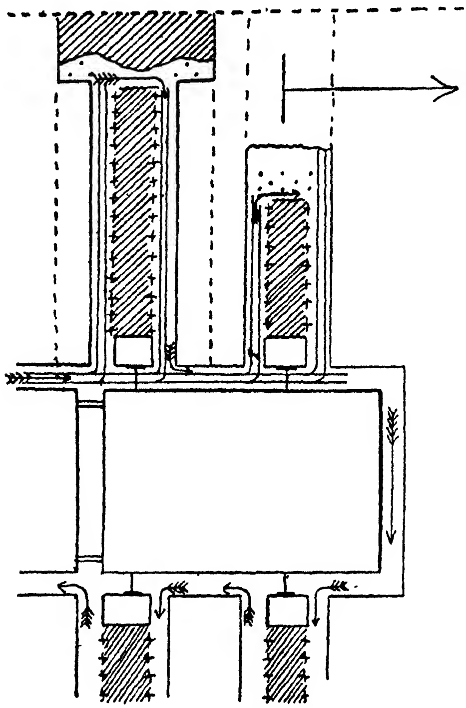


FIG. 97.—PLAN SHOWING DOUBLE-STALL WORKING.

to be used, owing to the proximity of the goaf behind. The men kirved in the good coal on top of the stone band when present.

After the stalls had attained the specified distance, the working back of the ribs which separate the juds or stalls from one another was commenced. That is to say, the ribs being 12 yards wide, a width of 6 yards was worked off each rib out of each stall road (see Fig. 97). The plan shows a stall in process of advancement, and in the adjacent stall the working back of the rib to the stall roads.

When the stall working was first introduced into this seam, it was the custom to work off the ribs from the inbye end of the stall towards the outbye or headways course end; but it was found, after a trial of some months, that owing to the very broken nature of the roof, there was a great saving of back timber by working off the ribs in the same direction as the stalls were driven; for by the first method the rib was worked off by a series of short juds, seldom being driven farther than 6 yards, then drawn out, and a fresh one set away in front of the drawn-out portion. By this means a place 6 yards wide plus the width of the stall, 2 yards = 8 yards, was timbered right across; and it will be readily understood how detrimental this great width of place was to economy in timber. By

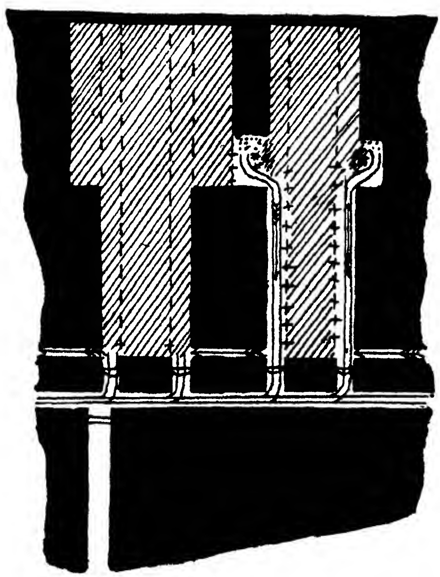


FIG. 98.—REMOVAL OF RIBS IN DOUBLE-STALL WORKING.

the second method, the timber in one-half of the road alongside the rib, about to be removed, was drawn completely out, and the roof allowed to fall, and a place being driven into the coal, half of the rib was worked off half its length (that is, length of rib, if the stall were 40 yards, = 20 yards), the width of the jud being 6 instead of 8 yards thick, as in the former case. This will be better understood by comparing Figs. 97 and 98.

There was nothing very complex about the ventilation. The air was forced up No. 1 stall road, down No. 2, up No. 3, and down No. 4, and so on. The safe ventilation of the workings, it will be observed, was dependent, in a great measure, on a large number of canvas doors, which were placed on the "going" or tramway (headways course). Constant traffic necessitated these canvas doors being constantly moved, and this, of course, tended to hinder the regular flow of air. In order to obviate this, holings were made through the ribs from stall to stall, the doors being placed in the stalls where the traffic was somewhat less than on the headways course. The air passed from stall to stall through the holing in the rib, thus shortening the distance it had to travel.

The produce of coal for a given area was greater by this system of working than by bord and pillar; the waste or loss in working, as nearly as could be calculated, being not more than 2½ per cent. No difficulty was experienced in getting the coal, which, when worked by bord and pillar, was found to be fairly hard in nearly all cases, generally necessitating the use of gunpowder, but this, as has already been stated, was in no case allowed under the double-stall system. It was thought that in bringing back the ribs some difficulty might be experienced in getting the coal owing to its having become "winded," but if anything, the produce per man from the ribs was greater than from the stalls. The following is a comparison of the average tons of coal hewn, per hewer per shift in the two systems as proved in the Maudlin seam, calculated over a single fortnightly pay:—

	Tons per Hewer per Shift
Bord and pillar, "whole" workings	3.04
" " "broken" "	3.95
Double-stall workings	4.06

The various kinds of labour employed did not materially differ from those of bord and pillar. The *hewers* kirved, wedged down, and filled the coal, their wages being based on the following prices (year 1890):—When driving the narrow places in the whole coal for the formation of the stook or pillar of coal, 13s. 10d. per score (21 tubs), each tub containing an average of 10 cwt. 2 qrs. (standard weight = 10 cwt.) weight of coals (= 1s. 3½d. per ton); when working the rib 12s. per score was paid (= 1s. 1d. per ton). The prices for bord and pillar in this seam were:—For whole working, 13s. 10d. per *score (= 1s. 3½d. per ton); and for broken, 13s. per *score (= 1s. 2d. per ton). Not less than four hewers per shift

* These prices were for *standard* weights, any overweight being paid for at the same rate.

were employed in each stall, there being ample room for them all. The following were the yard prices paid to the hewers :—For driving narrow bords in whole coal, 2 yards wide, 10d. per yard; for holing across from bord to bord, 2 yards wide, 1s. per yard; for driving headways course, 2 yards wide, 1s. 6d. per yard. The yard prices paid in the bord and pillar system were the same as those stated on page 200; and the wages of the putters, drivers, and deputies were the same under both systems.

As regards the drawing of the timber, there was this difference, that, whereas in bord and pillar the deputies both set and drew it, in the double-stall workings a special set of men were appointed for drawing the chocks, and were paid 3s. 10d. per shift, being employed at the rate of about five shifts each fortnightly pay for six stalls.

In connection with the cost of working, it should be stated that the system was in a transition state when the calculation set out below was made, and it was expected that the charges would eventually be somewhat reduced, as experience should from time to time suggest improvements in the method of dealing with the difficulties that always accompany the introduction of any new method of working. In this table the costs for getting the coal by the double-stall system, calculated over six fortnightly pays, are given side by side with those of the ordinary bord and pillar mode of working :—*

Labour.	Double-Stall.			Bord and Pillar "Whole" Working.			Bord and Pillar "Broken" Working.		
	Amount.	Tons.	Cost per Ton.	Amount.	Tons.	Cost per Ton.	Amount.	Tons.	Cost per Ton.
HEWING COALS—	£ s. d.		s. d.	£ s. d.		s. d.	£ s. d.		s. d.
Hewing ...	181 2 4	3,310	1 1.13	161 16 4	2,706	1 2.35	289 15 8	4,868	1 2.28
Yard work ...	8 2 6	...	0 0.59	27 7 5	...	0 2.05	3 13 9	...	0 0.18
Incidentals ...	3 1 4	...	0 0.22	5 16 11	...	0 0.51	7 2 7	...	0 0.35
Total hewing (percentages not included)	192 6 2	3,310	1 1.94	195 10 8	2,706	1 4.91	300 12 0	4,868	1 2.81
Deputy-work ...	34 4 1	...	0 2.43	31 19 0	...	0 2.83	51 6 1	...	0 2.52
Grand Totals	226 10 3	3,310	1 4.37	226 19 8	2,706	1 7.74	351 18 1	4,868	1 5.33

Owing to no separate accounts being kept of the timber consumed in each way, the cost of timber in each method cannot be

* Present-day costs would be, of course, considerably in excess of those quoted here.

stated, but it would undoubtedly be slightly higher for double-stall than for bord and pillar. The cost of *drawing* timber in the stalls is included in the table under the head of deputy-work.

In comparing the two sets of costs, the average cost of the whole and broken must be taken as the standard of comparison with double-stall. Taking a bord and wall to yield 812 tons, the yield of the pillar when removed by juds can be estimated very nearly in the same manner.

Thus—63 yards × 39 yards × 1.93 yards ...	=4,742 cubic yards.
$4{,}742 \times 18.83 = \frac{89.292}{20}$	=4,464 tons.
Deducting ⅛ for loss in broken working ...	= 558 „
	3,906 „

	£	s.	d.
Now 812 tons × 1s. 7.74d.	= 66	15	8.88
And 3,906 „ × 1s. 5.33d.	=282	0	10.98
4,718 „	£348	16	7.86

	s.	d.
Then £348. 16s. 7.86d. ÷ 4,718 ... ... =	1	5.74
Being the average cost of working the "whole" and "broken." Comparing this with "double-stall"—		
Bord and pillar	1	5.74
Double-stall	1	4.37
Difference in favour of double-stall ...	0	1.37

But this result does not represent all the advantages of the double-stall mode of working the seam in question over bord and pillar, as the percentage of round coal was much higher in the former than in the latter mode of working. There was also another advantage which ought not to be overlooked—namely, that the hewers could produce more coals per shift, as the following particulars, taken over three months, show:—

Hewers on double-stall produced	3.87 tons per shift.	
Hewers by bord and pillar „	3.49 „	
Difference in favour of double-stall	0.38 „	or 10.88 per cent. more.

Hence under these conditions fewer hewers would be required in a pit wholly worked by double-stall to raise a given quantity of coals; but a saving in hewers involves a saving in pit-room, and the cost on shift and stone work in preparing it. It also embraces a saving in houses and fire coal.

This system of working was found so satisfactory at Eppleton that it was adopted in working another seam—the Low Main—at

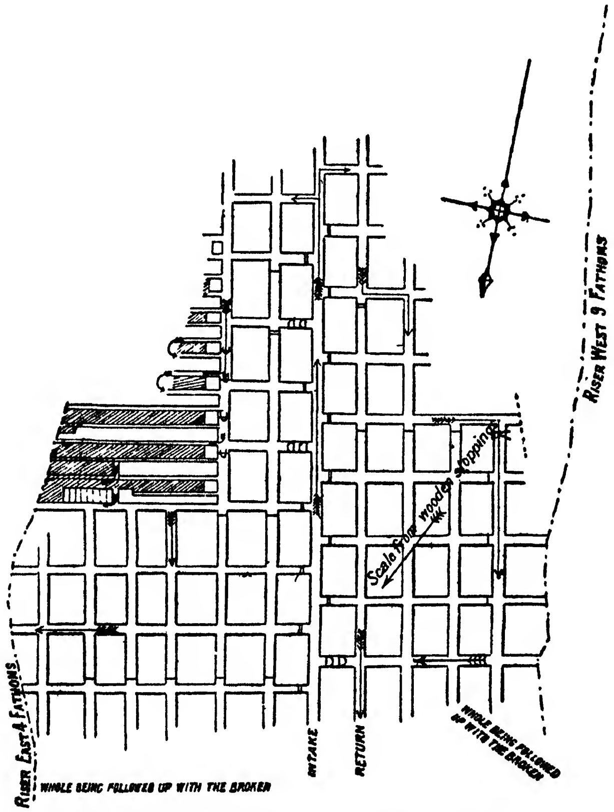


FIG. 99.—PLAN OF DOUBLE-STALL WORKING IN LOW MAIN SEAM AT ELEMORE COLLIERY.

Elemore colliery, in the same neighbourhood. Here, at the shaft, the Low Main lies at a depth of about 240 yards beneath the surface, and it has the following average section throughout the pit:—

	Ft.	In.	
Good coal	3	6	
Splint coal	0	4	for casting back which the hewer was paid 1s. 8d. per "score."
Total	3	10	

The workable section, therefore, was about 3 feet 6 inches of good coal. The roof was formed of a bed of arenaceous shale (bastard "post"), and the "thill" of hard black shale (black stone). The inclination of the seam was towards the east, dipping at the rate of 1 in 48. The coal was very strong, gunpowder being used in all the bord and pillar workings when going in the whole.

The manner of working was nearly the same as that in the Maudlin seam at Eppleton colliery, with the exception that the stalls were driven a much greater distance—in one instance, as much as 130 yards—before the working of the ribs was commenced. The reason for this was that a 4-fathom rise fault intersected the seam, as shown in Fig. 99, and to obtain the entire removal of the coal up to this fault the stalls had to be driven a greater distance than usual. The roof stood particularly well, so that when bringing back the ribs very little timber was lost. It was upheld by setting chocks 4 feet apart. As compared with the Maudlin seam at Eppleton, the loss in timber was very small indeed. It took 18 "nogs" to build a chock in this seam, whereas in the Maudlin it required on an average not less than 24 "nogs."

The ventilation was similar to that already described in the Maudlin, except that in some cases the distance the air had to travel was very much shortened by holing through the ribs about half-way up the stall.

Mention has already been made of the hardness of the coal; but although in working by bord and pillar (in the whole) it was necessary to use gunpowder as a means of bringing down the coal when kirved and nicked, no explosive whatever was employed in the double-stall workings, the coal—after it had been kirved across the face—being brought down by driving in steel wedges at the top of the seam. The following table shows the average tons per hewer per shift for six consecutive fortnights in the two ways of working:—

Pay.	Double-Stall.	Bord and Pillar.	
	Tons.	"Whole" Tons.	"Broken" Tons.
1	2.53	1.77	2.47
2	2.27	1.93	2.17
3	2.52	1.93	2.45
4	2.22	2.34	2.59
5	2.48	2.15	2.42
6	2.37	1.75	2.32
General average ...	2.39	1.98	2.40

The percentage of coal lost in working by double-stall was very low indeed. As it was in the Maudlin seam, so it was here, all coals hewn were sent to bank, no small being left in the pit.

The various kinds of labour employed were the same as those already described with reference to the Maudlin seam at Eppleton, with this exception, that whereas in that seam there was a special set of men employed to *draw* the timber (chocks), in this case the deputies both drew and set the timber. The hewers kirved, wedged down, and filled all coal, for which they were paid by the score of 21 tubs, the standard weight of tub being 8 cwt.

		s.	d.		s.	d.	
Double-Stall	In the stalls the score price was	12	4;	+	1	8	for casting back splint.
	Do., when forming "stooks" the score price was	14	9				
Bord and Pillar	In the whole the score price was	14	9;	+	1	8	for casting back splint.
	In the broken the score price was	11	2;	+	1	8	" "

The yard prices paid throughout the Low Main seam (both in double-stall and bord and pillar working) ran as follows:—

			s.	d.	
Winning headways,	2 yards wide	... ...	1	6	per yard.
Do.	3 "	... ...	1	4	"
Holing walls	3 "	... ...	1	2	"
Wide walls	5 "	... ...	0	7	"
Narrow bords	2 "	... ...	1	0	"
Bords	3 "	... ...	0	8	"
Cross-cut walls	... ...	... ...	1	4	"
Cross-cut bords	... ...	... ...	0	10	"

Considering the hardness of the coal, these prices may be regarded as very fair. The following was the cost of getting the coal:*—

Labour.	Double Stall.		Bord and Pillar. "Whole" Working.		Bord and Pillar. "Broken" Working.	
	Cost per Ton.	Tons Produced.	Cost per Ton.	Tons Produced.	Cost per Ton.	Tons Produced.
	s. d.		s. d.		s. d.	
Yard work	0 0.27	4,218	0 3.04	302	0 0.13	2,612
Incidental charges ...	0 0.65	...	0 0.14	...	0 0.74	...
Hewing	1 9.16	...	1 11.39	...	1 7.84	...
Total cost for hewing ...	1 10.08	...	2 2.57	...	1 8.71	...
Deputy-work	0 0.33	...	0 2.31	...	0 0.26	...
Total cost per ton for getting the coal	1 10.41	4,218	2 4.88	302	1 8.97	2,612

* The total cost of hewing was calculated on the total amount, and therefore included the sliding scale percentages existing at that time. These are excluded in costs given under the Maudlin seam. Present-day costs would be, of course, considerably in excess of these.

The costs were calculated over three months. In order to properly compare the cost of the two methods, it is necessary to find the average cost of the whole and broken together. Thus—taking a bord and wall to yield 327 tons, and the yield of the pillar when removed by the broken workings to be 1,122 tons—we have—

327	tons at 2s. 4.88d.	= £39	6	11.76
1,122	„ at 1s. 8.97d.	= 98	0	8.34
1,449	„	£137	7	8.10

Then £137. 7s. 8.10d. ÷ 1,449 = 1s. 10.75d., being the average cost of working the whole and broken. Comparing this with double stall, we have—

	s.	d.
Bord and pillar	1	10.75
Double-stall	1	10.41
Difference in favour of double-stall ...	0	0.34

Then again there was a gain in produce per man per shift, for by double-stall the produce was 2.39 tons per man, and by bord and pillar 2.30 tons per man, making a difference in tons in favour of double-stall of 0.09, which is 1.8 cwt., or 4.0 per cent.

Advantages and Disadvantages.—These instances of double-stall working go to show that, in the circumstances described, this system, in comparison with bord-and-pillar working, may be said to—

(1.) Allow of greater concentration of workmen, thus shortening the length of road to be maintained, and lessening the cost of shift and waste work;

(2.) Ensure a more speedy removal of the entire seam in any given area, which is a great advantage where the roof and thill are constantly on the move;

(3.) Increase the output of coal from the same number of men;

(4.) Give a larger percentage of round coal; and

(5.) The extraction of a larger proportion of the entire seam;

(6.) Enable the coal to be got without explosives, which were found necessary in working the same seam under bord-and-pillar method.

On the other hand, the comparative disadvantages of double-stall working were—

(1.) Increased cost for timber;

(2.) Insecurity of ventilation, the course of the air being dependent on a number of canvas brattice doors, and on the closeness of the fallen stone in the middle of the stall.

At **Celynen colliery**, near Aberdare, the Black Vein seam, lying at a depth of 354 yards, and of an average thickness of about 6 feet, but varying in this respect from 5 feet 6 inches to nearly 9 feet, was worked for some years by double-stall. This method has, however, been abandoned in favour of longwall, with gateways at intervals of 12 yards, and cross-headings every 70 yards. Its advantages over double-stall are found to be—

(1.) A larger proportion of round coal was obtained, 85 per cent. as compared with 70 by double-stall.

(2.) Ventilation was simpler and better.

(3.) There was more room for stowing the rubbish, which included a good deal of unsaleable small coal. This was more than sufficient to fill up the goaf solid.

An instance of **single-stall working** may be taken from **Yorkshire**, in a case where the seam—the Barnsley Bed—was dipping very heavily, 1 in 3, and working by longwall had been found not to answer. The inclination was "endways," and out of the "endings," which were made into "ginneys," the stalls were turned away at a course of S. 60 W., the level course being S. 85 W. The stalls (or "banks" as they are locally called) were driven 65 links (14 yards) wide, small pillars or stooks, ½ chain square (11 yards), being left next the ending. The ribs between the banks were left the same width, 65 links. The banks were carried a distance of 3 chains (66 yards), when they were cut off by another "ending." Only one hewer worked in each bank, and there was only one tramway,* which was laid along the dip side of the bank. The hewer shovelled his coals down the slope into the tub on the tramway. The seam was 6 feet 9 inches thick.

Reverting to **South Wales,** through the kindness of the late Mr Morgan W. Davies, who provided us with valuable notes on the subject, we are enabled to describe the manner of working the seams in the West Swansea district by the **single-stall system.** In the district referred to, the coal measures are highly inclined, the angle of inclination ranging from 22° to 50°. The direction of the dip in this part of the South Wales coalfield is north ; this being the southern outcrop of the basin. The configuration of the surface is less undulating here than is the case generally over the area of the coalfield, and workings on the outcrops of the measures have not therefore the advantage of cover that would obtain in hilly districts,

* Hence termed single, not double stall.

where the adits or slopes are invariably opened out in the escarped hill-sides which rise almost precipitously.

The mode of working adopted is shown in the subjoined sketch (Fig. 100). It consists of driving down a slope on the outcrop of the seam and following the coal downwards. Main level galleries about 9 to 12 feet wide (see Fig. 101), depending upon the character of the seam and the roof and floor, are driven outwards east and west at intervals of 20 to 30 yards apart on the slope, from which stalls 5 to 6 yards wide (when fully opened out) are developed to the rise at distances of about 15 yards apart on the main levels. When the main levels have attained the boundary of the royalty or other inbye limit, the pillars are taken out and the coal wrought

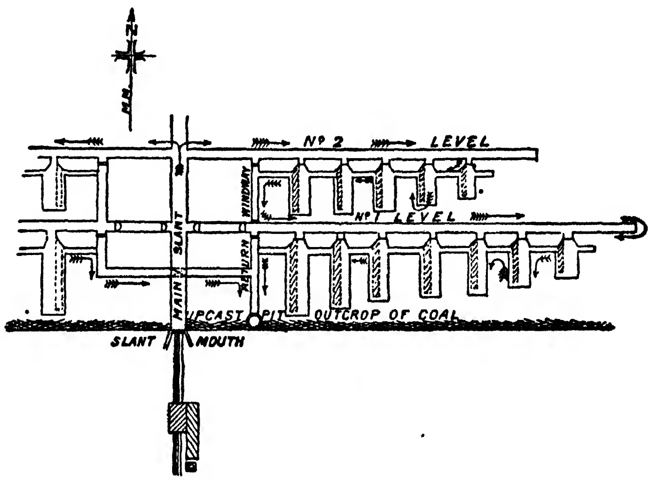


FIG. 100.—SINGLE-STALL WORKING IN SOUTH WALES.

homewards as effectually as possible, and not unfrequently at the expense of the subsidence of the surface, which the colliery lessee is invariably compelled to make good. The thickness of cover at the extremity of the upper range of stalls does not in some instances exceed 8 or 9 feet. There are no tram roads in the stalls. The coal is gravitated down; the stall is always almost full of coal, and so much as is required to fill a corve is liberated at the stall entrance into the tram or corve.

The mode of ventilation will be readily understood from Fig. 100. The current is taken down the slope, and after having made a circuit of the workings, returns to an upcast shaft. Motion is induced at the smaller collieries by furnaces or by carrying the exhausted steam of the underground pumping engines into the return windways, but at one or two of the larger collieries ventilation is effected by Waddle fans, made locally, which perform very good duty, and call for little or no attention in working. The current is carried up the stalls by bratticing, against which the little rubbish that is given off in working is packed. The shallow measures, as a whole, are tolerably free from fire-damp, and the question of ventilation does not therefore receive the attention it deserves.

When the main levels have attained a considerable distance inbye, the return windways are shortened by sinking small upcast

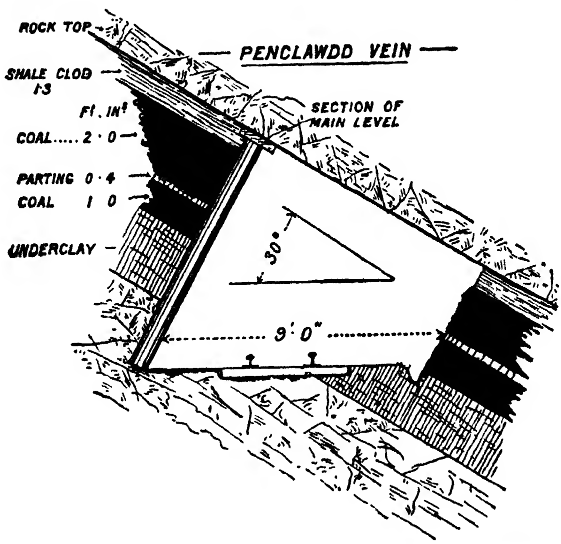


FIG. 101.—SINGLE-STALL WORKING IN SOUTH WALES (CROSS-SECTION OF MAIN LEVEL).

shafts on the outcrop, which are generally spaced at intervals of 15 to 20 chains apart.

Double-Stall in a Thin Seam.—The system is sometimes found to answer better than longwall. As a case in point, there may be mentioned a Durham colliery working a seam only 2 feet 2 inches in average section,* and having for the roof a strong shale, and the thill hard fireclay. When worked by longwall, the gateways were made at intervals of 12 yards, with packwalls 7 feet wide on each side. The average output per hewer per shift was 3 tons. When working

* *Brit. Soc. Min. Stud.*, vol. xv. "Double-Stall Working in a Thin Seam," by Edward Graham, Jun.

by the double-stall system the stalls were made 12 yards wide, and 12-yard ribs left between them. The stalls were driven a distance of 60 to 80 yards, and then the ribs were worked back. Twice the quantity of coal was got (24 yards), as compared with the longwall (12 yards), for the same amount of "packing" (two packs 7 feet wide). The quantity of coal got per hewer per shift averaged 2 tons 8 cwt. in the stall, and 4 tons in the rib, making, on the whole, more than was obtained by longwall; and the cost of working was about 4½d. per ton cheaper than by longwall.

Double-Stall in South Wales.—An instance of the successful application of the double-road stall system in South Wales, as carried out at a colliery near Neath, in the working of the Graigola seam at a depth of 433 yards at the shaft, has come under the notice of the authors. The section of the seam was as follows:—

		Ft.	In.	Ft.	In.
	Top coal	1	1	...	
	Coaly rashings cast back	...		0	11
	Good coal	2	4	...	
Filled separately—	Inferior coal	0	9	...	
		4	2 +	0	11 = 5 ft. 1 in.

The roof was for the most part a strong hard stone, requiring little timbering. Bottom stone was taken up where height was required. The tubs held 20 to 25 cwt. The gauge of way was 2 feet 7½ inches.

As shown on the accompanying plan of the workings (see Plate XXXII.), the stalls were made 14 yards wide, and the ribs or pillars of coal between them were left 30 yards in width. The space in the middle of the stall between the two roads was filled up closely with the part of the seam which is cast back, and with other "stowing," and the roof did not fall. The seam was not fiery. Four men at a time worked in the face of the stall, in sets of two. They were paid 1s. 2d. a ton of coal they got, 3d. a prop for setting timber, and 1d. a prop for drawing it, *plus* the current percentage. Their average output of coal was 3½ tons per man per shift of about eight hours in the face. Little or no explosive was used in getting the coal. The holing, or kirving, was done in the coaly rashings, which were thrown back; then the 1 foot 1 inch and the 2 feet 4 inches of good coal was got; and finally the 9 inches at the bottom, which was filled separately. The distance which the stalls were driven was usually 4 chains. The ribs were brought back in one face for their whole width of 30 yards.

CHAPTER XIV.

ON WORKING TWO SEAMS NEAR TOGETHER.

ONE of the most difficult conditions under which to work coal efficiently is where two seams lie near together, separated from each other by only a small thickness of stone. This was the case at some of the West Durham collieries, where the top Busty seam was separated from the bottom Busty by only a few feet of stone, the thickness varying a good deal. To take an actual instance, the section was :—

		Ft. In.	Ft. In.
Top Busty, 2 ft. 8 in. ...	Coal	0 3	...
	Band	...	0 3
	Coal	2 2	...
	Stone	...	12 0
Bottom Busty	Coal	3 3	...

The depth at the shaft to the bottom Busty was 50 yards. The main roads were made in the bottom seam, and inclines driven up to the top seam, which was worked off entirely before the lower one was further touched. Experience here went to prove that where the bottom seam was worked first, the top seam was quite spoilt. Opinions differ, however, on this point. At a neighbouring colliery it was considered best to commence with a first working in the bottom seam, getting a large proportion of it, and leaving pillars only 6 yards wide; then to work off the top seam; and lastly, to remove as much as possible of the pillars left in the other. The truth seems to be that in most cases, and especially when the intervening stone is firm and cohesive, it is certainly best to work the top seam first, allow the roof to settle, and then work the lower seam; but sometimes where the stone is loose and friable, the bottom portion should be first attacked, or otherwise it may be found impossible to work it at all.

In a paper on " Some Methods of Pillar Working in the South

Durham and Cleveland Districts,"* by Mr Wm. Spencer, a case at Woodifield colliery is mentioned, where the Five-quarter, averaging 3 feet 10 inches in section, was 26 yards above the Main Coal, which was 6 feet to 7 feet thick. The Five-quarter was worked both in the whole and in the broken over pillars and over goaf in the Main Coal, and it is stated that "after experience in the different plans, they decidedly prefer working the Five-quarter both in the whole and pillars before commencing with the Main seam."

In a paper by the late Sir George Elliot on "The Effect produced upon Beds of Coal by working away the Over- or Underlying Seams,"† the author states that at Monkwearmouth colliery, near Sunderland, on the northern bank of the Wear, the Maudlin seam lies at a depth of 530 yards, and is 6 feet thick, and the Hutton at 570 yards, 4 feet thick. In working the latter seam in its normal condition it was found to be easily worked, making in the ordinary course of working 50 per cent. of small coal, through screen bars ⅝ inch apart. The roof was uniformly bad, requiring much timber to support it. But when the workings extended under the Maudlin seam goaf, the conditions were entirely changed. The seam became much harder, requiring the use of gunpowder, and 20 per cent. less small was made. The roof, too, was strong, needing little timber.

At Usworth colliery, in the same county (Durham), the Maudlin seam is 310 yards deep, the Low Main seam 330 yards, and the Hutton seam 350 yards. Here, whenever the workings in the lower seams were carried on below goaf in the upper, the coal became "so hardened and bad to work that it became a difficulty to induce the men to work the coal." Eventually it was found necessary to stop the upper seams and advance the lower, "so as to work the coals entirely out in them before approaching with the workings in the upper seams." In collieries working seams at a less depth—namely, 160 yards—no effects of a similar nature were appreciable. The author's conclusion is as follows:—"Upon a careful review of all the circumstances arising out of the consideration of this interesting subject, I am of the opinion that it will prove to be of permanent advantage to deep coal-mines to work the upper seams first, and so improve the lower beds in hardness."

In working the Main Coal over goaf in the Low Main seam 50 yards below, at Trimdon colliery, in South-east Durham, the Main

* *Trans. North of England Inst. of Mining Engineers*, vol. iii.
† *Ibid.*, vol. iv.

Coal was found in some cases to have separated and fallen from the top stone, leaving a space through which men hewing in adjacent bords 20 yards apart could talk to each other. This space above the seam served as a kirving, and no other was necessary.

In a paper by Mr J. J. Jordan on "A Method of Working Two Seams of Coal lying near one another,"* it is shown that the experience gained in the Annfield Plain district of the county of Durham in working the Brass Thill below the Five-quarter (where the latter has been already worked in old times, and thin ribs of coal left 3 yards to 4 yards wide × 30 yards long, the stone between the two seams being fairly good, and varying in thickness from 9 inches to 10 yards), proves that there is more difficulty with the top stone when underneath the old pillars than under the old fallen bords; and Mr Jordan considers that it is best to first work off the top

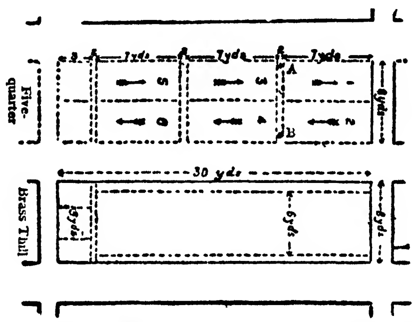


FIG. 102.—SKETCH SHOWING THE WORKING OF TWO SEAMS NEAR TOGETHER.

seam entirely, then allow the goaf to settle, and then commence with the lower seam. There is little doubt that this will be found the best plan in most cases.

Sometimes the upper seam is worked simultaneously with the pillar working in the lower seam. In one instance the section was:—

		Ft.	In.	Ft.	In.
Five-quarter	Good coal	2	9	...	
	Splint coal	2	3	...	
Soft band		...		1	0
Brass Thill: good coal		5	1½	...	

The depth was about 56 yards. The Brass Thill was worked in the whole first, the pillars being made 30 yards bords × 8 yards walls. In working the broken they cut up into the Five-quarter

* *Journal of the British Society of Mining Students*, vol. vi.

from the bord in the Brass Thill at a point about 7 yards back from the inbye end of the pillar, and drove a siding-over (A B, see Fig. 102) 2 yards wide in the Five-quarter. The block of Five-quarter, 7 yards × 8 yards, on the goaf side of the siding-over, was then removed in two bordway lifts (1 and 2, see Fig. 102). The same process of cutting up, siding-over, and working off the lifts was repeated twice, leaving a piece 3 yards × 8 yards to be worked. This was done by driving a jenkin in the Brass Thill pillar 3 yards up from the headways, and breaking up into the Five-quarter, and removing the remaining stooks in it. A jenkin 6 yards wide was then continued up the middle of the Brass Thill pillar, leaving a yard of coal on either side. When the old bords were fallen, the first step was to drive a jenkin 4 yards wide in the Brass Thill pillar.

A great deal of coal was lost, perhaps unavoidably. The reason for making the walls in the Brass Thill only 8 yards was that in working the Five-quarter, the coals were filled into the tub standing in the Brass Thill bord, and where there were more than 7 yards to cast the coals, extra wage had to be paid for it. It seems to be extremely difficult to work two seams in such circumstances without losing a considerable portion of the coal.

That it is better as a rule to work first the upper of two seams, when the distance between them is inconsiderable, is confirmed by another instance of practical experience recorded by Mr Joseph Carter.* Two seams, which were separated by 20 to 24 yards of strata, were being worked at one time by longwall, the lower seam a little in advance of the upper.

In these circumstances great difficulties were experienced in working the top seam. Frequently it was found to have fallen away from the roof, and the nature of the coal to be so changed that as much as 9d. per ton extra price had to be paid to the collier; similarly the props and chocks sunk away from the roof, and heavy falls of stone followed.

The longwall system of working was abandoned in favour of bord and pillar, but whenever pillars in the upper seam were worked over goaf in the lower, the same difficulties were encountered.

Experience proved that the working of the upper seam in advance of the lower was most decidedly the best method of proceeding, as being safer; more economical, the actual saving in working cost being sometimes as much as 1s. 3d. a ton; and also as yielding a greater produce of coal per man.

* See *Mining*, vol. iii., p. 47.

A recent instance of a *simultaneous* working of two seams lying near together having given the best results, is instructive. At St George's colliery, Natal, there are two seams, separated by about 4 feet of sandstone, lying at a depth of about 300 feet from the surface, the overlying strata consisting of sandstones and shales.

The top seam is about 4 feet thick, and the bottom seam 5 feet 6 inches, and they are lying approximately level.

After trials of different methods of working these seams, extending over several years, the following system was ultimately adopted throughout the mine.

Pillars, 25 yards by 13 yards, were made in the bottom seam by driving headings 5 yards in width. Places were then driven in the top seam, exactly overlying those in the bottom seam, care being taken that the pillars in the upper seam were exactly above those in the lower seam. All haulage roads were in the bottom seam, the top seam being reached by inclined roads, and a separate set of roads maintained in the top seam.

When pillar working was commenced, a lift 6 yards wide was driven for 13 yards across the end of a top seam pillar. As soon as this was completed, the timber drawn out, and the roof allowed to fall, the corresponding "lift" in the bottom seam was driven. In this way the goaf of the top seam was never more than 11 yards (6 yards lift *plus* 5 yards bord) in advance of the bottom seam. It was found in practice that, nearly always, the roof of 4 feet of sandstone between the bottom seam and the fallen goaf above, remained standing until the timbers of the working "lift" were withdrawn. By this method a much larger proportion of the two seams was got than by other methods previously tried. Good profits were earned and the life of the colliery prolonged.*

In a recent paper giving the results of his experience in working two seams near together at the Ibstock collieries, Leicester, Mr J. J. Torrance notes the advantage of working the upper seam first.†

When the upper seam of two seams lying near together has been extracted first, it may be impossible sometimes to work the lower seam profitably by hand labour, owing to the increased hardness of the coal and the difficulty in supporting the roof. In such cases the use of machines will enable the lower seam to

* See "Coal Pillar Extraction from Two Seams," by William Taylor Heslop, Mining Society of South Africa, 1922.

† See "The Application of Coal-Cutters to Difficult Mining Problems," National Association of Colliery Managers, read 5th February 1923.

be profitably worked. An instance of this at a Lancashire colliery is given in *M. and C. Machine Mining*, vol. iii., page 56. A 4-foot seam has been completely extracted, and 8 feet below it is a 3-foot 9-inch seam. With hand-holing the latter proved to be unworkable to a profit below the upper seam goaf. A coal-cutter was applied in the lower seam to undercutting a face of about 110 yards to a depth of 4 feet. By this means the face was advanced at the rate of 4 yards a week instead of about 1 yard, which was the usual rate of advance with hand-holing. The trouble with the roof disappeared, and the output per man employed in the face was increased fourfold.

The introduction of machines has turned the loss into a profit.

No hard and fast rule can be laid down for the best method of working two seams lying near together.

CHAPTER XV.

THE WORKING OF THICK SEAMS.

Thick Seams of South Staffordshire and Warwickshire.—The conjunction of several seams of coal, to the forming of one thick seam, has in the case of South Staffordshire, and in a part of Warwickshire, led to the development of special systems of working suited to the several conditions there existent, which are well worthy of consideration, for, although the "thick" coal of what may be termed the "exposed" portion of the South Staffordshire field is rapidly being exhausted, it has, as yet, been exploited only to a small extent east and west of the great boundary faults, and in the Warwickshire coalfield a large area of a thick coal-bed remains to be worked. Further, a knowledge of the systems of working pursued in these two fields will undoubtedly be of use to those who are engaged in wrestling with similar difficulties in other parts of the world—to name only a few instances: the thick seam in Fifeshire (18 to 20 feet), the Giridih seam in Bengal, India, and the thick seams in some parts of Australia and New Zealand.

The "Thick" Coal of South Staffordshire.—Over a large part of the South Staffordshire coalfield a number of seams—eight to thirteen—come together and rest directly upon one another, or the separate beds are divided by but thin intercalations of dirt or stone, so making up an aggregate thickness of, in some instances, 30 feet of coal, termed usually the "Thick" or the "Ten yard" coal. Although this bed, or aggregation of beds, has been worked at a thickness, inclusive of partings, of 34 feet 9 inches,* this is an unusual thickness: 24 feet would be considered

* At Mr Mills's colliery, near Hawne (see "Geology of the South Staffordshire Coalfield," by J. Beete Jukes, p. 178).

a typical section, and frequently it is below 15 feet. The particular section just referred to was as follows:—

	Ft. In.	Ft. In.
1. Roof coal	...	1 6
2. Spires coal	...	2 9
3. White coal	...	3 0
Parting	0 9	...
4. Fine floors coal	...	1 4
5. Tow coal	...	3 0
6. Brassils coal	...	1 6
Parting	0 6	...
7. Fine coal	...	2 9
Parting	2 0	...
8. Veins coal	...	2 0
9. Stone coal	...	3 0
Hard parting	0 6	...
10. Patchell's coal	...	2 9
Batt	0 4	...
11. Sawyer coal	...	1 4
12. Slipper coal	...	4 3
13. Benches coal	...	1 6
	4 1	30 8
Total with partings		34 9

Systems of Working.—In South Staffordshire two systems, of which there are several variations, have been in vogue for working

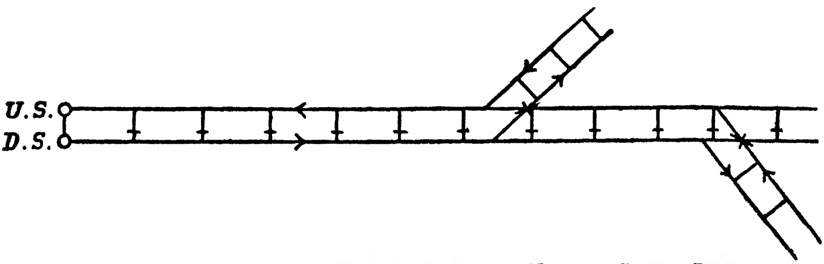


FIG. 103.—DIAGRAM SHOWING RELATIVE POSITIONS OF MAIN AND BRANCH ROADS.

the thick seam, and recently a third system has been devised. Firstly, that modification of the " pillar and stall " system known as " wide work " and sometimes as " square work "; secondly, a modification of longwall; and thirdly, a system first practised at Baggeridge colliery to be described later. The former is most commonly adopted, more especially in cases where the coal constitutes one continuous seam or the intervening layers or bands of dirt are very thin.

Briefly described, the wide work system consists in dividing the seam up into a number of compartments, termed "sides of work," which are separated from one another by ribs of coal, 8 to 10 yards thick, termed "fire ribs" (see Figs. 104 and 105), the "sides of work" being opened out from the gate-roads, and no more of them kept open at one time than are in active work. As each "side of work" is completed, and the pillars left to support the roof have been thinned as far as is safe, the roads connecting the "side of work" with the gate-roads are sealed up to prevent entrance of air, and so obviate the spontaneous combustion which is so characteristic of this coal. The manner of procedure in opening out a "side of work" will be best explained by the diagrams given below.

Having driven out the main roads a sufficient distance (see Fig. 103), preferably in some thin seam below the thick coal or in some

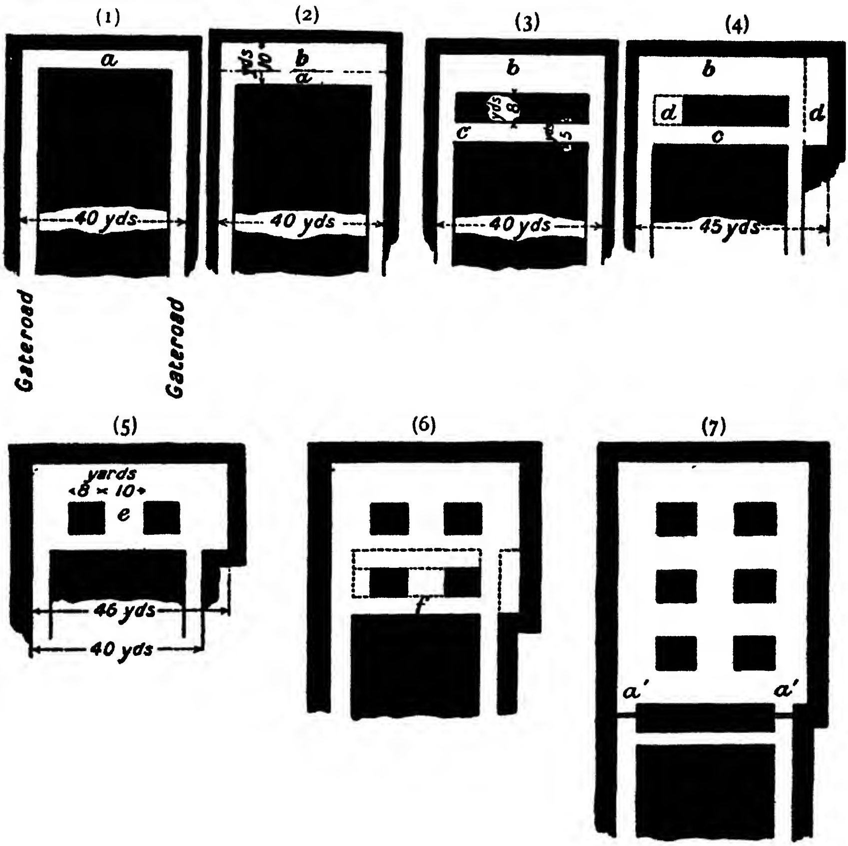


FIG. 104.—DIAGRAMS ILLUSTRATIVE OF DEVELOPMENT OF A "SIDE OF WORK."
Scale, $\frac{1}{16}$th in. = 4 yards.

suitable stratum of shale or stone, branch roads—there being the same distance between them as in case of the main roads, that is to say, between 35 and 45 yards—are turned away to the right and left, and driven in all probability in the bottom coal to the boundary of the colliery, the idea being to work "home" on the retreating system on account of the difficulties otherwise engendered by crush and spontaneous combustion. When the branch districts have been worked out, the main gate-roads are further proceeded with until they reach the boundary, when work is opened out as in the case of the branch roads, that is to say, the area to be worked is divided up into the large chambers or "sides of work," surrounded on all sides by the fire ribs or barriers of solid coal, through which are but two openings for ventilation and exit of coal and miners.

Opening out a "Side of Work."—Imagine, then, that a pair of gate-roads, driven 40 yards apart, having reached the boundary, it is

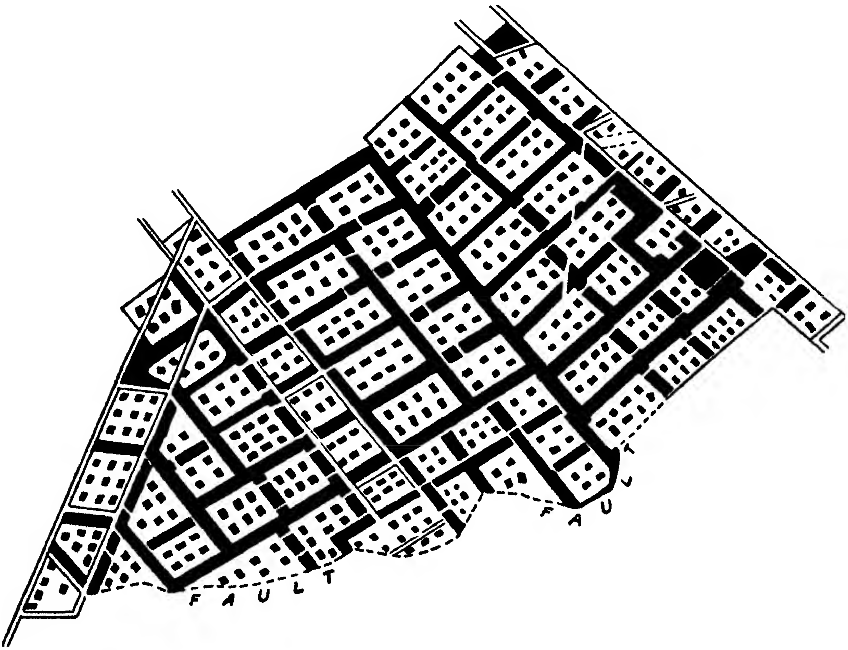


FIG. 105.—PLAN OF PART OF THE WORKINGS OF THE THICK COAL AT SANDWELL PARK COLLIERY. DEPTH FROM SURFACE, 490 YARDS. AVERAGE THICKNESS OF COAL, 17 FEET.
(*Taken from Report of Royal Coal Commission*, 1903.) Scale, 5 chains to 1 inch.

desired to open out a "side of work." This is done in the following manner:—The gate-roads are holed across as at (*a*), the holing being afterwards widened out to 10 yards by taking off the side coal. While this is being done a second cross-drivage (*c* (3), Fig. 104) is made about 5 yards wide between the two gate-roads, 8 yards back from the first holing, so leaving a block of coal 8 yards wide. The side gate-roads are then "side-laned" off, as at *d*, *d* (4), to 10 yards wide, and a "stall," *e* (5), driven 10 yards wide through the block of coal, forming two pillars 8 yards square.

These operations will have been conducted in the bottom coal or at a height of about 6 feet possibly, and the work has been merely a kind of bord and pillar working; but at this stage of the proceedings the upper layers of coal in the back opening will be taken down in sections and in layers, the successive portions of the seam being cut at the side by the "pikemen" standing on the heaps of fallen coal or on light wood staging to cut the upper layers. The coal is "nicked" or grooved along the side of the section which it is intended to take down, and divisions of coal or "spurns" are left in the "nicking," which are cut through in the upper part, afterwards further cut away, and finally knocked out by a workman known as a "pricker." Whilst this top coal is being taken down, a third holing, *f* (6), is made between the two gate-roads at a distance of 13 yards from the last one *c*, and *c* is widened out to 10 yards, the two pillars formed off as previously described, and again a fourth holing made, and the operations repeated until the "side of work" is complete, as in (7); when, after the pillars have been thinned as much as is compatible with safety to the workmen, the chamber will be dammed off at *a'a'* (7), and a new "side of work" commenced, leaving a rib of coal as a fire rib between this and the preceding side of work.

Fire Dams.—In putting in the fire dams, clay is seldom used, as it does not constitute a reliable dam owing to its cracking as it bakes, and so allowing of the passage of air. Usually a wall is built, behind which is a backing of fine river sand often as much as 10 feet thick, the front of the wall being cemented over.

Fig. 105 shows a series of sides of work as carried out in the thick seam at Sandwell Park Colliery at a depth of 490 yards from the surface, the average thickness of the coal being 17 feet.

Coal left in Working and Further Workings.—Speaking generally, in the *first* working, which has been just described, from 40 to 50 per cent. of the coal is left underground unworked, subsequently about 30 per cent. of the remaining coal is got, as the coal may be worked a second and even a third time ("turned over" three times) when not lying at a depth of more than 100 yards from the surface, in which case often as much as 90 per cent. of the total coal is recovered in all. But a considerable time, often many years, has to elapse between the several workings. In the *second* working considerable difficulty, in the majority of instances, is experienced in maintaining the roof; whilst in the *third* working the roads have to be made through the goaf itself, and are very close timbered, the roof being "slabbed" its entire length; nor can the coal working itself be said to be carried out on any systematic plan, as it practically resolves itself into a search for odd pieces of coal. In depths of less than 300 yards, the ribs and pillars should be recoverable by second and third workings to greater or less extent, such amount being in inverse proportion to the depth. No second or third workings have, so far, been found possible in depths greater than 300 yards, hence down to 300 yards (to which depth second workings may be carried on) it is better to make the pillars and ribs larger than smaller, and below that as small as possible, *i.e.*, to extract as much coal as possible in the one working.

A table, showing the amount of coal lost in working the thick seam by the wide-work system, was drawn up by the late Mr F. G. Meachem for a Royal Coal Commission, from actual working plans supplied by several well-known South Staffordshire coalowners and mining engineers, and is reproduced on the opposite page.

Modified Longwall.—The adoption of a system of modified longwall, which has been practised in some parts of the South Staffordshire field, has not hitherto been attended with that amount of success that one might have expected. It consists in forming a large pillar and working it back by longwall, leaving round the extracted pillar a complete fire rib, damming up the openings through the same, forming and removing another pillar, and so on.

The fire ribs are from 6 to 8 yards in thickness, and the extracted area they enclose is larger than that in the case of wide work (pillar and stall). If the seam is below 15 feet in thickness, it is worked in one getting, but if above that thickness, it is removed in two gettings, the top half being worked out first and the bottom half several years afterwards—six to eight years should elapse between workings, when the roof will have settled down and be in a state of rest. In the second working a thickness of about 2 feet of coal is usually left up to timber too, but in bringing back the workings some of this "top" coal is recovered. It is claimed that as much as 86 per cent. of the total coal area has been got by this system in some instances.

Working the Thick Seam at Great Depth.—The problem of working to a profit a thick seam lying at considerable depth from the surface is one which presents great difficulties to the mining engineer, and the satisfactory solution of which is of the greatest moment to the Midland mining industry, for the rapid progress towards exhaustion of the so-called "exposed area" of the coal.

Number.	Depth in Feet from Surface.	Thickness of Seam in Feet.	Gotten in First Working.	Left.	Measurements left in		Total Worked.	Area of Sides of Work	Pillars per Side.	Yield per Working.			Total Yield per Acre.	Percentage.		Theoretical Contents of Seam at 1.274 SG. =79 8 lbs per ft. reduced to 1,400 tons per acre for sale, &c.	Actual Yield per Foot per Acre.	Loss per Foot per Acre	Loss per Acre.
					Ribs.	Pillars.				First.	Second	Third.		Coal.	Slack.				
			%	%	%	%	%	Acres		Tons.	Tons	Tons.		%	%	Tons.	Tons.	Tons.	Tons.
1.*	300	24 to 30	55 to 65	10.00	...	...	85 to 90	1½	...	16,000	12,000	2,000	30,000	60	40	33,600	1,250	125	3,600
2.	450	24.0	69.39	32.61	20.61	12.00	80.0	1¼	14	,,	10,000	...	26,000	,,	,,	,,	1,083	266	7,600
3.	600	,,	66.40	33.60	25.20	8.40	70.0	1⅛	13	15,000	8,000	...	23,000	,,	,,	,,	965	241	10,600
4.†	600	,,	57.22	42.78	33.46	9.32	84.0	1¼	...	18,000	10,000	...	28,000	55	45	,,	1,161	239	5,000
5.	900	,,	60.00	40 00	25.00	...	89.0	1⅛	12	,,	8,000	...	26,000	52	48	,,	1,083	317	7,600
6.‡	1,200	,,	62.00	38.00	,,	13.00	62.0	1⅛	10	16,000	...	...	16,000	50	50	,,	666	733	17,600
7.‡	1,500	17.6	60.09	39.01	30.91	9.00	60.0	1¼	7	13,000	...	...	13,000	45	65	23,600	742	616	10,800
8.‡	1,800	20.0	57.00	43.00	36.00	7.00	57.0	¾	4	,,	...	..	,,	40	60	28,000	650	750	15,000
9.‡	2,100	14.0	54.25	46.75	37.47	9.28	54.25	¾ or less.	5 or less.	to 9,000	...	...	to 9,000	35	65	19,600	642	755	10,600

* Fine unsaleable slack was left under foot, but is included in measurements, as we are now considering system of work. Had the slack been of any use it would have been drawn out.

† There is a great discrepancy in weights owing to the various weights and parcels sold.

‡ No second working yet tried to my knowledge.

field will necessitate the opening out of the, as yet, little developed "hidden area" where the thick coal exists at considerable depth from the surface. In the Table, page 278, it has been shown that not much more than half of the total coal is recoverable, and of this no less than 60 per cent. is slack when working at and above 2,000 feet from the surface.* Inded, it is estimated that the relative proportion of the vend to the coal *in situ* is about 43 per cent. If these figures are correct, they show a very serious state of affairs and form much food for reflection.

That the high percentage of slack is not due alone to the pressure of the superincumbent strata is shown by the fact that in thinner seams lying at greater depths (as, for instance, in the southern portion of the North Staffordshire coalfield), and where the overlying strata are similarly constituted to that in the case before us, the amount of "crush" on the coal, as evidenced by the percentage of slack, is very much less. It would seem, therefore, that the pulverising effects are also ascribable to some extent to the inherent tension of the coal itself. At Hamstead colliery these effects are very noticeable, the workings there being much subject to eructations, termed "bumps," occasioned, doubtless, by the release of the tension of the coal by the driving of the roads. The "bumps" are of a very sudden and violent character, occurring

* Mr Meachem, in his evidence before the Royal Coal Commission, stated that the proportions of large and small coal obtained under the different systems were as follows :—

Depths of Seam from Surface.	Pillar and Stall.	Longwall.
Down to 100 yards deep	50 °/₀ coal, 50 °/₀ slack.	50 to 55 °/₀ coal, 45 to 50 °/₀ slack.
200 yards deep	45 °/₀ coal, 55 °/₀ slack.	50 °/₀ coal, 50 °/₀ slack.
300 to 400 yards deep ...	40 °/₀ coal, 60 °/₀ slack.	45 °/₀ coal, 55 °/₀ slack.
400 to 700 yards deep ...	30 to 35 °/₀ coal, 65 to 70 °/ slack.	Not tried to his knowledge.

See also Table on page 278.

usually in the floor of the roads driven in the bottom of the thick coal, much destruction resulting to timbering and the roads themselves, large fissures being made in the seam owing to the pressure and the resistance offered to the same by the floor; and there is little doubt, seeing that these fissures contain a certain amount of finely crushed and powdered coal, that the initial heat due to attrition, and the oxidation of the finely powdered coal in the

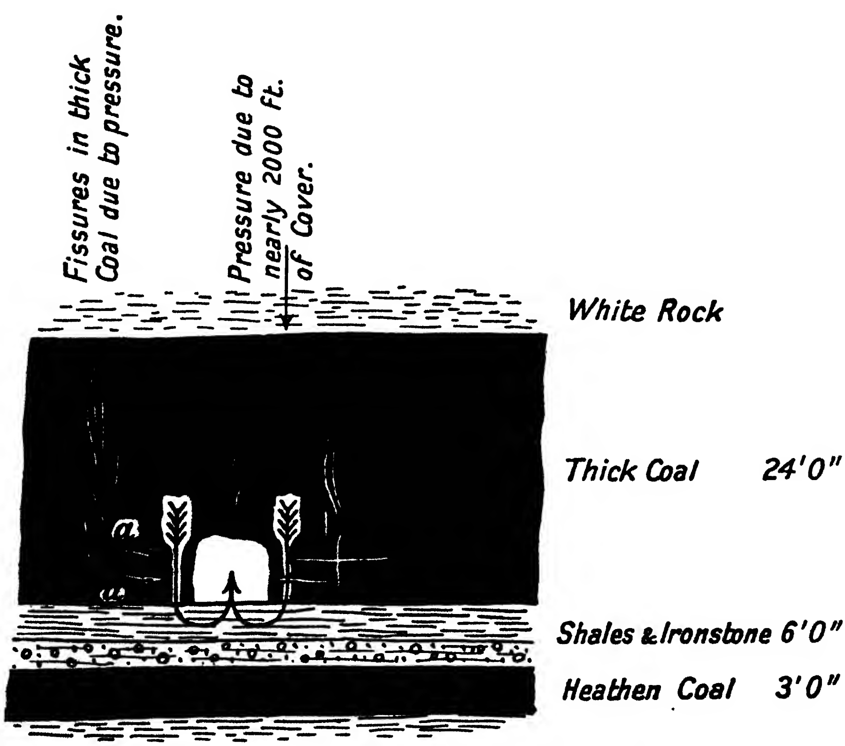


FIG. 106.—DIAGRAM ILLUSTRATING PRESSURE ON FLOOR BY ROADS DRIVEN IN THICK COAL. Arrows denote direction of pressure on bottom or floor. *a, a* denote side or horizontal fissures connecting with main or vertical fissures.

fissures due to leakage of air from the roads by means of cross fissures (*a, a*, Fig. 106). are the exciting causes of the spontaneous combustion which here sometimes occurs in the solid coal itself.

This, therefore, is an example of "thrust". in its severest form combined with the effects of coal tension. A possible remedy suggests itself to the writers, namely, that of providing an easement to this double pressure by working out a thin seam lying in close proximity to the thick coal, one preferably *below* the thick coal, say the "heathen coal" (see Fig. 106). For if an upper seam were worked first, it might tend to injure the roof of the thick coal; further, at Hamstead colliery there does not appear to be a seam of coal above the thick coal in near proximity thereto.*

A Method of Working the South Staffordshire Thick Coal recently practised.—This method, which was devised a few years ago by Messrs D. S. and J. W. Newey,† was carried out by them at Baggeridge colliery, situated beyond the western edge of the exposed coalfield of South Staffordshire, and where the thick coal lies at a depth of 1,800 feet from the surface and is at a thickness ranging from 10 to 27 feet, but averaging 20 to 22 feet inclusive of at least one band of dirt varying from 1 to 6 inches in thickness. The problem of successfully working the thick coal at such depth so as to secure a complete extraction of the coal with gradual and diminished subsidence of the overlying strata was, it will be seen, an extremely difficult one.

The operations were as follows:—

The gate roads were, as is the usual practice in working the thick coal, driven out to the boundary, and the coal worked back towards the shaft. Two main gate roads were driven at an angle of 45° to the line of main cleavage of the coal, at a distance of 51 yards from each other, centre to centre, and connected by cross-roads every 102 yards.

Having passed beyond the limit of the shaft pillar, three branch gate roads are set away from and driven at right angles to the main gate roads with the object of forming a "panel" or "side of work," the main gates proceeding and other branch roads set away, a barrier of coal being left between each set of branch

---

* The succession of the seams in a typical section of the "exposed" portion of the coalfield is, in descending order:—

1. The brooch coal.	4. The heathen coal.
2. The flying reed.	5. The new mine.
3. The thick coal.	6. The bottom coal.

The late Mr F. Meachem, who had great experience in working the thick coal, differed from the writers in that he was of the opinion that the top seams should be worked first, as forming thereby a cushion *over* the thick coal and limiting the force of the "bumps."

† See "A New Method of Working Thick Seams of Coal with Special Reference to the Working of the South Staffordshire Thick Coal at Baggeridge Colliery," by Dudley S. Newey, B.Sc., F.G.S., *Transactions Inst. M.E.*, vol. viii., pp. 257-281.

roads of such a width as to permit of a panel being formed later on when the other two panels have been brought back.

The roads are driven 8 feet wide in the lower half of the coal. The "side of work" or panel is formed by the three roads already mentioned, which are, like the main roads, 51 yards apart, and connected every 80 yards by crossroads for ventilation purposes, and also at the boundary, by a road 8 feet wide for cutting off the back rib, the panel being so divided into pillars 240 by 145 feet. When this is completed the position is then as shown in Fig. 107.

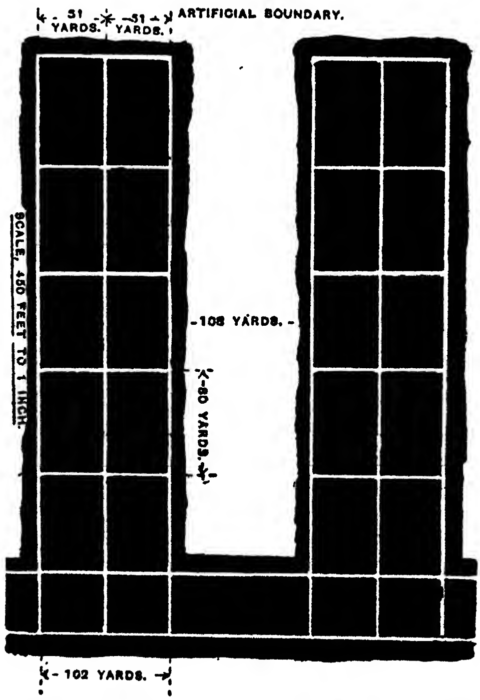


FIG. 107.—SHOWING DIVISION OF PANEL INTO PILLARS.

Work is then commenced in the back pillars, dividing them into four, as shown in Fig. 108; the back two of these four pillars being then further split up as also shown in the figure. These pillars are 116 by 43 feet.

Coal to the width of 8 feet is then taken off alongside the back rib road by a "pane," or stall, the latter being simultaneously packed solid with stone, and a width of 8 feet of coal is also taken out at the side of the outside road and similarly packed up (see Fig. 118).

After this a second pane is taken alongside the first by driving out of each of the six roads, a stone or timber cog 9 by 8 feet having first been built in the first pane on the opposite side of the

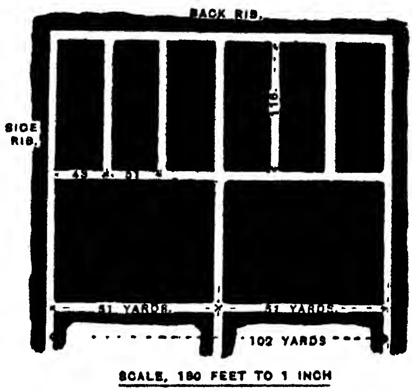


FIG. 108.—DIVISION OF BACK PILLARS INTO FOUR PILLARS, AND THE SPLITTING UP OF THESE.

road, the object being to afford support to the timbering of the first pane when second pane is being driven into the road. As the second pane advances further, similar cogs are built in the

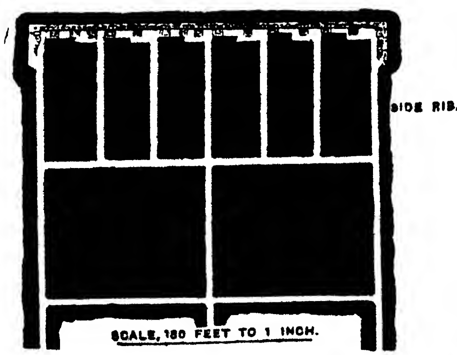


FIG. 109.—SHOWING MANNER OF WORKING OFF THE SMALL PILLARS BY "PANES."

first pane at intervals of 8 feet, the spaces between being the points at which the top coals are gotten. Great care has to be exercised in the construction of these cogs. The bottom is of rock built to a height of 5 feet, and above this there are built up pieces of timber 4½ feet long, placed crosswise, tire on tire, so that in working the top coals half of the cog can be taken off from adjacent "bolt holes," as the spaces between the cogs are termed (see Fig. 110).

Fig. 111 shows the position after the completion of the driving of the second pane right across the side of work.

So far all the work has been carried on in the lower portion of the seam.

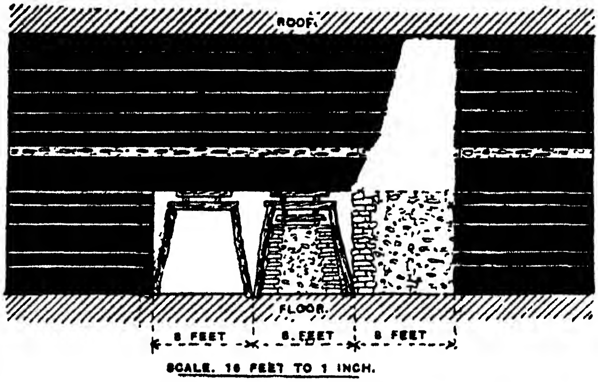


FIG. 110.—SECTION ACROSS FIRST AND SECOND "PANE."

The sequence of events carried on in the getting of the upper portion of the seam is as follows :—

The "pickers-in," as the workmen who cut into the top coal are called, cut up the coal over the backmost packing, standing on

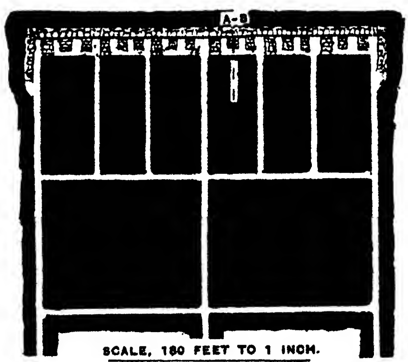


FIG. 111.—SHOWING PILLARS AFTER THE SECOND "PANE" HAS BEEN DRIVEN.

the packing for the purpose and, if necessary, erecting scaffolding thereon.

The back rib is then cut up to the roof for a width of 4½ feet on each side of the top bolt hole (space between cogs), and the centre cog is put on in the second pane. The men then commence cutting up from the middle bolt hole. The back rib cutting is connected through to that already done, and 4½ feet taken off on the other side, and so on, the various lengths of back rib cut off being separated by "spurns" of coal 17 feet thick. These spurns are gradually taken out and the rib cut up perpendicularly across the whole side of work after the road-end cogs have been put in in the second pane, and "entering up," as the cutting of the top coal is called, has been carried out from the road-end or straight-in bolt holes.

The side ribs are also cut off over the back of the side rib packing in the same way, for a distance of about 8 feet from the back rib. Whilst the above work is being carried on, a third pane is commenced and worked from each road, being driven

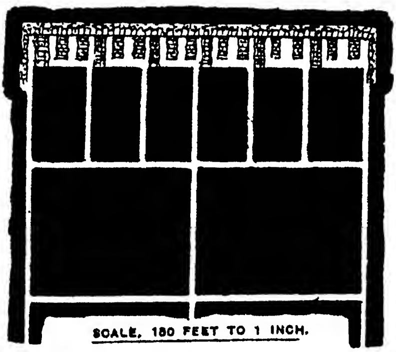


FIG. 112.—PILLARS AFTER THIRD "PANE" HAS BEEN DRIVEN.

through to the road above, when the top cogs are put on (see Fig. 112).

So far the work has consisted largely in opening-up. Now commences the working of the coal, which is carried out simultaneously in each stall.

Taking one stall as an example. There are usually three coal-getters, viz., a picker-in or stallman, who gets the top coal, assists in driving the panes and in timbering, and who is responsible for the safe working of the stall; a pikeman, who drives the panes, retimbers and "rises" the bolt holes when necessary, puts in the road-end crossings, and carries out repairs in the pane and stall road; and a loader, who besides loading the coal produced by the two last-mentioned workmen, assists the pikeman in the timbering.

It will be remembered that the distance between the stall roads is 51 feet, and the roads being 8 feet wide, the length of coal face remaining is 43 feet. There are three 9-feet cogs separated by bolt holes 8 feet wide, making three bolt holes to each stall. The cogs are known respectively as the "road-end," the "centre," and the "top cog," according to their position, and the bolt holes are called the "straight in," "centre," and the "top bolt holes."

The picker-in commences work in the top bolt hole by taking off half of the left-hand or top-back cog (see A, Fig. 113), undersetting the coal with timber whilst so engaged. When the half of the cog has been removed, the timber is withdrawn and the coal allowed

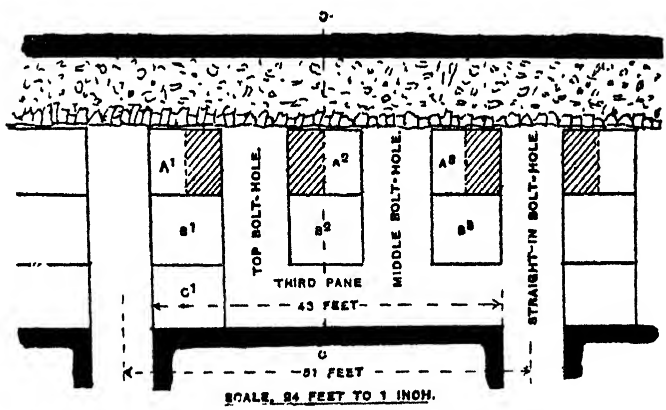


FIG. 113.—SHOWING THE ARRANGEMENT OF THE COGS.

to fall. Should it not fall, it is taken down layer by layer, and a loose end so formed. The process is then repeated in regard to the right-hand cog (see A^2, Fig. 113). Whilst this is being done, the pikeman retimbers the middle bolt hole (as the top pressure must have increased), and commences to do the same in the straight-in bolt hole.

The top bolt hole being finished, the centre cog is built in the third pane, the centre bolt hole is entered and the remaining half of the centre cog (A^2, Fig. 113) removed, and then the half of the cog on the right-hand side (A^3) and the top coals got down as in the preceding case. Whilst this is going on, the pikeman completes the retimbering of the straight-in bolt hole and commences driving a fourth pane. The middle bolt hole being finished, the way-end cog is built up in the third pane, and the top coals got down in the straight-in bolt hole in the manner already described. Fig. 114 shows in section the position of the workings at this stage of the proceeding. The work is carried on in this manner until the whole of the coal is worked off.

It is claimed by the Messrs Newey that by this method of working complete extraction of the coal is obtained, and they give

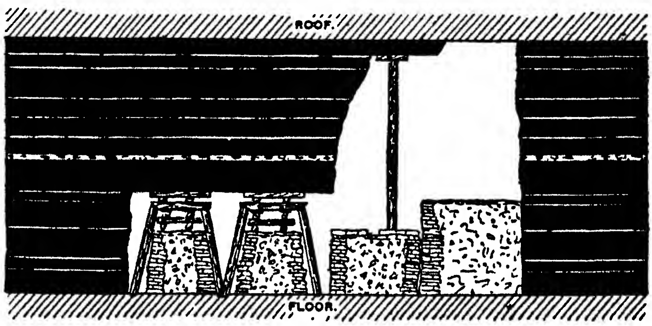


FIG. 114.—SECTION AT RIGHT ANGLES TO THE FACE IN FIG. 113

as proof of this contention a tabular statement of results relating to two areas taken over a period of twelve months, viz. :—

No.	Thickness of Coal.		Area Worked.	Output.	Output per Acre.	Output per Acre per Foot Thick.	Weight of Coal *in situ* per Acre.
	Ft.	In.	Acres.	Tons.	Tons.	Tons.	Tons.
1	20	4	0.620	19,476	31,413	1,545	31,613
2	19	6	0.953	28,205	29,596	1,517	30,322

Another Method of Working Thick Seams, or Seams in close proximity to each other, known as the "Hill" System.—Another method of working a thick seam at considerable depth from the surface, for details of which the writers are indebted to Mr J. H.

Laverick, is in operation in Warwickshire, and is well worth describing. The seam, which lies at a depth of about 500 yards, averages about 24 feet in thickness, and, like the "thick" coal of South Staffordshire, is due to the coming together of several seams—perhaps five—but for practical purposes is regarded as having three principal divisions, viz., the "two-yard" coal at the top, then the

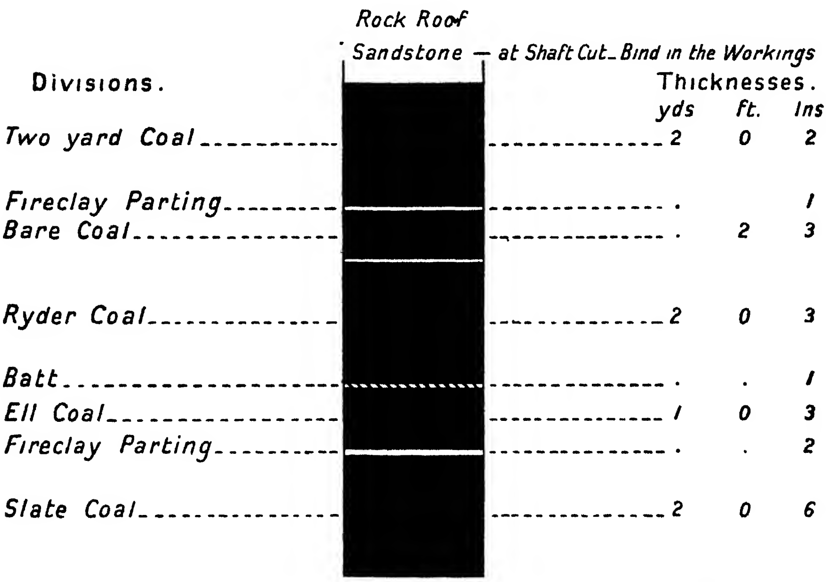


FIG. 115.—"HILL" SYSTEM OF WORKING THICK SEAMS IN WARWICKSHIRE.
The dip of the seam is variable, but in no part is it steep.

"Ryder" coal, and, at the base of the seam, the "slate" coal. A detailed typical section is shown in Fig. 115.

The roof at the shaft was good, consisting of sandstone; but in the workings some distance from the shaft the sandstone disappeared, its place being taken by a bed of bind, which did not constitute a good cover.

According to the old method of working, in the instance before us, it was customary to drive the roads in the two-yard coal and work this part of the seam by ordinary longwall, leaving the ryder

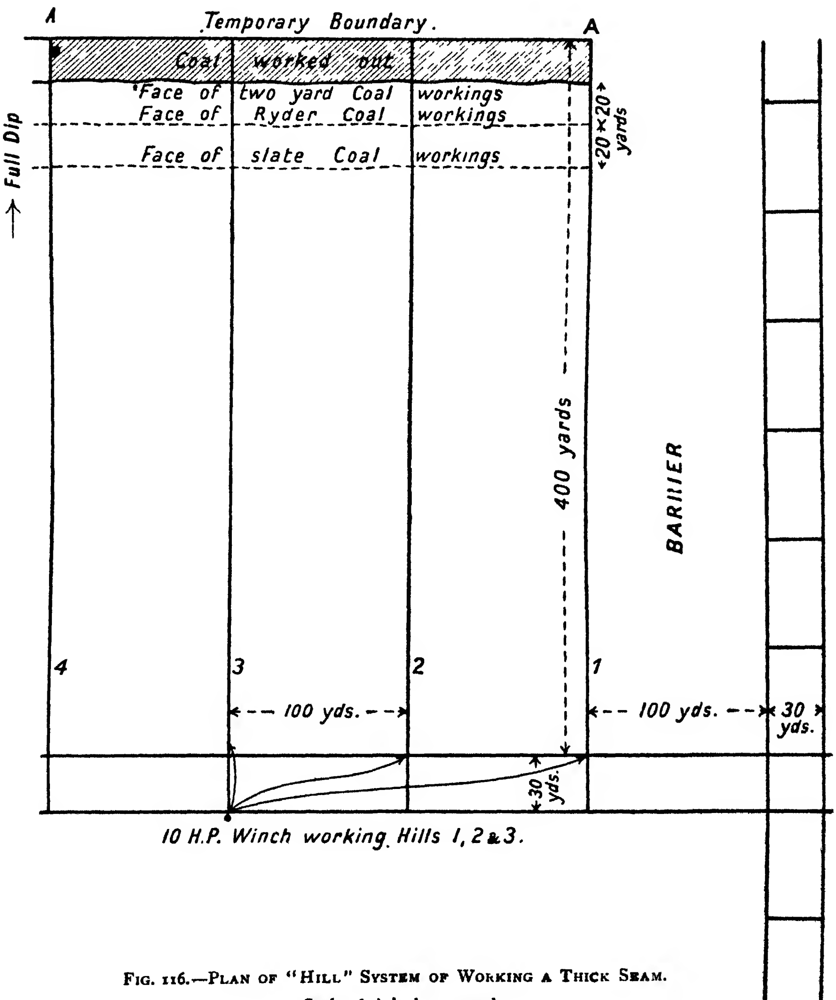


FIG. 116.—PLAN OF "HILL" SYSTEM OF WORKING A THICK SEAM.
Scale, $\frac{1}{10}$th inch = 10 yards.

and slate coals to be attacked by others at some future time. This answered well, no doubt, so long as the roof was a good one, though unquestionably it would have been much more profitable to remove the whole of the coal in one working, were that possible, but when succeeded by the bad roof of bind the timber cost would be very heavy, and the more recent method now to be described, and known as the "hill" system of working, is a great improvement on the old, for not only is a greater amount of the seam extracted in the one working but the timber costs are much reduced.

The main winnings were a pair of places driven 30 yards apart, on the full dip of the bed in the lower portion or "slate" coal (see Fig. 116). From these the "district" winnings or levels were turned away at right angles, and driven, also 30 yards apart, on the line of strike. From the levels, and at right angles

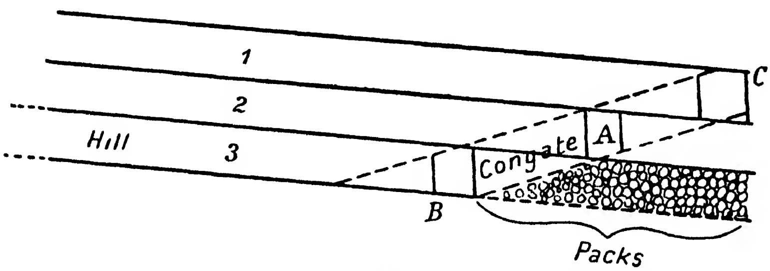


FIG. 117.—"HILL" SYSTEM OF WORKING SECTION, SHOWING ARRANGEMENT OF HOLINGS. (Not drawn to Scale.)

to them, the headways, or "hills" as they are locally termed, were turned away, in the same seam, at distances of 100 yards from each other, and driven to the full dip for about 400 yards, when they were, with the exception of the barriers, holed across as shown in Figs. 116 and 117. Each district was therefore made up of a number of pillars (say seven or eight, inclusive of the barrier) 400 × 100 yards each, formed in each division of the seam. These pillars were then worked back by longwall in each of the three sections of the seam as follows :—

Longwall was commenced in the bottom seam some little distance back from the temporary boundary AA, and longwall started in the other seams, the respective faces being connected by an inclined road or "congate" (BC, Figs. 117 and 118), and as the workings retreated this road was carried on the packs of the lowest seam and ripped through the other seams if they were not worked. It will be seen, therefore, that there was a small initial loss of coal (which might afterwards be recovered by the workings lower down) in the shape of an angular block of coal left against the boundary. It was desirable to have as little distance as possible between the faces in the successive seams, so as to keep well in advance of gob fires, which are very frequent in this field It was found practicable, indeed, to advance the face by steps of not more than 20 yards. In this respect we may call attention to the advantage of driving out to the dip and working back on the rise. Heavy though the haulage may be, this drawback is

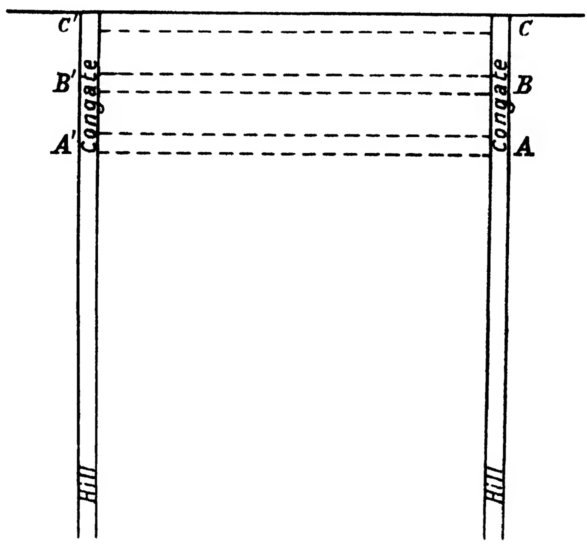


FIG. 118.—"HILL" SYSTEM, DETAILED PLAN OF WORKINGS. (Not drawn to Scale.)

CC'—Holing between Congates in Upper Division.
BB' ,, ,, ,, Middle ,,
AA' ,, ,, ,, Lower ,,

far more than compensated for by being able to work out the coal without fear of gob fires, for the water can be allowed to rise in the goaf behind and extinguish them or prevent their occurrence.

The gob was packed with the bottom stone in which the holing was done, to a large extent by coal-cutting machines, and also with lumps of bad coal (there are bands of inferior coal): the rule observed being that there should be alternately 2 yards of packing and 5 yards of waste, which ensured the bad coal being sorted out underground.

The labour system for coal getting was that of—(1) stallmen or contractors, (2) holers or getters, (3) fillers. The stallmen being the only men in receipt of payment as from the company, they, of course, being paid by the ton of coal got and by the yard for ripping (where such was necessary), and for sundry extra work, such as cutting a "fast-end," heading by falls, &c. The setting of the timber and putting in of the packs was included in the tonnage (*i.e.*, charter) price, the stallmen paying the holers and fillers datal wages for their work.

System of Labour employed in Working the Thick Coal.—The system of labour employed in working the thick coal was very similar to that in operation in longwall workings in the Midlands, with the exception, of course, that there were more loaders in each stall in the former; there was very little "stint" (piece) work in thick coal working. The system may be epitomised as follows:—

1. *Contractors, or stallmen,*—who were paid per ton with a standard price of say 1s. per ton of round coal and 5d. per ton of slack, with percentage on each (about 40 per cent. above standard in 1905), as well as a heading price for driving the roads out to split the work up. Besides seeing to the getting of the coal, the stallman set the timber and kept the tubs going. He employed either one or two pikemen and two or three loaders; as a rule three men worked at one "band."

2. The *pikeman* got the coal and kept the loader going, and in the absence of the stallman set the timber and otherwise undertook his duties. He was paid a datal wage by the stallman.

3. The *loader* filled the tubs with the coal, and, if a sufficiently experienced man, was sometimes also employed in getting coal. He also was paid by the day by the stallman.

4. The *repairers* were paid a yardage for lowering (bating) the floor, stripping roof, and setting timber; or if at work at a breakdown of rock (fall of stone) they were paid either by daywork or on the number of tubs of dirt loaded.

The getting of the bottom part of the coal, or "undergoing" as it was locally termed, was not very profitable to the stallmen, so that the colliery company had often to advance them money on account, deducting the sum lent when they got (drop) the top coal.

CHAPTER XVI.

WORKING OF WELSH STEAM COAL SEAMS.

Peculiar Structure of Welsh Coal Seams.—The steam coal seams and the anthracite seams of South Wales are different from most others in the presence in them of numerous smooth partings known as "slips," extending right through the seam from floor to roof, and inclined at an angle with the floor and roof.

When a working place is advancing so that the slips make an obtuse angle with the roof, and slope away from the man towards the floor, he is said to be working on the "face" of the slip, and when coming in the opposite direction, he is on the "back" of the

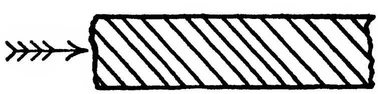
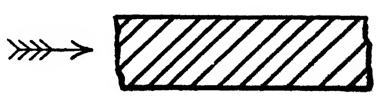


FIG. 119.—ADVANCING ON FACE SIDE OF "SLIPS."



DITTO ON BACK SIDE OF "SLIPS."

slip (Fig. 119) The thinner anthracite seams work best on the "face" of the slips, and for working on the "back" a higher hewing price amounting to 1d. to 2½d. a ton is often paid; but in the thick seams the advantage is rather the other way, especially where there are some inches of soft stone or "clod" above the seam. In the steam coal seams it is the rule for the same price to be paid for hewing, whether working on the face or back of slips.

This peculiarity of structure renders the seams easy to hew; the coal falls readily in large blocks, holing or shearing is unnecessary, and as a rule no shot firing is required. Consequently these seams are not suitable for the use of longwall coal-cutting machines, as owing to these numerous slips it is difficult to keep a face straight, and also the coal tends to fall on the machine.

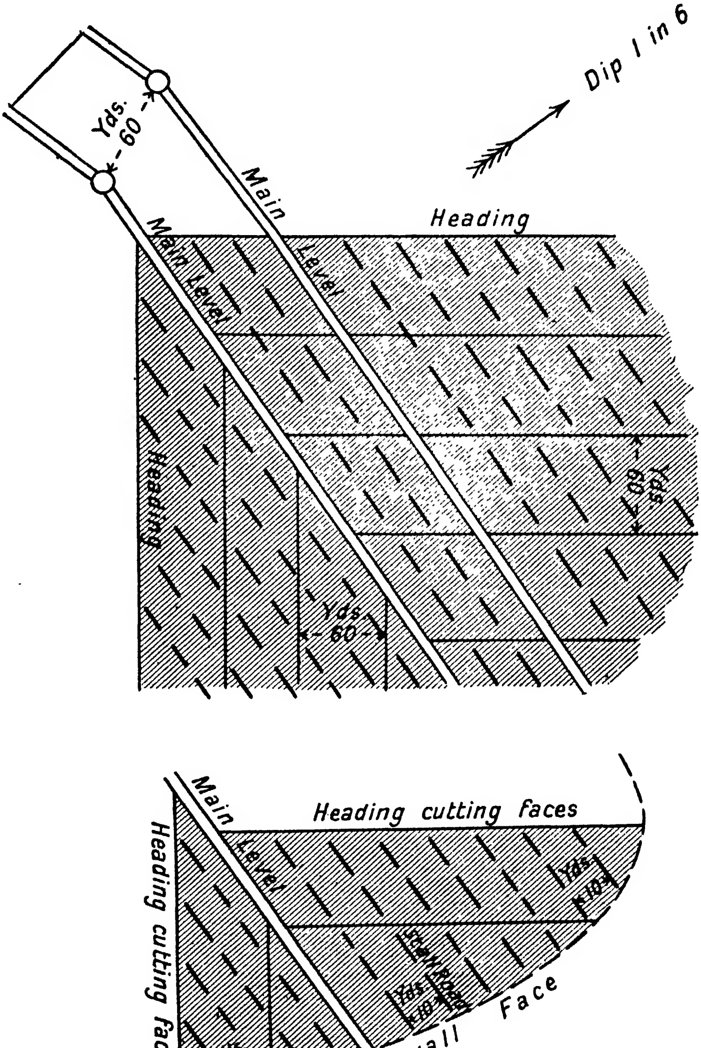


FIG. 120.—SKETCH SHOWING METHOD OF WORKING STEAM COAL SEAM (see page 299).

There are, however, many seams in South Wales where coal-cutting machines may be employed with advantage.

Supporting of Roadways and Working Places in South Wales.—Some idea of the great number of seams and their close proximity one with another in the South Wales coalfield will be conveyed by the following section taken at a characteristic colliery in the Rhondda Valley:—

Upper or Bituminous Seams.	Depth from the Surface in Yards.	Section of Seam.
		Ft. In.
No. 1 Rhondda	23	3 0 in two beds
Forrest Vach	77	2 10 in two beds
No. 2 Rhondda	86	2 6 in one bed
No. 3 Rhondda	148	3 0 to 3 ft. 6 in.
Hafford	209	2 5
Eight thin seams lying together, all of which are under 2 feet in thickness	250 to 260	...
Main seam	300	...
Two-feet-nine seam	349	5 1 in three beds divided by clod
Four-feet seam	366	5 6
Six-feet seam	391	6 0 in two beds with 1 in. parting between
Red coal	410	3 0
Nine-feet seam	422	5 7 in two beds
Lower four-feet seam—		
Top coal	440	3 6
Bottom coal	443	3 0
Five-feet seam	470	{ 4 0 top coal; 3 0 to 5 ft. rashings; 3 0 bottom coal

There is little doubt but that the great number and close proximity of the seams has an important bearing on the movement of the strata.

The workings in the South Wales coalfield are, more than in any other coalfield in the United Kingdom, subject to pressure and resultant movement of floor, roof, and sides. The Committee appointed by the Royal Commission to inquire into accidents from falls of ground, &c., say in their report in regard to this pressure: "The area alluded to in South Wales is subjected to an additional difficulty, namely, great pressure, which we are of opinion is not a vertical pressure (such as in the case of the No. 15 pit of the Monceau-Fontaine Company in Belgium), but is inclined.

The explanation of the peculiarity may, perhaps, be found in the highly denuded surface of the country forming the deep and narrow valleys, in or near the bottom of which the collieries are usually situate. The mountains, for instance, above the Great Western colliery in the Rhondda Valley, rise about 700 feet above the level of the river." The pressure would therefore appear to be diagonal, and so account for the great difficulty which is experienced in most of the collieries, particularly in the steam coal seams, in supporting the sides of the roadways (see Fig. 121).

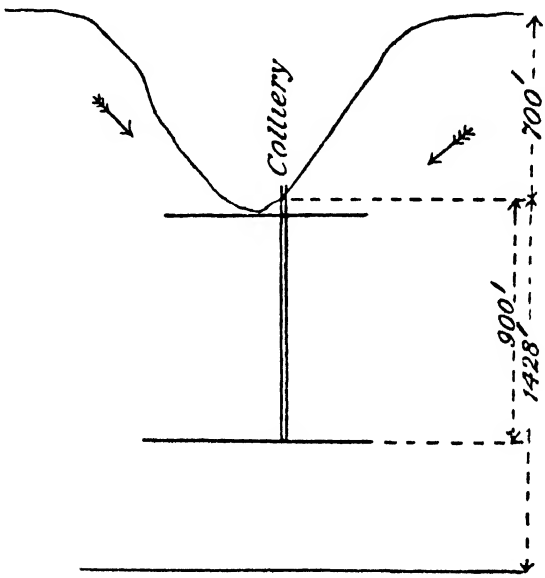


FIG. 121.

The floors, too, are subjected to considerable "heaving" or squeezing up. This complication of movement necessitates the adoption of special methods of timbering

As indicating the great amount of heave or creep of the floor, the following section may be given (see Fig. 122). It was taken by one of the authors in the main return airway of a Rhondda Valley colliery, one mile from the face and the same distance from the shaft, and it shows how much higher the floor of the return airway is than the top of the seam—a fact, in this instance, due to the damping of the road with water.

The manner of timbering the haulage road in the Main Seam

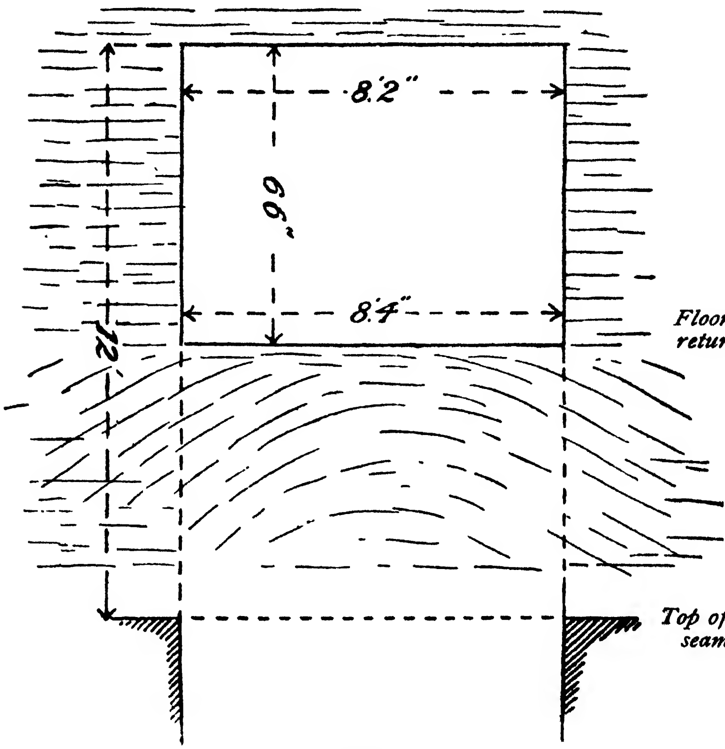


Fig. 122.

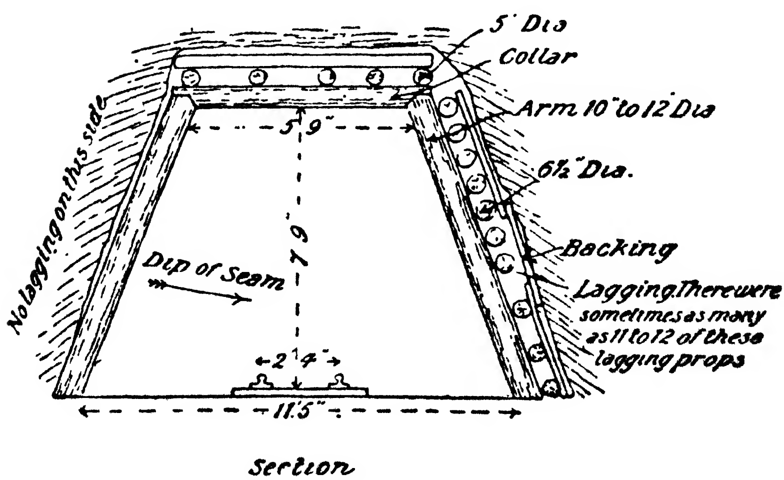


Fig. 123.

at this colliery is shown in Fig. 123, and may be regarded as characteristic of other collieries in the district. The seam, which lies at a depth of 300 yards from the surface, has the following sections:—

	Ft.	In.		Ft.	In.
Roof—					
Rock clift (*i.e.*, blue or grey metal shale) ...	3	0	to	10	0
Clod	0	4			
Top clod	1	3			
Rashing (*i.e.*, dirt band)	0	8			
Coal (bottom seam of main seam)	4	6			
Floor—					
Rashing	1	0	to	1	6
Coal	2	6	unworked.		

The roof in this case may be taken as typical of South Wales steam coal seams.

It will be noted that the props (leg or arms) on the main haulage road are inclined in order to support the side. Vertical timbering on the North country system has been tried on the roads of South Wales collieries, but has always failed. The timber used is Spanish, Portuguese, or French pine. It will be observed that the ends of the "collars" are notched, and those of the "arms" shaped to fit the notch and so prevent movement due to side pressure. The shaping of the ends of the arms has to be performed with a certain amount of care so as to allow the arm to press against the collar, but not to cut it.

As has been stated, in parts of South Wales a greater number of seams of coal than is usual (except, perhaps, in the case of Lancashire) occur within a given thickness of strata, so that the beds of stone and shale constituting the "cover" to any seam are of limited thickness. It is probably owing to this that the similarity of roof conditions is due which exist between the collieries of the steam coal area of South Wales and those of some of the French (Pas de Calais) and Belgian mines, in these cases the stone constituting the immediate roof being of a "short" or broken nature. It is largely on this account that it has become customary to leave the timber supports in the goaf or gob of South Wales collieries. In some cases the attempt to withdraw the timber would undoubtedly be attended with considerable danger, nor would it be possible to recover it all, but in other cases a considerable recovery could undoubtedly be obtained with safety, and the withdrawal would result in improved face conditions by reason of the more regular and even settlement of the superincumbent strata in the waste, but it is difficult to overcome the ingrained custom of years.

Longwall in South Wales.—Apart from these peculiarities, and also that the seams are lying generally at a gradient of 1 in 6 or more, the general system of working them by longwall is much

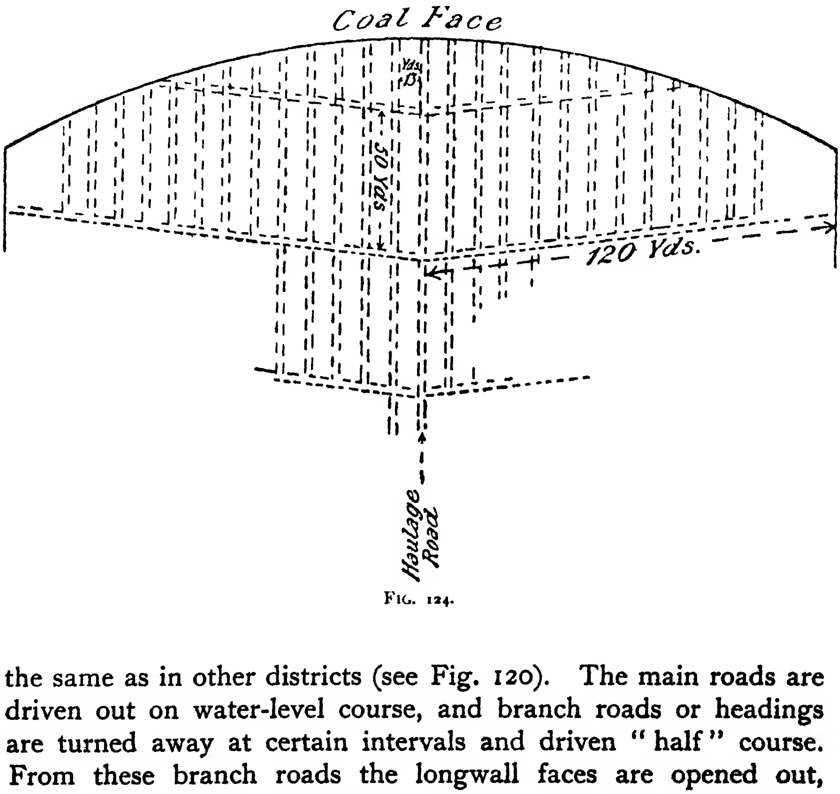


FIG. 124.

the same as in other districts (see Fig. 120). The main roads are driven out on water-level course, and branch roads or headings are turned away at certain intervals and driven "half" course. From these branch roads the longwall faces are opened out, advancing either on the level or to the rise. All the coal is removed outside the shaft pillar, the roads being maintained through the gob.

The general system is to make the stall roads (or gateways) into the face at intervals of 10 or 12 yards, even in seams of 6 feet or more in thickness. The tram is taken to the face, and the coal filled into it on the stall road. The gob between the stall roads is stowed tight by the collier, and the stowing kept close up to the coal face. After the stall has been cut off by the heading, the stall roadway is stowed up with rubbish. Long continuous faces are kept hundreds of yards in length, not straight, but on a gradual curve. The curve seems to be determined by the way the slips run, and the gradient of the seam.

The timbering in the face consists usually of single props set "off and on," not in straight rows, and "cogs" at the sides of the stall roads. A good deal of the back timber is lost.

An actual example may be given. The colliery is situated in the Rhondda Valley. The section of the seams is that given on page 295. The system of longwall practised is very similar to that in operation in Northumberland as described on pages 240 to 248, the stalls or gateways being 13 yards apart

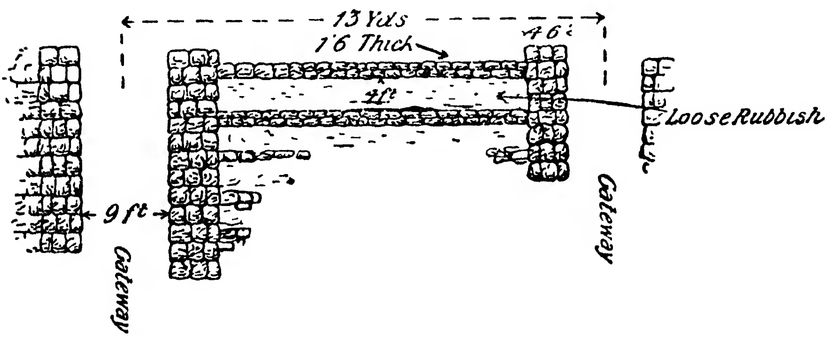


FIG. 125.—SIDES AND WASTE PACKS IN A SOUTH WALES COLLIERY.

centre to centre, the cross-headings being made as shown or sometimes at an angle of 45 degrees, with the stalls which they cut off at 50 yard distances. The maximum distance between the roof supports (props or otherwise) is 10 feet, and 6 feet between the chocks or cogs set alongside the stall sides.

The face timbering is by means of props and crowns, props 6 feet 6 inches long with 6 to 9 inch tops being used, the crowns being split props. Besides these, props with lids are occasionally set, the lids being placed at right angles to the line of face.

The ripping, which is done by the collier, is kept up to the face where possible, but normally is from 1 to 4 yards back from the coal.

The collier sets and draws the timber, when any is drawn, which is seldom. He is paid (this was in the year 1908) 1s. for each "set" (pair of gears), and he alone decides, within the rules, the position and number of the props to be set; the tendency, therefore, is to set them close. The packing stone is taken out of the waste, as the ripping does not afford sufficiently good stone. The packing, which is done by night men, is from 4 to 6 feet back from the face. Should the distance much exceed 6 feet, a fresh pack has by rule to be built (see Fig. 125).

As already mentioned, mechanical coal-cutting is not suitable, as owing to the number of slips in the seams the coal is mostly got by pulling it off the face. These slips are much inclined from the vertical, and passing into the roof are a source of much danger. The coal would not stand for mechanical coal-cutting. The slips run in all directions, and the coal is much subject to "bumps."

The loss of timber is very great, and the cost for timbering in the Rhondda Valley before the war (say year 1910) would certainly not average less than 10d. per ton of coal got. The consumption may be said to be about equally divided between the face and the stall roads. The only timber recovered is that in the stall roads.

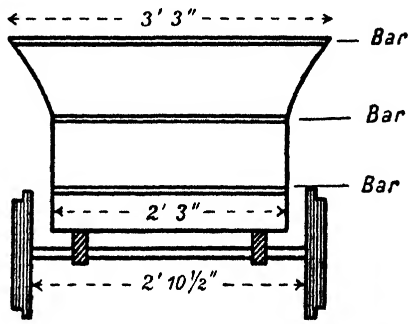


Fig. 126.—Tram used in Welsh Collieries.

There are several collieries in the South Wales coalfield working on the Nottingham, or what is locally known as the "Barry," system of longwall. Here the trams are taken along the face, and the roadways are driven at intervals of 80 to 100 yards. This system is principally adopted where the measures are lying fairly horizontal, the roof generally strong, and the seam yielding a considerable amount of rubbish in the faces.

Fig 126 shows the tram commonly used in Welsh collieries. Its dimensions over all are: Length, 6 feet; width at bottom, 2 feet 3 inches; at top, 3 feet 3 inches; depth, 2 feet; weight, empty, 9½ cwt. Gauge of way, 2 feet 10½ inches. Carrying capacity, 25 cwt. to 2 tons of coal when properly built up with large coal above the top of the tram. It is open at the ends except for the three bars shown in the illustration. Large lumps of coal are built up next these bars, so as to prevent the smaller coal from falling out. At some collieries trams with closed ends are now being used.

In each stall, consisting of 10 or 12 yards of coal face, extending 5 or 6 yards on each side of the stall road, two men are employed, a collier and an assistant, the latter being not less than sixteen years of age. The assistant was paid by the collier in 1904 about 3s. 2d. a shift. These men do all the work in the face, including the timbering and packing and ripping stone and laying way on the stall road. A price per ton is fixed for large coal passing over a 1¼-inch screen, another for "through" or unscreened coal, and other prices for ripping stone, setting timber, &c.

To take an actual instance of a six-foot seam, the cutting price on large coal in 1904 was 1s. 1½d. per ton, plus the current percentage, which also has to be added to the following basis prices :—

Ripping top stone up to 18 inches thick, 1d. per inch per yard.
" " above 18 " 1½d. " "
Setting cogs, 1s. 4d. each. Props, 3d. Double timber, 1s. 2d.
Flats (a plank with props), 1s. 0½d.
"Clod" up to 12 inches thick paid by "consideration."
"Rib" at one side, 1s. a yard.
Unloading rubbish, 4d. per tram.

In a six-foot seam with trams holding about 22½ cwt. of coal, the average daily output per stall (two men) ran 5 to 6 trams of large coal, say 6 tons, or when filling "through" coal about 8 trams, say 9 tons. When the small coal was not wanted, it was cast back into the "gob." Of the coal the men filled as "large" coal, 65 to 75 per cent. passed over the screen, and on this they were paid.

When the collier is paid on the large coal scale, the small is supposed to be thrown back into the gob, and any small sent to the surface is deducted from the gross weight of mineral passed over the machine to arrive at the net weight of large coal, but of late years the small coal has come much more into demand, and consequently is in most cases filled up and sent to the surface and the collier given an "allowance" for it.

A usual rate of advance of a longwall face in a six-foot seam working single shift is about 4 yards or 12 feet a fortnight.

The stall roads are cut off by cross-roads at intervals of 50 to 60 yards. The interval is determined by the nature of roof, and should be such that one ripping only is necessary before the stall road is cut off by the cross-road.

The permanent roads require several "rippings." They usually need to be cut out of the solid stone above the seam before they will stand. In some of the deeper pits the crush on the roads is very severe, and causes much expense. A large staff of repairers has to be employed, and the cost of this work is often 1s. to 1s. 6d. a ton. Much of it is done on "bargain" price (piece work).

The double-stall system of working is largely practised in South Wales, especially in the bituminous coal collieries. An instance of this is described at page 265; and No. VII. example scheduled in Chapter XVII. is another instance.

The schedule of prices agreed on for working the seam in No. VII. example was as follows * :—

			s.	*d.*
1.	Cutting through coal, irrespective of thickness	per ton	1	8
2.	Gobbing holing where requested by management, per ton	extra	0	2
3	Opening out stalls from heading to full width	each	8	0
4.	Making shafts for carting stalls		9	0
5.	Carting after first five yards	extra per ton	0	2
6.	Cutting clay in carting stalls, 11 feet wide, first 12 inches, per inch per yard		0	1
6*a*.	Cutting clay in carting stalls, 11 feet wide, after 12 inches, per inch per yard		0	1½
6*b*.	Splitting clay in carting stalls, 11 feet wide, 12 inches thick, per inch per yard		0	2
7.	Shifting coal back after first 6 yards	extra per ton	0	1
8.	" " uphill in stalls, first 6 yards	" "	0	2
9.	" " " "	for each succeeding yard	0	1
10.	Stalls, with 2 fast ribs	per yard	1	0
11.	Pillars left behind at manager's request exclusive of first 10 yards from airway		1	0
12.	Driving airways, first 10 yards	per yard	1	6
12*a*.	" " each succeeding 10 yards ...	extra "	0	6
13.	Double shift in stalls and skips	extra per ton	0	2
14.	Driving narrow or wide headings, 8 feet wide ...	extra per yard	6	0
15.	Double shift in headings	" "	1	0
16.	Three men in headings	" "	0	6
17.	Walling waste for airways	" "	0	6
18.	Road props in headings, 6 feet or 9 feet	each	0	6
19.	All road props in stalls	"	0	4
20.	Cogs stood on clay	"	1	3
21.	" " hard bottom	"	1	9
22.	Standing flats	"	1	0
23.	Double timber	per pair	2	0
24.	Tumbling places where required	each	2	0
25.	Colliers performing day work	per day	5	0
26.	Discharging rubbish	per tram	0	3
27.	Hauliers	per day	4	3
28.	Hauliers in wet places	"	4	6
29.	Tippers	"	3	10

* These are all "pre-war" examples, most of them dating back to twenty years or more, but as basis figures they still hold good in many cases, a percentage being added.

A list of prices paid in working an anthracite seam is also appended. The seam runs about 3 feet thick good coal, and is lying at a gradient of 1 in 4 to 1 in 6. It is worked by longwall with 15 yard stalls. These prices show the importance of the "slips" which are peculiar to these seams, described at page The list reads as follows :—

"The following prices are agreed upon by the undersigned to be paid for working the Pumpquart vein * :—

			s.	d.
"1.	Cutting large coal, face side ...	per ton	1	8
2.	„ „ back side ...	„	1	9
3.	Cutting through coal, either side ...	„	1	2½
4.	Culm ...	„	0	6
5.	Sticking coal to be mutually arranged between managers and workmen.			
6.	Heading cut, narrow levels, face side ...	per yard	2	0
7.	„ „ back side ...	„	3	0
8.	Opening out from narrow to wide (*a*) gradually ...	„	2	0
	(*b*) straight up ...	„	2	0
	(*c*) straight down ...	„	3	0
9.	Long cut in stalls ...	„	1	2½
10.	Square „ „ ...	„	0	11
11.	„ „ skips ...	„	0	9
12.	Heading tophole in solid ...	„	3	0
13.	Ripping top in levels, stalls, and other headings to be paid at the rate of 1½d. per inch per yard, forward measurement	per inch	0	1½
14.	Clod to be paid by an extra price per ton on coal as follows :—			
	When clod is 4 inches thick ...	per ton	0	1
	„ „ 7 „ ...	„	0	2
	„ „ 10 „ ...	„	0	3
	And over 10 inches in the same proportion.			
15.	Deep headings in solid and opening out work ...	per yard	3	9
16.	„ „ not in solid „ „ ...	„	1	5
17.	Slopes in solid „ „ ...	„	2	9
18.	„ not in solid „ „ ...	„	1	2½
19.	Walling waste, per side ...	„	0	6
20.	„ topholes, per side ...	„	1	0
20*a*.	„ slants ...	...	1	0
21.	Pass by for trams ...	each	2	0
22.	Timbering on levels ...	per pair	1	8
23.	„ topholes ...	„	0	10½
24.	Nogs alongside levels and slants ...	each	0	6
25.	Props under top, above clod, levels, and slants ...	„	0	3
26.	Cogs, usual height ...	„	1	6
27.	Double shift in narrow places ...	per yard	1	0
28.	„ „ wide places ...	per ton	0	2
29.	Props taken out ...	each	0	1
30.	Changing trams to be mutually arranged between manager and men.			
31.	Competent men working on consideration ...	per day	4	7
32.	Unloading rubbish ...	per tram	0	6

* See footnote, p. 303.

33. Percentage on or off this list to be subject to advances and reductions as per agreement dated.
34. House coal to workmen to be a settled and fixed price of 1½d. per cwt. for small coal from screens.
35. Permission to be given to the workmen's committee to examine any working in dispute when requested by either employer or workmen.
36. Carting coal, same payment as in Stanllyd."

These price lists, customary at Welsh collieries, are more complicated and troublesome than those in most other mining

CHAPTER XVII.

CONDITIONS AND RESULTS OF WORKING IN DIFERENT DISTRICTS COMPARED.

Local Variations in Method of Working.—Considering the close proximity of the coalfields of Great Britain, it is remarkable that so much variation should exist in the arrangements of labour and the systems of working.

Each district—especially the older districts, as Northumberland and Durham, and Staffordshire and South Wales—has developed its particular system under the stress of local conditions and requirements, and in the main independently of the others.

It is interesting and not unprofitable to inquire how far do these local peculiarities tend to economical production and general efficiency. For instance—

Is it better to subdivide the labour in the coal face, having one set of men to hew the coal, another to set the timber, another to make height and build packs: or to put it all into the hands of one set?

Is it better that each man should be paid independently, or that several should share together?

Does the "butty" or "contractor" system conduce to economical working?

What length of shift tends to the greatest efficiency?

How may the shifts of the different classes of labour be best arranged relatively to one another?

What size of coal tub gives the best result?

With a view to throwing light on such questions as these, the authors have obtained detailed particulars of the labour employed, the number of men in each class, the wages paid, the hours worked, &c., and the results obtained in output and cost of working at fairly typical collieries—eleven in number—in some of the principal districts.

These collieries included (1) and (2) two Northumberland steam coal collieries; (3) a Durham coking colliery; (4) a Durham gas coal colliery; (5) an East Durham gas and house coal colliery; (6) a Welsh steam coal colliery; (7) a Welsh bituminous coal colliery; (8) a Warwickshire colliery; (9) a Staffordshire colliery; (10) a Nottingham house, steam, and manufacturing coal colliery; and (11) a Yorkshire house and coking coal colliery. The particulars ascertained have been scheduled as follows (pp. 308-329):—

No. I.—NORTHUMBERLAND STEAM COAL COLLIERY.

Output per fortnight	13,202 tons.
Number and Nature of Seams worked	Five. Hard coal, requiring to be shot down, after kirving, even in longwall faces.
Average Thickness of Coal	5 feet (2,608 tons), 3 feet 6 inches (3,207 tons), 4 feet 6 inches (4,570 tons), 2 feet 8 inches (2,046 tons), 2 feet 5 inches (771 tons).
Gradient	About 1 in 7 usual. Some level. Workings to the rise. 30 self-acting inclines.
Method of Working	5 foot seam, bord and pillar. 3 foot 6 inch seam, bord and pillar. 4 foot 6 inch seam, bord and pillar. 2 foot 8 inch seam, longwall, with gateways 12 to 15 yards apart. 2 foot 5 inch seam, longwall.
Stock of Coal tubs	1,020.
Weight of Coal per Tub	8¼ cwts.
Number of Coal-drawing Shafts	Two.
Depth " "	90 yards and 160 yards.
Hours of Coal Drawing	10 hours daily, 7 A.M. to 5 P.M., for 10 days a fortnight. 10 " 4 A.M. to 2 P.M., " 1 " 110 hours for 11 "

Labour Employed—

		Number.	Relative Proportion.	Net Earnings per Shift including % (18¾).	Length and Number of Shifts per fortnight.
			Per cent.	s. d. s. d.	
Below	Hewers	400	49	6 7 —	Eleven 7-hour shifts.
	Stonemen and Shifters	127	16	3 9 to 8 0 (piece-work)	Nine 8-hour and three 6-hour.
	Putters	54	7	6 0 —	Eleven 10-hour.*
	Drivers and other Boys	168	20	1 7 to 4 5	" Boys below 16, laid idle to comply with Act.

	Deputies	27	3	5 9 —	Eleven 8-hour and one 6-hour.
	Various—Wastemen, Rolleywaymen, &c.	37	5	3 9 to 6 0	Eleven 10-hour.
	81 per cent.	813	100		
Surface	19 „	180			
Total	100 per cent.	993			

		s. d.	Per cent.	
Cost per ton†	Hewing	2 1.6	58	
	Other Labour below	1 6.36	42	
		3 7.96	100	
	Surface	6.82		Includes cost of haulage of coal about 2 miles on surface to shipping harbour, but no shipment charges.
		4 2.78		

Tons per Hewer per Shift	3 tons.
Average Daily Output per hand employed below	1.47 „
Average Daily Output per hand employed below and surface	1.20 „

* According to Home Office statistics, there are 10,000 boys under 16 years of age employed at Northumberland and Durham collieries. In compliance with the Coal Mines Regulation Act, these boys do not work more than 54 hours in any one week, nor 10 hours in any one day.

† Except when otherwise stated, the costs per ton in these examples are calculated on the output.

N.B.—Most of the men in Northumberland and Durham are supplied with houses free of rent, and with fire coal. The money value of this was calculated to be 9d. a shift in 1905. At Northumberland steam coal collieries, a house is required for about every 2 tons of daily output. For 1,000 tons a day, or 11,000 tons a fortnight, a capital expenditure on building houses is required of about £75,000 (£150 a house).

No. II.—NORTHUMBERLAND STEAM COAL COLLIERY.

Output per fortnight	12,800 tons.
Number and Nature of Seams worked	Two. Hard coal.
Average Thickness of Coal	2 feet 7 inches (7,250 tons), 4 feet 9 inches (5,550 tons). No gas nor dust.
Gradient	Slightly undulating.
Method of Working	In 2 foot 7 inch seam, longwall, with gateways at 11 yards intervals. In 4 foot 9 inch seam, bord and pillar, at present working the pillars. Not much pressure on roads; not costly to maintain.
Stock of Coal tubs	In 2 foot 7 inch seam, 350. In 4 foot 9 inch seam, 350. Total, 700.
Weight of Coal per Tub	11½ cwts. 13 cwts.
Number of Coal-drawing Shafts	One.
Depth " "	250 yards.
Hours of Coal Drawing	*11 hours daily, 6 A.M. to 5 P.M., for 10 days. 10 " 5 A.M. to 3 P.M., " 1 " } 120 hours for 11 days a fortnight.

Labour Employed—

		2 foot 7 inch seam (longwall). Day.	Night.	Total.	Per cent.	Usual Length of Shift. Hours.	In 4 foot 9 inch seam (pillar working). Day.	Night.	Total.	Per cent.	A.M. P.M.
Below	Hewers	200	20	220	44	Fore 7½ Back 7	97	14	111	40	Fore Shift, 3.30 to 11.0. Back " 10.0 " 5.0.
	Stonemen and Shifters	137	9	146	29	8	71	10	81	29	
	Putters	18	2	20	4	10	11	1	12	4	
	Drivers and other Boys	54	6	60	12	10	19	12	31	11	

Deputies and Chargemen	18	2	20	4	8	11	5	16	0
Various — Wastemen, Rolleywaymen, &c.	28	2	30	7	8	26	1	27	10
	455	41	496	100	235	43	278	100

	Total Hands Employed	- Below -	774	83 per cent.	
Surface - - -	Banking, &c. 98	- Surface -	163	17 ,,	Includes men required to keep in repair colliery houses and to do the scavenging.
	Mechanics, &c. 65				
Total - - -	163		937	100	

Cost per ton - - - - - In 2 foot 7 inch seam—

	s. d.	Per cent.		Per cent.		s. d.	
Hewing -	2 1	51	Hewing price, 1s. 10d. a ton (including per cent.) for a height of 2 feet 7 inches. Other prices for "Ramble," &c.	50	Hewing	1 5½	Hewing price 1s. 2.8d. per ton (including per cent). Other prices for "Ramble," Yard Work, &c.
Other Labour	2 0	49		50	Other Labour	1 5½	
	4 1	100		100		2 11	

Surface - -	Banking and Screening -	3.2d.		(A good deal of "dirt" picked out of coal.)
	Mechanics, Enginemen, &c.	3.8d.	7d.	

Tons per Hewer per Shift - - In 2 foot 7 inch seam, 3 tons. Over both seams, 3.51 tons. In 4 foot 9 inch seam, 4.54 tons.

Average Daily Output per hand employed below - - - 1.50 ,,

Average Daily Output per hand employed below and surface - 1.24 ,,

* *N.B.*—At all Northumberland and Durham collieries, the hours of coal-drawing include time occupied in sending down the men and boys in the morning at 6 A.M., and in changing the shift of hewers about 10 A.M. This occupies usually 1 hour to 1½ hours, and reduces the hours of coal-drawing accordingly.

No. III.—DURHAM COKING COLLIERY.

Output per fortnight	6,880 tons.
Number and Nature of Seams worked	Two. Soft coal easily hewn. Got mostly as "Small," "Round" coal not being wanted.
Average Thickness of Coal	1 foot 10 inches (2,959 tons), 4 feet 6 inches (3,921 tons).
Gradient	Slight. 1 in 30 maximum.
Method of Working	1 foot 10 inch seam, longwall. 4 foot 6 inch, bord and pillar.
Stock of Coal Tubs	870.
Weight of Coal per tub	9 cwts.
Number of Coal-drawing Shafts	One.
Depth " "	140 yards.
Hours of Coal Drawing	10 hours daily, 6 A.M. to 4 P.M., for 10 days a fortnight. } (Includes sending down men and boys, and changing the shift of hewers.)
	9 " 4 A.M. to 1 P.M. " 1 "
	109 hours for 11 "

Labour Employed—

		Number.	Per cent.	Net Earnings per Shift (including % 28¾). s. d. s. d.	
Below	Hewers	207	44	6 0 —	7 hour fore shift, 4 A.M. to 11 A.M., } 11 days per fortnight. 6 " back " 10 A.M. " 4 P.M., }
	Stonemen and Shifters	125	27	3 10 to 6 8	Eleven 8-hour shifts, and one 6-hour shift, 94 hours.
	Putters	45	10	3 9 " 4 8	Ten 10-hour shifts, and one 9-hour shift, 109 hours.
	Drivers and other Boys	45	10	1 6 " 2 6	" " " Boys below 16, laid idle to comply with Act.

Deputies - - -	16	3	face 6 0½; backbye 5 4	Eleven 8-hour shifts, and one 6-hour shift, 94 hours.
Various—Wastemen, Rolleywaymen, &c.	30	6	3 0 ,, 5 6	Ten 10½-hour shifts, and one 9½-hour shift, 114½ hours.
92 per cent.	468	100		

Surface - - -	8 ,,	39	"Fitting" is done at central shops away from colliery, nor are masons included.
Total - - - -	100	507	

		s.	d.	Per cent.
Cost per ton - - - - -	Hewing - - - -	1	11.21	48
	Other Labour below -	2	0.77	52
		3	11.98	100
	Surface - - - -	0	2.42	
		4	2.20	

Tons per Hewer per Shift - -	3 tons.
Average Daily Output per hand employed below - - -	1.33 ,,
Average Daily Output per hand employed below and surface -	1.23 ,,

No. IV.—DURHAM GAS COAL COLLIERY.

Output per fortnight	5,254 tons drawn, less 425 tons (colliery consumption and workmen's coal), leaves 4,829 tons saleable, on which the costs per ton are calculated.
Number and Nature of Seams worked	Two. Soft coal, sold as gas coal, round coal not required.
Average Thickness of Coal	4 feet 2 inches (3,415 tons), 4 feet (1,839 tons).
Gradient	Usually about 1 in 30.
Method of Working	All bord and pillar working. Pillars 33 yards by 22 yards. Some square, 33 yards by 33 yards. About 70 per cent. of output from pillar working. Workings extensive and scattered, and most of them more than a mile from the shaft.
Stock of Coal Tubs	610.
Weight of Coal per tub	8 cwts.
Number of Coal-drawing Shafts	One.
Depth " "	120 yards.
Hours of Coal Drawing	10 hours daily, 6 A.M. to 4 P.M., for 10 days a fortnight.
	8 " 5 A.M. to 1 P.M., " 1 "
	108 hours for 11 "

Labour Employed—

		Number.	Per cent	Net Earnings.	
Below	Hewers	97	39	5s. 8d.	
	Stonemen and Shifters	53	21	3s. 10½d., 4s. 7½d., 8s. (piece work).	
	Putters	22	9	4s. 2d.	Hours the same as in
	Drivers and other Boys	41	16	1s. 8d. to 3s. 4d.	Instance No. III.

	Deputies		12	5	Face, 6s.; backbye, 5s. 4d.
	Various—Wastemen, Rolley-waymen, &c.		24	10	3s. 9d.; 4s. 5d. Onsetter, 6s. 9d. (piecework).
		79 per cent.	249	100	
Surface		21 "	67		
Total		100	316		

		s. d.	Per cent.	
Cost per ton	Hewing	1 3.26	48	
	Other	1 4.45	52	
		2 7.71	100	
	Surface	0 7.41		Includes care of houses.
		3 3.12		

Tons per Hewer per Shift	4.84 tons.
Average Daily Output per hand employed below	1.92 "
Average Daily Output per hand employed below and surface	1.51 "

N.B.—This instance shows that in spite of a small output and scattered workings, coal may be economically produced. The total cost into trucks at the pit, including cost of materials, rents, rates and taxes, and all expenses, is below 5s. a ton on the saleable coal.

No. V.—EAST DURHAM GAS AND HOUSE COAL COLLIERY.

Output per fortnight	13,155 tons, less 1,547 tons (colliery consumption, and workmen's coal and stones and dirt), leaves 11,608 tons saleable, on which the costs per ton are calculated.
Number and Nature of Seams worked	Three seams. Chiefly gas coal, some "house," and a little "forge." Hard seams requiring "shooting." 7,000 shots fired per fortnight. Safety lamps.
Average Thickness of Coal	3 feet 6 inches (6,840 tons, about 40 per cent. of this is round, and goes as house coal); 4 feet 8 inches (5,525 tons, all gas coal); 2 feet 9 inches (790 tons forge coal).
Gradient	Generally about 1 in 30.
Method of Working	The 3 foot 6 inch and 2 foot 9 inch seams are worked longwall with gateways at 15 yard intervals. The 4 foot 8 inch seam, bord and pillar. Pillars 33 yards by 22 yards, and 40 yards by 30 yards.
Stock of Coal Tubs	1,156.
Weight of Coal per tub	8 cwts.
Number of Coal-drawing Shafts	Two. About a mile apart.
Depth " "	One, 250 yards deep, drawing 900 tons daily; the other, 176 yards deep, drawing 300 tons daily.
Hours of Coal Drawing	10 hours daily, 6 A.M. to 4 P.M., for 10 days a fortnight. 8 " 4 A.M. " 12 P.M., " 1 " 108 hours for 11 "

Labour Employed—

		Number.	Relative Proportion. Per cent.	Net Earnings per Shift. s. d.	s. d.	
Below	Hewers	436	44	6 6	—	A.M. Fore shift, 4 to 10.45 A.M. / Back " 9.30 to 4 P.M. — Ten shifts, 6½ to 7 hours; one shift, 5½ hours.
	Stonemen and Shifters	239	24	3 10 and	4 8	Stonemen, Shifters, and Wastemen, usually 86 hours a fortnight.

	Putters	53	6	5 0	—	Putters 108 hours a fortnight.
	Drivers	56	6	1 8	—	
	Deputies	29	3	Face, 6 0; Backbye, 5 4		7½ hour shifts in the face, 8 „ „ backbye } 11 or 12 shifts a fortnight.
	Various—Wastemen, Rolleywaymen, Onsetters, &c.	172	17	4 0	—	Onsetters and Rolleywaymen, 10½ hour shift, about 114 hours a fortnight.
	82 per cent.	985	100			
Surface	18 „	207				Two screening establishments, and a large amount of dirt picked out of coal. Surface labour includes keeping houses in repair and scavenging.
Total	100 „	1,192				

		s. d.	Per cent.	
Cost per ton	Hewing	2 7.14	56	These costs are taken on the saleable coal, not on the gross output.
	Other Labour	2 0.70	44	
		4 7.84	100	
		0 8.77		
		5 4.01		

Tons per Hewer per Shift	2.84 tons.
Average Daily Output per hand employed below	1.21 „
Average Daily Output per hand employed below and surface	1.00 „

No. VI.—WELSH STEAM COAL COLLIERY.

Output per fortnight	19,000 tons. Total drawn, large and small.
Number and Nature of Seams worked	One. Gassy and dusty. Water spray jets on roads.
Average Thickness of Coal	6 feet 6 inches. Full of "slips." No shooting nor holing required.
Gradient	About 1 in 9.
Method of Working	Longwall. Stall roads at 10 yards intervals, level course. Heavy pressure on roads; costly to maintain. About 700 tons of timber used each fortnight. About 20 per cent. of the coal is left below.
Stock of Coal Tubs	750.
Weight of Coal per tub	2 tons.
Number of Coal-drawing Shafts	Two. Downcast and upcast.
Depth	760 yards.
Hours of Coal Drawing	10 hours daily, 7 A.M. to 5 P.M., for 8 days a fortnight. (Some coal drawn at nights also to clear the roads.)
	7 „ 7 A.M. to 2 P.M., „ 4 „
	108 hours for 12 „

Labour Employed—

		Day.	Night.	Total.	Per cent.	Net Earnings per Shift. s. d. s. d.	(Includes $43\frac{3}{4}$ °/₀ on basis rates.)
Below	Colliers	360	96	456	35	8 0 —	For coal-getting, colliers are paid on large coal only (*i.e.*, what passes over $1\frac{1}{2}$ inch bar screens), 1s. 7.4d. (including °/₀). Other prices are paid to colliers for ripping (cutting stone) and timbering, &c.
	Repairers and Rippers	251	175	426	33	5 4 to 7 2	
	Hauliers	73	51	124	10	5 0 —	
	Wallers and Labourers	86	74	160	13	2 10 to 4 4	

	Firemen	8	7		15	1	7	2	—	About 70 per cent. of what comes to bank is "large."
	Various—Airways, &c.	56	51		107	8	—	—		
		834	454	90 %	1,288	100				
Surface				10	142					
Total				100	1,430					

		s. d.	s. d.		
Cost per ton	Colliers, Hewing	1 7.4	—	30	These costs are on the large coal, *i.e.*, about 70 per cent. of the gross drawings.
	" Other work	0 10.6	2 6	17	
	Remainder		2 10	53	
			5 4	100	
	Surface		10.5		
			6 2.5		

Tons per Collier per Shift	3.5 tons.	These tonnages are calculated on the gross drawings, large and small.
Average Daily Output per hand employed below	1.22 "	
Average Daily Output per hand employed below and surface	1.10 "	

N.B.—This instance shows that in the steam coal seams of South Wales, the cost of hewing is relatively low, but the cost of other labour is high, owing partly no doubt to the heavy crush on the roads.

No. VII.—WELSH BITUMINOUS COAL COLLIERY.

Output per fortnight	5,563 tons.
Number and Nature of Seams worked	One seam: soft coal. No shooting nor holing. 70 per cent. of produce is small, over a $2\frac{1}{8}$ inch bar screen.
Average Thickness of Coal	2 feet 8 inches. A little gas. No dust. All coal sent out.
Gradient	1 in 6 to 1 in 4 dipping inbye. Seam crops out at surface. Won by day drifts.
Method of Working	Double stall. Main slant driven in seam down full dip. Levels turned away right and left at intervals of about 70 yards. Double stalls 20 yards wide driven to full rise off levels. Pillars between double stalls 12 yards wide. Coal filled in face into low trams (carts) 2 feet 2 inches high over all. Stall roads self-acting inclines. Coal tipped into big trams (23 cwt.) standing on level. Carting and filling into trams done by boys, one boy to each stall road. Distance of haul up main slant about 1,000 yards.
Stock of Coal Tubs	250 large trams, and 300 small trams (carts).
Weight of Coal per tub	Large trams hold about 23 cwt. of coal, and small trams about 8 cwt.
Number of Coal-drawing Shafts	Day drift and hauling engine.
Depth	
Hours of Coal Drawing	10 hours daily, 7 A.M. to 5 P.M., for 8 days a fortnight. 7 " 7 A.M. to 2 P.M., " 4 " 108 hours for 12 "

Labour Employed—

		Number.	Per cent.	Net Earnings. s. d.	s. d.	
Below	Colliers	230	60	7 2	—	The regular hours of work for all classes of labour are 54 per week, the same as the coal-drawing hours.
	Colliers' Boys	115	30	2 9 to	3 6	
	Hauliers and Riders	25	7	5 7	—	

	Firemen		4	1	50 0 a week.
	Roadmen, &c.		8	2	6 2 —
		92 per cent.	382	100	
Surface		8 ,,	33		
Total		100 ,,	415		

		s. d.	s. d.	Per cent.	
Cost per ton	Colliers Hewing	2 4.5		59	
	Colliers' and Boys' Deadwork	1 1 4	3 5 9	27	
	Other Labour Below		6 77	14	(Good roads, easily maintained.)
			4 0 67	100	
	Surface		6 79		
			4 7 46		

Tons per Collier per Shift . . 2 tons.

Average Daily Output per hand employed below . . . 1.21 ,,

Average Daily Output per hand employed below and surface . 1.116 ,,

N.B.—In working this thin steep seam by double stall 90 per cent. of the labour (and 86 per cent. of the cost) is employed in and about the face. The cost of hewing is high, and the output per collier low.

No. VIII.—WARWICKSHIRE COLLIERY.

Output per fortnight	12,700 tons.
Number and Nature of Seams worked	Three seams, producing house and steam coal. Very little explosive used. Coal not hard.
Average Thickness of Coal	6 feet 3 inches (4,882 tons), 10 feet 6 inches (6,804 tons), 5 feet 2 inches (1,814 tons).
Gradient	1 in 3 to flat.
Method of Working	Longwall, with faces going both to the rise and to the dip. Stall roads 75 to 100 yards apart. Much crush on roads, costly to maintain. "Butty" system of labour. The stallmen (butties) engage and dismiss and pay the holers and getters. Stallmen's price, 1s. 10d. a ton (including per cent.) for getting and filling coal, tramming to top of "jig," timbering in face, and 15 yards outbye on stall roads, building all packs, shifting and laying way in face and 15 yards back on roads, and taking down top stone on roads over some distance for height of 4 feet 6 inches.
Stock of Coal Tubs	570.
Weight of Coal per tub	9½ cwts.
Number of Coal-drawing Shafts	One. 30 to 40 per cent. of the output is drawn at nights. "Round" coal loaded separately from the "slack" over 2 inch forks. Some "small" coal left below.
Depth	265 yards.
Hours of Coal Drawing	Day—10 hours, 6 A.M. to 4 P.M. Night—9 hours, 9 P.M. to 6 A.M. 40 minutes' stop for "bait." 18 hours 20 minutes daily. Sunday nights 8 hours, 10 P.M. to 6 A.M., 228 hours' coal-drawing per fortnight.

Labour Employed—

		Number.	Relative Proportion. Per cent.	Net Earnings per Shift (including 45 per cent). s. d.	s. d.	
Below	Stallmen	120	46	6 5	—	Usual length of shift for all hands, 9 to 9½ hours, with 40 minutes' stop for "bait."
	Holers and Getters	200		5 2	—	

	Repairers	128	18	5 2	—
	Trammers	108	15	4 0	to 5 2
	Deputies	12	2	6 5	—
	Various—Aircourses, Bondminders, &c.	132	19	3 0	to 5 2
	79 per cent.	700	100		
Surface	21 ,,	181			
Total	100 ,,	881			

		s. d.	Per cent	
Cost per ton	Stall Work	1 10	44	Costs taken on saleable tons (large and small), colliery consumption being deducted from drawings.
	Other Labour Below	2 3.6	56	
		4 1.6	100	
	Surface	0 5.0		
		4 6.6		

Tons per Hewer per Shift	3.3 tons.	Calculated on total output.
Average Daily Output per hand employed below	1.50 ,,	
Average Daily Output per hand employed below and surface	1.20 ,,	

No. IX.—STAFFORDSHIRE COLLIERY.

Output per fortnight	11,914 tons per fortnight, working half-time owing to slack trade. 6.49 days = about 55 hours.
Number and Nature of Seams worked	Three; one of them exceptionally hard.
Average Thickness of Coal	5 feet 9 inches (7,148 tons), 5 feet 10 inches (2,978 tons), 3 feet 6 inches (1,788 tons).
Gradient	Level to 1 in 3.
Method of Working	Longwall, with stall roads about 30 yards apart. Coal filled with rakes and pans, 10 to 25 per cent. being filled separately as "slack." Charter price varies from 1s. 8d. to 2s. 5d. (including per cent.) per ton on large coal sent out. This price covers coal-getting and loading, face timbering, building packs, shifting way in face, and delivering tub on stall road. Stallmen pay for their explosives. The company find all tools. Separate prices paid for filling "slack."
Stock of Coal Tubs	1,200.
Weight of Coal per tub	10 cwts.
Number of Coal-drawing Shafts	Four (3 downcast and 1 upcast), within a distance of about 2 miles.
Depth	375 yards; 303 yards; 300 yards (upcast); 127 yards.
Hours of Coal Drawing	8½ hours, 7.30 A.M. to 4 P.M., with half-hour's stop (11.30 to 12) for "snap."

Labour Employed—

		Number.	Per cent.	Net Earnings per Shift (including per cent.) s. d. s. d.	
Below	Stallmen	340	51	7 5 —	8½ hours bank to bank.
	Holers and Loaders (paid by Stallmen)	108		6 8 and 5 6	
	Datallers	95	11	5 0 to 4 4	
	Trammers	26	3	4 10 to 2 4	

	Pony Drivers and Nippers		140	16	4 10 to 1 3 } 9½ hours.
	Deputies		15	2	6 8 —
	Various		148	17	1 10 to 5 3
		77 per cent.	872	100	
Surface		23 "	263		There are three separate screening and boiler plants. Surface labour includes also canal boat loading (23 men) and plate-laying (10 men).
Total		100 "	1,135		

		s. d.	Per cent	
Cost per ton	Stall Work	2 0.32	57	*N.B.*—These costs are taken on the saleable tons (large and slack), got by deducting the colliery consumption from the gross drawings.
	Other Labour Below	1 6.29	43	
		3 6.61	100	
	Surface	0 9.59		
		4 4.20		

Tons per Hewer per Shift	4.10 tons (includes Holers and Loaders with Stallmen).	} Calculated on the total coal drawn.
Average Daily Output per hand employed below	1 70 " over the whole year 1904.	
Average Daily Output per hand employed below and surface	1.32 " " "	

No. X.—NOTTINGHAM HOUSE, STEAM, AND MANUFACTURING COAL COLLIERY.

Output per fortnight . . .	31,780 tons.
Number and Nature of Seams worked	Four. The Top and Deep Hard, the Low Main and Deep Soft. Half of the output is derived from the Deep Soft.
Average Thickness of Coal . .	Top Hard, 4 feet 4 inches (645 tons); Deep Hard, 2 feet 11½ inches (6,064 tons); Low Main, 4 feet 6 inches (9,159 tons); Deep Soft, 3 feet 8¼ inches (15,912 tons).
Gradient	Moderate.
Method of Working . . .	Longwall in each seam.
Stock of Coal Tubs . . .	
Weight of Coal per tub (average) .	10 cwts. in Top Hard, 9 cwts. in Deep Hard and Low Main, 9½ cwts. in Deep Soft.
Number of Coal-drawing Shafts .	Five.
Depth " " .	141, 356, 409, and two 384 yards.
Hours of Coal Drawing per day .	9 hours, less 20 minutes for "snap," and 6 hours on Saturday.

Labour Employed—

		T. H.	D. H.	L. M.	D. S.
Below . . .	Stallmen, Holers, Loaders . . .	50 per cent.*	66 per cent.*	58 per cent.*	73 per cent.*
	Stonemen and Shifters . . .			None.	
	Putter			None.	

	Hours per Shift		8 hours 40 minutes.		
		s. d.	s. d.	s. d.	s. d.
	Net Earnings per Shift	6 3.7	7 6.7	6 10.2	7 7.1
	Drivers and Boys of all Classes		2 0 to	3 6	
	Deputies, Firemen	6 8	6 8	6 8	6 8
	Remainder, Various (Datallers)		4 8 to	5 6	
	Hours of Labour		Same as above.		
	Total Underground Labour		1,042		1,029
Surface	Total Surface Labour		263		295
	Total		1,305		1,324
		s. d.	s. d.	s. d.	s. d.
Cost per ton	*Total* Underground Labour	5 8.6	3 11	3 5.9	3 10.9
	Surface Labour	11.1	7.9	6.4	8.7
	Total Labour Cost	6 7.7	4 6.9	4 0.3	4 7.6
Tons per Collier per Shift		2	2.75	2.75	2.6
Average Daily Output per hand below and on surface	Below		1.2 tons.		1.35 tons.
	Surface		6.0 ,, (in time pit works).		6.15 ,,

* These figures are the percentage of total labour in each seam.

No. XI.—YORKSHIRE HOUSE AND COKING COAL COLLIERY.

Output per fortnight	18,996 tons per fortnight of 10 days worked.
Number and Nature of Seams worked	Six. Of the usual character of the best house and coking coal seams of the Barnsley district.
Average Thickness of Coal—	

Seam.	Thickness	Output.
Lidgett	2 feet 0 inches	1,332 tons.
Fenton	3 ,, 0 ,,	608 ,,
Parkgate	4 ,, 8 ,,	5,301 ,,
Thin Coal	2 ,, 6 ,,	3,894 ,,
Silkstone	4 ,, 2 ,,	3,156 ,,
Whinmoor	2 ,, 10 ,,	4,704 ,,

Gradient	1 in 12.
Method of Working	Longwall (with coal-cutting machines) for the Lidgett and Thin Coal Seams, and modified longwall in the other seams.
Stock of Coal Tubs	3,500.
Weight of Coal per tub	6½ cwts.
Number of Coal-drawing Shafts	Four.
Depth ,, ,,	146, 210, 211, and 91 yards respectively.
Hours of Coal Drawing per day per week	10.

Labour Employed—

		No.	Per cent. of Total.	Hours per Shift.	Net Earnings per Shift. s. d.
Underground	Hewers (Colliers)	605	43	8	6 11½
	Stonemen and Shifters	103	7	8	8 1
	Putters	316	23	8	5 9¼
	Drivers and Boys of all Classes	243	18	8	3 3½
	Deputies (Firemen)	18	1	8	7 3
	Remainder (Various)	109	8	8	5 10¼
		1,394	100		
Surface		500			
	Total	1,894			

			s. d.
Cost per ton for labour	*Underground*	(1) Hewing,	2 9½
		(2) Offhand,	1 8
	Total		4 5½
	Surface		0 9¾
	Total		5 3¼

Tons per Shift - - - - (Collier and Trammer) = tons "per set" per shift, 3½ tons.

Average Daily Output per hand employed - - - - Below ground, 1.36 tons.
Surface, - 3.79 „

Examples I. to XI. Compared.—Much information may be gathered from the foregoing examples. They cover most of the conditions under which coal is got in Great Britain—namely, thin seams and thick seams (1 ft. 10 in. to 10 ft. 6 in.); deep and shallow (760 yards depth of shaft to seams cropping out at surface, and won by day drift); level and highly inclined (1 in 3 to flat); gassy and dusty seams, where water spray jets are required along the main roads, to seams worked with naked lights; good roofs, where the roads stand without timbering, to bad roofs where the strongest timbering requires constant renewal; seams worked on different methods, longwall, bord and pillar, and double-stall; and with various arrangements of labour: the two shifts of hewers system in the North of England, the collier system of South Wales and the Midlands, and the butty system of Warwickshire and Staffordshire.

At Northumberland and Durham collieries, from 40 to 50 per cent. of the hands employed underground, *i.e.*, rather less than half, are hewers.

The tons of coal they hew and fill per shift vary in the instances given from 2.84 to 4.84 tons, the average being 3.54 tons. These instances hardly cover the extreme limits, which may be put at about 2 tons in some of the thin, hard, steam coal seams to 5 and 6 tons in some of the thick, soft coking and gas coal seams. The 4 foot 9 inch seam working pillars in the No. II. instance must not be taken as typical of the Northumberland steam coal collieries, the results in tons per hewer and cost of working being much better than the average. But the average over the whole of Northumberland and Durham of 3½ tons is probably not far from the mark.

The *cost* of hewing at the North country collieries constitutes from 48 to 58 per cent., rather more than half of the total cost of underground labour. This proportion of cost varies generally as the tons got per hewer, which is reasonably to be expected. The actual figures in the six instances vary from 1s. 3.26d. to 2s. 7.14d., and give an average of 1s. 11d. a ton as the cost per ton of hewing and filling the coal into tubs.

The average daily output per hand employed below is 1.48, say 1½ tons, and 1.23, ¼ ton less, when the surface hands are taken into account also.

At the Welsh steam coal colliery the colliers form 35 per cent., *i.e.*, about one-third instead of about one-half, of the total hands employed underground. They work 108 hours * a fortnight (full

* Under the Seven Hours Act this becomes eighty-four hours.

time) in place of the 76 hours of the North country hewer, and their earnings per shift are higher in about the same proportion as the longer time they work, allowing for the value of the free house and coal of the North country miner. But much of his time the Welsh collier is employed not in hewing but in stone work and timbering. About two-thirds of his wage is for hewing, and one-third for other work. In some of the thinner seams with a bad top stone, and little room for stowing it, this proportion is reversed, two-thirds of the colliers' time being employed on "dead" work, and only one-third on "coal" work. The best steam coal seams of South Wales, 5 feet and 6 feet thick, and full of "slips," require very little hewing, and are as different as possible in this respect from the hard steam coal seams of Northumberland.

Taking this into account, the production per man of the Welsh collieries is comparatively low, and the cost of hewing is high. This may be partly due to the use of the large tram holding 1 to 2 tons. A man will fill a 10-cwt. tub towards the end of his shift, where he would not attempt a 2-ton tram, and at many of the Welsh collieries the men restrict themselves to filling a certain number of trams, the limit being generally below what they might do.

The difficult natural conditions of many of the Welsh collieries, their depth, the heavy pressure on the roads, the precautions needed to prevent explosions of gas and dust, are apparent in the relatively high cost of off-hand labour or dead work, which forms 70 per cent. of the total underground cost, in comparison with 57 per cent. at the North country collieries. But these conditions by no means prevail throughout South Wales. The circumstances of the bituminous coal collieries and the anthracite collieries to the west of the coalfield, working shallow seams cropping out at the surface, are altogether different from those of the deep steam coal seams farther east. This is quite apparent from a comparison of examples No. VI. and No. VII. In No. VII., a bituminous coal colliery, working by day drift, a 2 foot 8 inch seam dipping inbye at a gradient of about 1 in 6 on the double-stall system, nearly all the work is done in the stalls; 60 per cent. of the men employed are colliers; and 59 per cent. of the underground cost is for hewing. The output per collier per shift is only 2 tons, and per hand below 1.21 ton, and the cost per ton of underground labour is 4s. 0.67d.

It is interesting to compare this with No. IV., a Durham gas coal colliery raising a similar quantity of coal of a similar quality, most of the output being "small" coal in both cases, and the hours of coal drawing per fortnight the same, 108 (in 1904). Here the production per hewer, working shorter hours, is 4.84 tons, and per hand employed below 1.92 ton, and the total underground cost on the saleable coal, 2s. 7.71d. The output is got from two seams instead of one, and the workings are much more scattered and cover a wider area. On the other hand, they are thicker seams, and lying generally level instead of highly inclined.

But allowing for such differences, there can be no doubt that the results show a higher state of efficiency in the one case than the other.

At the Welsh colliery 382 hands are employed below, and 230 of them (60 per cent.) are colliers, the most highly paid class of labour.

At the Durham colliery 249 hands are employed for a similar output, and 97 of them (39 per cent.) are hewers. They work shorter hours (76 per fortnight as compared with 108), but they get more than twice as much coal per man per shift. Most of the other work, the dead work, is done by men who receive a lower wage. To put the bulk of the work into the hands of the most highly paid men does not tend to economy of production.

Nos. VIII., IX., and X. are examples of longwall working on the butty system, where one man contracts to do all the work in a given length of face at a fixed price per ton of coal got, himself engaging and paying the other men needed. Strictly, it is the "little butty" system which is in operation in these examples, where the butty is the stallman, in contradistinction to the butty or contractor system, where a contractor undertakes the coal getting of a whole district, or it may be of the whole pit.

In No. IX. instance it is noticeable that the contractors or stallmen do most of the work themselves, the holers and loaders numbering only about one-fourth of the total employed in the face. This is due, no doubt, to the short time that the collieries are working, only six and a half days in the fortnight, which induces the stallmen to do more work, and to earn all they can for themselves.

The effect of the short time is shown also in the high production per man, 4.10 tons per collier, and 1.7 ton per man employed below.

In No. VIII. instance there are, roughly, two holers and getters to each stallman.

The cost per ton of the stall work, which includes a good deal more than getting and filling the coal, as stated—1s. 10d. and 2s. 0.32d.—corresponds closely with the cost of hewing at the North country collieries.

This comparison suggests that the butty system tends to economy.

In No. VIII. and No. IX. the proportion of men employed in the face—stallmen, holers, and getters—is also very similar to the proportion of hewers at Northumberland and Durham collieries, rather less than half the total engaged underground.

In the Potteries district, where the butty system is in general operation,* the work of the holers and loaders is very irregular, as they "play" a good deal, owing to the fact that their wives and daughters and sisters work in the potteries. In this district it would be very difficult to work on the North country system of hewers. A system which may work very well in one district may be quite unsuitable for another, owing to different local circumstances.

The high cost of the off-hand labour in No. VIII. instance, 2s. 3.6d. higher than any of the others, with the one exception of the Welsh steam coal colliery, is explained partly by the unusual crush and pressure that exist on the main roads, making them very expensive to maintain. It is much the same at many of the Welsh collieries, and is a condition of things which adds seriously to the cost.

In No. VIII. example, coal-drawing is carried on during the night as well as the day, and the hours of coal-drawing per fortnight (228 hours) are twice as many as is usual. This also tends towards an increased cost of off-hand labour, as a good deal of the repairing work is done in the short interval of five hours between the day and night shift.

No. X. example covers much the largest output and the most extensive scale of working, 31,780 tons a fortnight from four seams.

It will be noticed that no stonemen, shifters, or putters are employed, the greater part of the work that falls to these classes of labour in the Northern coalfield being here performed by the stallmen, or by others paid by the stallmen. The costs are low, with the exception of the top hard seam, from which only a very small output is obtained.

In No. XI. example, of a Yorkshire colliery, a noticeable point is the large proportion of putters employed, 23 per cent. of the total below; and the high wages they are paid, 5s. 9½d. a shift. Owing to the gradient of 1 in 12, and to the roof being generally bad, the putting is exceptionally difficult, and men rather than lads are needed for the work.

The low proportion of deputies or firemen in this and other

* The Butty system is not now so general as it was when this was written.

instances—only 1 per cent. in comparison with 3 to 5 per cent. at Northumberland and Durham collieries—is due to the fact that at the latter the deputies do much of the timbering and laying way, which at the former is done by the colliers.

Size of Tub.—As regards the rolling stock, or number of tubs required, the large tubs which are customary in South Wales of course reduce the number needed for the same output.

Expressed in tons of output per fortnight, at the Welsh steam coal colliery, it is 25 tons per tub of 40 cwt., as compared with 5.4 tons per tub of 6½ cwt. at the Yorkshire colliery in No. XI. example, and 8 tons per tub of 8 cwt. at the Durham colliery in No. IV. example; or four and a half times as many tubs are required in No. XI. case as in No. IV. for the same output.

But when we reduce it to the "least common denominator" of "cwts. of coal held by the tub," the Welsh colliery comes out lower than any of the others, giving 0.625 ton of fortnightly output per tub per cwt. held as compared with 1 ton at the Durham colliery, and 0.834 ton at the Yorkshire colliery.

The increased use of the rolling stock, and consequently the fewer tubs required, where work goes on during the night as well as during the day, is shown by the results in No. VIII. example, where the output per fortnight is 22 tons per tub of 9½ cwt., or 2.31 tons per tub per cwt. it holds.

A good result is shown in No. II. example, where 7,250 tons are got from a 2 foot 7 inch seam with 350 tubs of 11½ cwt., equal to 20 tons per tub, or 1.74 ton per tub per cwt. Perhaps this size, 10 to 12 cwt., may be taken as the "golden mean."

As regards the relative cost and weight of the tubs, the 2-ton steel tram of the Welsh colliery, with Rowbotham wheels, cost £6. 9s. 6d. in 1904, and weighs empty about 12 cwt., whereas the wooden tub of the Durham colliery costs £3. 2s. 6d., and weighs a little over 4 cwt. The stock of 750 trams of the Welsh Steam Coal colliery, therefore, represents a capital expenditure of £4,856.

To provide a similar carrying capacity of 1,500 tons (*i.e.*, 750 trams of 2 tons each), 3,750 of the 8-cwt. tubs would be required, and 3,750 tubs at £3. 2s. 6d. each would cost £11,718.

The big tram is relatively much more economical in first cost, and also in cost of upkeep. It also adds considerably to efficiency in hauling and winding.

With two 2-ton trams, a single-decked cage brings up 4 tons of coal at a wind, and no movement of the cage is needed for changing trams. For a similar load with 10-cwt. tubs, eight of them would be required, and a cage with two or more decks, requiring more time for changing tubs, and adding much to the dead weight to be lifted.

As showing what can be done in hauling with the big tram, the following is an actual instance of horse haulage at a small Welsh colliery worked by day drift. The tram, in this instance, holds on an average 22½ cwt. of coal. It is made of wood, and weighs empty 6½ cwt.; it is fitted with Rowbotham wheels (well known for their efficient lubrication). The size of the wheels is 14 inches diameter, and most of the road is very wet. From the top of an engine bank the trams are conveyed by horses along a water-level road 350 yards in length, which brings them out to the day to the top of a self-acting incline leading to the screens. Two horses are employed, and one man and a boy; 8 to 9 trams go to each "set," or 9 to 10 tons of coal, and there are always two "sets" on the road, one following the other, the man going with the front set and the boy following. In this way, 437 tons of coal, besides stone, have been led in ten hours, representing about twenty-five journeys each way, or a distance travelled by the horses of close upon ten miles.

The useful performance of each horse is therefore 220 tons of coal led 350 yards, or 44 tons of coal conveyed by each horse one mile per day—a very good result.

The labour is paid at a bargain price of ¾d. a ton (net), and this includes the conveyance of the coal down the self-acting incline to the screens, and the wages of another man employed at the bottom of the incline, besides the man and boy already mentioned.

General Summary.—If these examples of coal working (Nos. I.-XI., pp. 308-329) may be taken as fairly typical of British collieries, it appears that, at the rate of wages prevalent during the year 1904, the cost of labour on the average (omitting No. VI. example, where the cost is given on the large coal) was 3s. 11.3d., say 4s. a ton on labour employed underground, and 7.5d. on surface labour (screening, mechanics, etc.), making a total of 4s. 7d. This of course must be taken only as a rough average, to which there are many wide exceptions. It may be well to add that it is the cost of labour only, forming as a rule about 50 to 60 per cent. of the total cost of coal getting. To it has to be added the cost of materials, of royalty rent, of rates and taxes, and of management.*

The average production of coal per hewer per shift runs about 3 tons. Per hand (man and boy) employed underground the average daily production is 1.39 tons, and including the surface hands 1.19 tons. In other words, under average conditions of British coal mining in 1904 for a daily output of 1,000 tons, 840 men and boys were required, 720 of them underground and 120 on the surface ; of the 720 employed below, about 360 were hewers, receiving a wage of 6s. to 7s. a shift, and the other 360 were variously engaged at a lower wage, with the exception of some stonemen or repairers or rippers who are paid by the piece, and who earn high wages.

Now (June 1923) the average earnings of all classes of colliery workers of all ages in Great Britain are 9s. 11d. a shift.

For the quarter year ended 30th June 1923 (the most recent available at time of writing), the cost of wages per ton of saleable output was 11s. 11.46d. ; and the output per man-shift 17.90 cwt. of saleable coal.†

Compared with 1904 the lower "get" per man-shift, and the higher cost of wages per ton, are apparent.

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* Comparing the years 1913 and 1917 costs calculated over the United Kingdom were as follows :—

	1913.		1917.	
	s.	d.	s.	d.
Wages - - - - - - -	5	6	12	0
Stores and pit wood - - - - -	1	0	3	0
General expenses, including everything except depreciation, see "The British Coal Mining Industry during the War," by Sir R. Redmayne	1	3	1	6
	7	9	16	6

† See official figures issued by the Mines Department.

CHAPTER XVIII.

ACCIDENTS AND DISEASE AND THEIR PREVENTION.

DURING the last fifty years steady progress has been achieved in the prevention of fatal accidents in coal mines.

This is evident from the following Table showing the death-rates from accidents per 1,000 persons employed and per 1,000,000 tons raised during the period 1873 to 1922.

Decennial Period or Year.	Death-Rate.	
	Per 1,000 Persons Employed Below and Above Ground.	Per 1,000,000 Tons of Mineral Raised.
1873-1882	2.24	7.42
1883-1892	1.81	5.65
1893-1902	1.39	4.70
1903-1912	1.33	4.76
1913	1.55	5.81
1917	1.34	5.27
1918	1.39	5.86
1919	0.94	4.67
1920	0.88	4.60
1921	0.66	4.49
1922	0.95	4.32

There are ups and downs during the passing years, but the general trend towards greater safety is quite clear.

The death-rate per 1,000 persons employed has been less than 1 during recent years. As Dr J. S. Haldane said in a lecture to the Derbyshire Mining Students' Association at Derby in 1921: "By accumulated human endeavour, skill, and experience, coal-mining has been changed from a dangerous and unhealthy occupation to one in which the combined risks to health and life are considerably below the average"

The most recent figures available at the time of writing are as follows for the year 1922 :—

PERSONS KILLED AND INJURED DURING 1922 AT MINES UNDER THE COAL MINES ACT, 1911.

	Killed.	Injured.
Explosions	73	105
Falls of ground	551	63,035
Shaft accidents	39	971
Haulage accidents	211	46,839
Miscellaneous underground ...	125	59,254
Total below ground	999	170,204
On surface	106	15,293
	1,105	185,497

The year 1922 was marked disastrously by three serious explosions of fire-damp and coal-dust, causing the death of 57 persons.

These figures show that there is need for continued effort to reduce yet further the serious injury and loss of life to which those engaged in the occupation of coal mining, with its many natural risks and dangers, are liable.

It is well known that far the most deadly source of danger, which causes about half the total accidents, though most of them are single fatalities, is falls of ground.

This is not surprising when one thinks of the enormous extent of open roadways and of coal face in the (about) 3,000 collieries at present at work, all subject to the constant and sometimes overwhelming pressure of the surrounding strata.*

* As evidence of what can be achieved in preventing accidents from falls of ground, the following extract from Divisional Inspector J. Masterton's last Annual Report for Scotland Division is instructive :—

" *Timbering.*—Analysis of the reports of the fatal accidents from falls of roof and sides shows that approximately 30 per cent. were due to defective practice, 5 per cent. to neglect by officials, 8 per cent. to neglect by workmen, and 57 per cent. to unavoidable causes.

"There is one colliery where complete success has followed the adoption of proper lay-out of districts and control of the roof, both in longwall and stoop and room workings. This is Newbattle Colliery, owned by the Lothian Coal Co. Ltd., Midlothian. Seams of about 6 feet, 4 feet 6 inches, and 2 feet thick are being worked, and they lie at inclinations varying from 45° down to flat.

Next to falls of ground as a cause of accidents comes haulage, *i.e.*, the moving trucks and trams and ropes; 20 to 25 per cent. of the total accidents are due to this source. Thus from 70 to 80 per cent., say three-quarters, of the total accidents are due to falls of ground and haulage.

How Far are Accidents Avoidable?

Some light on this question may be derived from the annual reports of H.M. Inspectors of Mines, who carefully investigate every fatal accident that occurs.

Sir Thomas H. Mottram, C.B.E., late Chief Inspector of Mines, wrote in a recent report:—

"All accidents have again been classified to show whether or not they were avoidable, and so far as 'falls of ground' are concerned, about 72 per cent. were found to be unavoidable, while from other accidents the percentage was 45.6. In arriving at these figures, accidents have been classified as unavoidable unless there was clear evidence to the contrary. These figures point to there being greater scope for reducing the death-rate of accidents arising from other causes than falls of ground."

So also Mr Dyer Lewis, late Divisional Inspector of Mines for South Wales, remarked in his report for the year 1918:—

"Many of the falls of roof are pure accidents which no care could prevent."

The props used at the working faces are steel tubes with wooden filling and renewable wooden plugs at the ends. Steel straps are also used with the props. The setting and withdrawal of the props is all done on a carefully thought-out system, and falls at the working face are almost unknown, although some of the working faces are 2,500 feet deep. The methods of supporting the roof on the roads is also excellent, as steel arches are set 3 feet apart, and on the main roads the spaces between girders are brick built, while in the roads nearer the working faces lighter steel arches are in use, packed behind with light slabs of timber. Some of the working faces are over 2½ miles from the main winding shaft, which is 270 fathoms deep, and on all the length of roads the number of repairers is very small indeed; there being only a few men who take out and replace girders which become badly bent, and brickwork which rushes out. Since the system of road and roof support was begun in 1914, the number of reported accidents from falls of roof and sides has been two fatal and two non-fatal. The total number of men employed underground is nearly 1,200. The results speak for themselves, but they have not been arrived at without the proper organisation and rigid discipline necessary."

What Can be Done to Prevent Accidents ?

With respect to the avoidable accidents, they might have been prevented by greater caution or alertness or foresight on the part of those concerned.

Remarks to this effect are frequent in the Inspectors' reports. For instance, the late Mr J. R. R. Wilson, Divisional Inspector of the Northern Division, wrote :—

" One regrets to have to repeat year after year that a large number of accidents should never have occurred. So long as men are careless and thoughtless, when they cease to realise that the very nature of their occupation requires alertness, fatalities are bound to happen. Out of the total of 214 deaths, 91 might reasonably have been avoided. . . . The workmen are not alone to blame in this respect, for better discipline and supervision and a keener appreciation of the value of safety appliances by officials would certainly tend to reduce the number of accidents."

Again :—

" Taking the fatalities as a whole, 45 per cent. of them were avoidable by ordinary care and precaution."

Again :—

" Year after year the lamentable fact has to be recorded that many of these accidents are avoidable, and are the result of carelessness, indifference, or want of thought."

The personal factor is a most important element in the occurrence of accidents. Of fatal accidents occurring in coal mines during 1921, the accidents preventable by the action of the individual were found to represent 33 per cent. of the total.*

Safety First Campaign.

Recognising this outstanding fact, some enterprising managers have undertaken a " Safety First Campaign " at their collieries.

It is necessary, of course, in the first place, to enlist the interest and sympathy of officials and workmen. All depends on the right spirit being active. Then warning notices of a brief and pithy kind, and illustrated posters designed to catch the eye and rivet the attention, are produced and placed in prominent positions both on the surface and in the mine.

* See " Report of Medical Research Council," December 1922.

Mr J. E. Henshaw has described the methods adopted at Talk o' th' Hill colliery, Stoke-on-Trent.*

"Suggestion Boxes," of the letter-box type, have elicited some excellent suggestions from the workmen, which have been adopted. Prizes are given for good practical suggestions.

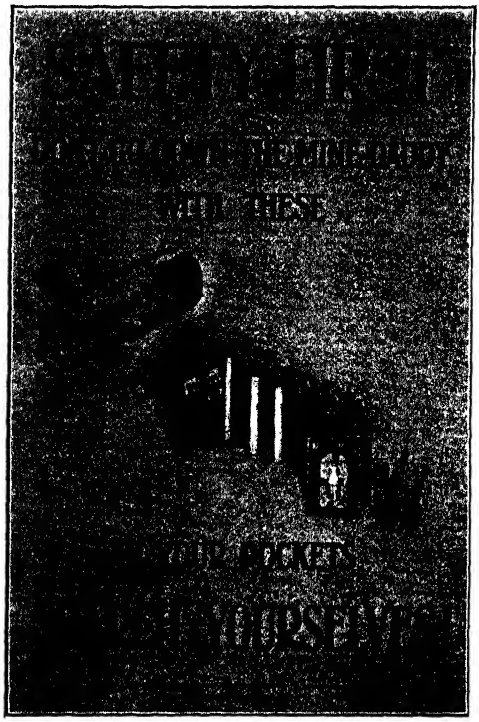

Fig. 127.

Another pioneer in this "Safety First" movement is Messrs Fletcher, Burrows, & Co. Ltd., who have adopted it at their Atherton collieries, near Manchester. Some of their ingenious posters are shown in the accompanying illustrations.

It is the art of advertisement and the power of suggestion directed to awaken the attention, and the interest, and the co-operation of officials and workmen in the prevention of accidents. For attaining this desirable object it is an admirable movement.

* See *Trans. Inst. Min. Engineers*, vol. lxiii.

Safety Committees.

This Safety First Campaign may be carried on best in conjunction with a Safety Committee consisting of representatives of officials and workmen.

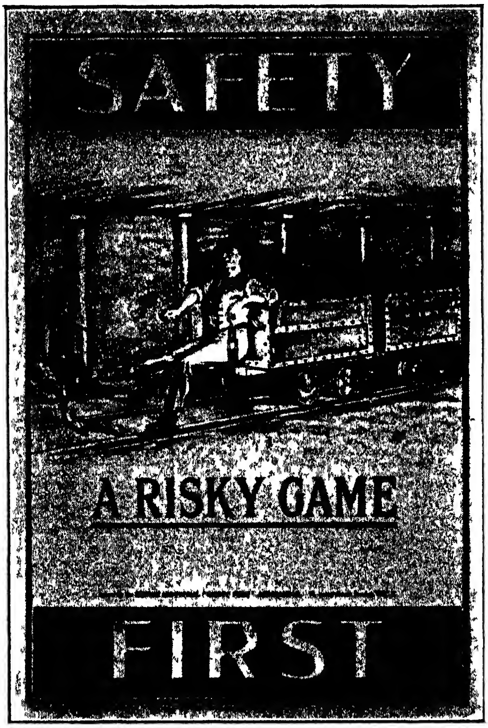

FIG 128.

This was suggested by Mr Henry Walker, H.M. Inspector of Mines, in his annual report for 1917 :—

" I think the appointment of a committee of officials and workmen at each mine, which would have placed before it the details of every accident which occurred at the mine, and which should take power to make recommendations to be adopted to prevent similar accidents in future, should be considered."

This is recommended by Sir T. H. Mottram also in a recent report :—

" There is in my view a possibility of reducing the number of accidents, fatal and otherwise, from falls of ground (which are far too numerous) by constituting Safety Committees at all pits. . . . Such committees should have the opportunity of promulgating information and suggestions likely to educate officials and workmen in the direction of improving methods and in exercising greater care."

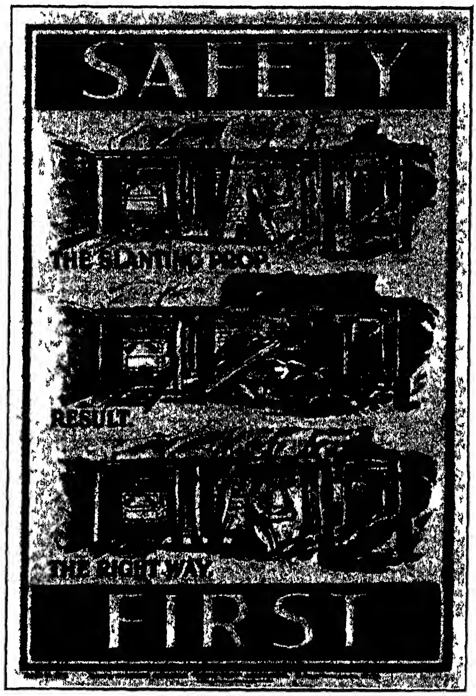

FIG. 129.

Monthly Magazine.

A useful method of promulgating information and suggestions is the publication of a monthly magazine, such as, for instance, is published by the Ashington Coal Co. in Northumberland. It has a circulation of 2,500 copies. Besides "Safety," such a magazine can deal, of course, with other subjects of general interest.

Serious Injuries.

The serious injuries to which miners are liable give rise to much weakness and suffering, which might be averted by prompt and adequate treatment. The experience gained by the medical profession during the war has stimulated a great advance in the successful treatment of these diseased conditions. An interesting example of what can be done in this remedial way in the industrial sphere is afforded by the "massage centre" which has been established by the employers of coal and iron industries in North Staffordshire.

Dr T. Lister Llewellyn is the medical officer in charge. Speaking at a conference of medical men working in industrial districts, which was held in London in June 1921, Dr Llewellyn stated with respect to this establishment that the attendance averaged about 200 a week; that the men attended regularly and much appreciated it; that the treatment consisted of massage, and electrical applications, and exercising; that the results had been very satisfactory.

A similar establishment is maintained by Messrs Pilkington Brothers Ltd., at St Helens, Lancashire. Dr James R. Kerr, C.B.E., is the surgical director. Here there are in beneficent operation all the most improved appliances for physio-therapy treatment.

Scratches and abrasions of the skin are a minor injury which, if neglected, frequently give rise to blood poisoning. It is a good practice to have a First-Aid Post at the colliery with a trained man always in attendance, to treat such injuries when the men are coming from or going to their work.

General Health of Coal Miners.

Coal miners are on the whole a strong and healthy body of men. The complaints to which they are prone are chiefly nervous diseases, such as nystagmus and neurasthenia, and amongst the older miners respiratory diseases, such as bronchitis.

The alarming increase in the number of cases of nystagmus and of the resulting incapacity amongst coal miners in recent years, led to the appointment of a Committee to inquire and report on it. The members of the Committee are Dr J. S. Haldane, Prof. E. L. Collis, Dr T. L. Llewellyn, and Mr G. H. Pooley.

Their second report, published in August 1923, brings out the important fact that there has been hitherto a mistaken and unfortunate tendency to aggravate the seriousness of the complaint. Miners have been kept idle and reduced to a state of incapacity when they would have been better at work. One of the conclusions of the Committee is :—

"Most cases of miners' nystagmus are only partially incapacitated; they benefit physically and psychologically by work. Some require work above ground; others are fit for suitable work below ground. All men in this group should receive every encouragement to start work as soon as possible."

Dr Edgar L. Collis has published some instructive figures bearing on the mortality of coal miners.*

Dr Collis' object was to show that the unrest and dissatisfaction of miners, as expressed by the number who voted for a strike in 1920, was proportionate roughly to their liability to death by accident.

However this subconscious influence may prevail, an analysis of his figures shows that out of 4,989 deaths of coal miners, in seven coalfields, during the three years 1910 to 1912, 762, or 15 per cent., were due to accidents, and 1,318, or 26 per cent., were due to respiratory diseases—phthisis, pneumonia, and bronchitis.

For all occupied and retired males the percentage of deaths from these respiratory diseases was 62 per cent., or more than twice as much.

In spite of their dangerous occupation and liability to accidents, miners live longer and enjoy better health than most men.

It is by the adoption of such methods as have been outlined briefly in this chapter that further advance will be made in the prevention of accidents and in the alleviation of weakness and suffering amongst miners.

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* See his letter in *Times*, 2nd September 1920.

APPENDIX I.

THE TERMS OF SETTLEMENT FOR THE RESUMPTION OF WORK AFTER THE NATIONAL STOPPAGE OF COAL MINERS IN 1921.

THE "Terms of Settlement" of the coal dispute, issued by the Board of Trade on 28th June 1921, were as follow :—

1. A National Board shall be constituted forthwith, consisting in equal numbers of persons chosen by the Mining Association of Great Britain and persons chosen by the Miners' Federation of Great Britain.

There shall also be established District Boards, consisting in equal numbers of persons representing owners and workmen in each district.

The National and District Boards shall draw up their own rules of procedure, which shall include a provision for the appointment of an Independent Chairman for each board.

2. The wages payable in each district shall be expressed in the form of a percentage upon the basis rates prevailing in the district, and shall be periodically adjusted in accordance with the proceeds of the industry as ascertained in such district.

3. The amount of the percentage to be paid in each district during any period shall be determined by the proceeds of the industry in that district during a previous period, as ascertained by returns to be made by the owners, checked by joint test audit of the owners' books carried out by independent accountants appointed by each side.

4. The sum to be applied in each district to the payment of wages above the standard wages as hereinafter defined shall be a sum equal to 83 per cent. of the surplus of such proceeds remaining after deduction therefrom of the amounts of the following items during the period of ascertainment :—

(*a*) The cost of the standard wages ;

(*b*) The costs of production other than wages ;

(*c*) Standard profits equivalent to 17 per cent. of the cost of the standard wages ;

and the share of the surplus applicable to wages shall be expressed as a percentage upon the basis rates prevailing in the district.

Provided that if in any period the ascertained proceeds, after deduction of costs other than wages and the cost of the standard wages, prove to have been insufficient to meet the standard profits, the deficiency shall be carried forward as a first charge to be met out of any surplus, ascertained as above, in subsequent periods.

5. If the rates of wages thus determined in any district do not provide a subsistence wage to low-paid day-wage workers, such additions in the form of allowances per shift worked shall be made for that period to the daily wages of these workers, as, in the opinion of the District Board, or in the event of failure to agree by the parties, in the opinion of the Independent Chairman, may be necessary for the purpose. Such allowances shall be treated as items of cost in the district ascertainments.

6. For the purpose of these periodical adjustments the units shall be the districts set out in the schedule hereto, and shall only be varied by the decision of the District Board or Boards concerned, provided that no variation shall take place prior to 1st February 1922 in the grouping of any district unless it is mutually agreed by the representatives of both sides in the district or districts concerned.

7. The standard wages shall be the district basis rates existing on 31st March 1921, plus the district percentages payable in July 1914 (or the equivalents in any district in which there has been a subsequent merging into new standards), plus, in the case of piece workers, the percentage additions which were made consequent upon the reduction of hours from eight to seven.

8. In no district shall wages be paid at lower rates than standard wages plus 20 per cent. thereof.

9. The National Board shall forthwith consider what items of costs are to be included for the purposes of paragraph 4 (*b*) above, and in the event of agreement not being arrived at by 31st July, the matter shall be referred to the Independent Chairman for decision.

10. The wages payable by the owners up to 31st August inclusive shall be based upon the ascertained results of the month of March, and the wages payable during September shall be based upon the ascertained results of the month of July. The periods of ascertainment thereafter shall be decided by the National Board.

11. During the "temporary period" as hereinafter defined the following special arrangements shall apply in modification of the general scheme set out above :—

(*a*) In calculating the proceeds for March the deduction to be made in respect of costs other than wages shall be the average of such costs during January, February, and March.

(*b*) In any district in which reductions in wages continue to be made after the first ascertainment, no part of the surplus proceeds shall be assigned to profits if and in so far as this would have the effect of reducing the wages below the level in the preceding month.

When in any district there is a break in the continuity of reductions in wages upon the periodical ascertainments at that point and thereafter the general scheme shall apply fully in regard to owners' surplus profits.

(*c*) The proviso to paragraph 4 regarding the carrying forward of deficiencies in standard profits shall not apply, but any net losses shall be so carried forward.

(*d*) The Government will give a grant not exceeding £10,000,000 in subvention of wages.

(*e*) This subvention shall be available for making such increases to the wages otherwise payable in any district as may be necessary to prevent the reductions below the March rates of wages being greater than the following amounts:—

> During July, 2s. a shift for persons of 16 years of age and upwards, and 1s. a shift for persons under 16.
> During August, 2s. 6d. and 1s. 3d. respectively.
> During September, 3s. and 1s. 6d. respectively.

Provided that the balance of the subvention is sufficient for this purpose.

(*f*) If any district in which in any month the proceeds available for wages, calculated in accordance with the terms of this settlement, are sufficient to admit of a rate of wages equal to or higher than the rate payable under the maximum reduction for that month, the wages payable by the owners shall be calculated not in terms of basis plus percentage, but on the same basis as during March, less flat rate reductions uniform throughout the district for persons of 16 years of age and upwards and persons under 16 years of age respectively.

(*g*) In any district in which the wages calculated in accordance with the terms of this settlement are less than the wages payable under the maximum reductions aforesaid, the difference shall be met by the owners in that district during September to the extent of the aggregate net profits realised by them on the district ascertainment for July, and during October to the extent of the aggregate net profits realised by them on the district ascertainments for July and August.

(*h*) The expression "temporary period" means the period from the date of the resumption of work to 30th September 1921.

12. The period of duration of this agreement shall be from the date of resumption of work until 30th September 1922, and thereafter until terminated by three months' notice on either side.

13. It is agreed as a principle that every man shall be entitled to return to his place when that place is available for him, and that men temporarily occupying places during the stoppage shall give way to men working in those places before the stoppage.

It is agreed that on the other hand there shall be no victimisation of men who have been keeping the collieries open, not in the sense that they are to remain at the jobs they filled during the stoppage, but that they shall not be prevented from going back to their own jobs or from working subsequently at the colliery.

Schedule Referred To.

Scotland; Northumberland; Durham; South Wales and Monmouth; Yorkshire, Nottinghamshire, Derbyshire, Leicestershire, Cannock Chase, and Warwickshire; Lancashire, North Staffordshire, and Cheshire; North Wales; South Staffordshire and Salop; Cumberland; Bristol; Forest of Dean; Somerset; Kent.

REGISTER OF HOURS OF WINDING-ENGINEMEN. *Sec.* 57 (3), COAL MINES ACT, 1911.

Month, and Day of Month.	Signature of Winding-Engineman.	Hours of Employment.		Where a winding-engineman is employed in any day in pursuance of the exemption contained in Regulation 3 or Regulation 7, full particulars of the case must be stated in this column.	Column for Initials of Person examining the Register in pursuance of Regulation 9 (*a*).
		Hour of Commencement.	Hour of Termination.		
(1)	(2)	(3)	(4)	(5)	(6)

NATIONAL WAGES AGREEMENT OF JUNE 1924.

EARLY in 1924 the miners gave notice to terminate the existing Agreement. After prolonged negotiations between the Mining Association and the Miners' Federation and the sitting of a Court of Inquiry, presided over by Lord Buckmaster, appointed by the Government, a new Agreement was made in June 1924 as follows:—

National Wages Agreement.

1. A National Board shall be constituted forthwith, consisting in equal numbers of persons chosen by the Mining Association of Great Britain and persons chosen by the Miners' Federation of Great Britain.

There shall also be established District Boards, consisting in equal numbers of persons representing owners and workmen in each district.

The National and District Boards shall draw up their own rules of procedure, which shall include a provision for the appointment of an independent chairman for each Board.

2. The wages payable in each district shall be expressed in the form of a percentage upon the basis rates prevailing in the district, and shall be periodically adjusted in accordance with the proceeds of the industry as ascertained in such district.

3. The amount of the percentage to be paid in each district during any period shall be determined by the proceeds of the industry in that district during a previous period, as ascertained by returns to be made by the owners, checked by joint test audit of the owners' books carried out by independent accountants appointed by each side.

4. The sum to be applied in each district to the payment of wages above the standard wages as hereinafter defined shall be a sum equal to 88 per cent. of the surplus of such proceeds remain-

ing after deduction therefrom of the amounts of the following items during the period of ascertainment:—

(*a*) The cost of the standard wages.

(*b*) The cost of production other than wages.

(*c*) Standard profits equivalent to 15 per cent. of the cost of standard wages.

And the share of the surplus applicable to wages shall be expressed as a percentage upon the basis rates prevailing in the district.

Provided that if in any period the amount of the ascertained proceeds is less than the sum of the amounts of (1) costs other than wages; (2) the cost of the minimum wages as defined in Clauses 5 and 6; and (3) standard profits, the deficiency shall be carried forward to be made good in subsequent periods according to the following method:—

In any ascertainment in which the amount of the proceeds is greater than the amount required to meet (1) costs other than wages; (2) the cost of the minimum wages as defined in Clauses 5 and 6; (3) standard profits; and (4) an amount equal to 12/88ths of the difference between the cost of standard wages and minimum wages as defined in Clauses 5 and 6, one-third of the balance shall be applied so far as may be necessary to make up any deficiency brought forward from previous ascertainments. The other two-thirds, together with such portion of the first third as may remain after the deficiency brought forward has been met, shall be divided between wages and profits in the proportions of 88 per cent. to wages and 12 per cent. to profits.

If there should be no balance available for meeting a deficiency brought forward or if the deficiency brought forward exceeds one-third of the balance determined, as in the preceding paragraph, the deficiency or such portion thereof as remains shall be again carried forward to be made good in subsequent periods according to the above method.

5. In no district shall wages be paid at lower rates than standard wages plus $33\frac{1}{3}$ per cent. thereof.

6. In no district as defined in Clause 8 (*b*) shall the wages of any adult day-wage workman fall below a figure 40 per cent. above the standard wages of the lowest paid class of day-wage workman in such district at the date of this Agreement; provided that this shall not exclude local mutual arrangements in the case of men with special disabilities.

7. If the rates of wages thus determined in any district do not provide in any period a subsistence wage to low-paid day-wage workers, such additions in the form of allowances per shift worked shall be made for that period to the daily wages of these workers as, in the opinion of the District Board, or, in the event of failure to agree by the parties, in the opinion of the independent Chairman of the District Board, may be necessary for the purpose; provided that the amounts of any allowances or subsistence wages which have already been fixed under the provisions of Clause 5 of the Terms of Settlement of 1st July 1921, shall be increased by one-eighth, and the amounts so increased shall not be varied during the continuance of this Agreement.

Allowances made under this Clause, including those made under the proviso thereto, shall be treated as costs other than wages in the district ascertainments.

8. (*a*) For the purposes of this Agreement the districts shall, save as provided in paragraph (*b*) of this Clause, be the districts set out in the first schedule hereto.

(*b*) For the purposes of Clause 6 the districts shall be those set out in the second schedule hereto.

(*c*) The districts specified in the two schedules hereto shall only be varied by the decision of the District Board or Boards concerned.

9. The standard wages in any ascertainment shall be the district basis rates during the period of working on which the ascertainment is based plus the district percentages, payable in July 1914 (or the equivalents in any district in which there has been a subsequent merging into new standards), plus, in the case of pieceworkers, the percentage additions which were made consequent upon the reduction of hours from eight to seven.

10. In ascertaining the proceeds and surplus in terms of Clause 4 the accountants shall follow the principles set out in the third schedule hereto, and any amendment or addition to such principles which may hereafter be adopted by the National Board.

11. The wages payable by the owners from 1st May 1924 to 30th June 1924, inclusive, shall be based upon the ascertained results of the months of January and February 1924. The periods of ascertainment thereafter shall be determined by the National Board.

12. The period of duration of this Agreement shall be from 1924 to 30th June 1925, and thereafter until terminated by one month's notice on either side.

First Schedule.

Scotland; Northumberland; Durham; South Wales and Monmouthshire; Yorkshire, Nottinghamshire, Derbyshire, Leicestershire, Cannock Chase and Warwickshire; Lancashire, North Staffordshire, and Cheshire; North Wales; South Staffordshire and Salop; Cumberland; Bristol; Forest of Dean; Somerset; Kent.

Second Schedule.

List of Districts for the Purpose of Clause 6.—(1) Lanark, (2) Fife, (3) Lothians, (4) Ayr, (5) Northumberland, (6) Durham, (7) South Wales and Monmouthshire, (8) West Yorkshire, (9) South Yorkshire, (10) Midland Counties, (11) Nottinghamshire and Erewash Valley, (12) South Derbyshire, (13) Leicester, (14) Cannock Chase, (15) Warwickshire, (16) Lancashire and Cheshire, (17) North Staffordshire, (18) North Wales, (19) Flint, (20) South Staffordshire and East Worcestershire, (21) Salop, (22) Cumberland, (23) Bristol, (24) Forest of Dean, (25) Somerset, (26) Kent. The above are the districts covered by the respective District Coal Owners' Associations.

Third Schedule.

Principles to be followed for the Purposes of Periodical Ascertainments.

1. The industry (of which the proceeds, standard wages, and cost of production other than wages, determine the wages payable in addition to the standard wages) is the coal industry; it does not include other "activities" such as:—

Coke ovens and by-product plant.
Smokeless fuel plant.
Manufacture of patent fuel.
Selling agencies, merchanting depots.
Wagons, ships, barges.
Private railways (as distinct from colliery sidings).
Farms and cottages.
Washeries and electric power plant, except those situated at and owned by the colliery.

It does comprise all the operations of coal mines, including the incidental raising of other products.

When, however, coal itself is raised incidentally to other minerals, *e.g.*, fireclay, ironstone, for the purpose of working the mine or treating the minerals raised therefrom, the whole of the figures relating to the mine are to be excluded from the ascertainment, notwithstanding that it may govern the wages of the workers employed there.

All figures relating to an excluded "activity" are to be excluded from the ascertainment. Figures relating partly to a colliery and partly to an excluded "activity" are to be apportioned on an equitable basis. Fair transfer prices, based on current market values, are to be charged in respect of transactions between a colliery and allied concerns (*e.g.*, iron and steel works, brickworks, &c.) and departments not included in the ascertainment.

The returns from collieries temporarily closed are to be included in the periodical ascertainments, whatever be the cause of the temporary closing, whether accident (such as fire, explosion, or flooding), industrial dispute or question of policy; provided that a colliery temporarily closed shall cease to be included in the ascertainments as respects any time during which it remains closed after the expiry of three months from the date of closing, except in so far as the returns relate to the provision of services such as pumping, &c., for other collieries.

Stocks of coal (and ancillary minerals): The difference between the value of the stock at the beginning of the period and that of the end is to be taken into account in computing the proceeds of the industry, the basis of valuation being cost, or market value if lower than cost.

2. The proceeds are to include all sales and transfers not only of coal but of other products of the mine, *e.g.*, any sales of water, and also any sum received as compensation for leaving minerals unworked, except such proportion, applicable to the ownership of freehold minerals, as would, in the case of leasehold minerals, have been paid to the proprietor.

3. Standard wages include the standard wages of all colliery workers whose remuneration is calculated by means of basis rates and percentage thereof, and in the case of manual and semi-manual workers whose wages are not so calculated, the same proportion of their wages as the standard wages bear to the total wages of workers paid by means of basis rates and percentages, but do not include :—

(*a*) Any portion of the remuneration of the clerical and administrative staffs.

(*b*) Any wages charged as part of capital expenditure.

(*c*) Any part of the value of privileges in the form of coal or houses free or at reduced rates.

4. Costs of production other than wages.

I. *Admissible.*

(*a*) Timber and stores: Cost of what is consumed, stocks being adjusted on the basis of cost or market value if lower than cost.

(*b*) Depreciation and renewals: Amounts calculated on income tax principles.

(*c*) Freehold coal royalties: A charge equivalent to royalty calculated upon the Mineral Rights Duty basis.

(*d*) Surface damage and restoration of surface at end of lease: Where the colliery does not own the surface, only actual payments for surface damage to be charged. Damages to surface belonging to the owners of the colliery to be included to the extent to which the damage is made good by actual expenditure, or, where it is not made good, then to the extent of the loss suffered by the owners

(*e*) Workmen's Compensation payments and insurance: Actual expenditure as admissible for income tax, subject to adjustment for deficit or surplus of mutual insurance association as ascertained for income tax purposes; the adjustment, expressed as percentage of premiums, to be certified by the association's auditors; the independent accountants for the district to have discretionary right of access to books of companies owned or controlled by a colliery or collieries. If not so owned or controlled, but colliery interests preponderate, colliery owners to take any steps in their power to enable facilities for such access to be granted, if requested.

(*f*) National Health and Unemployment Insurance: Owners' proportion of contributions.

(*g*) Remuneration of owner managers: Amount to represent the fair remuneration which would be payable in the district for the work done or services rendered, as measured by the facts and circumstances in comparable cases where officials have no interest in the ownership.

(*h*) Clerical and administrative salaries: being the emoluments of men ordinarily employed in and in connection with the management of the colliery or in and about its offices, but not including men who are fulfilling manual or mechanical or such other duties as relate to the getting, handling, hauling, and despatching of the coal, and the direct oversight needed for the due fulfilment of the duties of such men. The expression includes remuneration of surveyors, under-managers, and draughtsmen, also weigh clerks and weighers, despatch clerks, timekeepers and storekeepers if wholly or mainly employed in clerical work.

It does not include salaries of overmen, deputies, and enginewrights.

(*i*) Fire brigades, rescue and aid services, &c.: District expenditure to be allowed as a deduction from the district aggregation, but no contributions to be allowed as deductions in returns of individual collieries.

(*j*) Welfare levy of 1d. per ton under the Mining Industry Act, 1920.

II. *Inadmissible.*

(*a*) Interest on capital and loans (whether debentures, other fixed loans, or bank overdraft).

(*b*) Amortisation of capital expenditure (except so far as it is included in income tax allowances for depreciation).

(*c*) Charitable subscriptions and donations.

(*d*) Contributions to trade associations (except as provided under (1) (*h*) above).

(*e*) Pensions.

(*f*) Contributions to mutual societies for benefit of particular classes of employees.

(*g*) Income tax and corporation profits tax.

(*h*) Consequential loss insurance premiums (recoveries also to be excluded from proceeds).

5. Forms of return (T.S. 1 and T.S. 2) as drawn up by the accountants and issued to the collieries are to be completed in duplicate, one copy of each form being sent to the auditor representing the owners in the district and one copy to the auditor representing the workmen. Tonnage statistics are to be included in the returns. All information regarding individual collieries disclosed to the independent accountants is to be treated as confidential.

6. Test Audits.—Any question on which the independent accountants fail to agree to be submitted to the independent Chairman of the District Board, who shall refer any question of

general principle to the independent Chairman of the National Board.

In the event of a difference of opinion as to whether or not the issue involves a question of general principle, the National Board shall decide such difference.

The independent accountants may include in the district aggregation a provisional sum and bring into a subsequent aggregation the amount, if any, by which the sum ultimately determined differs from that provisionally included.

Any adjustment shall be given effect to by addition or deduction in the ascertainment subsequent to the amount of such adjustment being agreed.

Arrangements shall be made whereby the independent accountants may obtain expert advice on technical questions arising in the course of a test audit, the mode of selection of such experts to be decided by the National Board.

7. Small collieries employing ten men or less are to be excluded from the district aggregation and consequently no form of return is required to be completed in such cases, the District Chairman to decide in case any question arises as to the inclusion or exclusion of such mines in the district concerned.

APPENDIX II.

FORMS OF DAILY AND WEEKLY REPORTS.

GENERAL REGULATIONS, 10TH JULY 1913, ELECTRICITY (SEC. 131).

DAILY LOG-SHEET for 19

1. Name of electrician in charge
2. Report as to :—

(*a*) Condition of the Insulation of the system :—

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(*b*) Specific defects of Insulation (particulars of each failure of apparatus should be given) :—

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(*c*) Accidents or Dangerous Occurrences (including any cases of electric shock, and any cases of open sparking in apparatus in use in places where Regulation 132 applies) :—

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(*d*) Examinations of Apparatus as provided by Regulation 131 :—

(i) Routine examinations as required by paragraph *c* (i) :

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(ii) Special examinations as required by paragraph *c* (ii) :

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State which apparatus has been examined or tested, and result

3. Remarks :—

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Signed *Electrician.*

Examined by *Manager.*

NOTE.—This log-sheet should be filled in as completely as possible. If, for instance, there are no defects of insulation to report, the word "none" should be written in the vacant space.

REPORT OF THOROUGH EXAMINATION OF THE STATE OF THE AIRWAYS FOR WEEK ENDING . *Sec.* 66 (*d*).

Airways or Parts of Airways Examined.	Date of Examination.	Time of Examination.		State of Airways or of Parts of Airways as disclosed by *thorough* Examination.	Entries in foregoing Columns certified to be a Full and Accurate Report of Result of *thorough* Examination. (*Person certifying to sign here.*)	Counter-signatures of Manager and Under-Manager, and Date.
		Commenced.	Completed.			
(1)	(2)	(3)	(4)	(5)	(6)	(7)

RECORD OF READINGS OF HYGROMETER. *Sec.* 71.

Year. Day. Month.	Hour.	Whether M.I. (Main Intake) or M R. (Main Return).	Readings of Hygrometer.		Signature and Rank of Person taking the Reading and making the Entry.
			Dry Bulb.	Wet Bulb.	
(1)	(2)	(3)	(4)	(5)	(6)

REPORT OF THOROUGH EXAMINATION OF STATE OF SHAFTS IN WHICH PERSONS ARE LOWERED OR RAISED DURING WEEK ENDING . *Sec.* 66 (*c*).

Name or Number of Shaft.	Date.	Time of Examination.		State of Shaft disclosed by *thorough* Examination.	Entries in preceding Columns certified to be a Full and Accurate Report of Result of *thorough* Examination. (*Person certifying to sign here.*)	Counter-Signatures of Manager and Under-Manager, and Date.
		Commencement.	Completion.			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
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DAILY REPORT OF EXAMINATION OF EXTERNAL PARTS OF WINDING MACHINERY, GUIDES, &c. *Sec.* 66 (*a*).

I, being a person appointed for the purpose by the Manager, certify that I have this day examined thoroughly

Strike out anything not examined by the person reporting.

(i) The external parts of the machinery.
(ii) The guides.
(iii) The headgear, ropes, chains, cages, and other similar appliances, which are in actual use for the purpose of lowering and raising persons in the shafts,

and that the following is a full and accurate report of the result of the examination :—

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Examination { *commenced at*
completed at

Signed *Date*

Countersigned *Date*

Under-Manager.

Date

Manager.

REPORT OF THOROUGH EXAMINATION OF STATE OF MACHINERY, GEAR, AND OTHER APPLIANCES DURING WEEK ENDING . *Sec.* 66 (*b*).

Machinery, Gear, and other Appliances examined. (1)	Date of Examination. (2)	State of Machinery, &c., as disclosed by *thorough* Examination. (3)	Entries in preceding Columns certified to be a Full and Accurate Report of Result of *thorough* Examination. (*Person certifying to sign here.*) (4)	Counter-Signatures of Manager and Under-Manager, and Date. (5)
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HORSEKEEPER'S RECORD AND DAILY REPORT OF HORSES UNDER HIS CARE. *Third Schedule* (13).

Date *Name or Situation of Stables*

Name or Number of Horse. (1)	Time at which taken from Stables. (2)	Driver. (3)	Entries in Columns 2 and 3 certified correct. (*Person certifying to sign in this column.*) (4)	Time at which returned to Stables. (5)	Condition. (6)	Entries in Columns 5 and 6 certified correct. (*Person certifying to sign in this column.*) (7)
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Countersigned { *Under-Manager.* *Date*
Manager. *Date*

RECORD OF MEASUREMENTS OF AIR-CURRENTS. *Sec.* 29 (2), COAL MINES ACT, 1911.

Date

Name of Seam.	Main Air-Current.		Splits.		Other Points of Measurement.		General Remarks.
	Point of Measurement.	Volume in Cubic Feet per Minute.	Name or Description of Split and Point of Measurement.	Volume in Cubic Feet per Minute.	Point of Measurement.	Volume in Cubic Feet per Minute.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

I certify that the above measurements have been made by me and are correct.

Signed *Date*

Countersigned { *Under-Manager.* *Date*

Manager. *Date*

COAL MINES REGULATION ACT, 1908, AND SEVEN HOURS BILL, 1919: REGISTER OF TIMES OF DESCENT AND ASCENT.

Date

Extension of Time.—The time below ground on this day is extended by one hour in pursuance of section 3.

Signature of Owner, Agent, or Manager

SHIFTS.

1. Name or Description of Shift, and Number going into the Mine. N.B.—*Firemen, examiners, or deputies; pump-minders, fanmen, or furnacemen must not be entered with a shift of other workmen. If forming a shift of themselves, they will be entered in this column as a separate shift. Otherwise they will be entered on the opposite page.*		2. Time of Lowering or Admission.		3. Entry in preceding Column certified correct. *(Person certifying to sign in this Column.)*	4. Time of Raising or Return.		5. Entry in preceding Column certified correct. *(Person certifying to sign in this Column.)*	6. Where any shift or any member of a shift is below ground for more than the time fixed by this Act, full particulars of the cause must be stated in this Column, and if it is claimed that the case falls within any exception allowed by the Act (sec. 1 (2), sec. 1 (4), sec. 1 (7) (*b*)), this should be stated.	7. Entry in preceding Column certified correct. *(Person certifying to sign in this Column.)*
Name or Description.	Number going in.	Commencement.	Completion.		Commencement.	Completion.			

APPENDIX III.

DESCRIPTION OF THE HARRIES' AND THE "P.P." PATENT SHOT-FIRING APPLIANCES.

(1) The Harries' Patent Shot-Firing Appliance.

For the following description of this appliance we are indebted to Professor George Knox, whose paper on the subject, read before the South Wales Institute of Engineers, we have abstracted as follows:—

The dangers arising from shots which have missed fire through either faulty leads or faulty detonators are sufficiently well known to everybody connected with mining operations.

Several attempts have been made—mostly based on the principle of the withdrawal of the leads and detonator in the case of missfire—to overcome these dangers.

Such appliances cannot, however, be used in mines unless an Exemption Order can be obtained from the Home Secretary, who must be satisfied that such appliance will enable the detonator to be removed with safety after the shot hole has been charged.

This exemption applies to Clause 2 (*c*), which states that:—

> "No explosive shall be forcibly pressed into a hole, and when a hole has been charged, the explosive shall not be unrammed *nor shall any part of the stemming be removed nor shall the detonator leads be pulled out.*"

Also to Clause 3 (*e*), which provides that:—

> "Except where the missfire is due to a faulty cable or a faulty connection and the shot is fired as soon as practicable after the defect is remedied, *another shot shall be fired in a fresh hole which shall be drilled not less than twelve inches away from the hole in which the shot has missed fire and shall as far as practicable be parallel to it.*"

An exemption had been granted in respect of shots which are fired with the appliance known as the P.P. apparatus. Another appliance, however, has been invented for the purpose of safely withdrawing the detonator in the case of missfire, by Mr R. D. Harries; it is a simple method of withdrawing the detonator and inserting a fresh one, thus getting rid of the dangers attendant upon searching for a live detonator in a heap of fallen material.

The appliance consists of a tube about $\frac{7}{16}$ inch external diameter and about 3 to 4 feet long (as required), having a scoop at the inner end and a handle at the outer end as shown in Fig. 3. A rod about $\frac{3}{16}$ inch diameter runs down the centre of this tube and is tipped with rubber at the inner end (Fig. 3, C). This rod also acts as the ejector for the detonator, which is contained in the scoop of the tube previously referred to.

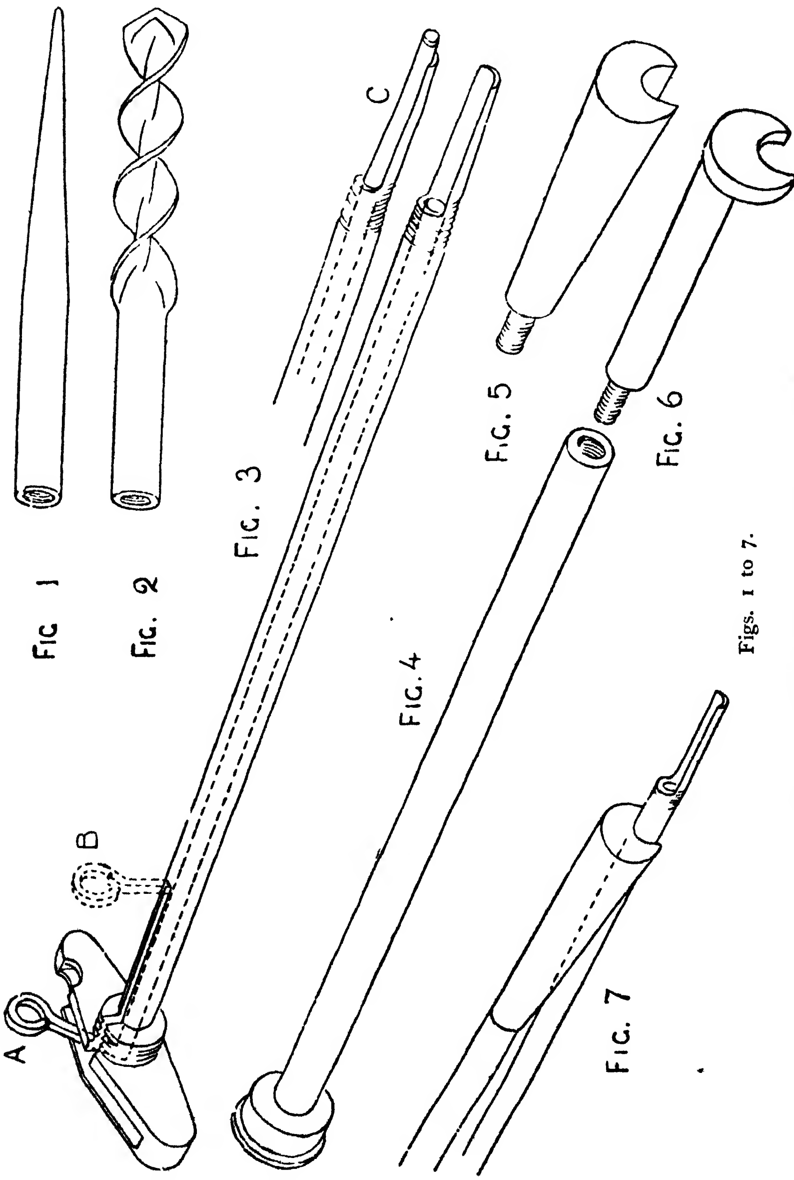
The handle of the ejector rod is bent at right angles and slides along a slot in the tube as the detonator is being ejected. When the ejector is drawn back into the tube its handle is turned round into the handle of the tube, which locks it and keeps it in the retracted position.

The two extreme positions of the ejector rod are shown in Fig. 3. In the retracted position at A (with the bent portion partly turned into the handle of the tube) and in the forward position when the detonator has been ejected at B (when the ejector has reached the extremity of the slot in tube), and at C, where the forward end is shown projecting beyond the scoop.

A portion of the scoop end of container tube is screwed so as to receive the pointed tool (Fig. 1) or the small drill (Fig. 2). The tube then serves as a handle to these tools.

The pointed tool is used for piercing the end of the last cartridge (see Fig. 8), thus making a hole for the reception of the detonator. When the charge has been placed in position at the back of the shot-hole, the container tube (Fig. 3) in which the detonator has previously been inserted is put into the pierced cartridge and pushed back against the charge as in Fig. 9. The outer tube, Fig. 4, which serves as a cover for the container tube when not in use, having the part shown in Fig 5 and Fig. 2 screwed into it, is then used as a tamping bar as shown in Fig. 9. The hole is then tamped around the container tube in the usual way until within 6 to 8 inches of the outer end of the shot-hole. The detonator by means of the ejector rod is then pushed into the charge (see Figs. 11 and 12) and the container tube withdrawn. The last

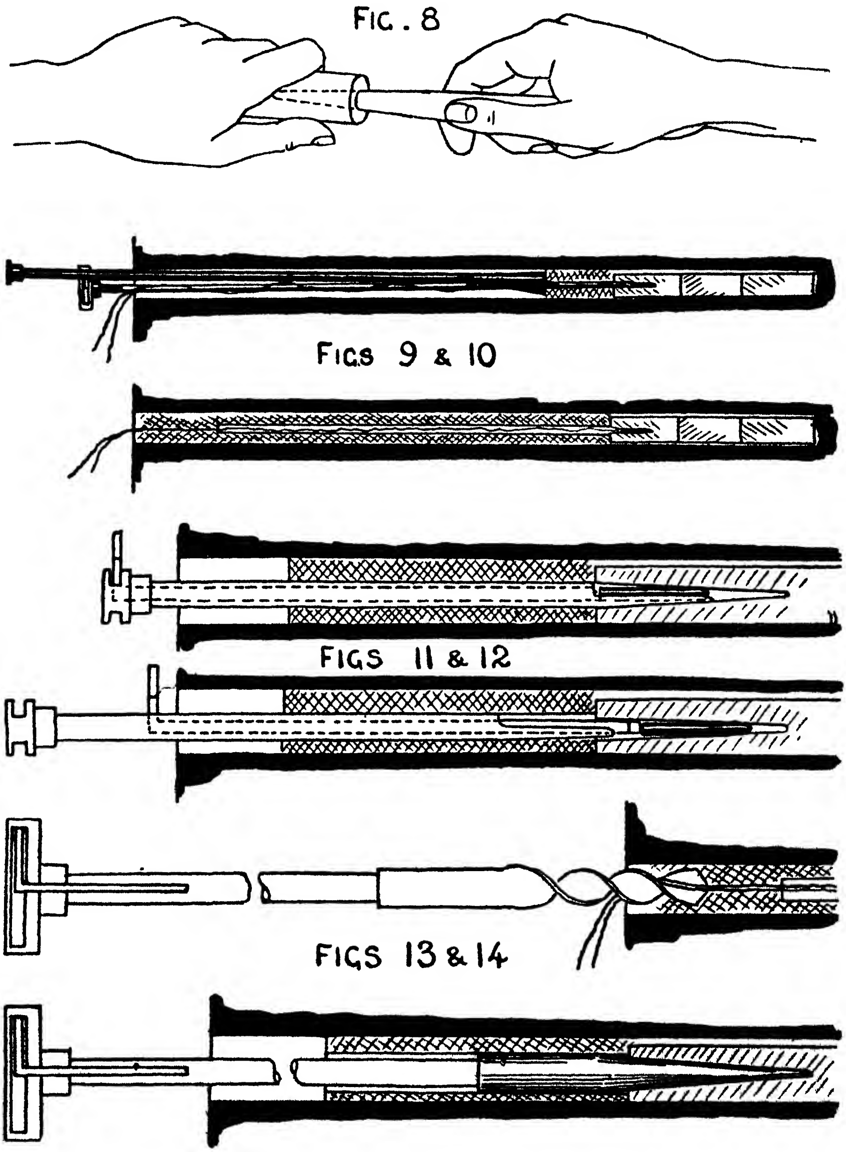
8 or 12 inches of the hole is then tamped round the leads and the shot is ready to be fired.



Figs. 1 to 7.

Fig. 130.—Harries' Safety Shot-Firing Appliance.

Should the detonator missfire the small drill is screwed on to the outer tube, and the outer 8 or 12 inches of tamping is drilled out until the hole left by the container tube is reached (Fig. 13). The detonator and leads can now be withdrawn and the hole in



Figs. 8 to 14.

FIG. 131.—HARRIES' SAFETY SHOT-FIRING APPLIANCE.

the cartridge reformed by inserting the pointed tool screwed on to the end of the container tube (Fig. 14). This tool is withdrawn and the pointed tool detached. A new detonator is then inserted in the container tube, pushed home and ejected as previously described (see Figs. 11 and 12).

The container tube is then withdrawn and the outer end of the hole tamped up as before. The connection is again made to the battery and the shot fired.

The whole of these tools are made of copper or aluminium or other non-sparking metals, and both the outer tube and container tube are engraved for the whole of their lengths in inches and are used as depth gauges, so that the shot-firer knows exactly whether the detonator in the second case has been placed in the proper position.

A scraper may also be fitted into the outer tube if required, as shown in Fig. 6.

(2) THE "P.P." SAFETY SHOT-FIRING APPLIANCE.

The "P.P." Safety Shot-Firing Appliance provides a simple means of increasing safety and at the same time effecting economy in blasting operations. It comprises :—

(1) Patent shields into which electrically-fired detonators are fitted at the factories, therefore ready for immediate use ; and

(2) Charging tool which enables shot-holes to be charged expeditiously and with a maximum of safety, in such a manner that missfires are almost entirely prevented (or should they occur, owing to a faulty detonator, can be remedied in a few moments) ; and which further ensures an increased efficiency in the use of high explosives in that larger sized coal or rock is brought down and thus the usual proportion of small coal or dust is considerably diminished.

The detonator shield (Fig. 132) is slightly larger in diameter than the detonator case, and before the latter is enclosed within the shield at the factory a knot is made in the wires near the point of connection with the detonator so that when the detonator is enclosed within the shield any strain put upon the wires is received by the shield, and is not transferred to the internal contents of the detonator. By this means it becomes possible to withdraw a missfired detonator from a shot-hole, provided the hole is rammed in such a manner that the shielded detonator can be

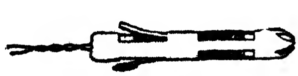
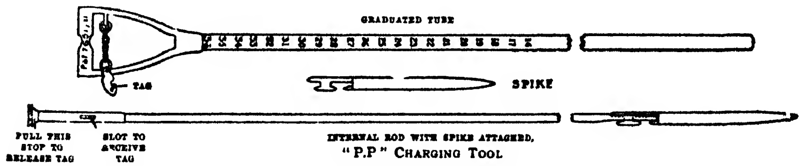


FIG. 132.—"P.P." SHIELDED DETONATOR.

drawn through an annular space in the ramming. This annular space is obtained by using the "P.P." charging tool (Fig. 133), consisting of a hollow tube graduated in a scale of inches on the outside, and provided with a handle, through which passes a rod (Fig. 134), to the forward end of which a detachable spike is fitted. In use the rod, with spike attached, is in the first instance locked within the tube by means of a tag at the handle end.



FIGS. 133 AND 134.—DETAILS OF "P.P." APPLIANCE. CHARGING TUBE AND ROD.

Prior to 1st September 1913, the withdrawal of a detonator from a shot-hole by pulling out the detonator leads was (by the provisions of the then existing Explosives in Coal Mines Order) prohibited in mines subject to the Coal Mines Act of 1911. On that date a new Order was issued by the Home Office in which, as the result of prolonged trials under working conditions and severe tests at the Home Office Testing Station at Rotherham, a clause was inserted granting exemption, in cases where the "P.P." appliance is used, from the rules prohibiting the withdrawal of a detonator and governing the treatment of missfired shots.

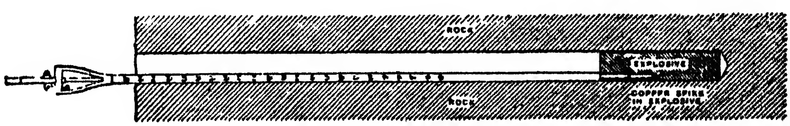


FIG. 135.—CHARGING TOOL WITH EXPLOSIVE IN SHOT-HOLE READY FOR RAMMING.

In charging shot-holes with high explosives, it has hitherto been the practice to prepare the priming cartridge by tying or otherwise fixing the detonator therein before insertion into the slot-hole. The dangers inherent in this method arise from the handling of a powerful explosive cartridge containing a sensitive detonator, which in vertical or steeply-inclined holes may tend to fall backward by gravitation unless some force is used to press it firmly into the hole; and further, from the possibility of exploding the charge while the hole is being rammed. There is, moreover, always the risk that the insulating material on the wires, or the wires themselves, may be damaged during the ramming, and it is estimated that 99 per cent. of missfires with electric detonators arise from this cause.

All these risks are obviated by the " P.P." method. The priming cartridge is pressed on to the spike of the charging tool (which spike projects from the graduated tube) and is then inserted into the shot-hole on the end of the charging tool, the latter lying

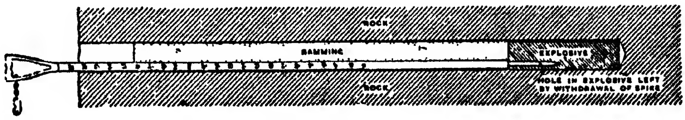


FIG. 136.—SHOT HOLE RAMMED TO WITHIN 4 INCHES OF MOUTH, INTERNAL ROD AND SPIKE WITHDRAWN, LEAVING CLEAR PASSAGE THROUGH HOLLOW TUBE INTO EXPLOSIVE

along (and in contact with) the wall of the bore-hole (Fig. 135). The hole is now rammed to within about 4 inches of its mouth, with the charging tool still in the hole, using a grooved ramming rod which passes over the charging tool (Fig. 136).

After withdrawing the inner rod which brings with it the spike, the rod, from which the spike has been detached, is used to insert the shielded detonator through the tube into the primer. Before

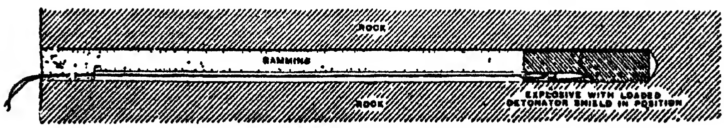


FIG. 137.—SHOT-HOLE AFTER INSERTION OF LOADED DETONATOR SHIELD, WITHDRAWAL OF CHARGING TOOL, AND COMPLETION OF RAMMING. SHOT NOW READY FOR FIRING

insertion the two side wings of the shield are bent outwards, and, when the shielded detonator enters the cartridge, these wings prevent its withdrawal unless a pull is exerted of sufficient force to cause the wings to give way. After first withdrawing the inner rod, and then the tube, from the hole, the mouth of the hole is rammed completely. In this manner the detonator has been inserted into the primer through a smooth tube after the shot-hole has been rammed. No damage (by abrasion, &c.) to the wires is therefore possible, and consequently missfires are prevented. The wires will, after the withdrawal of the charging tool, lie in an annular air space which extends from the priming cartridge to a point 4 inches from the mouth of the hole, from which point the hole has been rammed completely (Fig. 137). This annular air space contributes to increase the work done by the explosive by converting a localised shattering action into a more extended rending action along the line of the hole. No pocket is left at the end of the hole in the case of shots fired by the " P.P. " method; and with horizontal shots for bringing down roof the effect of the blast extends from the explosive right along the line of the hole.

The " P.P." method of charging, whilst being simple and rapid, obviates, in the event of a missfire, the loss of time involved in drilling a fresh hole and in searching for the missfired detonator and charge in the debris By applying from a place of safety a pull (of about 8 lbs.) upon the cable, sufficient to cause the side wings of the shield to give way, the missfired shielded detonator can be drawn through the annular air space and out of the hole, and by reinserting the complete appliance into its former position in the shot-hole a further shielded detonator may be inserted into the original primer in the same manner as before, the whole operation taking only a few moments.

The " P.P." method makes it practicable to withdraw the detonator after a hole has been charged, in the event of circumstances, such as the presence of gas, rendering it advisable to postpone firing the shot. In such cases all danger of the detonator being exploded by any movement of the roof in the meantime is avoided. A shielded detonator can again be inserted and the shot fired when conditions are favourable.

GLOSSARY OF MINING TERMS

USED IN THIS BOOK.

Backbye Work.—Work done between the shaft and the working face, in contradistinction to face work, or work done at the face.

Bait Time.—Meal time underground. A term in use in Northumberland and Durham; in other districts "Snap" or "Whiff."

Balks.—(1.) Irregular shaped masses of stone intruding into a coal seam, or bulgings out of the stone roof into the seam. (2.) Big pieces of timber for supporting the roof.

Bank.—The surface-land immediately surrounding a pit's mouth.

Bannocking.—See *Kirving.*

Bat, Batt, *or* **Bass.**—A compact black bituminous shale which splits into fine laminæ. Is often interstratified in layers with coal.

Bearing.—See *Kirving.*

Bind.—A local term for shale.

Black Stone.—A carbonaceous shale.

Blue Metal.—A local term for shale possessing a bluish colour.

Blue Stone.—An argillaceous rock of a more amorphous and less shaley nature than blue metal.

Bolt Holes.—The narrow roads connecting a "side of work" with the other workings of the mine in thick coal workings. A term peculiar to the "Wide" or "Square" system of working.

Bondminder, *or* **Rolleywayman,** *or* **Roadman.**—A man in charge of the rolleyway.

Bord (Narrow).—A road less than 4 yards in width driven in a seam in a direction at right angles to the main cleavage planes of the coal seam, usually about east and west in the Newcastle coalfield.

Bord Room.—The space excavated in driving a bord. The term is used in connection with the "ridding" of the fallen stone in old bords when driving roads across them in pillar working; thus, "ridding across the old bord room."

Bord (Wide).—A road in same direction as in Narrow Bord, but four or more yards wide.

Bordways Course.—The direction at right angles to the main cleavage planes. In some mining districts it is termed "On face."

Brattice.—A partition for purposes of ventilation.

Broken.—A district of coal pillars in process of removal—so called in contradistinction to the first working of a seam by bord and wall, or working in the "whole." See *Whole Working.*

Brushing, Brushers.—Stonework; shooting top or bottom stone to make height. "Brushers" are stonemen. See *Ridding* and *Ridders.*

Buttocker.—One who breaks down the coal which has been undercut by the "holers." A "getter."

Butty.—An underground contractor. See *Small Butty* and *Charter Master.*

Canch, *or* **Caunche.**—A thickness of stone requiring to be removed to make height, or to improve the gradient of a road. If above a seam, it is termed a "*Top Canch*"; if below, a "*Bottom Canch.*"

Carting.—Conveying coal in small tubs along low roads to the big trams on a main road.

Cauldron Bottoms.—The fossil remains—or, more correctly speaking, the "casts"—of the trunks of sigillariæ, which have remained vertical above or below the seam.

Cavils.—Lots drawn by the hewers each quarter-year to determine their working places.

Charter Master.—A contractor who engages to work a seam, or sometimes a small colliery, at a tonnage price for the owner or owners, the charter master finding and paying the underground labour. (Staffordshire.)

Chocks.—Pieces of hard wood about 6 inches square by 1 foot 6 inches long, built crosswise two and two to form supports for the roof.

Cleat, *or* **Cleavage.**—The smooth facings or partings which run through a seam of coal in two directions, at right angles to each other, one set (the bordways cleat) being usually much more pronounced than the other. Some seams are without it.

Clift.—Local term for shale.

Clod.—A soft stone immediately above a seam.

Clunch.—Tough clay or marl, fireclay.

Coaly Rashings.—Soft dark shale, in small pieces, containing much carbonaceous matter.

Cogs.—A pillar of chocks (see *Chocks*) with the centre space stowed with stone or rubbish.

Cope, *or* **Coup.**—An exchange of working places between hewers.

Cropping Coal.—The leaving of a small thickness of coal at the bottom of the seam in a working place, usually in order to keep back water. The coal so left is termed "*Cropped Coal.*"

✓ **Cross-cut.**—A road driven in a direction diagonal to the cleavage planes of the coal seam.

Cross-heading, *or* **Cross-gateway.**—A road kept through goaf, and cutting off the gateways at right angles or diagonally.

Crowntree.—A piece of timber set on props to support the roof.

Dead Work.—Excavations other than coal work.

Deputy, *or* **Deputy Overman.**—An under official acting under the overman, and whose duty it is to make the daily examinations of the workings in the district in which he is stationed, to set timber, lay "way," and in some cases fire the shots for the men.

Dillies, *or* **Ginneys.**—Short self-acting inclines, where one or two tubs at a time are run.

Dirt.—A soft or shaley stone band in a coal seam.

Double Timber.—A balk and two props of big timber properly dressed and notched.

✓**Drift.**—Any road cut through strata.

Drive, To.—To cut a road through strata.

Dyke.—A "wall" of igneous rock passing through strata, with or without accompanying dislocation of the strata.

Face, *or* **Coal Face.**—The place where the hewers are working.

Fast.—A road driven in a seam with the solid coal at each side is termed "fast." "Fast at an end," or "fast at one side," implies that one side is solid coal, and the other open to the goaf or some previous excavation.

Feeder.—A runner of water.

Fiery.—Applied to a mine containing explosive gas in dangerous proportions.

Fireman.—A Midland and South Wales equivalent to a "*deputy*" (which see) with this exception, that a fireman does not set timber or lay way.

First Working.—See *Whole Working.*

Flat.—The siding or station laid with two or more lines of railway, to which the putters bring the full tubs from the working face, and where they get the empty tubs to take back. The area of working places, from which coal is brought to the same station, is also called a "flat." In South Wales a plank supported by two or more props. "*Putter's Flat,*" in Northumberland and Durham, a siding to which the putters bring the loaded tubs from the face.

Following Stone.—Roof stone which falls on the removal of the seam.

Gateway.—A road kept through goaf in longwall working.

Gears, *or* **Pair of Gears.**—Two props and a plank, the plank being supported by the props at either end.

Ginneys.—See *Dillies.*

Girdle.—A thin bed or band of stone. A roof is described as a post roof with metal girdles, or a metal roof with post girdles, according as the post or the metal predominates.

✓ **Goaf,** *or* **Gob.**—The part of a mine from which the coal seam has been taken, and the roof allowed to fall, or the space stowed with stone and rubbish.

Going Headways, *or* **Going Bord.**—A headways or bord laid with rails, and used for conveying coal tubs to and from the face.

Grey Metal.—Shale of a greyish colour.

Hade.—The slope or inclination of a fault—that is, its deviation from the vertical.

Heading.—See *Winning Headways.*

Headways.—A road, usually 9 feet wide, in a direction parallel to the main cleavage planes of the coal seam, which direction is called "*Headways Course,*" and is generally about north and south in the Newcastle coalfield. It is termed "*On end*" in other districts.

Heaving.—The rising of the thill (or floor) of a seam, where the coal has been removed.

Hitch.—Local term for a fault of no great throw.

Hole.—The act of making an opening from one road into an adjacent one.

Holing.—An opening or road connecting one part of the mine with another part. A connection made between two or more roads underground. See *Kirving.*

Inbye.—Towards the working face.

Instroke.—The right to take coal from a royalty to the surface by a shaft in an adjoining royalty. A rent is usually charged for this privilege.

Intake.—The road by which the fresh air is conducted to the working face.

Jenkin.—A road cut in a pillar of coal in a bordways direction—that is, at right angles to the main cleavage planes.

Jig, *or* **Jig Brow.**—A self-acting incline, usually made on the full rise of the seam. In longwall workings to the rise, the gateways are, in highly inclined seams, the "jigs."

Jud.—(1.) A portion of the working face loosened by "kirving" underneath, and "nicking" up one side. The operation of kirving and nicking is spoken of as "*Making a Jud.*" (2.) The term jud is also applied to a working place, usually 6 to 8 yards wide, driven in a pillar of coal. When a jud has been driven the distance required, the timber and rails are removed, and this is termed "*Drawing a Jud.*"

Keeker.—An official who superintends the screening and cleaning of the coal.

Kenner.—See *Loose.*

Kirving, *or* **Holing,** *or* **Bearing.**—A horizontal cutting made into a seam, preparatory to breaking down the whole height of coal. Usually this is made in the bottom of the seam, but sometimes in a band of stone or "dirt," if the seam contains such; sometimes in a fireclay underlying a seam; and sometimes in a soft stone above the seam. (The last method is called in Staffordshire "*Bannocking.*")

Kist.—The wooden box or chest in which the deputy keeps his tools. The chest is always placed at the flat or lamp station, and this spot is often referred to by the expression, "at the kist."

Leader.—The earthy deposit in the line of a fault, which is followed in searching for the coal seam.

Lift.—Any working place about 6 or 8 yards wide driven in a pillar.

Loose.—Applied to a working place to denote that it is open at both sides—that is, that the coal has been previously removed at both sides. "Loose at an end," or "loose at one side," denotes that the coal has been already worked at one side. The end of a shift or of the day's work is spoken of as "*Loosing time,*" or "*Loose,*" or "*Kenner*"; and when the workmen leave, the pit is said to be "*Loosed out.*"

Marrow.—A partner.

Metal.—See *Blue Metal* and *Grey Metal.*

Mothergate.—The main road of a district in longwall working.

Narrow Work.—All work for which a price per yard of length driven is paid, and which therefore must be measured.

Nicking.—A vertical cutting or shearing up one side of a face of coal.

Nip-out.—The disappearance of a coal seam by the thickening of the adjoining strata, which take its place.

Nippers.—Boys who attach the "clips" to the tubs and rope in endless rope haulage.

Nogs.—Timber in places above the coal. See *Chocks.*

Nook.—The corner of a working place made by the face with one side.

Outbye.—Towards the shaft.

Outstroke Rent.—The rent which the owner of a royalty receives on coal brought into his royalty from adjacent properties.

Packwalls.—Pillars of stone, built to support the superincumbent strata.

Panel.—Used in two senses. (1.) A division or district in bord and pillar working. (2.) A thick bed of stone—for example, "A thick panel of strong white post."

Parting.—A layer of dirt or foreign material in a coal seam.

Picture.—A screen to keep off falling water from men at work.

Pike Man.—A Staffordshire term for a coal hewer.

Place.—The portion of coal face allotted to a hewer is spoken of as his "working place," or simply "place."

Plank.—See *Crown Tree.*

Plates.—Metal rails 4 feet long.

Post.—Local term for sandstone. Post stone may be "strong," "framey," "short," or "broken."

Ramble.—Stone of little coherency above a seam, which falls readily on the removal of the coal. See *Following Stone.*

Repairers.—Men who do stone work and repair the roads.

Ridding.—Clearing away fallen stone and *débris.*

Riding.—Ascending or descending the shaft in the cage.

Rippers.—Stonemen.

Ripping.—Removing stone from its natural position above the seam.

Rock.—Sandstone. See *Post.*

Rock Binds.—Sandy shale or shaley sandstone.

Rolleyway.—A main haulage road.

Royalty.—An area of coal owned as a distinct property, the rent paid to the proprietor thereof for working the coal being called "*Royalty Rent.*" The royalty rent is also in common parlance often termed "royalty" simply.

Sagre, *or* **Seggar.**—A local term for fireclay, often forming the floor (or thill) of coal seams.

Scale of Air.—A small quantity of air escaping (or sometimes allowed to pass) at a door or stopping, or brattice.

Scallop, To.—To hew coal without kirving or nicking, or shot-firing.

'Shaft.—A space made by the side of the rolleyway for a tram to stand at the bottom of a stall road where the coal is filled into it by "carting." (South Wales.)

Shaft Pillars.—The coal left for the support of the shafts.

Sheth.—An old term denoting a district of about eight or nine adjacent bords. Thus, a "*Sheth of Bords,*" or a "*Sheth of Pillars.*"

Shift.—The duration of a day's work.

Side Laning.—Taking off side coal to widen out a place in a "side of work." (Staffordshire.)

Side of Work.—An expression used to denote the face in the "wide" or "square" system of working. (Staffordshire.)

Siding-Over.—A short road driven in a pillar in a headways direction.

Skips.—Skirtings for widening out a coal road. (South Wales.)

Skirting.—A road driven next a fall of stone, or next an old fallen place.

Slab.—See *Crowntree.*

Small Butty.—A contractor who engages to work a certain part of a seam—usually reckoned as a certain width of face—at a tonnage price, the contractor finding and paying the labour necessary to get and deliver the coal at the bottom of the gate road. (Staffordshire.)

Snapping.—See *Bait Time.* (Staffordshire.)

Splint.—Coarse coal.

Split.—A division of the air current.

Sprag.—A short prop of timber used for supporting the upper part of a seam during or after kirving; also as a brake to coal tubs, being inserted between the wheel spokes.

Staple.—An underground shaft.

Stenton.—A narrow place or holing made between a pair of winning roads for the purpose of ventilation.

Stint Work.—Bargain work.

Stone.—Ironstone. (Staffordshire.)

Stook.—A block of coal a few yards square left to support the roof in certain stages of pillar working.

Stopping.—A wall built to prevent the passage of air.

Stowing.—Filling a place with stone or *débris.*

Stythe.—Poisonous gas, generally carbonic acid (CO_2).

Swally, *or* **Swelly.**—A trough, or synclinal, in a coal seam.

Taking, *or* **Take.**—See *Royalty.*

Thill.—The floor of a seam.

Thirling.—See *Stenton.*

Token.—A piece of leather or metal stamped with the hewer's or putter's number or distinctive mark, and fastened to the tub he is filling or putting.

Topholes.—Places going to the full rise.

Trammers, *or* **Putters,** *or* **Hauliers.**—Big lads who convey the coal tubs to and from the working places.

Tree.—A local term for a prop.

Trouble.—Local term for a "fault," or geological disturbance interrupting the continuity of a seam.

Tumble Up.—Room by the side of the way for the empty tram to be turned over so that the full tram can pass it. (South Wales.)

Under Looker.—A Midland equivalent to the North Country fore-overman.

Under the Top.—A road in which a layer of coal is left standing to form the roof is said to be "under the top."

Viewer.—The old term for a Colliery Manager.

Wailing.—Picking stones and dirt from amongst coals.

Wall.—A road, usually 6 to 8 feet wide, between two adjacent bords, at right angles to them. The solid coal between two bords is also called a "wall." A "*Half-pillar wall,*" or "*Split wall,*" is a road driven across the middle of a pillar on headways course.

Warrant.—Kind of fireclay.

Wash-out.—The erosion of an appreciable extent of a coal seam by aqueous agency.

Waste.—(1.) The portion of a mine occupied by the return airways. (2.) Also used to denote the spaces between the packwalls in the gob of longwall working

Whole Working.—The first working of a seam, which divides it into pillars.

Winning Headways.—A headway driven in advance to win out room for the bords. Any leading drift is termed a "*Winning.*"

Yard Price.—Various prices per yard driven (in addition to the tonnage prices) paid for roads of certain widths, and driven in certain directions

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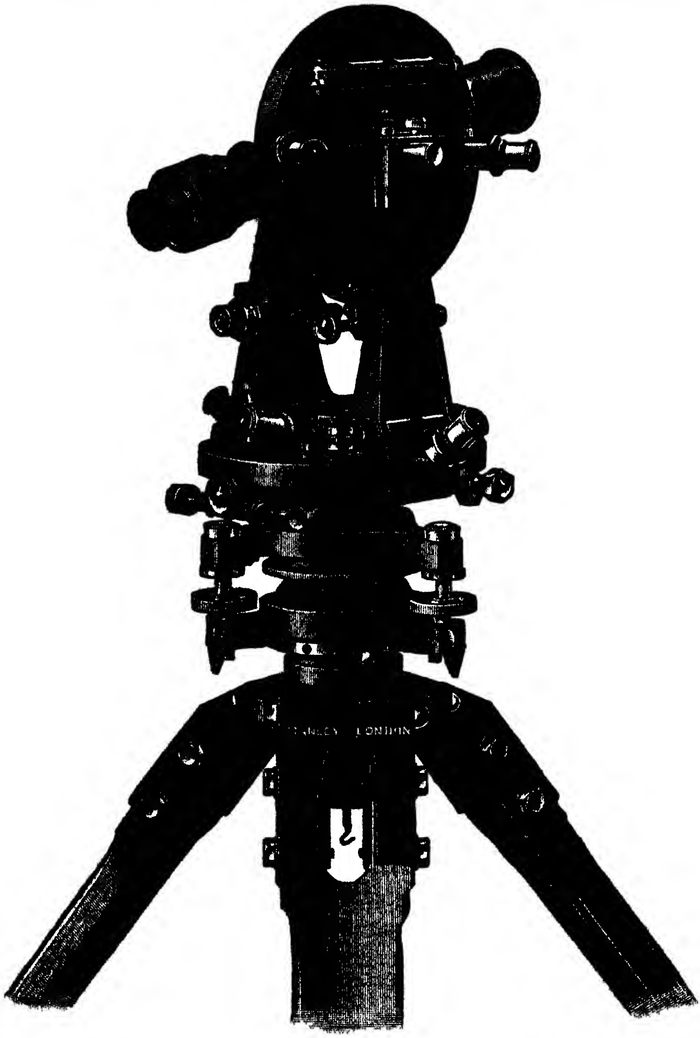

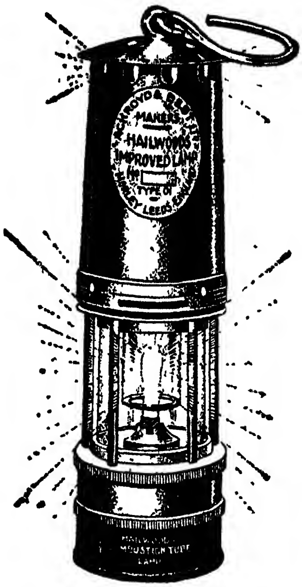

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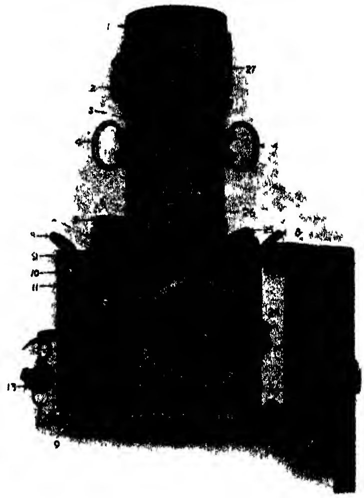

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