The Science and Art of Mining.

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NEWS AND NOTES.

Overwinding Prevented by Safety Appliance

Following upon the "gob-fire," which caused such an extraordinary sensation recently, there was another mishap at the Hickleton Main Colliery. During the process of drawing coal, the engineman at one of the shafts would have over-wound the cages but for the patent safety appliance (which is the Hickleton Main Company's own design, and which has been in use at this colliery for about two years). This appliance caught the rising cage firmly, and at the expense of a good deal of damage to the top compartment stopped the over winding. The damage temporarily interfered with the drawing of coal, but prevented a much more serious accident. At the same time, had the appliance failed to act there was still a mechanical arrangement in reserve which would have probably prevented the overwinding.

German Coal Trade.

The import of British coal into Germany shows a decrease from 9,650,000 to 9,420,000 tons. The difficulties of German inland navigation in 1911 were, no doubt, to some extent responsible, says a Consular report, yet it is to be expected that the developments of recent events upon the German coal market and the construction of more efficient waterways, especially by way of the Baltic, will help to make the decrease of 1911 only a temporary one. The total export of German coal rose by 3,150,000 tons, the export to the United Kingdom, which is never considerable, receded by 1,700 tons. The progress made by German coal in Egypt is worth noting; this export amounted to 160,000 tons, thus rising in 1911 by over 66,000 tons. The increase of coal furnished to foreign ships in German ports is also remarkable; it rose from 186,000 tons in 1910 to 236,000 tons in 1911.

Board of Trade Labour Statistics.

The Board of Trade *Labour Gazette*, in an article on the state of the Labour market in March, says: Employment in all industries was affected by the coal strike. In the pig-iron and steel, tinplate, pottery, glass, and brick trades the effects of the dispute were felt at an early date, and became increasingly marked with each successive week. Employment in connection with railways, shipping, and docks was also seriously reduced. The influence of the strike was less marked in the cotton, hosiery and lace trades, while the linen and shirt and collar trades even showed improvement as compared with a month ago. The jute industry had a dispute of its own at Dundee. Compared with a year ago most of the principal industries showed a decline, due to the coal strike, but in the cotton, lace, and boot and shoe trades there was improvement. In 392 Trade Unions, with net membership of 675,535, making returns, 76,144, or 11·3 per cent., were returned as unemployed at the end of March, 1912, compared with 2·8 per cent. at the end of February, 1912, and 3 per cent. at the end of March, 1911. The great dispute in the coal mining industry, involving about a million workpeople, began on March 1st and continued throughout the whole of the month and early part of April. The total number of workpeople involved in all disputes in progress during the month was 1,040,542, as compared with 164,650 in February, 1912, and 46,577 in March, 1911. The estimated aggregate duration in working days of all disputes in progress during March was 24,579,500, as compared with 463,500 in the previous month, and 723,800 in the corresponding month of last year.

Big Output of Coal.

The approximate output from the collieries of the Dominion Coal Company for March will be 353,000 tons, an increase of about 21,927 tons over the February output. The output in February was 330,073 tons, and in January was 280,854. The total output for the company for the year up to the present is about 975,000 tons, which is a great increase over the amount up to this time last year.

Engineering Imports and Exports.

The Board of Trade returns show that during the first three months of this year the imports of iron and steel and manufactures thereof amounted to £2,909,896, or £113,114 more than in the corresponding period of last year, while the exports reached the value of £12,339,318, an increase of £1,290,926. The imports and exports of other metals and manufactures thereof were £7,673,152 and £2,852,605, which, compared with last year, show increases of £1,058,711 and £159,757 respectively. The imports of electrical goods increased by £53,711, and the exports by £493,416, the totals being £411,261 and £1,190,738. The imports of machinery amounted to £1,632,483, an increase of £169,944, and the exports to £7,812,470, an increase of £332,585. Ships (new) were imported to the value of £10,867, a decrease of £32,654, and were exported to the value of £1,175,729, an increase of £56,125. During the month of March alone substantial increases are shown to have occurred in the imports of all the above classifications, as compared with March of last year, with the exception of iron and steel and manufactures thereof, in which case a loss of £218,906 is recorded. In the exports increases took place in connection with iron and steel (£579,899), electrical goods (£394,060), and machinery (£33,733); decreases are shown in connection with other metals and manufactures thereof (£9,329), and ships (£34,742).

A Compensation Bill.

The following is the text of the Compensation for Mineral Damage (Scotland) Bill introduced in the House of Commons by Mr. Duncan Millar, and backed by Sir H. Dalziel, Sir W. Menzies, Mr. Hodge, Mr. Murray MacDonald, Mr. Pringle, and Mr. Whitehouse: A bill to amend the law relating to feus and leases for building in Scotland and to secure compensation for injury caused by mineral workings. (1) Subject to the provisions of this Act, where land shall be or has been feued or let upon the condition that buildings are or were to be erected thereon, any contract or agreement purporting—(*a*) To entitle the superior or lessor to do any act whereby the buildings may be injured which but for such contract or agreement he would not have been legally entitled to do without making full compensation for the injury thereby caused; or (*b*) to release the superior or lessor from any obligation to pay damages for doing injury to such buildings which but for such contract or agreement he would have been liable to pay; or (*c*) to bind the feuar or lessee to accept any compensation or damages less than full compensation for the injury actually caused, shall be void. (2) Where prior to the passing of this Act land has been feued or leased for building subject to any such contract or agreement as aforesaid, it shall be lawful for the superior or lessor at any time within six months after the passing of this Act to resume possession of the land with the buildings thereon on payment of their value. (3) The parties, if they do not agree upon the value, may jointly appoint an arbiter, whose decision shall be final; or each party may appoint an oversman, whose decision shall be final. (4) The value shall be estimated as if no such contract or agreement had been made. (5) This Act may be cited as the Compensation for Mineral Damage (Scotland) Act, 1912.

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Q.—*Describe the "Winhey" arrangement for breaking the circuit when a leakage occurs in the D.C. system.—(Submitted by* W.P.)

A.—The principle upon which the Winhey leakage detector acts, according to Mr. Robert Nelson, H.M. Electrical Inspector of Mines, is that "the earthing of the neutral point of the generator is made through a resistance so high that, in case of accidental contact with live metal by any person, the resulting current to earth passing through the person making contact is so small in quantity as not to be dangerous to life."*

The apparatus is the invention of Mr. Walter Winsborough, and Messrs. Heyes and Co., of Wigan, are the makers of the instrument. It consists of a trip relay, operated by a detector through a local battery. A 230-volt circuit operates the trip. The trip breaks the knuckle joints of a pair of Reyrolle triple-pole circuit breakers controlling the main cables. In the case of a person coming into contact with any live part, such as switchgear, terminals, faulty cables, machine frames, &c., protection is afforded the person by the detector operating by a current which flows through the body before it has had time to contract the muscles of the person; the current operating being just sufficient to give an appreciable shock as a warning.

Its scope of usefulness, so far as we have gathered, seems to be somewhat limited. It cannot be used on any high-pressure system, say of so high a tension as 2,000 or 3,000 volts. Its usefulness seems to be limited to the medium-pressure system of 500 to 600 volts. With the higher tension the normal leakage current is such as would in many cases produce fatal results in itself. One of the chief objections to the use of the Winhey leakage detector is that should a fault occur bringing the device into action, the whole installation is at once disconnected, which in the case of a large system will be a serious matter. The tripping circuit might be arranged to produce only the shutting down, or disconnection, of the underground portion of any mining system, leaving the surface portion alone, but even that is at the least inconvenient, and may possibly be dangerous. There is no doubt at all that if a leakage should occur through short-circuiting in any portion of a system in the mine, that portion should be shut down until the fault is removed, and it would be a decided advantage to bring that portion of the system to rest suddenly before serious results occurred, but for that purpose any leakage detector should be capable of being installed on each separate feeder to ensure disconnection of the faulty feeder only.

Q.—*The return air of a mine shows by analysis $1\frac{3}{4}$ per cent. of fire-damp. The volume is 100,000 cubic feet per minute, and the water-gauge in the fan drift is $2\frac{1}{2}$ inches. Find* (a) *the volume of air required to reduce the quantity of fire-damp to 1 per cent.;* (b) *the additional horse-power required from the fan to circulate the increased volume.—(Manchester District Examination, First Class).*

A.—It is, of course, assumed that the volume of 100,000 cubic feet passing through the return is inclusive of $1\frac{3}{4}$ per cent. of fire-damp, and hence this volume will be made up of air and fire-damp. The volume of fire-damp present in the total volume of mine air may be found by simple proportion:—

As 100 per cent. : 1·75 per cent. : : 100,000 cubic feet : 1,750 cubic feet.

The volume of fire-damp passing per minute, then, is 1,750 cubic feet, and the volume of *air* passing in addition to the fire-damp is 100,000 — 1,750 = 98,250 cubic feet. Now, the volume of fire-damp passing per minute remains constant, whilst the volume of air is increased until the proportion of fire-damp in it is decreased to 1 per cent., hence, the total volume now passing will be 1,750 × 100 = 175,000 cubic feet. The first measured volume is 100,000 cubic feet per minute, the total required volume to reduce the percentage of fire-damp to 1 per cent. is 175,000 cubic feet per minute, hence (*a*) the volume of air required to reduce the quantity of fire-damp to 1 per cent. is such as will give a total *measured* quantity of 175,000 cubic feet per minute.

* Transactions Institute Mining Engineers, Nol. XLI, page 191.

The horse-power in the air is found by the formula:—

$$\text{H.P. in air} = \frac{\text{W.G. in ins.} \times 5{\cdot}2 \times Q}{33000}$$

Where Q = quantity of air passing in cubic feet per minute. To circulate the first quantity,

$$\text{H.P.} = \frac{2{\cdot}5 \times 5{\cdot}2 \times 100000}{33000} = 39{\cdot}39, \text{ or say } 40 \text{ H.P.}$$

(*b*) The additional horse-power required from the fan to circulate the increased volume may be found in two ways; first, by formula above, for which the increased water-gauge will be required; second, by simple proportion.

(1) *Increased Water-Gauge.*—The ventilating pressure, and consequently the water-gauge, varies directly as the square of the quantities passing, therefore, by proportion

As $100{,}000^2 : 175{,}000^2 :: 2{\cdot}5$ inches : x inches.

$4^2 : 7^2 :: 2{\cdot}5 : x.$

$\therefore 16 : 49 :: 2{\cdot}5 : x.$

$$\therefore x = \frac{2{\cdot}5 \times 49}{16} = 7{\cdot}656 \text{ inches.}$$

$$\text{Then, H.P.} = \frac{7{\cdot}656 \times 5{\cdot}2 \times 175000}{33000} = 211{\cdot}12.$$

(2) *By Simple Proportion.*—Rule, power varies directly as the cube of the quantity, then,

As $100{,}000^3 : 175{,}000^3 :: 40$ H.P. : x H.P.

$4^3 : 7^3 :: 40 : x.$

$$\therefore x = \frac{343 \times 40}{64} = 214 \text{ H.P.}$$

Since we have approximated from 39·39 H.P. in the first instance to 40 H.P., the calculated H.P. in the second case will be about 212 H.P.; the *additional* horse-power required then from the fan to circulate the increased volume is

212 — 40 = 172 H.P.

Q.—*It is proposed to wind 1,000 tons per day of eight hours from a shaft 400 yards deep, the ropes being balanced. The ventilation required is 150,000 cubic feet per minute, at an estimated water-gauge of 3 inches. The power plant during winding hours generates an average of 600 k.w., and supplies power for all purposes, other than for winding and ventilating. Give the approximate brake horse-power of* (a) *the winding engine,* (b) *the fan engine;* (c) *generating engine, and state what steam pressure, and what size, type, and number of boilers you would adopt.—(Manchester District, First Class, and submitted by* Resolven).

A.—The boiler power must be sufficient to deal with the maximum load, or give the maximum power required, at any time, and therefore the approximate total horse-power, plus a reserve power, will have to be calculated, capable of keeping the whole plant fully equipped at the same time.

(*a*) *The Winding Engine.*—Assuming the "eight hours" per day mentioned in question to be the time actually spent in winding coal, then the number of tons to be wound per hour $= \frac{1000}{8} = 125$ tons.

It is next required to ascertain the time occupied per wind. An excellent rule for ascertaining the mean cage speed in feet per second is given by Mr. T. A. O'Donahue, in his *Mining Formulæ*, as Cage speed (mean) in feet per second = $10 + 5D$.

Where D = depth of shaft in hundreds of yards.

Therefore, according to above, the mean cage speed for a shaft 400 yards deep may be taken as $10 + (5 \times 4) = 30$ feet per second. If we allow, say, 20 seconds for banking decks, this means that the time occupied per wind $= \frac{1200}{30} + 20 = 40 + 20 = 60$ seconds per wind, or 60 winds per hour. (In many cases at a depth of 400 yards this speed of winding will be exceeded).

Since it is required to raise an output of 125 tons per hour, then $\frac{125}{60} = 2{\cdot}08$ tons per wind. The actual amount of coal raised per wind will, of course, depend on the capacity of the cage and the size of tub used; and, therefore, in order to provide

Arrangement of Compressor and Driving Plant.—Accompanying this answer are two diagrammatic sketches of the methods of arranging the compressor, and (*a*) the steam plant (*b*) the electric motor. For the general idea of these sketches my thanks are due to my class teacher, Mr. B. Richards, County Lecturer, from notes taken at class. As is seen, the compressor consists of a second cylinder placed in line, and directly behind the steam cylinder, the only difference being that it is slightly larger in diameter than the latter. The back piston rod of the engine is connected directly to the piston rod of the compressor. As the piston of the engine is on its forward stroke it carries with it the compressor rod, which compresses the air in its path, simultaneously opening the inlet valves and drawing in (by the suction principle) air from behind, thus providing a cylinder full of air in readiness for the back stroke. Towards the end of the forward stroke, as soon as the pressure of the air in the cylinder exceeds that of the air in the receiver, the delivery valve opens, and the air is forced into the receiver. During the momentary pause preparatory to the back stroke all the air having been forced out of the cylinder, the delivery or outlet valve closes, the inlet valves on this side of the piston open, while those on the other side close. The air in the other side is then compressed in exactly the same manner as described in the first case. Evidently, it is seen that at the commencement of the stroke the steam pressure is at its maximum, while the air resistance in the compressor is at its minimum. The result is, as the piston proceeds the force of the steam driving it forward gradually diminishes, while the air in front of the compressing piston tends to offer an increasing resistance, until at the end of the stroke the air resistance is at its maximum, while the steam pressure available is at its minimum. Consequently, the importance of a flywheel, or of arranging the compressors in pairs, with their cranks coupled at right angles, with the flywheel between.

Assisted by Boulton's *Practical Coal Mining.*

A. Nelson, Maes-y-Dyffryn, Glyn Neath, Glamorgan.

[Note.—This question met with a very small number of answers. Rather more was required than a simple description of the principle of an air compressor, such as one or two students sent in.—C.C.M.]

A. Stephens, E. Ambrose, J. Grundy, R. Graham (*12 marks each*).

FIRST CLASS.

Approaching Old Workings.

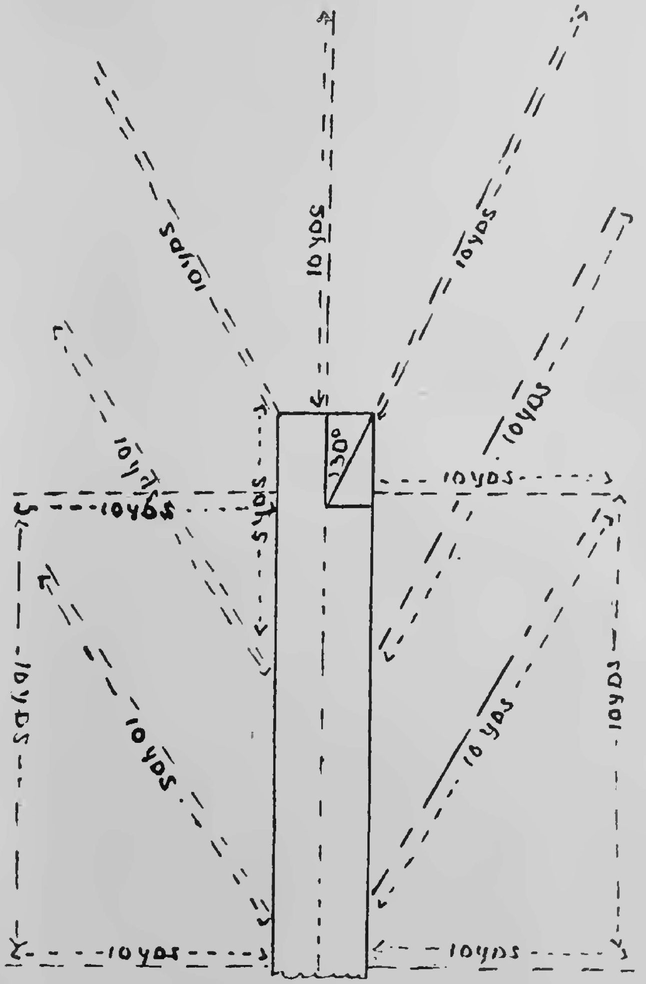
Q. 9.—*Give your reasons for having only one heading and 15 feet bore-holes in front and flank when approaching old workings of which no reliable plans can be found. Mention any other precautions you would use in such work.*

A.—Many serious accidents have occurred in coal mines on account of holing into old workings containing water. In some instances the old workings have not been actually holed into, but the barrier of coal dividing the old workings has been worked so thin that the pressure caused by the water in the old workings has burst the barrier, and thus flooded the workings of the mine, causing in some instances heavy loss of life.

It is advisable, therefore, when approaching old workings, especially as in this case when no reliable plans can be found, to just drive one heading in the direction of the supposed old workings so as to weaken as little as possible the barrier of coal intervening between the two workings.

The C.M.R.A., 1887, General Rule 13, states that where a place is likely to contain a dangerous accumulation of water the working approaching that place shall not exceed at any point within 40 yards of that place 8 feet in width, and there shall be constantly kept at a sufficient distance not being less than 5 yards in advance, at least one bore-hole near the centre of the working, and sufficient flank holes on each side. Now, as reliable plans of the old workings cannot be found, I should substitute instead of "not being less than 5 yards in advance," not being less than 10 yards in advance, also the same as regards the flank holes, as an extra precaution. I would also, say every 10 yards, have a hole bored in on either side, not at angles of 30° as would be the other flank holes, but at right angles to the heading; these holes would be the same depth as the others. We should then be able to ascertain whether the old workings extended further in one direction than another, and thus safeguard against working the coal too thin between the heading and the old workings.

If water was suspected at a high pressure it would be advisable to employ a boring machine, such as the Burnside machine. The special object of this machine is to control the sudden



Illustrating Question 9.

outrush of water through the hole. With this apparatus water has been tapped at a pressure of 110lb. per square inch through a $2\frac{1}{2}$-inch hole 210 feet in length. The highest pressure recorded as having been dealt with by it is 262lb. per square inch.

W. T. Hughes, 103, Wigan Road, Ashton-in-Makerfield.

[Note.—The fact that the rule of the 1887 Act with regard to driving towards old workings likely to contain water has only been very slightly modified by the new Act bears out our own opinion that the rule, as stated in the question, carries out all that we require in the interests of safety. Of course, the chief point to be observed is that the bore-holes must be kept never less than the five yards in advance; that is to say, as a rule they must be in advance considerably more than five yards.

The slight modifications made by the new Act, which does not, however, come into force until July, are that the flank bore-holes shall be at intervals of not more than five yards, and that the rule as to approaching workings likely to contain water shall also apply to approaching any disused workings unless they have been examined, and found to be free from water or any other liquid matter. (We are rather at a loss to know what liquid matter there could be discovered in old workings other than water; possibly oil is suggested.—C.C.M.]

F. Hutchinson, W. Heys (*12 marks each*).

COLLIERY ENGINEERING.

By CLANSMAN.

No. 9.—Linear and Angular Motion.

We give herewith summary in which is shown analogous relations in Linear and Angular Motion:—

Linear.		Angular.	
Time in seconds	$= t.$	Time in seconds	$= t.$
Displacement in feet	$= l.$	Angular displacement in radians ..	$= \theta$
Velocity in feet per second	$= v.$	Angular velocity in radians per second	$= \omega.$
Acceleration in feet per sec. per sec. ..	$= a.$	Angular acceleration in radians per sec. per sec.	$= a.$
Mass or inertia	$= m = \frac{w}{g}.$	Moment of Inertia $= I = mk^2$ ..	$= \frac{w}{g} \times k^2.$
Force in lb.	$= F = ma = \frac{w}{g} \times a.$	Torque, in lb.-ft. units	$= T.$
Momentum	$= mv.$	Angular momentum	$= I\omega.$
Impulse in lb.	$= Ft.$	Angular Impulse in lb.	$= T \times t.$
Work in ft.-lb.	$= F \times l.$	Work of rotation	$= T \times \theta.$
Kinetic energy in ft.-lb.	$= \frac{mv^2}{2} = \frac{wv^2}{2g}.$	Kinetic energy of rotation	$= \frac{I\omega}{2}.$
Power in ft.-lb. per sec.	$= F \times v.$	Power	$= T\omega.$

Relations:—$l = \theta R$, where R = radius in feet. $v = \omega R$ and $a = a R$.

Uniform velocity	$l = vt.$	Uniform angular velocity:	$\theta = \omega t.$
With initial velocity	$= v_1.$	With initial angular velocity	$= \omega_1.$
And final velocity	$= v_2.$	And final angular velocity	$= \omega_2.$
Then uniform acceleration	$a = \frac{v_2 - v_1}{t}.$	Uniform angular acceleration	$a = \frac{\omega_2 - \omega_1}{t}.$
	$\therefore v_2 = v_1 + at.$		$\therefore \omega_2 = \omega_1 + at.$
	$l = v_1 t + \frac{1}{2}at^2.$		$\theta = \omega t + \frac{1}{2}at^2.$
	$v_2^2 = v^2 + 2al.$		$\omega_2^2 = \omega_1^2 + 2a\theta.$
Acceleration from rest	$a = \frac{v}{t}.$	Angular acceleration from rest	$a = \frac{\omega}{t}.$
	$\therefore v = at.$		$\therefore \omega = at.$
	$l = \frac{1}{2}at^2.$		$\theta = \frac{1}{2}at^2.$
	$v_1^2 = 2al.$		$\omega^2 = 2a\theta.$
Constant Force	$F = ma = \frac{w}{g} \times a.$	Torque: $T = Ia$	$= mk^2a.$
Impulse	$Ft = mv.$	Angular Impulse: $T \times t$	$= I\omega.$
Or Impulse causing change of momentum	$Ft = m(v_2 - v_1).$	Or Angular Impulse causing change of momentum: $T \times t$	$= I(\omega_2 - \omega_1).$
Work and Energy: $Fl = \frac{1}{2} mv^2$, or		Work and Energy: $T' \times l$	$= \frac{1}{2}I\omega^2.$
for change of velocity:	$Fl = \frac{1}{2}m(v_2^2 - v_1^2)$	Or, for change of angular velocity: $T \times l$	$= \frac{1}{2}I(\omega_2^2 - \omega_1^2).$
Acceleration	$= \frac{\text{Force}}{\text{Mass}}.$	Angular acceleration ..	$= \frac{\text{Torque}}{\text{Moment of Inertia}}.$
Impulse	= change of momentum.	Angular impulse	= Change of ang'l'r m'mnt'm
Or since .. .. .. F	$= \frac{m(v_2 - v_1)}{t}$	Or since T	$= \frac{I(\omega_2 - \omega_1)}{t}.$
Force	= rate of change of m'm'nt'm	Torque	= rate of change of moment of m'm'nt'm
Work	= change of kinetic energy.	Work	= change of kinetic energy.

The following examples may enable the reader to make himself acquainted with the foregoing analogies:—

Ex.—A shaft makes 80 revolutions per minute. Express this in radians per second.

Eighty revolutions per minute $= \frac{80}{60}$ revolutions per second. Each revolution $= 2\pi$ radians, and radians per second = radians in one revolution × number of revolutions per second. ∴ radians per second $= 2\pi \times \frac{80}{60} = 2 \times 3{\cdot}1416 \times \frac{8}{6} = 8{\cdot}377.$

The shaft carries a pulley 4 feet in diameter. Find the speed of its rim.

The speed $v = \pi DN = 3{\cdot}1416 \times 4 \times \frac{80}{60} = 16{\cdot}75$ feet per second.

Ex.—A man walks 20 feet in 4 seconds. Find his average speed.

Here $v = \frac{l}{t} = \frac{20}{4} = 5$ feet per second.

Ex.—A wheel turns through 480° in 3 seconds. Find its average angular speed.

Average angular speed in degrees $= \frac{480}{3} = 160°$ per second, and since $\frac{\theta}{\pi} = \frac{d}{180}$ where d = number of degrees and θ = number of radians.

$$\theta = \frac{\pi}{180} \times d = \frac{3{\cdot}1416}{180} \times 160 = 2{\cdot}792 \text{ radians per second.}$$

Ex.—A point moves in a straight line. At a certain instant its speed is 10 feet per second. After 8 seconds its speed is 50 feet per second. Find the average acceleration.

CORRESPONDENCE.

Correspondence is invited upon all matters affecting coal and metal mining and the kindred industries. The Editor cannot be held responsible for the opinions expressed nor for the accuracy of the information. It is important that correspondents should observe the following rules:—(1) To write only on one side of the paper. (2) To submit sketches, if any, on unruled paper, separate from the MSS., and in Indian Ink. (3) To write plainly, especially all proper names (4) To write with brevity and point. (5) To avoid personalities (6) To enclose with letters intended to be published anonymously their names and addresses as evidence of good faith. (7) Correspondents who desire to preserve their letters should keep copies, as the Editor cannot undertake to return rejected communications

Information Wanted.

To the Editor of The Science and Art of Mining.

SIR,—Will some reader please solve the following problem:—The winding space in a shaft is 8 feet × 6 feet. The door-heads are $7\frac{1}{2}$ feet high. Find the length of the longest "stick" that could be taken into the mine.

Yours, &c.,

A PIT-BOTTOMER.

To the Editor of The Science and Art of Mining.

SIR,—Will any of your readers describe by sketch what is meant by working coal on the "face," "on end," and "half on?" Thanking you in anticipation.

Yours, &c.,

WELSH TYRO.

To the Editor of The Science and Art of Mining.

SIR,—Will you kindly allow me space for the following questions in your paper?—

1.—Suppose there was a large fall of roof in the main return air-way; what effect would it have on the water-gauge?

2.—Can any reader sketch and describe clearly some contrivance for "greasing" a haulage rope other than using the ordinary bucket and brush?

Yours, &c.,

J. W. T.

Laws of Falling Bodies.

To the Editor of The Science and Art of Mining.

SIR,—In reply to JAMES HISSETT in No. 18, Vol. 20, I could understand how he arrived at $16s = 805t - 402{\cdot}5$. I wanted an explanation of

$$\therefore \frac{s}{t} = \frac{402{\cdot}5}{16}.$$

This is where the solution fails. The transposing is incorrect—

$$16s = 805t - 402{\cdot}5. \quad \therefore \frac{s}{t} = \frac{805}{16} - \frac{402{\cdot}5}{16t}.$$

$$\therefore s = 50{\cdot}3125t - 25{\cdot}15625.$$

$$s = \tfrac{1}{2}gt^2 = 16{\cdot}1t^2. \quad \therefore 50{\cdot}3125t - 25{\cdot}15625 = 16{\cdot}1t^2.$$

$$\therefore \frac{t^2}{t} = \frac{50{\cdot}3125}{16{\cdot}1} - \frac{25{\cdot}15625}{16{\cdot}1t} = 3{\cdot}125 - \frac{1{\cdot}5625.}{t}.$$

$$t = 3{\cdot}125 - \frac{1{\cdot}5625}{t}.$$

Without bringing it any further 2·5 or ·625 will satisfy the equation.

Yours, &c.,

T. W.

Ventilation.

To the Editor of The Science and Art of Mining.

SIR,—Being a constant reader of your valuable Mining Journal, I have come across the following in Vol. XXII., No. 17. What would happen if the doors on top of the upcast were opened? Would the fan stop, slow down, or increase in speed? Well, they all say that it would increase in speed; and ENGINEERING STUDENT says, by aid of a formula extracted from a book by H. W. G. Halbaum, that it would increase in speed if the underground separation doors were opened.

Will you kindly insert the following for a little discussion. I say the fan would slow down and deal with a larger volume of air, because the friction or drag of the mine would be cut off. I know of an instance some time ago where the mine separation doors were opened, and the fan slowed down, and had a bumping sound as if dealing with a heavier load. I am willing to fall into my mistake if there is any, but it seems the general thought of modern mining engineers that the fan will slow down.

Yours, &c.,

A. DAVIES.

To the Editor of The Science and Art of Mining.

SIR,—What would happen to the fan if the doors at the top of the upcast were suddenly opened? Would the fan stop, slow down, or increase in speed?

In answering this question in your issue of March 30th your contributor TYKE suggests that the fan would speed up. May I suggest that he try the experiment for himself and see. I think he will find—by whatever process of reasoning he arrives at the cause—that the fan will really slow; that is, if it be driven by an ungoverned engine. Whether or not the fan would really stop depends in some measure on the kind of engine driving it, and the rate at which the engine runs. Because if the engine were a single, slow-running one, conveying its force through gear or belting to the fan, with just sufficient motion on to carry itself over its centres when running normally, it is more than likely that it would stop when the extra volume of air entered the fan. I was amused at the curiously fallaceous arguments that your contributor adduced to establish his contention. For example, he says, as a result of opening upcast doors a large volume would rush in to the fan drift from the outside atmosphere, *which air would certainly offer less resistance to the fan than the air from the mine.* The last part of that remark is incorrect. The air entering from the atmosphere is certainly denser than the air originally coming from the mine, therefore, what more natural than that the fan should not pass so easily through it? He admits that the W.G. has fallen in the fan drift. This is itself an admission that the air entering the fan is now denser. He also talks of the opening of the doors *taking th eresistance of the mine off the fan.* That also is a fallacy. Air will be entering the fan not only from the atmosphere, but from the mine, so long as both ways to the fan are left open, because air cannot enter the fan drift through the upcast doors without meeting *some* resistance, and just the same measure of resistance shall be offered by the mine to the passage of such air as shall reach the fan through it. Hence, what has really been done by the opening of the doors at the upcast shaft is equal to an increase of the equivalent orifice of the mine—reckoning the entry through the doors as a part of the mine—because we would have the fan running at the same rate and producing the same increased quantity of air—if some magician had come along and increased the size of existing air-ways instantaneously, just enough to give the same easy access of air to the fan through the mine itself with upcast doors shut, as it now has through the mine and the open upcast doors combined. In adducing the pump as an illustration your contributor misses the point entirely, or rather applies it in an inverted way. To make any approach to a truthful comparison he should have had the pump going first on air, and then given it a little water, and finally solid water; watching the effects the while. This, in some degree, would have compared with a fan pumping air somewhat attenuated through a mine, and then being fed and filled with air somewhat less attenuated through a combined mine and doors. Or, he might just imagine a fan set to work driven by an ungoverned engine, exhausting air out of a completely closed chamber, and measure how much it exhausts after it has run a minute or so. He could then commence opening an aperture into the chamber. After having opened it a bit he could test whether the fan was now passing more air than it did when the chamber was closed, and whether it was running faster as a result? If he gradually kept widening the aperture, and watching the effect, I can imagine his eyes gradually widening with wonder at the result, because, while the flow of air gradually increased, the speed of the fan would be gradually reduced.

Yours, &c.,

Larkhall. WM. M. KILPATRICK.

Here average acceleration $= \dfrac{\text{Change in velocity}}{\text{Time of change}} = \dfrac{50 - 10}{8}$
$= 5$ feet per sec. per sec.

It is usual to write 5 feet per second per second as $5'$ per sec.^{2}

Ex.—A rotating body changes its angular velocity from 3 to 8 radians per second in 4 seconds. Find its average angular acceleration during this interval.

Here average angular acceleration
$= \dfrac{\text{Change in angular velocity}}{\text{Time of change}} = \dfrac{8 - 3}{4} = 1{\cdot}25$ radians per second^2.

Ex.—A rotating piece has at a certain instant a speed of 60 revolutions per minute, and an angular acceleration of 5 radians per second^2. Find the linear speed and the tangential acceleration at this instant of a point 2 feet from the axis of rotation.

Let R = distance of point from axis.

Linear speed of point $= 2\pi RN = 2 \times 3{\cdot}1416 \times 2 \times \frac{60}{60}$
$= 12{\cdot}56$ feet per second.

Tangential acceleration = linear acceleration of point at instant taken.

$\therefore a$ = acceleration in radians $\times R = 5 \times 2 = 10$ feet per second^2.

Ex.—A train moving from rest with uniform acceleration takes 5 minutes to travel over the first mile. What speed has it acquired at the end of that time? How long does it take to travel over the second mile?

If we take v = velocity acquired, then the displacement
$l = \frac{1}{2}vt$, and $v = \dfrac{2l}{t} = \dfrac{2 \times 5280}{5 \times 60} = 35{\cdot}2$ feet per second.

Let v_1 = velocity at end of second mile.

It begins the second mile with velocity $v = 35{\cdot}2$, and the acceleration continues. $a = \dfrac{v}{t} = \dfrac{35{\cdot}2}{5 \times 60}$.

$\therefore v_1^2 = v^2 + 2al = 35{\cdot}2 \times 35{\cdot}2 + 2 \times \dfrac{35{\cdot}2}{5 \times 60} \times 5280$
$= 1239 + 1239 = 2478$.

$\therefore v_1 = \sqrt{2478} = 49{\cdot}8$ nearly.

Average velocity during second mile
$= \dfrac{v + v_1}{2} = \dfrac{35{\cdot}2 + 49{\cdot}8}{2} = \dfrac{85}{2} = 42{\cdot}5$,

and $t = \dfrac{\text{Displacement}}{\text{Average velocity}} = \dfrac{5280}{42{\cdot}5} = 124{\cdot}3$ seconds.

Ex.—A pulley starting from rest and moving with uniform angular acceleration takes 8 seconds to make 6 turns. What is the angular velocity at the end of that time? How long does it take to make the next 6 turns?

The angular displacement $\theta = \frac{1}{2}\omega t = 6 \times 2\pi$.

$\therefore \omega = \dfrac{2\theta}{t} = \dfrac{2 \times 12\pi}{8} = 3 \times 3{\cdot}1416$.

$\therefore$ angular velocity $\omega = 9{\cdot}425$ radians.

Let ω_1 = angular velocity after 12 turns.

Pulley begins 7th turn with angular velocity $= \omega = 9{\cdot}425$, and the acceleration continues. $\alpha = \dfrac{\omega}{t} = \dfrac{9{\cdot}425}{8} = 1{\cdot}178$.

$\therefore \omega_1^2 = \omega^2 + 2\alpha\theta = 9{\cdot}425 \times 9{\cdot}425 + 2 \times 1{\cdot}178 \times 12\pi$
$= 88{\cdot}83 + 88{\cdot}83 = 177{\cdot}66$; and $\omega_1 = \sqrt{177{\cdot}66} = 13{\cdot}37$ radians per second.

Average angular velocity during second 6 turns
$= \dfrac{\omega + \omega_1}{2} = \dfrac{9{\cdot}425 + 13{\cdot}37}{2} = 11{\cdot}4$,

and $t = \dfrac{\text{Angular displacement}}{\text{Average angular velocity}} = \dfrac{6 \times 2\pi}{11{\cdot}4} = 3{\cdot}32$ sec.

Ex.—A train moving at 20 miles per hour is brought to rest in 100 seconds, the retardation being uniform. Find the space passed over during this time.

Here the velocity $v = \dfrac{20 \times 5280}{60 \times 60} = 29{\cdot}3$ feet per second.

Let a = retardation, then $a = \dfrac{v}{t} = \dfrac{29{\cdot}3}{100} = {\cdot}293$,

and the space passed over, $l = \frac{1}{2}at^2 = \frac{1}{2} \times {\cdot}293 \times 100 \times 100$.

$\therefore l = 146{\cdot}6$ feet.

CANADIAN COAL PRODUCTION.

The quantity of coal produced in 1910 was 12,909,152 short tons, value \$30,909,779; last year the amount was 11,291,553 tons, value \$26.378,477. This represents a decline of 1,617,599 tons, and \$4,531,302 respectively. These figures are from the preliminary report of the Department of Mines, and for the falling off the long continued strike in the coal mines of southern Alberta and eastern British Columbia is held responsible. There was an increase of 562,978 tons in Nova Scotia, and of 23,097 tons in Saskatchewan. In Alberta the decrease was returned at 1,396,412 tons, or 48 per cent., and in British Columbia 794,243 tons, or 24 per cent.

The production by provinces was approximately as follows, the figures for 1909 and 1910 being also given:—

Province.	1909.		1910.		1911.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
		\$		\$		\$
Nova Scotia	5,652,089	11.354,643	6,431 142	12.919.705	6,994,120	14,050,687
British Columbia .	2,606,127	8.144,147	3,330,745	10,408,580	2,536,502	7,926,569
Alberta..................	1.994.741	4.838,109	2,894.469	7.065.736	1,498,057	3,933,958
Saskatchewan	192,125	296,339	181,156	293,923	204,253	342,921
New Brunswick ...	49.029	98,496	55,455	110,910	55 781	111.562
Yukon Territory...	7,364	49,502	16,185	110,925	2 840	12,780
Totals	10,501,475	24,781,236	12,909,152	30,909,779	11,291,553	26,378,477

Temperature of Ice.—Is ice any colder in winter than in summer? Most people suppose not. They understand that ice is ice, and cannot be any colder or warmer. If a thermometer is buried in ice in summer it will indicate thirty-two degrees. If you throw a piece of ice into boiling water and leave it there till it is almost gone, what is left will still be at thirty-two degrees. Ice can never be gotten above that temperature. But while ice can never be warmed above thirty-two degrees, it will go as much below that as the weather does. An iceman delivering ice one zero day in January was asked whether his ice was any colder than in July. He thought not. But as a matter of fact a piece of summer ice, if he had had it, would have been something of a foot-warmer for him, as it would have been thirty degrees warmer than the air of the bottom of his wagon. Mixing salt with ice makes it much cooler. The ice in an ice cream freezer goes down to about zero. This is why the point zero on our common thermometers was fixed where it is. It was supposed to be the lowest point that could be reached by artificial means. Since then we have reached about 383 degrees below zero by chemical processes. Ice will cool down with everything else, on a cold night, to zero or below. What should prevent it? On a day when it is just freezing, a block of iron and a block of ice outdoors will stand at thirty-two degrees. If the weather grows warmer the iron will warm up with the weather, but the ice will stay at thirty-two degrees and melt away. But if the weather grows colder the iron and the ice will cool off too, and one just as much as the other. As the ice grows colder it gets harder and more brittle. There can be no "hickory bend" on the skating pond on a zero day, for ice is then too brittle. Slivers of ice dipped in liquid air become so hard that they will cut glass. Water thrown on ice in the Arctic regions will shiver it like pouring boiling water upon cold glass. This is because the ice is so much colder than the water.

A Mis-statement.

To the Editor of The Science and Art of Mining.

SIR,—I venture to correct a mis-statement which occurs in your last issue, p. 415, in connection with the composition of the air. In speaking of oxygen and its proportion in the atmosphere normally, your contributor states that "To produce an atmosphere fit to breathe, *no free oxygen can be allowed.*" (The italics are mine).

May I point out that *all* the oxygen in the atmosphere is in the free condition. None of it is combined. Air is a *mixture* of gases, not a compound. If there is no free oxygen in an atmosphere human life cannot exist.

Yours, &c., T. H. BYROM.

[NOTE.—"TYKE" proposes to deal with the above questions by "A Pit-Bottomer," "Welsh Tyro," and "J. W. T." as time and space permit. He also proposes to deal with the letters from Messrs. A. Davis and Wm. M. Kilpatrick.]

SURVEYING.

By COLLIERY SURVEYOR.

Y and Dumpy Levels

The following remarks relating to Y levels are made by Mr. W. F. Stanley in his excellent work on *Surveying and Levelling Instruments* :—

"The oldest form of surveyor's level is that known as the Y level, so called from the telescope being supported in Y-formed bearings. It was invented by Jonathan Sisson in the last century. It is very little used nowadays, especially in Great Britain, but on the Continent and in America it appears to still hold a place. In the eyes of the *optician* it is still the most perfect level, possessing all the instrumental refinements of adjustment. The reason for its partial abandonment is owing to the number of loose parts, the loss of any of which is a serious matter when work is being done far away from civilisation and facilities for replacement. Other objections are that Y's and collars wear by constant friction in being carried about, and tend to form facets ; the collars also become corroded, and they collect flying dust, which gives rise to imperfection. Also, that the cross bubble which is always attached to the *dumpy* level saves a lot of time over swinging the telescope backwards and forwards. Also in the dumpy level the vertical and horizontal webs of the diaphragm are fixed, and cannot be disturbed by rotation of the telescope when once fixed up, and this is specially useful to enable the observer to determine whether the staff is held vertical or not, which is otherwise a great difficulty with the ordinary form of Y level reading."

Figure 111 shows a good form of dumpy level. It consists of a telescope *T* which carries a ray shade at the object glass end to avoid the direct rays of the sun when low on the horizon. The eye-piece *EP* is adjustable inwards or outwards, either by rotating or by sliding. *BT* is the bubble tube, and *CB* is a cross bubble tube at rt. ∠s to *BT*. *H* is a hinge joint, and *LN* are locking nuts which serve to support and also to adjust the bubble tube parallel to the telescope axis. *WD* indicates the position of the webbed diaphragm, which moves in a slide piece, and is adjustable by means of the capstan headed screws *CS*. *S* and *S* are straps passing round and soldered to the telescope, and afford support for the bubble tube, as well as support for the whole upon the limb *L*. *SS* is the socket screw, around which the instrument rotates. *FS* is the focussing screw, by means of which the inner sliding tube with its object glass can be moved as required to give a clear vision. *LS* are the mill-headed screws used for levelling the telescope, and *A* is the point of attachment (by means of an internal thread) to the tripod.

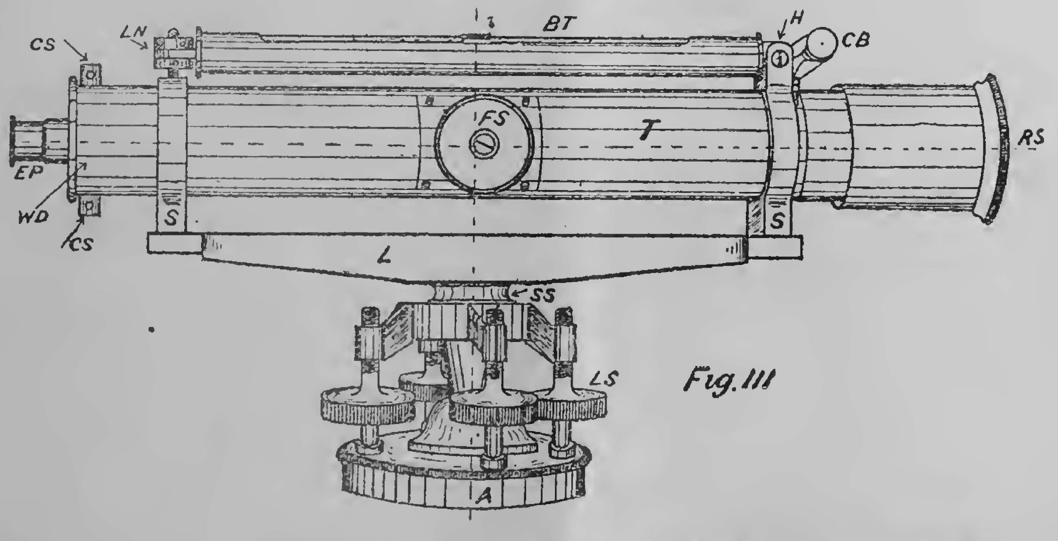


Fig. 111

Examples to be Worked Out.

Readers working out the appended questions and who desire a test o their ability, should submit their answers to COLLIERY SURVEYOR, care of he S ience and Art of Mining Office, Wigan. The answers will be examined and corrected by the writer of this series of articles, and returned privately to students with, where possible, the source of error indicated. Enclose with each set of answers for examination a stamped addressed envelope together with P.O. (or stamps) for 6d. A set of answers means nswers to four questions taken from a single issue. The nominal charge of 6d. is made to meet the bare costs of examining the answers submitted. An allowance of time will be made for readers in the Colonics and Foreign countries, who may take part in this scheme, remitting by Int. Money Order 1s. (one shilling) with each set of answers to cover mailage costs, &c. Answers to the following questions where circumstances permit should be submitted to COLLIERY SURVEYOR at the convenience of readers. There is no time limit, but as far as possible readers are advised to keep in touch with the r gular series of articles.

1.—*Draw a neat sketch, with letters of reference, of the Dumpy level, and, if you can, show in cross section the arrangement of the webbed stop in the diaphragm.*

2.—*State the causes which have operated to cause the displacement of the Y level by the Dumpy ; in other words, compare the Y and Dumpy levels.*

3.—*If the line of collimation in a Dumpy level was out of adjustment, how could you find two level points ?*

4.—*Find the quantity of earth required for an embankment whose uniform depth is 20 feet, surface width 33 feet, length 1 chain, and slopes $1\frac{1}{2}$ to 1.*

PEAT POWER AS LOCOMOTIVE FUEL.

The problem of finding a suitable form for peat as a practical and economic fuel for locomotives continues to engross the attention both of railway authorities and peat experts. More especially in Sweden the problem is to the fore, but no satisfactory solution appears to have been arrived at as yet. The general director of the State Railway is much interested in the matter, and recently submitted drawings of locomotives to a very well-known peat expert for him to design a suitable fire-box, which, however, has not yet been done. It would seem that, although peat powder may prove a desirable fuel for stationary boilers, the difficulties offered by the locomotive have not yet been disposed of.

ADEQUATE BRAKES FOR WINDING ENGINES.

By MYLES BROWN.

"*A.B.S. Brake*" (*Patent*).—The A.B.S. Patent Brake was invented jointly by the manager and engineer of an important colliery, and in the first instance was fitted to a pair of 24 inches × 48 inches winding engines. The brake is now in daily operation, and giving excellent results.

The elevation (*Figure 3*) shows the application of the A.B.S. Brake to a winding engine.

The diagram is a record of experiments made with a brake arranged as an "A.B.S." Brake, and as an ordinary strap brake, *the same strap and brake path being used in each case.*

Line No. 1 is the record for the "A.B.S." Brake; line No. 2 the record for the ordinary strap brake with the drum running in the most favourable direction; and line No. 3 the record for the ordinary strap brake with the drum running in the least favourable direction. The experiments were made by hanging different loads at the circumference of a drum, and recording the least pressure on the brake tramp which was necessary to prevent the load moving. The *brake mechanism* used in both cases was identical. It will be observed that in the case of the A.B.S. Brake the weight supported at the drum circumference for any given load on the tramp is greater than that supported when the ordinary strap brake is used, even with the drum revolving in the best direction, and very much greater when the drum is revolving in the least favourable direction.

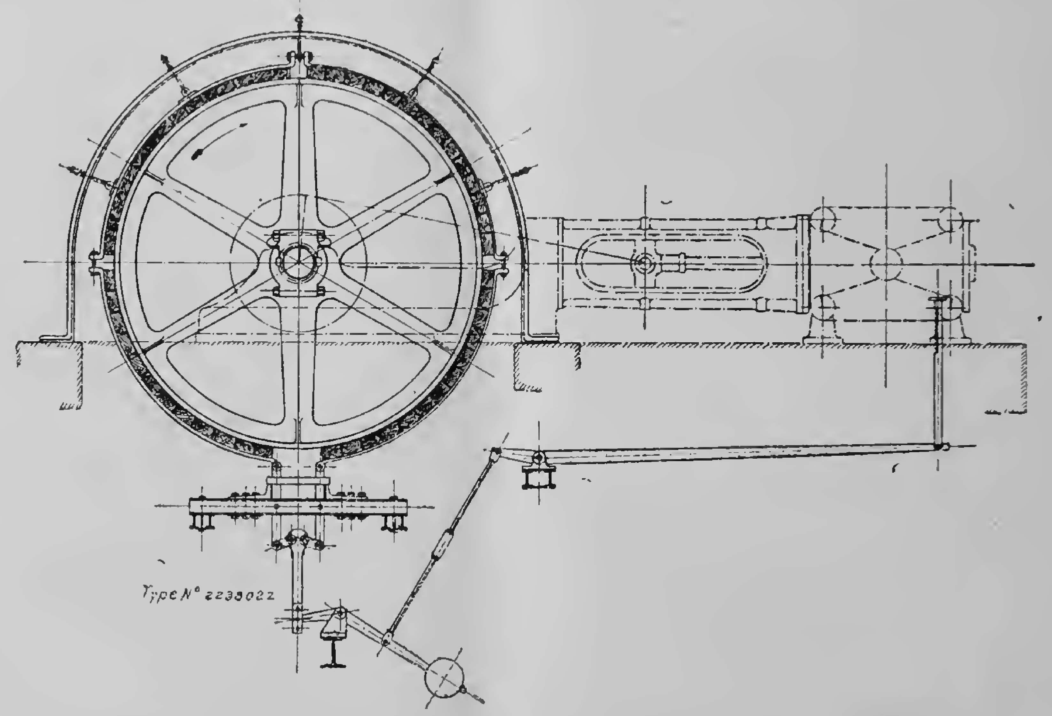


Figure 3.—Elevation showing Application of the "A.B.S." Brake to a Winding Engine.

Special Features of the Brake.—(1) The sole makers (Messrs. Andrew Barclay, Sons, and Co., Ltd., Caledonia Works, Kilmarnock) specify the brake to effectively fulfil the requirements of the new Mines Act. The Act requires that "where the apparatus used for lowering or raising persons is worked by mechanical power, there shall be provided one or more brakes of sufficient power by themselves to hold the cage when loaded at any point in the shaft."

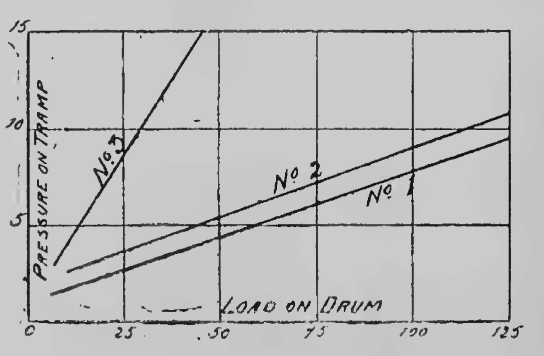


Figure 4.

(2) The power of the A.B.S. Brake and its effectiveness for both directions of running is accomplished by a specially-designed brake with toggle joint, which is clearly shown in the illustrations given. The power of the A.B.S. Brake compared with the ordinary strap brake is shown in the accompanying diagram (*Figure 4*):—

(3) The A.B.S. Brake exercises no distorting force on the drum, and as there is a large brake surface the wear and tear and the necessity for frequent adjustment are consequently reduced.

(4) The A.B.S. Brake, although very powerful, is remarkably easy to control; very little effort is required to put it on.

(5) The exertion of one man is capable of holding any load, at any point in the shaft, or lower the loaded cage into the pit bottom without the use of steam against the engines. It is stated that at the colliery where this brake was first applied the loaded cage could be made to creep in the shaft, controlled by the brake entirely, without any assistance from the engine.

Application or Working of the A.B.S. Brake.—The brake is applied by the usual tramp action, which causes a pull on the vertical rod which straightens out the toggle joint, thus tightening the strap.

The brake is particularly easy of application; indeed, it could well be applied at full power by the pressure of the fingers. This is due to the fact that when the strap is in contact with the brake path the drag of the brake path on the strap draws it up tighter, consequently, the effort applied by the engineman only takes up the slack, and in this way full advantage of the coil friction is obtained. The brake can be brought into action very gently, being put on against the resistance of springs hung from a steel arch, or it can, when necessary, be instantly applied at full power. In the same way the brake may be released in the most gradual or sudden manner.

Perfect contact is secured between the brake path and the brake strap by making the strap in four separate segments, and in this way also a great range of adjustment is obtained. It is possessed of great holding power in both directions, and certainly has a manifest advantage over the ordinary post brake, as its enormous braking power is not dependent upon any large expenditure of physical force by the engineman.

The A.B.S. Brake can be adapted to existing engines as readily as it can be fitted to new engines. It is also suitable for steam as well as foot or hand application, though a steam brake of this design would only be necessary with engines of the largest size.

DISCIPLINE IN MINES.

In considering the matter of mine discipline the great desideratum of moral courage should not be overlooked. The lack of this quality in officials no doubt often leads to disaster, and while the results may be trifling if the cases are taken separately, the cumulative effect is nevertheless very great.

The mine inspector or mine official who lacks the courage to reprimand, or, if need be, prosecute the workman whom he finds flagrantly violating the law, is falling short of doing his duty as an official, whose thought and effort should be given to remedying or removing conditions that may be a menace to safety. The annual report of the Pennsylvania Mines Department says the moral courage that will enable a man to adhere strictly to the line of duty at all times, even in the face of the opposition, interference, or intimidation of officials or employés, is absolutely necessary to the successful carrying out of the laws and rules of safety.

There is no place in which discipline is more necessary than in the coal mines where aliens who cannot speak English are employed in great numbers. Most of them have come from European countries where they were more or less under military restrictions, and, we are told, they mistake the liberty they enjoy in America for licence. Many of them are unfamiliar with mining practices, and the discipline under which they are obliged to work makes them restless and often resistant; they resist it whether it be imposed by the owners or by their own organisations. These people, however, need discipline, not only for their own protection, but for the protection of their fellow-workmen, and while the discipline may be kind, it must be firm; they must be held to strict obedience. A deplorable percentage of accidents can be attributed to the lack of discipline that makes it possible for the mine workers to become careless and negligent to an extent that they are a menace, not only to their own lives, but to the lives of their fellow-workmen.

A mine may be a model institution as far as equipment and safety appliances go, but without the enforcement of rigid discipline among the employés it is still a place of great danger. Violations of the laws and of the rules of the mine should invariably be punished, and the Director of the Mines Department says the official who fails to exact punishment should be counted as guilty as the person who committed the violation. In addition to the immediate calamitous results that may follow a laxity in demanding compliance with the laws and rules, there is bred in the minds of the workmen a disregard for all discipline and control.

The question resolves itself practically into the matter of the official compelling the employé to protect himself, but just to what extent the official should interfere and demand compliance with the law is a problem difficult of solution. Too great exactitude is resented by the worker, and may result in his refusing to continue at work, while, on the other hand, leniency means constant liability to disaster and a weakening of authority.

There is undoubtedly at all times room for discipline in connection with the working of coal mines, and in America the problem is all the more acute by reason of the "mingling of the nations." From particulars collected by the Pennsylvania Mines Department a table has been prepared showing the nationality of the anthracite mine workers, and although those classified as American include all born in the country even though their parents are foreign and unacquainted with the English language, it must be confessed that the percentage of Americans working inside the mines is not a high one. The foreigner predominates, as will be seen upon reference to the table appended:—

Nationality.	*Below.*	*On Surface.*	*Totals.*
American	25,370	20,322	45,692
English	4,144	1,346	5,490
Welsh	5,272	960	6,232
Scotch	745	232	977
Irish	7,861	3,184	11,045
German	3,516	2,006	5,522
Slavonian	8,315	4,093	12,408
Italian	7,490	3,828	11,318
Polish	24,847	4,376	29,223
Hungarian	3,065	1,878	4,943
Austrian	3,629	1,245	4,874
Swedish	153	65	218
Russian	15,720	2,140	17,860
Belgian	——	10	10
Bohemian	55	9	64
French	98	60	158
Canadian	16	8	24
Lithuanian	13,963	1,200	15,163
Greek	804	420	1,224
Tyrolean	761	62	823
Danish	15	7	22
Syrian	18	90	108
Montenegrin	35	9	44
Horwat	66	14	80
	125,958	47,564	173,522

ILLINOIS COAL STATISTICS.

In the 30th annual coal report the statistics relating to labour and output at the mines in the State of Illinois are set forth with considerable detail to the year ending June 30th, 1911. The impression given is that the small mine is being eliminated, seeing that whereas the number of mines operating in 1906 was 1,018, the figure was reduced to 845 in 1911, representing the closing down of 17 per cent. of the collieries. Notwithstanding this, there has been an increase of 15,127, or 24 per cent., in the number of employés, and it requires but a simple calculation to ascertain that whereas in 1906 the labour force averaged 61 for each colliery, last year the average was 91. In the matter of coal output there has been a rise of 11,847,518 tons, last year's total of 50,165,099 tons representing a percentage increase of 31 on the six years' working. These figures are of interest as showing the modern tendency to operate on a larger scale, an experience with which the colliery people in Great Britain are themselves not unfamiliar, and a table of totals and averages for the six years may at the present time be specially appropriate as follows:—

Year.	Mines.	Men.	Tons.	Machines.	Coal got by Machines.	Killed.	Deaths per 1,000.	Tons coal per death.	Output per person.	% Machine got coal.
1906	1,018	62,283	38,317,581	962	9,563,230	155	2·5	247,210	615	25
1907	933	66,714	47,798,621	1,105	14,490,454	165	2·5	289,689	716	33
1908	922	70,841	49,272,452	1,160	15,210,423	183	2·6	269,248	695	30
1909	886	72,733	49,163,710	1,246	16,407,692	213	2·9	230,816	676	33
1910	881	74,634	48,717,853	1,289	18,176,254	406	5·4	119,997	653	37
1911	845	77,410	50,165,099	1,430	19,998,259	157	2·0	319,523	648	39

Coal in Canada.

It has been estimated by the Canadian Geological Department that the total coal content of the three Provinces of Manitoba, Saskatchewan, and Alberta, together with Eastern British Columbia, is 143,490,000,000 tons, covering an approximate area of 22,506 square miles, says *Western Canada Progress.* Of this quantity about 400,000,000 tons are anthracite, 860,000,000 tons range from anthracite to semi-anthracite, 43,070,000,000 tons from semi-anthracite to bituminous, and the balance is of a poorer quality of coal or lignite.

CONTENTS.

The Science & Art of Mining.

ESTABLISHED 1890.

WIGAN, SATURDAY, APRIL 27, 1912.

MINE GASES AND GAS TESTING.

[A Series of Articles specially arranged for Firemen, Deputies, or Examiners.]

By M.E.

No. 6.—Flame Tests for Fire-damp—(continued).

In mine air containing less than 2 per cent. of fire-damp the safety-lamp in its ordinary working condition and without special fittings, is not sufficiently sensitive to give to the average fireman, examiner, or deputy, definite and *unmistakable* indications of the small amount of gas present.

The gas cap obtained in such circumstances is extremely delicate in outline, and is not easily distinguished from the natural "fuel cap" produced by the oil flame when reduced, particularly if the mine temperature is high.

At the best, the effects produced are small, and considerable training in the detection of minute differences in the structure of caps in all kinds of conditions is necessary, before an official can accept with confidence any observation as an indication of a definite percentage of gas.

For practical purposes it is not satisfactory that the estimation of small percentages of gas should have to depend on such elusive effects. In order to increase the range of certainty and reliability obtainable with a safety-lamp, various attempts have been made to devise methods by means of which the cap can be made more apparent and of an increased size. Some of these methods are given below.

The Cunynghame-Cadman Device.—This device has been worked out by Sir Henry Cunynghame, of the Home Office, and Dr. Cadman, Professor of Mining at the University of Birmingham. Its simplicity in action and the soundness of the principle on which it is based recommend its application.

As previously explained, an envelope of burning gas exists around all flames exposed to an atmosphere containing fire-damp, the size of which increases with the size of the flame. In ordinary circumstances this is invisible owing to the activity of the white light. It is obvious, therefore, that if the large cap formed on the full flame could be made visible the value of the safety-lamp as a gas detector would be increased.

Certain chemical salts, such as carbonate of soda, and cuprous chloride, when inserted in a flame, react upon it in such a way as to give it a distinctive colour—the former salt giving a yellow colour; the latter, green. Hence, by suitably introducing either of the above chemical substances to the flame of a safety-lamp burning in a gas mixture, the fire-damp cap takes on the colour due to the salt, and becomes visible, even when the oil flame is full sized.

The "C.C." device is an easy means whereby this effect can be produced in practice. It consists of a strip of thin asbestos sheeting steeped in a suitable solution of either of the above chemical salts. The strip of impregnated asbestos is held in a horizontal position by a suitable holder. This can be operated from the outside of the lamp by a wire passing through the oil vessel. *Figure 2* shows an arrangement of the device in which the asbestos strip and the operating wire can be seen.

When a test is to be made, the asbestos strip is brought forward by means of the wire and inserted into the *full flame*, about one-quarter of an inch above the top of the wick. In the absence of gas no increase of flame is produced. If gas is present the fire-damp envelope is coloured according to the chemical used, its size and distinctness varying with the percentage. In 3 per cent. of gas the cap is very striking, and may be seen a considerable distance away. In 1 per cent. (on a full flame) a distinct coloured cap nearly half an inch high is produced.

A certain amount of experience in manipulation of the device is necessary to obtain the best results. With this, as with all flame tests, the conditions under which the test is made must be standardised.

The asbestos strips are renewable, and any existing lamp can be adapted to the device for a small sum.

The Briggs Loop.—This device has recently been introduced by Mr. Henry Briggs, of the Heriot-Watt College, Edinburgh.

Its object is to make visible a larger gas envelope than can be obtained by the ordinary method of testing. This is attained by suitably introducing to the full flame a loop of No. 22 S.W.G. copper wire. The effect of the insertion of the loop is to asbtract

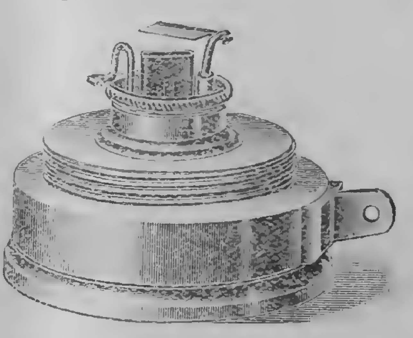


Figure 2.

The Cunynghame-Cadman Device.

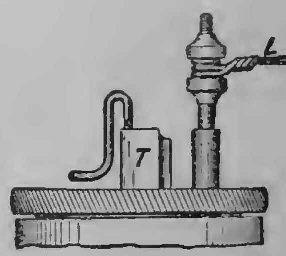


Figure 3.

The Briggs Loop—withdrawn from the flame.

heat from the flame in sufficient quantity to destroy the incandescence of the minute carbon particles which give rise to the white light, thereby rendering the test flame practically non-luminous. As the introduction of the loop does not greatly reduce the size of the oil flame a large test flame is produced, which, it is claimed, can be easily standardised by adjusting the position of the loop.

The loop is one-eighth of an inch broad, and in length is equal to the breadth of the wick tube. It is supported on a vertical brass stalk which extends through the oil vessel of the lamp. This can be operated so as to move the loop horizontally in or out of the flame as required. A certain amount of vertical movement can be obtained on the stalk. The upper end of the vertical stalk with the loop *L* attached is illustrated in *Figure 3*. *Figure 4* shows the loop, fitted to a Davis A1 fireman's lamp, in the position for testing.

The testing flame is produced without drawing down the wick, hence, there is no risk of losing the light. The device can be fitted to any type of lamp, and as it is not delicately constructed promises to be a useful aid to gas testing.

The loop accentuates the "fuel cap" with all common safety-lamp oils. It is necessary, therefore, to become familiar with the appearance of the test flame in pure air before and after the insertion of the loop. With a reasonable amount of training it is claimed that a person can detect well below ½ per cent. of gas.

The Clowes Hydrogen-Oil Safety-Lamp.—This is essentially an oil lamp, adapted to take hydrogen from a small cylinder attached to its side for testing purposes.

As a rule the oil lamp used is of the improved Gray type, admitting air below the flame from three or four vertical tubes. The oil vessel is provided with a special fitting to which the small steel cylinder can be rapidly attached. From this fitting a fine copper tube extends through the oil vessel, and terminates near the oil wick. The cylinder is provided with a valve to regulate the supply of hydrogen to the jet tube. It is attached to the lamp only when testing for small percentages of gas, during which process it serves as a convenient handle. At other times the cylinder may be carried in the pocket. See *Figure 5.* The oil flame is used for ordinary purposes of illumination, and for testing in air containing 2½ per cent. or more, the reactions being the same as in any other lamp.

If no distinct cap is seen on the reduced oil flame, the hydrogen cylinder is taken from the pocket and attached to the special fittings. The valve is slowly opened and hydrogen gradually admitted to the jet, where it ignites at the oil flame. The oil flame is now extinguished by drawing down the wick, and the gas tests made on the small hydrogen jet.

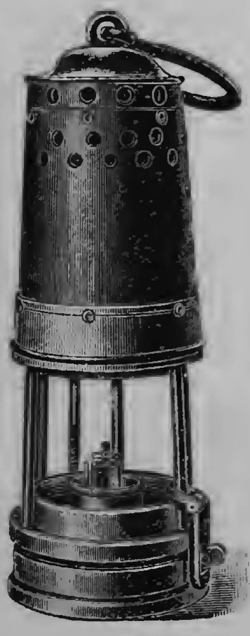


Figure 4.
The Briggs Loop in test position.

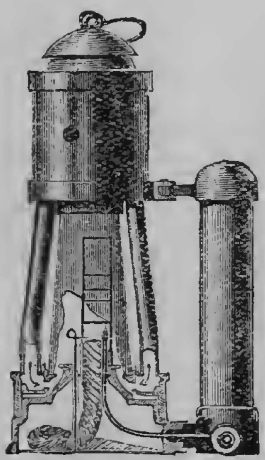


Figure 5.
The Clowes Hydrogen-Oil Safety Lamp.

Like all other test flames, the hydrogen flame must be standardised before definite results can be obtained. The standard height used is 0·4 inch. As the flame is naturally non-luminous no further adjustment is necessary. The caps obtained on such a test flame are as follows:—

Percentage of Gas.	*Height of Cap in Inches.*	*Remarks.*
·25	0·7	Cap pale and hazy in outline.
·50	0·7	Cap more definite in outline.
1·00	0·9	Increased definition and density of colour.
2·00	1·2	Ditto, ditto.
3·00	2·1	Ditto, ditto.

When the hydrogen test is completed the oil wick is pushed up and kindled at the hydrogen jet. The hydrogen valve is now gradually closed and the cylinder detached from the lamp.

A ladder scale is provided with the lamp to denote the gas percentages. The bottom wire of the ladder marks the height of the standard flame. The tip of the copper jet tube must always be precisely 0·4 inch below the standard mark. The other register wires on the scale indicate the percentages given in the above scale.

For fine readings, such as are required by the Coal Mines Act in intake air-ways, in return air-ways, in open light pits, and in any circumstances in which there is less than 2 per cent. of gas, this appliance, in the hands of an experienced person, should prove useful.

The Stokes Alcohol Lamp.—This is a gas-testing lamp devised by the late Mr. A. H. Stokes, H.M. Inspector of Mines, and is a modified Gray safety-lamp to which a small vessel containing absolute alcohol can be attached for fine testing. The safety-lamp itself is used in the ordinary way for illumination, and for testing for gas in air containing 2½ per cent. or more. If no distinct cap is shown on the oil flame, the alcohol vessel is attached to the oil vessel. The former has a long wick which, when in position for testing, extends through the oil vessel, and terminates near the oil wick, at which it can be ignited. After the alcohol flame has been properly established the oil flame is extinguished by drawing down the wick by means of the pricker. Further tests are now made on the non-luminous alcohol flame.

The standard flame is half an inch high, and gives the following caps:—

Percentage of Gas.	*Height of Cap in Inches.*	*Remarks.*
0·5	0·60	Very pale. Not clearly seen.
1·0	1·00	Pale blue. Clearly seen.
1·5	1·44	Pale blue. Clearly defined.
2·0	1·68	Clear blue. Cone.
2·5	2·00	Distinctly defined cap.

The alcohol tester is not intended to be used until the oil flame has failed to detect gas. As it is small and can be carried in the waistcoat pocket, the appliance should be a useful aid to an official having occasionally to make fine observations.

The Garforth Gas Detector.—This detector is specially useful for shot-firers in their examinations previous to the firing of shots, and was highly commended by the late Royal Commission on Mines.

The principle of this device consists of collecting a sample of the atmosphere to be tested by means of an indiarubber ball, and passing it through a tube into the oil vessel, to the oil flame, at which it is ignited. In the report of the Royal Commission Mr. Garforth describes the arrangement as follows:—

"The detachable rubber ball is inserted into a break in the roof, and after the air contained in it has been expelled by pressure of the hand it is allowed to expand, whereupon it becomes filled with a sample of the suspected atmosphere. The contents of the ball are then introduced on to the flame of the lamp through a safety gauze-protected pipe, which the brass nozzle of the ball exactly fits. If fire-damp be present it is shown by an elongation of the lamp flame, and by a blue cap burning at the top of the gauze-pipe, which latter is fitted with a small spring valve raised when desired by the serrated brass nozzle of the ball. . . . As the method of detecting fire-damp by means of the indiarubber ball has been in daily use for the past twenty-four years, it is interesting to note that the opinion of more than one hundred colliery officials is:—

(*a*) That the ball enables a deputy to discover fire-damp which cannot be found by the ordinary tin shield lamp. . .

(*b*) That it is safer to bring a suspected atmosphere to the lamp by means of the ball than to introduce a lamp into gas. . . . ."

Other claims are made for this device, which undoubtedly is a useful appliance.

Numerous other special gas detectors are made, but probably sufficient have been mentioned to indicate the general nature of the methods adopted to detect fire-damp without having recourse to gas analysis.

PRIZE COMPETITION.

" Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXII.

In this column we give *Twelve Questions* in each issue—four Preparatory, four Second Class or Under-Managers, and four First Class or Colliery Managers. The competition is open to all who have not secured first place in Honours or First Class in earlier volumes, and competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of One Shilling. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer, with the question attached, must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches (wherever they are desired they should be given) must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript.

The answers submitted by Competitors will be awarded marks according to order of merit, The SELECTED PUBLISHED ANSWER will possess a value of *15 marks;* whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. At the end of the volume the total marks obtained by each Competitor throughout the volume will be added together to ascertain the three Competitors in each stage whose work has in general been distinguished by the highest degree of merit. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured.

The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

Then in addition to the prize awarded each issue for each successful answer in each stage, we offer the following special prizes:—We shall give Book Prizes to the three competitors who have in the aggregate obtained or been awarded the highest number of marks on the answers submitted for competition during the volume in the Preparatory Stage; also three in the Second Class and three in the First Class. The photo of the most successful of the three First Class men will be published, and he cannot take part in the Competition of later volumes. The Editor will give—in addition, of course, to the Publishers' prizes—special prizes to the best student in each Stage; the students will be allowed to make their own selection, the value in the case of the Editor's prizes being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than

Tuesday, May 7th, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

—READ THIS: IMPORTANT REGULATION.—

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the head of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[*In all cases where quotations or extracts are made the source and authority must be stated. The selected answers to the following questions will appear, not in No. 20, Vol. XXII., but in No. 21, Vol. XXII.*]

PREPARATORY.

Q. 1. ROPE BORING.—*Describe simply the method of putting down a deep bore-hole by the American system of rope boring.*

Q. 2. EXPLOSIVES.—*Briefly and concisely, under what circumstances do you consider a high explosive preferable to ordinary gunpowder?*

Q. 3. SUPERHEATED STEAM.—*What advantages are claimed for superheated steam?*

Q. 4. WALLING CRIBS.—*If you were engaged in fixing a walling crib or curb in bad ground, what precautions would you take?*

SECOND CLASS.

Q. 5. METHODS OF WORKING.—*What would guide you as to the length of a wall face in working a seam of 3 feet thick and under?*

Q. 6. TIMBERING.—*Sketch the various systems of timbering with which you are acquainted, and briefly explain the circumstances suitable to each.*

Q. 7. VENTILATION.—*Give the rule and an example in estimating the work done in ventilation at a colliery by a fan.*

Q. 8. PUMPS AND PUMPING.—*What diameter of pump will be required to deal with 500 gallons of water per minute, allowing 10 per cent. off for leakage, if the effective speed of the pump is 35 feet per minute?*

FIRST CLASS.

Q. 9. SURVEYING.—*Describe a level chain and levelling staff. State for what each is used, and the means you would adopt for testing the chain.*

Q. 10. TIPPLERS.—*Describe one modern type of automatic tippler, showing the method of operating it.*

Q. 11. VENTILATION.—*What means would you adopt to ascertain if the ventilation of a mine, working with naked lights, was adequate?*

Q. 12. PUMPS AND PUMPING.—*Sketch a pump suitable for raising 6,000 gallons of water per hour through a vertical height of 160 yards, and give principal dimensions.*

Best Answers Received to Questions in No. 17, Vol. XXII.*

With Notes by C.C.M.

PREPARATORY.

Oil Shale.

Q. 1.—*What is oil shale, and what useful substances are obtained from it?*

A.—Oil shale is consolidated mud or clay, which has been altered by time and pressure and is found stratified in various formations. Bituminous shale, as it is called, has been found in various parts of the world. It is regarded as mineral matter, which has been impregnated largely with the products of decaying vegetation during the time of its formation. In appearance, oil shale resembles some coals, which only differ in degree, or shall we say in the quantity of vegetable matter or bye-products, which they contain. Oil shale, like coal, may be called stratified rock, containing mineral matter and other volatile products. Many oil shales have been known to yield great quantities of mineral matter, as much as 80 to 90 per cent., and in some cases 20 per cent. of other volatile matter.

Peel, in his *Coal Mining* (page 20) tells us that large quantities of oil shale are annually worked in the United Kingdom. The shale industry is carried on to a great extent in Scotland, due to the fact that it is rich in oils, both burning and lubricating oils, and many other useful substances, which make the shale industry a profitable one.

In order to ascertain what useful substances are obtained from oil shale, we know that the shale must undergo some process in order to obtain the useful substances from it. This is accomplished by what is known as distillation, which is brought about by heating the oil shale in special apparatus, or closed retorts, similar to those employed in the manufacture of gas. When oil shale is heated in the closed retorts or furnaces, a solid substance is left called charcoal or coke; also many other useful substances are brought into existence by this process.

In connection with this process of distillation, we find that many volatile products are obtained. Some of these products are permanent gases, such as hydrogen, carbon monoxide, carbonic acid gas, &c., and many hydro-carbons. In addition, we have the remaining tarry liquids, which are collected in tanks or receivers. This tarry liquid, by special processes of distillation, is found to contain various useful substances, known as light oils, medium oils, and heavy oils. After the oils have been extracted there remains something in the form of grease. This is further distilled and separated until nothing is left but pitch,

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

being used for making asphalt artificially, and the modern artificial fuel known as briquettes.

Oil shale by various processes of distillation contains many useful substances which may be related as follows:—By the distillation of shales we get many useful substances, such as ammonia, naphtha, benzene or benzole, vaseline, bitumen, asphalt, crude naphtha, and various other products. From oil shales we get many kinds of mineral oils.

Petroleum and paraffin oils are obtained in great quantities; in some instances the oil has been found dripping from the shales, and thus collected. It is useful for burning in lamps.

Heavy oils are also obtained, being utilised for lubricating purposes. Paraffin wax is also obtained for candle making.

In conclusion, oil shale, like coal, by distillation and analysis, is found to contain many useful substances. These substances can be separated by fractional distillation, and utilised for many useful purposes.

Assisted slightly by ADAM'S *Chemistry*, Chapter VIII.

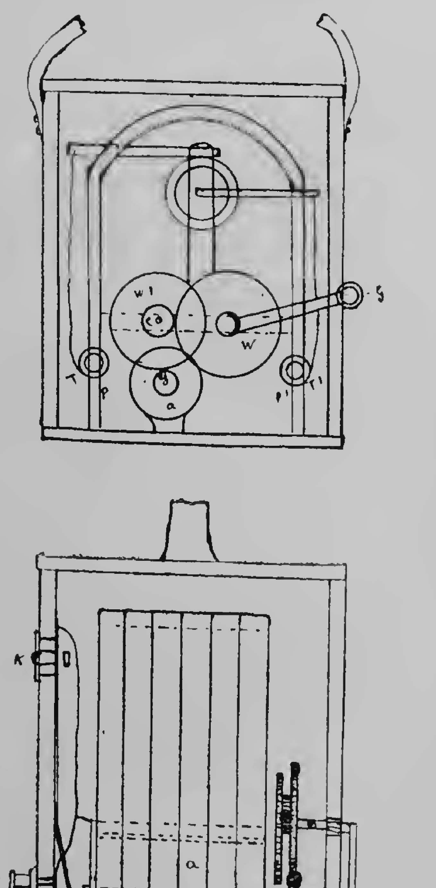
THOS. GASKELL, 138, Downall Green Road, Bryn.

L. J. Thomas, W. Glover, W. Heaton, J. Smith, Junr., J. W. Brough, A. Thomson, W. Williams, A. Moores, J. Brooks, W. Atherton, C. Simpson, J. C. Rodman (*12 marks each*).

G. Poll, T. Evans, Junr., J. E. Tredgold, D. McBurnie, T. U. Parr, G. Davies (*8 marks each*).

Shot-Firing.

Q. 2.—*Which is the best electric battery to use—high or low tension? Give reasons.*



Illustrating Question 2.

A.—The electric battery consists of an armature revolving between two poles of a set of magnets. The general scheme of the battery may be gathered from the accompanying sketches, where a shuttle armature (*a*) is shown in gunmetal bearings concentrically with soft polar extensions (*P* and P^1). The latter pieces, which serve to distribute the magnetic fluid, are enclosed by the legs of horse-shoe magnets arranged with their positive poles together on one, and their negative poles together on the other side, so as to form a powerful magnet. A high armature speed is attained by suitable toothed wheels (W, W^1, e and e^1), the main driver being actuated by a detachable handle (*g*). The opposite side of the hard wood containing case carries terminals (T and T^2), and a push botton (*K*). The battery is enclosed in a box of polished teak wood, and is suitable for firing high and low tension detonators. Nobels' Twist exploder is capable of firing both high and low tension detonators.

In selecting a suitable battery you also have to select the kind of detonators you are going to use, since a high tension battery is only suitable for firing high tension detonators, and the same with low tension batteries. Advantages are claimed from detonators, both high and low tension. Low tension detonators can be tested by a galvanometer before they are sent into the mine, thus reducing the liability of miss-fires, but with high tension detonators it is impossible to test them without destroying them. With high tension batteries producing a high voltage and little current, high tension detonators may be fired, and with low tension batteries producing a large current with a low voltage low tension detonators may be fired, so that the type of battery governs the type of detonator. In using a magneto exploder grip it firmly with one hand, and after connecting the wires to the terminals, turn the handle a few times sharply, and then press the firing button while the handle is still being turned. Care should be taken not to touch the terminals when firing, as when using a low tension battery there is a danger from shock. The low tension battery may generate sufficient current to do serious injury should the physical condition of the person using the battery be very weak. High tension detonators are subject to climatic conditions, as they are affected more or less by moisture and heat; on the other hand, low tension detonators are more liable to go wrong or to fail in manufacture owing to the extreme fineness of the platinum wire. Thus, considering the many conditions for selecting a suitable battery, in my opinion the most suitable for mining in coal is the high tension, but for sinking shafts I should prefer a low tension battery with suitable detonators.

Assisted by BAILE'S *Modern Mining Practice.*

J. H. CUMBERBATCH, 4, Degg's Fields, Longton, Stoke-on-Trent.

[NOTE.—The fact that there are two classes of electric battery and detonator in general use makes it difficult for the "man in the street" to say definitely which type is the better. One feature in favour of low tension caps, and, therefore, indirectly, in favour of low tension batteries, is that they alone can be tested before use, without exploding them. A feature of high tension batteries is that they can be used, within limits, to fire low tension, as well as high-tension caps, and this, of course, is in their favour. We have selected the above answer because the writer gives the conditions under which each is the better. Taking the other answers, it may be said that there are just about as many in favour of one system as of the other.—C.C.M.]

W. Heaton, C. Simpson, J. C. Rodman, T. Evans, Junr. A. Davies, W. Atherton, W. Williams, J. Smith, Junr., T. Gaskell, L. J. Thomas, J. Bradshaw (*12 marks each*).

G. Davies, J. A. Hill, J. Brooks, D. McBurnie (*8 marks each*).

Electric Terms.

Q. 3.—*Explain what is meant by the electric terms "high," "medium," and "low" voltages.*

C. Simpson, J. E. Tredgold, J. C. Rodman, T. Evans, Junr., F. Kershaw, J. Brooks, J. H. Spence, J. Cheetham, A. Moores, I. Hollins, A. Thomson, W. Williams, S. F. Middup, J. A. Hill, Geo. Winfield, F. Mitchard, T. Gaskell, G. Davies, L. J. Thomas, W. O. Dodd, J. Scott, W. Bretton, E. R. Hindle, W. Glover, T. G. Lippitt, J. Bradshaw (*12 marks each*).

Horse-Power of Engines.

Q. 4.—*What horse-power of engine would be required to raise 1,000 tons of coal in eight hours from a depth of 480 yards?*

A.—Assuming that the eight hours is the actual winding time for coal only, the number of tons to raise per minute will be

$1{,}000 \div (8 \times 60) = 2\frac{1}{12}$ tons. Taking the average speed of winding as 1,800 feet per minute, or 30 feet per second, one wind will take $\dfrac{480 \times 3}{30} = 48$ seconds, and allowing (say) 10 seconds for banking we have $48 + 10 = 58$ seconds per complete wind. As we have to wind $2\frac{1}{12}$ tons per minute, every wind we must raise $\frac{58}{60} \times 2\frac{1}{12} = 2$ tons (nearly).

Now, find the weight of the rope. The cage will weigh as much as the coal, and reckon the tubs to weigh half as much.

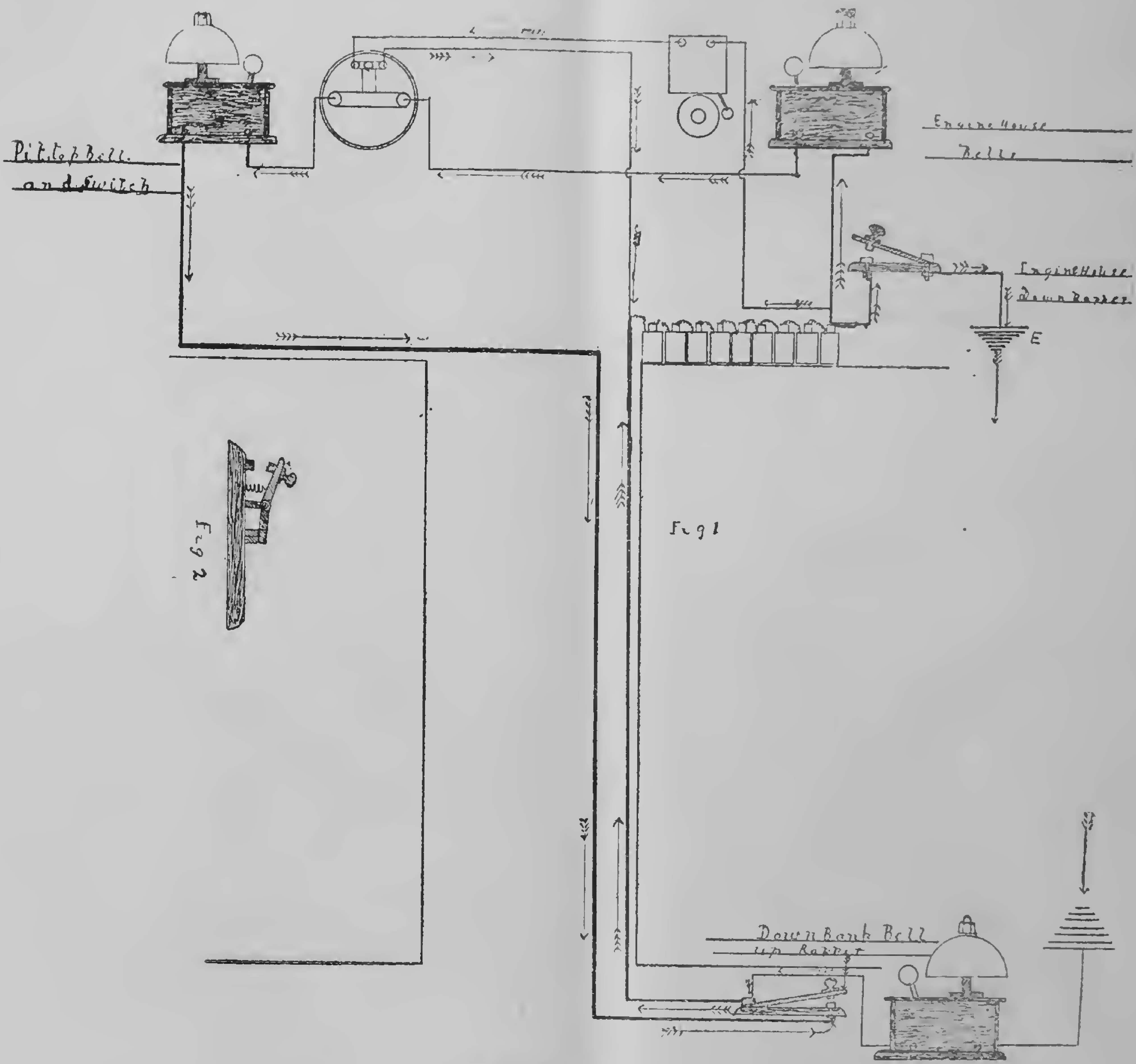
It will be seen that the cages and tubs will balance each other, therefore, the engines have only to lift the coal and the rope, which is $4{,}480 + 4{,}094 = 8{,}574$lb.

The horse-power of the engine will be

$$\frac{T \times V}{33000}.$$

Where T = total weight on engines;
V = velocity in feet per minute.

Then



Illustrating Question 5.

We have 5 tons or 11,200lb. at the end of the rope. Now

$$W = \frac{L}{1792 - D}.$$

Where W = weight of rope per yard in lb.;
L = total load at end of rope in lb.;
D = depth of shaft in yards.

Then

$$W = \frac{11200}{1792 - 480} = 8{\cdot}53\text{lb.}$$

Therefore, the total weight of the rope hanging in the shaft will be $480 \times 8{\cdot}53 = 4{,}094$lb.

$$\frac{8574 \times 1800}{33000} = 468 \text{ H.P.}$$

Owing to the intermittent work of the engine, the attaining of a high speed in the shaft and other considerations, I would make one cylinder of the winding engine equal to this horse-power, therefore, the total horse-power required would be $468 \times 2 = 936$ H.P.

Indebted to back numbers of *The Science and Art of Mining* for assistance in the preparation of this answer.

JOHN A. HILL, St. John's Chapel, Co. Durham.

[NOTE.—The majority of answers merely give the theoretical horse-power represented by the raising of the coal in the given time, taking no account whatever of the weight of rope to be lifted, friction of engines, and other contingencies. If it were necessary to adopt or design a pair of engines to do the work in the question the engines would be made of such a size as to give not less than 1,000 horsepower.—C.C.M.]

T. Telford, W. Atherton, F. Taylor, J. H. Cumberbatch (*12 marks each*).

J. Bradshaw, J. Lawrie, Junr., W. Glover, W. Bretton, F. Mitchard, J. Smith, Junr., J. W. Brough, S. Beardsley, J. H. Spence, J. Brooks, J. L. Hughes, A. Davies, E. J. Baber, C. Simpson, J. C. Rodman, W. May, J. E. Tredgold, S. F. Middup, E. R. Hindle (*8 marks each*).

G. Poll, T. Evans, J. Ridgeway, F. Kershaw, T. J. Hay, A. Moores, T. Douglas, I. Hollins, W. Williams, A. Thomson, D. McBurnie, G. Winfield, T. U. Parr, T. Gaskell, G. Davies, D. McCarely, W. O. Dodds, J. Scott (*4 marks each*).

SECOND CLASS.

Signalling.

Q. 5.—*Describe the best method of signalling you are acquainted with* (a) *in sinking shafts*; (b) *in winding shafts.*

A.—In the most modern mines, some of which are sunk to great depths, electric signalling finds a great deal of favour in communicating from the shaft bottom to the surface, as the signals can be given more rapidly and with greater precision. The old ordinary hammer is employed at some mines of shallow depths up to about 100 fathoms, but beyond this depth it is better to use the electric signal. The power used for electric signals is generally obtained from a number of Leclanche cells, the number used being according to the resistance to be overcome. As General Rule 8 does not apply to winding shafts unless winding is being carried on in the upcast, the stipulated voltage must be adhered to, viz., 250 in any one circuit.

The best method of signalling which I am acquainted with is shown in sketch. It can be equally applied in sinking shafts and winding shafts, only as the sinking proceeds the live wires will be required to be carried forward. For electric signals in sinking or winding shafts I would prefer the single stroke bell, both on surface and at shaft bottom, as the signal is much better and distinct. The sketch shows the single stroke bells on pit-top and in engine house. These bells, where winding operations are carried on, will ring simultaneously as shown by diagram when the switch on the pit-top closes the circuit. The low resistance trembler in the engine house connects the engineman with the banksman. When the banksman communicates any signal to the engineman the engineman can only receive that signal, as the switch on an arrangement of this description would only require one man and the putter in, as automatic greasers would be used underground.

Peter Wilson, 54c, Elizabeth Street, Workington, Cumberland.

[Note.—For giving definite and distinct signals there is nothing superior to the single stroke electric bell. The one point in which the "trembler" has the advantage lies in the fact that if the wires are in contact anywhere up the shaft the bell will continue ringing, until, of course, the batteries run down, and thus give notice that there is something out of order. We always advocate a wire and knocker arrangement to be kept in a shaft in case the electric signals should get out of order. This is also the kind of signal which we prefer for a sinking pit. It can be easily lengthened, and besides, it is not liable to damage through shot-firing, as is an electrical installation.—C.C.M.]

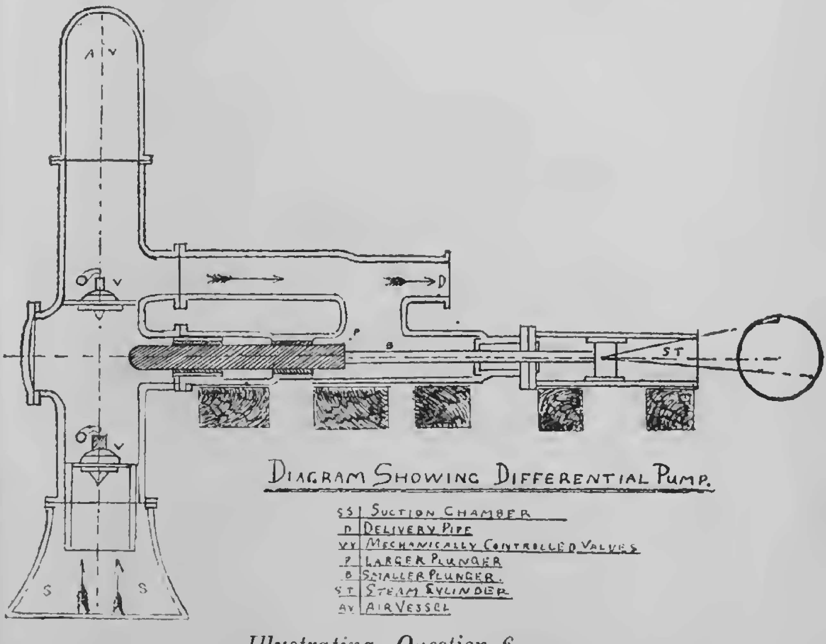
A. Nelson, W. H. Brealey, R. Graham, A. Stephens, E. Ambrose, J. Grundy (*12 marks each*).

Pumps and Pumping.

Q. 6.—*Describe the principle of the differential or telescopic pump, and say how it is applied in deep mines.*

A.—The requirements of this question are somewhat doubtful, the only connection the term "telescopic" has in pumping (as far as the writer is aware) is in sinking pumps which are sometimes provided with sliding or a telescope suction pipe, to reduce the inconvenience of constantly lowering the pump itself. Again, when considering the first term, viz., differential, we naturally think of the pump introduced by Professor Riedler, of Berlin. However, I intend discussing the latter, as it is *the* pump in deep mines.

As seen in the sketch, its action can be readily understood. It is double-acting, and is specially suitable in deep mines. Unlike ordinary double-acting pumps, it has only two valves—one suction and one delivery—therefore, the pump has less moving parts, and the efficiency is enhanced. The most important feature of this pump lies in its valve action. The valves open automatically, *i.e.*, by the action of the water underneath them, but are closed *at the proper instant* mechanically—by means of a specially designed controller, conducted from the engine shaft. The advantages thus obtained are numerous: (1) Slip is considerably reduced, with a consequent increase in efficiency; (2) the water is not unnecessarily impeded while on its journey; (3) water hammer and shocks are practically avoided, and thus wear and tear, especially of the moving parts, is greatly reduced. While the piston or plunger is making its backward stroke (to the right in sketch) the upper valve leading to the delivery main is closed (by the little fork just above it actuated through the medium of the controller) at the proper instant, independent of the reaction of the water which must occur immediately the plunger completes its forward stroke. Immediately the plunger has completed its backward stroke the suction valve is mechanically shut at the proper instant, and this process is repeated as long as the mechanical controller



Illustrating Question 6.

is kept in repair. The tappets or forks above each valve must be carefully protected and supervised, otherwise dirty water will soon have effect, either in totally "clogging" them, or destroying their accurate action.

The action of the pump may be briefly stated as follows:—The plunger on its forward stroke (to the left) forces the water before it, through the delivery valve V, and into the delivery main, as indicated by the arrows; half the discharge passes through the pipe D; the other half lodges in the barrel B. On its return stroke the *difference in area* of the two sections of the plunger discharges the water in the chamber B through the delivery pipe D; the result is obviously a double-acting pump. This constant delivery of water makes it well adapted for high lifts, which will have to be considered in future mining operations.

As seen in the diagram, the plunger proper consists of two sections. The outer one P is twice the sectional area of B, therefore it is apparent that half of each delivery of water will accumulate in this difference of area as said above. On account of the valve arrangement of this pump it is usually worked at a high speed, from 90 in the larger sizes to 140 or 150 in pumps of smaller capacity. Pumps generally do not allow of being driven direct by means of a motor, on account of the great difference in speed between the two, but in the case of the Riedler pump this direct coupling is possible, and, therefore, this adaptation of speed is very important in increasing the efficiency. As regards the larger sizes, the connection may be obtained either by means of a belt or rope, and it is urged that these provide an elastic medium between the somewhat impulsive action of the pump and the uniform motion of the motor. The introduction of this kind of pump enables a more extensive employment of electricity, for it provides a closer adaptation of speed, which is essential for efficient working of electricity.

It is provided with a barrel-like air vessel, fixed above the delivery valve; it is also convenient to have another formed round the suction, as shown in the diagram. These store up energy and impart it back to the water when the delivery is checked by the reciprocating motion of the plunger. Therefore, a constant delivery is maintained.

If I had the option of driving this pump, a three-phase induction motor, direct coupled, would be installed; seeing that it possesses no commutator, sparking is practically absent. The power could be conducted by means of a three-core cable, with good insulation. If the roadway along which it was carried was extensively used for haulage and travelling purposes, I should place the cable in prepared wooden boxes, provided with troughs in which it may rest. The box should then be well covered with pitch, not that it is a good insulator, but it will prevent damage to the cable when the top is not of a strong nature.

This answer is strictly original; the sketch is drawn from memory.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

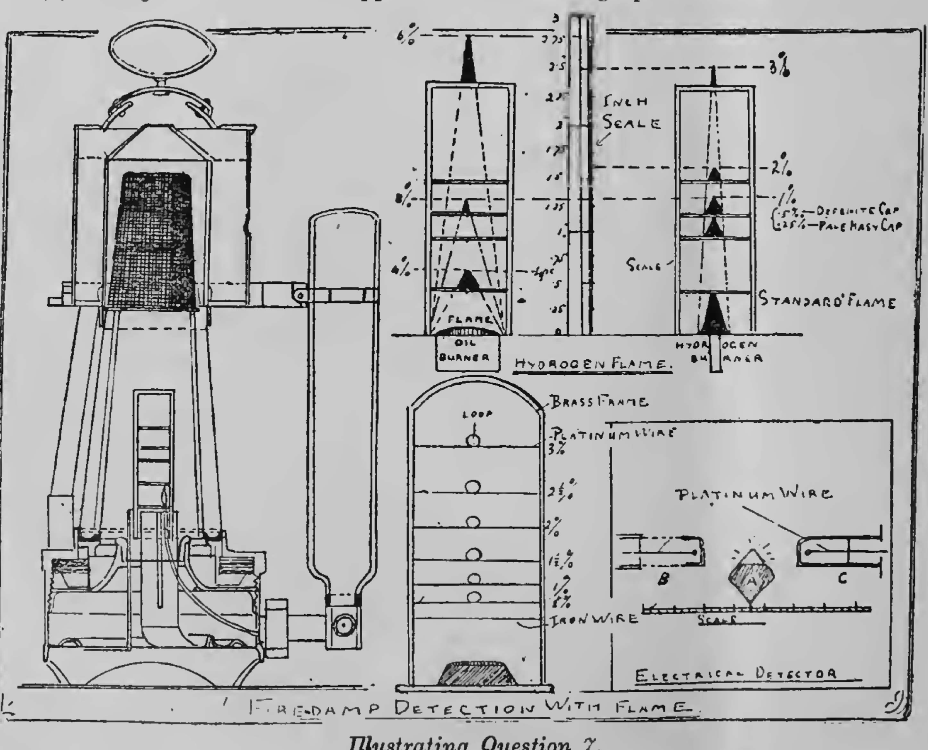
A. Stephens (*12 marks*).
E. Ambrose (*8 marks*).

Gases in Mines.

Q. 7.—*What methods are employed for detecting the principal gases met with in coal mines? What proportion of atmospheric air renders them harmless?*

A.—The estimation of fire-damp in mine air consists chiefly of observing the behaviour of the flame of a protected lamp when introduced into the atmosphere supposed to contain inflammable gas. Testing the air should, strictly, be divided into (*a*) testing in air which is supposed to contain large percentages of gas; and (*b*) testing when it has been proved by experiment that the percentage supposed to be present is very minute. Therefore, the first operation is to see what amount of gas is likely to be present, which can readily be done by the use of an ordinary miner's safety-lamp; if the lamp shows no sign of gas, then recourse must be had to more scientific and sensitive methods. Practically every miner is familiar with the appearance of the "blue cap," and a device whereby this phenomenon is employed appeals more strongly to the majority than any other apparatus. There prevails no doubt whatever that for any instrument designed for gas detecting underground, simplicity is most important, and the "cap" test possesses this qualification to a high degree, but, as in many other cases, simplicity and accuracy are not synonymous terms, and every gas detector utilising it suffers greatly from three defects: (1) The personality of the operator enters into every determination, *i.e.*, one person may easily see the action of gas upon a flame, even with low percentages, whilst another with the same lamp could see nothing unusual, in some cases colour blindness, eye troubles, and nystagmus being responsible. (2) The cap as employed to measure small percentages of gas must, to enable reliable results to be obtained, be maintained of a uniform height. (3) With some lamps a cap may be perceived when ·25 per cent. of gas is present, yet if the lamp is raised into a higher zone containing ·5 per cent. (100 per cent. increase), the resulting elongation of the cap is hardly perceptible. When testing with the ordinary lamp the flame is lowered until only a speck of yellow is to be seen, and the size of the yellow speck forms the criterion on the size of the test flame; so that the flame can be reset to the standard height each time an examination is made. The more delicate gas-testers, however, employ a large flame as a testing flame; its standard height can only be procured in fresh air (in the intake or near the bottom of the downcast shaft), and it should not be re-adjusted in air likely to contain impurities, on account of the effect of "spiring"; therefore, we can never be certain whether, in examining the air, the flame has crept up or worked down a little. The height of a cap over a flame when enveloped by a gaseous mixture depends directly on—(1) The length of the flame or standard height; and (2) the intensity of the flame. At this stage in dealing with this matter I acknowledge indebtedness to GREENWELL'S *Pocket-Book*. In the first case, all improvements on the original Davy (burning colza) so as to make the lamp a better gas detector, were based on the first of these conditions, or on both in combination. As gas-testers, the lamps usually employed in this country may be said to be improvements on the Davy by the use of different oils, or mixtures of oils, giving a flame of higher intensity than the Davy. The improved Gray lamp is also an improvement upon the Davy, but a higher temperature flame, that of benzoline, is used in it; it enables a careful operator to detect about 1·5 per cent. of gas. The same may be said of the Wolf (benzine) lamp, which also can detect about 1·5 per cent. Of the lamps designed to take advantage of both of these facts, *i.e.*, length and heat of flame, must be classed the alcohol lamps of Pieler, Chesneau and Stokes, and the hydrogen lamp of Clowes. Of the alcohol lamps in this country the best known is the Pieler. This is a gas-testing lamp pure and simple, and, therefore, an ordinary lamp must be carried with it as an auxiliary. This lamp is capable of detecting as low as ·5 per cent. of gas.

Originally, the Pieler lamp may be described as a large unprotected Davy, in which alcohol is burnt in place of colza, a round wick, preferably of silk, being used. The flame burns inside a short chimney, which serves a double purpose, namely, shielding the eyes from the faint rays of the flame, and forming a means of adjusting the flame to a standard height (1·2 inches); the tip



Illustrating Question 7.

of the flame being set exactly on a level with the top of the chimney, in gas-free air, previous to commencing any tests. This lamp is greatly improved by enclosing it in an iron shield possessing a graduated glass or mica window. With this addition, introduced by Mr. W. N. Atkinson, the lamp is rendered suitable for use in moderately rapid air currents, and also providing a ready means of reading off, to a fair degree of accuracy, the gas percentage as indicated by any length of cap.

Next is the Clowes' hydrogen lamp (see illustrations), a very scientific and delicate gas-tester based on the flame test. In reality it is an A.H.G., fitted with a gas-testing attachment. It owes its excellence and delicacy to the employment of the hottest and least luminous of all gaseous flames, namely, that of hydrogen. In both of these respects, therefore, it forms the highest development of this class of gas-detectors. In *Figure 1* is shown a vertical section through the instrument. It shows the small detachable cylinder containing compressed hydrogen at the side. This supplies the small hydrogen flame (shown burning in the sketch) when examining the air for fire-damp. The flame is adjusted to the standard height by means of the stop-cock and key. When the lamp is not employed for gas-testing the cylinder is detached and carried in the pocket. The lamp then becomes little else than an ordinary A.H.G. In endeavouring to measure the percentage of gas present by means of the ladder, the eye has not only to distinguish the exact apical point, but also as to the distance, 0·2 inch; whereas, if it happens that the percentage lies between those indicated by two adjacent rungs of the ladder, the eye has further to estimate the interval—an operation complicated by the fact that the rungs are at gradually increasing distances apart. This lamp will detect 0·2 per cent. of gas, and as a means of *detecting* small proportions of fire-damp it is really the very best instrument of its kind. In all cases whereby the blue cap test is used, the results are invaluable as far as *detection* is concerned, but as a means of *measuring* those detected quantities they are not, unfortunately, so reliable.

The percentage (referring to Clowes lamp) is determined as much from the brightness as from the height shown by the cap.

In the illustrations is shown the so-called "electrical detector" of Professor Liveing; the principle may be gathered from the simple diagram. *A* and *C* are precisely similar spirals of platinum wire, which are connected in series to a magneto-electric machine, by means of which they may be heated to a dull glow. *C* is enclosed in a glass vessel containing pure air; *B*, on the other hand, is accessible to the surrounding atmosphere by being enclosed in a gauze casing, having a glass front. Rays from the glowing spirals illuminate the opposite sloping faces of the block *A*, the sides being covered with white paper. If no gas is present the spirals will glow equally brightly, and the block will have to be adjusted exactly midway between them, so as to have the sloping surfaces equally illuminated. If a small percentage of gas is present the brilliance of *B* increases, due to the fact that a hot wire has the property of slowly burning out the fire-damp from the air in its vicinity; therefore, in order that the sloping surfaces of the block *A* shall be again equally illuminated it must be moved in the direction of *C*, and by means of a scale underneath graduated by trial experiments in various mixtures of gas and air.

What Proportion of Atmospheric Air renders them Harmless?

Fire-Damp.—The actual proportion of fresh air necessary to so dilute this gas as to render it harmless can only be determined by discussing its effects upon the system at certain percentages. The effects produced are those produced by a diminution of oxygen. According to the new Coal Mines Act any current which contains upon examination more than $\frac{1}{4}$ per cent. of fire-damp must be considered dangerous, and not free from gas, therefore to render ·25 cubic feet of fire-damp harmless we must have (100 — $\frac{1}{4}$) $99\frac{3}{4}$ cubic feet of atmospheric air to mix with it. If we have 1 cubic foot ($\frac{1}{1} \div \frac{1}{4}$) we must increase our air supply four times, or $99\frac{3}{4} \times 4 = 399$ cubic feet, &c.

Carbon Dioxide.—The actual percentage of this gas in mine air, or strictly speaking fresh air, is 0·03 per cent. by volume. According to the above Act, a working place is not inhabitable when the CO_2 exceeds $1\frac{1}{4}$ per cent., therefore, for every $1\frac{1}{4}$ cubic feet of CO_2 we must supply (100 — $1\frac{1}{4}$) $98\frac{3}{4}$ cubic feet of atmospheric air, or if we desire to have a safety margin of not more than 1 cubic foot of CO_2 in the air, we must have (100 — 1) 99 cubic feet of fresh air to render it harmless.

Carbon Monoxide.—The highest allowable limit for this gas in the air is 0·05 per cent., therefore, if 0·05 cubic foot of this gas exists anywhere, a supply of (100·00 — ·05) 99·95 cubic feet of fresh air is essential to maintain safety. If 1 cubic foot is present a supply of (1·00 ÷ ·05) 99·95 × 20 = 1,999 cubic feet of atmospheric air is necessary to render it harmless.

Sulphuretted Hydrogen.—Even 0·05 per cent. of this gas is capable of producing alarming symptoms upon a man. It should never exceed ·01 per cent. in any case, and it is questionable whether this minute percentage is harmless. Thus, ·01 ($\frac{1}{100}$ of a cubic foot) requires 99·99 cubic feet of air, whilst 1 cubic foot of this gas will require 99·99 × 100 = 9,999 cubic feet of air to render it harmless.

Latter part of answer is original.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

[Note.—The chemist is going to play a big part in the future in connection with gas testing in mines. He will take samples of air underground, and in the laboratory discover correct to two places of decimals the percentage of oxygen, carbon dioxide, carburetted hydrogen, carbon monoxide, sulphuretted hydrogen, and nitrogen present in such sample. But he must be thoroughly conversant with the work. We have seen a little amateur testing, and it was not at all convincing. Unless the tester is a thoroughly competent analyst, we should prefer to pin our faith to testing by the hydrogen flame; at any rate, as far as fire-damp is concerned. As we said in our remarks recently, when comparing the theodolite with the ordinary dial, seeing that the theodolite is so much finer an instrument than the dial, and, therefore, capable of much more exact results under suitable conditions, it is at the same time, and perhaps as a natural consequence, far more capable of error if carelessly used. In the same way we believe that the chemical analysis of mine air, if unskilfully carried out, is capable of bigger blunders than the ordinary flame tests, although, if properly employed, it will give us far more exact results. Of course, we must not forget that the flame test is no use for the testing for percentages of any of the other gases, although it will give some indication of their presence, especially in the case of carbon dioxide. —C.C.M.]

A. Stephens (*12 marks*).
E. Ambrose, R. Graham (*8 marks each*).

Surface Arrangements.

Q. 8.—*What inclination would you lay your railway sidings under the screens on the surface? What inclination would you lay your rails at pit-eye for full tubs?*

A.—It must be remembered that, especially in the case of trams, the gravity force of the full tram must be sufficient to overcome all its resistances, and also possess a surplus power to set in motion and gain enough speed or acceleration to make the employment of manual labour unnecessary. Another important point is that the necessary force at the commencement from the pit-eye must be capable of overcoming the inertia of the tram; once having gained speed, the force then necessary to maintain motion is not so great, the only force required being that capable of overcoming the friction of the wheels and in moving through air. But, seeing that the force is constant throughout the length of road (providing the gradient is constant), this tends to accelerate the speed of the tram, hence, these facts must be kept in mind when determining inclinations for any mine wagon or tram. To surmount the undesirable feature of this acceleration during the completion of the journey towards the screening plant, it is usually wise to modify the inclination towards the screens. Also the steepest part of the roadway should be at the top, which will enable the full load to accumulate extra power at the commencement, and the reduced gradient at the bottom of the road near the screen will assist in the retardation of the trams as they approach. Usually the trams, after running by gravity to the tippler at a gentle inclination, are elevated to a sufficient height to enable them to run back to the shaft by gravity. For this purpose a vertical lift or a creeper is employed. The inclination from pit-mouth will depend to a certain extent upon the type of tram used, method of lubrication, and type of rail used. When the tippler is no great distance from the pit-mouth a fair starting gradient is 1 in 42, which will provide the necessary starting of the tram and for accumulating acceleration. Locking or spragging is resorted to for retarding them. If the roadways are fairly long, and moderately clean, 1 in 50 to 1 in 58 is common. For T-head rails, clean and well laid, and providing the run is long, a gentler gradient, such as 1 in 70, may be successful. To ensure success of the easy working of trams from pit-mouth, the rails must be well laid, and as straight as possible, as a tortuous road greatly assists in the derailment of trams. The gradient must be considered too low if it causes the trams to stop on the run, and will, therefore, require pushing; on the other hand, a steep gradient tends to accumulate too great a velocity, and difficulty will be experienced to arrest them. A good idea as to the coefficient of friction of the wagon is of great importance in determining gradients. The resistance to traction through friction at the axle is equivalent to $L \times C \times A$, where L is the total load on axles; C coefficient of friction; and A ratio of axle diameter to diamater of wheel. In addition to this, we must consider the friction due to the rubbing of the wheel on the rails. This may be neglected for practical purposes (being only about $\frac{1}{1000}$ portion of the total load), but in the case of rails being almost covered with dirt and small coal, and the rails' surface sunk below the sides, the resistance thus introduced is very considerable. Consequently, it is economical in all cases of suitable gradients to maintain clean rails, and well elevated above the surrounding ground. Of course, in certain cases, such as where the gradient is made of necessity steep (on account of surface undulations), and it is found that trams gain too high a speed, the rails are usually covered with a fine coating of sand or dirt. Where curves are negotiated the gradient must be steeper, 1 in 30 to 1 in 35 being usual. Curves vary from 6 to 16 feet radius—for easy running they should never be less than 8 feet; a common radius is 10 feet.

The sidings underneath the screen are usually laid according to the capacity of the wagons. For 12 tons capacity, which is common in this country, an inclination of 1 in 75 in favour of the load is very suitable. For 50-ton wagons, common on the Continent, 1 in 90 to 1 in 100 is sufficient, if kept clean. For use directly under screens, where no rope is used for moving the wagons, 1 in 60 is most usual, and lowered to 1 in 70 and 1 in 90 as the length of the sidings increases. At a colliery I am acquainted with the inclination at the sidings, for 12-ton wagons, is 1 in 80, and it works successfully. The above gradients will be found too low for wagons not properly lubricated, but in the case of trams the slope must be made for the sluggish and bad running ones; the easy running trams often require spragging.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

[NOTE.—We have always been led to believe that an inclination of 1 in 100 or thereabouts, was a very convenient inclination for railway sidings under the screens, where it was possible to have one's choice. Of course, in some cases where the ground rises rapidly a greater gradient than this is necessary; in fact, we know of one case where the fall is almost 1 in 30. It must always be remembered that the inclination under the screens is also the inclination up which the empty trucks will have to be pushed by the locomotive, and on this account alone we should aim at having no more inclination under the screens than will just allow of the trucks to move under the influence of gravity.

As regards the gradient of the rails at the pit-eye for the full tubs, small tubs holding from one-third to one-half of a ton will run on an inclination of about one inch to the yard, or 1 in 36. Large trams, such as are used in South Wales, holding from a ton to 30 hundredweight, will run if well greased on an inclination of two-thirds of an inch to the yard, or 1 in 54. These inclinations apply only to perfectly straight roads; if there are curves in the roads the inclination must be increased; in fact, around very sharp curves it will be necessary to give a fall of nearly 3 inches to the yard in order to get the tubs to move under the influence of gravity alone.—C.C.M.]

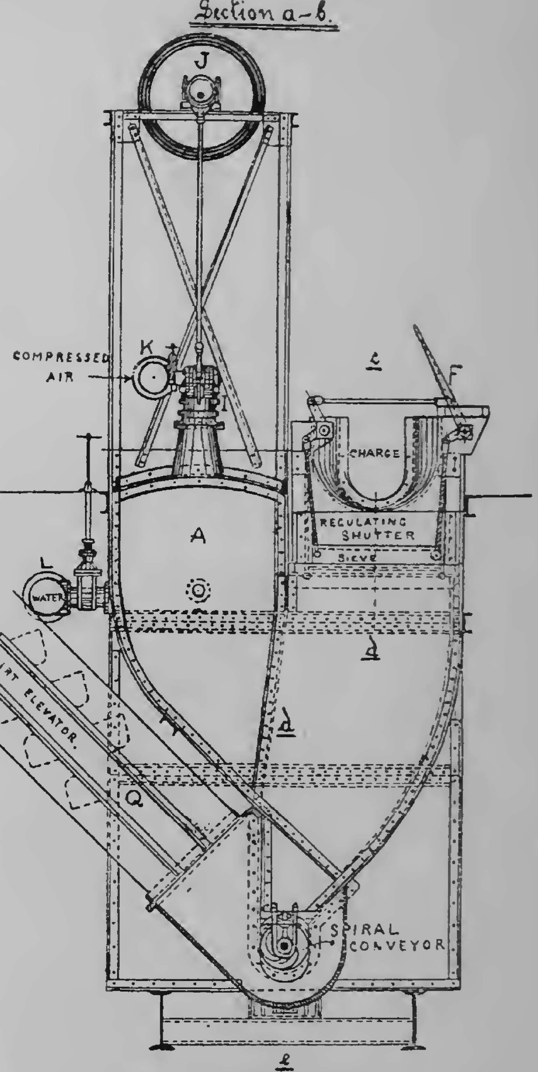
J. Grundy, E. Ambrose, A. Stephens (*12 marks each*).

FIRST CLASS.

Coal Washing Machine.

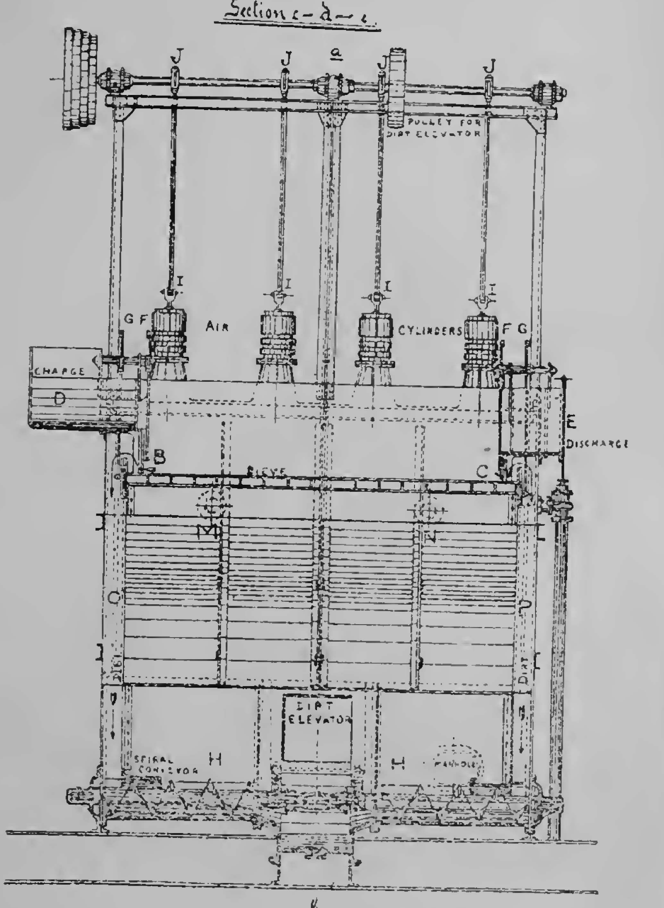
Q. 9.—*Describe and sketch the coal washing machine with which you are best acquainted.*

A.—Owing to the gradual exhaustion in this country of the finest and cleanest seams of coal it is becoming necessary, and will be more so in the near future, to work the thinner and dirtier seams. Mr. F. Baum, of Herne, Westphalia, who has devoted himself for the last quarter of a century to the questions of screening, sizing, and washing of coal, is responsible for what may be described as one of the most perfect systems of coal cleaning. Formerly the Baum system, like most others, consisted in the preliminary classification of the coal into several sizes for the different washers. Latterly Mr. Baum has adopted the principle of "wash first, then classify." The particulars given below appear in the *Mechanical Equipment of Collieries*, by C. M. PERCY, and, together with the sketches, were placed at his disposal by Messrs. Simon-Carves, Ltd., of Manchester, the representatives of the Baum washer in England.



Illustrating Question 9.

The pulsating or jigging washer used in the Baum system relies upon compressed air, instead of a piston, to effect the pulsation of the water. The air, compressed to one and a half to two pounds per square inch, is delivered to the air-tight compartment A, forming the left side of the washer, by the pipe K. The admission is controlled by a piston valve I, worked by the eccentric J. It will be understood that during the time the piston valve admits the compressed air to the chamber A, the water on that side is rapidly depressed, simultaneously rising in the other compartment, where the washing takes place. When the piston valve closes against the admission of compressed air, it allows the air already delivered to escape into the outer atmosphere. It will thus be evident that whilst the water with the mixed or unwashed coal rises quickly, under the influence of compressed air, it falls slowly, merely due to the inch or two of difference in the level of the water in the two compartments. In this way the suction action, common to washers with a piston, is avoided, together with its objectionable features. Instead of the coal and shale being drawn back in a more or less compact mass, by the suction effect of the piston in its upstroke, in the Baum washer the downward movement is so slow and gradual that, as a matter of fact, the smallest pieces of coal do not appear to sink at all, but to remain floating or suspended in the water.



Illustrating Question 9.

Washing Machine.—The Baum Washer is one which washes from 0 to $3\frac{1}{4}$ inches without preliminary classification. In its general construction the washing machine on the Baum system is similar to that of the well-known pulsating washers, with much larger dimensions, but the essential difference is that the pulsating motion is obtained by the action of the compressed air (4 feet water-gauge) which acts upon the surface of the water in compartment *A* in such a manner that the movement is more elastic, but nevertheless more energetic than that obtained by a piston. The pulsating motion in the front compartment of the washing machine is quicker in the upward than in the downward movement. This is effected by a constant inlet of water into the compartment *A* at *M* and *N*. The pulsating motion, combined with the movement of the water running through the washer, is such that the coal, when passing into the front compartment of the washing machine on top of the sieve *BC*, and going from *D* towards *E*, is classified in layers according to specific gravity, the heavier particles sinking to the bottom. The lower layer, composed of dirt and shale, is mechanically taken out at *B* and *C* through apertures of which the height is regulated by levers *F*. After having passed through these apertures the shale has to pass over a dam, of which the height is regulated by means of levers *G*.

Having passed through the apertures *B* and *C* the dirt falls to the bottom of the washing machine through the openings *O* and *P*. From there it is taken by two Archimedian screws *H*, and an elevator *Q* with perforated buckets to allow the water to run off. The admission and exhaust of the compressed air are regulated by sliding valves *I*, actuated by the eccentrics *J*. These valves are situated between the pipe *K* (conveying the compressed air) and the compartment *A*.

The coal is introduced by means of a current of water into the front compartment of the washing machine at *D*. The water necessary for the washing process is clarified and carried by the pipe *L*, which introduces it at *M* and *N*.

Classifying Drum.—The exit of the washing water and of the washed coal is effected at *E* through a trough which leads the whole to a classifying drum of large diameter, and with superimposed sieves, where the screening is facilitated by a current of water, which forces the coal through the holes of the different sieves of the drum. This peculiarity explains the good results obtained by this apparatus. Each size of coal is then led through troughs to the bunkers for loading into wagons, after having received a quick rinsing with fresh water, and a passage over metallic gauze, which allows the water to run off.

Re-Washing of Fine Coal.—The fine coal (under say, $\frac{1}{2}$ inch) is taken with the washing water underneath the classifying drum by a centrifugal pump, which sends it to another washing machine similar to the one described above, where it is washed again before being sent to a draining conveyor.

Separation of Intergrown Coal.—If the quantity of coal contained in the intergrown coal and dirt is only insignificant, the intergrown coal is simply allowed to go away with the dirt. If, however, the quantity of coal is important, the intergrown coal is separated from the dirt, and in that case the coal, after having passed through the first washing machine, is sent to a second washing machine similar to the first, in which the lower layer will be formed by the intergrown coal, which is recovered as described above.

Separation of the Dirt out of the Intergrown Coal.—It is sometimes advisable to crush the intergrown coal in order to effectively separate the dirt from it. In that case the crushed intergrown coal is mixed with the fine coal before it enters into the last washing machine.

The draining plant is able to reduce the added mixture in the coal to such reasonable percentage as may be required. At the same time it clarifies the washing water by extracting a great part of the slurry by filtration through a constantly renewed layer of fine coal. The settling tanks are established in such a manner that the slurry still contained in the washing water, after its passage through the draining conveyor, is automatically and continuously recovered. The slurry falling to the bottom of the tank, is continuously extracted in the form of liquid mud through a pipe which takes it to the draining pipe if it is clean, and where it remains with the fine coal, or if it is too dirty it is sent into tanks of small area, outside the washer, where it is collected, and used when and where the colliery finds it advantageous.

WALTER HEYS, 1, Walter Street, Huncoat, Accrington.

F. Hutchinson (*12 marks*).

Surveying.

Q. 10.—*How would you lay down a short underground survey on the surface, starting from the shaft? If the ground was steep, how would you lay off the lengths of the bearings?*

A.—A method commonly used in practice of laying down the underground survey on the surface is by means of the magnetic needle. Much can be said in favour of this method, although not generally advocated, where the readings can be taken absolutely free from attraction. Where it is impossible to obtain these readings, and also where the available shafts to the same seam are at a considerable distance apart, it becomes imperative to resort to the use of lines down one or both shafts, or to the use of a theodolite for taking sights down the shaft. Notwithstanding the many drawbacks to suspending wires down the shaft due to vibration, where the shafts are a a considerable distance apart, it is admitted to be the best method known. Without detailing any special features of either system the one I intend to describe is the transit-theodolite method, Let the underground survey be completed at the shaft bottom. The instrument is then set up in this position at the bottom of the shaft, and in such a manner as to enable its telescope to be pointed upwards in the requisite vertical plane. It is necessary here to state that a diagonal eye-piece is employed with this instrument, consisting of a small right-angled glass prism, placed at the end of the telescope, and which reflects the line of sight from the plane of hypotenuse vertically upwards.

Setting up the instrument in the centre of the shaft it is then carefully levelled, and the greatest precaution taken to see that the theodolite is in perfect adjustment so as to ensure the telescope revolving in a vertical plane. The instrument in this position is in an exact line with the last sight taken. The telescope is now directed to an object, usually a small light, placed at a point at the top of the shaft and exactly coinciding with a similar point at the bottom of the shaft, which must be one of the points in the last bearing. We may term this point at the top of the shaft *A*. The vertical circle is now clamped, and the telescope again directed in a vertical plane up the shaft, but to a point diametrically opposite to the last point at the top of the shaft, and corresponding with the last point taken in the last bearing underground. We may now place two permanent marks at these two points, *A* and *B*, and I venture to say that if the greatest care be taken to ensure these two points being in perfect alignment with the two points underground, both the points at the top and bottom will be in the same vertical plane.

If we now wish an instrument may be set up on the surface and a line, corresponding to that underground in length and direction of bearing, set up cutting the points *A* and *B* to *C* according to the length, the operations being repeated precisely the same as in the mine. Permanent station marks may be put up at each station corresponding with the same stations underground. Another method of laying down the survey on the surface is by trigonometrical calculation of the bearings made out and measured out. This entails careful calculation if the bearings are to correspond in every detail with the survey book of the underground traverse. In fact, all operations in laying down the survey on the surface require the greatest care.

As regards the second part of the answer, it is a well-known fact that in chaining down a slope of any kind the measurements taken on the incline cannot be correct for horizontal purposes. In other words, instead of obtaining the hypotenuse of a right-angled triangle, what we require is the measurement of the base line. There are several methods of doing this, and the first is "stepping" the chain. This method of obtaining the horizontal measurement is very expeditious, but only approximate results can be obtained, and it is generally only employed on gently sloping ground. The chain is held and pulled taut whilst raised to the horizontal position, meanwhile holding a staff perpendicular against the chain or otherwise sticking the staff vertically in the ground. Instead of using the staff an arrow may be dropped from the chain, when in the horizontal line, to the ground, and the position where the arrow strikes gives the distance required. A plumb bob or a piece of chalk may also be used for this purpose. It will thus be seen that errors are liable to occur, and in order to reduce these as much as possible a spirit level is employed with the chain to ensure as near as practicable its being held in a horizontal position. Where the ground is too steep this method is carried out by means of $\frac{1}{2}$ or $\frac{1}{4}$ chains. Where accurate measurements are to be made, probably the best method is to obtain the angle of inclination by means of a clinometer or other suitable instrument, and the actual horizontal measurement can be ascertained by calculation. Thus: Cos of the angle of dip × hypotenuse = horizontal distance. Suppose the first measurement taken on the slope to be 300 links, and the angle of inclination to be 30°, then the correct horizontal distance is equal to $300 \times \cos 30° = 300 \times \sin 60° = 300 \times \cdot866 = 259\cdot8$ links.

There are now many instruments fitted with an external arc for obtaining the angles of inclination simultaneously with the horizontal angles, thereby saving calculation.

A most convenient method is to measure along the slope and to make deductions for each length, the amount of that deduction being according to the rate of inclination, and generally derived from tables given for that purpose. Thus, assuming same conditions as before, an angle of 30° of dip is equal to about 1 in 1·7, and the correction to be made for each chain length is 13·4 links, therefore deduction for 300 links is equal to $13\cdot4 \times 3 = 40\cdot2$ links, as before.

This deduction is obtained, for each measurement if required, and may be deducted by pulling the chain backwards or forwards if necessary, through a distance equal to the required correction.

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[NOTE.—We must admit that we have never seen the operation mentioned actually carried out, and granted that our surface plans are correct, we do not see any advantage to be gained by it, especially when the ground is steep, as mentioned in the second part of the question. The object of making a surface plan is to reduce every feature on the surface to its relative position on one horizontal plane, on which the underground surveys can be plotted, these also being reduced to the horizontal. Our competitor is not correct when he recommends that in marking out an underground survey on the surface reductions must be made for inclination if the ground be steep. On the contrary, additions must be made for inclination. If the horizontal length of a line underground be 100 yards, and this has to be marked out on the surface the inclination of which, in the direction of the line to be marked out, is, say, 10 degrees, the 100 yards must be divided by the cosine of 10 degrees, giving us a result of more than 100 yards, seeing that the cosine of 10 degrees is less than unity. Or, roughly, we may square the number of degrees, add 50 per cent., and divide by 100, to give the amount of length to be added to the 100 yards. In this case the actual length to be marked out on the slope would be $101\frac{1}{2}$ yards, to correspond to the horizontal length of 100 yards measured underground. But, as we have said before, granted that we have a correct surface plan, we see no benefit to be gained by marking out an underground survey on the surface.—C.C.M.]

Ventilation.

Q. 11.—*Two pits close together are to be sunk to a depth of 250 fathoms. Describe the plant and arrangements you would adopt for their ventilation whilst sinking.*

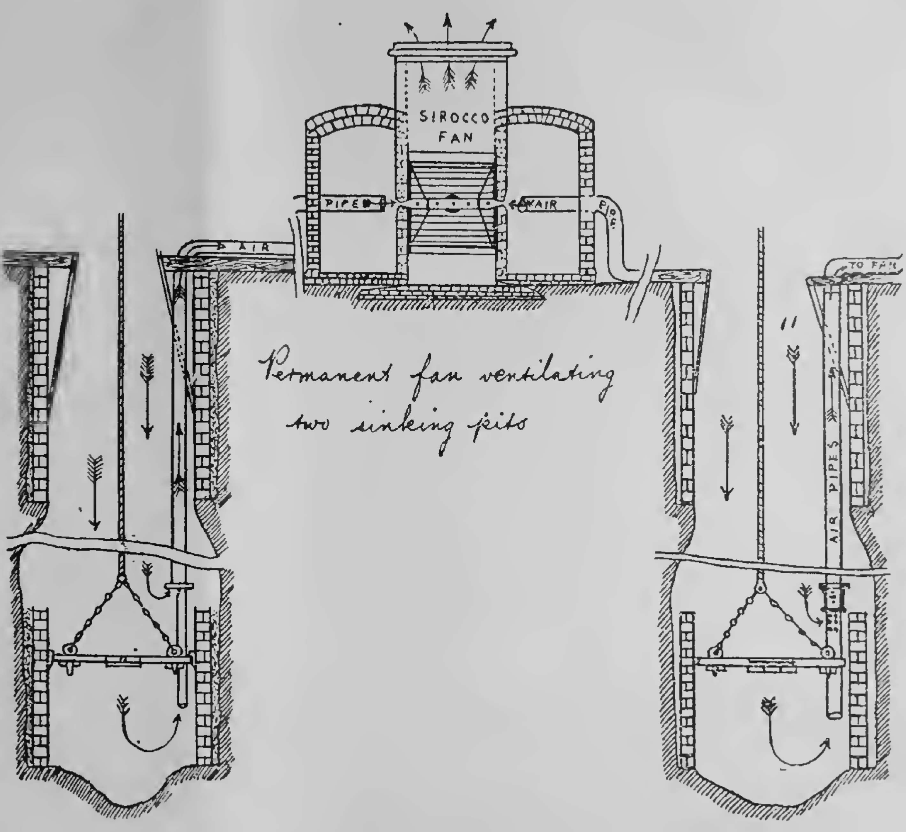
A.—The ventilation of sinking pits rarely presents any serious difficulty. Various methods of ventilation are employed, these chiefly depending upon the existing circumstances, but whatever method is employed it is absolutely essential that ample ventilating power should be provided, so that the smoke from the shot-firing operations will be quickly cleared away.

For the efficient ventilation of two sinking pits I should endeavour to ventilate both by the same fan. This could be done as shown in sketch, the fan installed being a double-inlet Sirocco. It can be installed as a permanent fan with as much ease as a temporary fan of any other make which is used for sinking purposes. I would recommend this fan owing to its general suitability, small cost of erection, and small foundations and size of buildings to house the fan.

This fan as shown exhausts the air from the sinking pits, each shaft being separately ventilated, having a separate line of air-pipes in each shaft. The air pipes would be of light galvanised iron, the size being such as required the diameter being generally from 16 to 24 inches diameter. The pipes are usually 9 feet in length, and are attached to each other by means of the ears or lugs riveted on each pipe, through which strong bolts are passed. The air-pipes are either fixed by spiked iron collars to the sides of the shaft, or to buntons fixed across the shaft and let into the brickwork. The fan may be driven by belting from a small steam engine, but preferably by a direct-coupled motor. Whilst the sinking is proceeding the permanent housing for the fan may be built, the air pipes being carried through the brickwork as shown. During bricking or walling operations the air pipes must be continued past the scaffold so that the bottom of the shaft may be adequately ventilated. If a grid scaffold is in use no special arrangement is necessary, but with the ordinary wooden type of scaffold the ventilation is sometimes choked to a certain extent owing to the small amount of space left between the scaffold and the sides of the shaft. This difficulty is overcome by adopting the arrangements shown in the sketch. In one the continuation is made by air pipes of less sectional area, the joint being such that a sufficient quantity of air is supplied to those engaged in walling operations, whilst at the same time enough fresh air passes down the pipes below the scaffold to keep the shaft bottom clear of gas. In the other shaft there is shown a somewhat different arrangement. In this case the pipe immediately above the scaffold is perforated by several small holes, say of $\frac{1}{2}$ to 1 inch diameter, over which a sliding shutter may be placed in such a way as to completely close the holes, and thus prevent the air from escaping. During walling operations the sliding shutter is raised so that a current of fresh air is allowed to sweep the top of the scaffold, the shaft bottom being kept clear by the current of air passing directly down to the bottom of the pipes. If sinking is being carried forward, the sliding shutter is lowered over the holes, thus allowing the whole of the air current to pass down to the bottom of the shaft.

It must be understood that these arrangements can be carried out by either a force or exhaust fan, but I give preference to the latter method since the quantity of air allowed to sweep the scaffold can be regulated by means of the sliding shutter. In sketch the exhaust method is shown, the fan used being the double inlet Sirocco.

It is just as easy to apply the forcing method of ventilation, a different arrangement being, however, required at the surface. In this method the fan would force the air current down the main air-pipes, these splitting in two directions, a suitable branch pipe being used. Each line of air-pipes would ventilate each shaft in the ordinary way.



Illustrating Question 11.

Although there are many more ways of ventilating two sinking pits placed in close proximity, I think the above method (as sketched) is the easiest and best and the one I should adopt, but, of course, sufficient power must be provided or the ventilation of the sinking pits will suffer. The number and size of pipes will vary owing to the depth of shaft, length of each pipe, and as regards size according to depth of shaft and other existing conditions.

Taking into consideration the depth of the shaft I should have the air-pipes about 24 inches diameter. During shot-firing operations I should either protect the bottom pipe, or more preferably have a wire-armoured hose pipe for the bottom pipe, so that it would not need as frequent renewal as an ordinary pipe.

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F. Hutchinson (*12 marks*).

Methods of Working.

Q. 12.—*Under what physical conditions is the long wall system of working coal most suitable?*

A.—The long wall system of working is suitable for nearly all kinds of seams, except under special circumstances, and is generally advocated wherever possible. The physical conditions naturally depend upon the nature of the seam, and it is often quoted that long wall is more suitable to hard thin seams than soft friable ones, especially those with a very hard roof and floor. Soft seams are, however, worked on the long wall principle with advantage where the amount of small coal made is not a matter of any consequence. As a general rule, this system is well adapted to those seams which require, in the production thereof, a maximum percentage of round coal, for this system is the best to achieve this result, due probably to less undercutting required. A seam of average thickness, with a good roof and floor, freely interspersed with dirt, and lying at practically any angle, is well suited to ordinary long wall. Seams having a good floor, but moderately weak roof, are generally worked by some modification of long wall. It enables seams to be worked which would otherwise have to be left alone. For instance, seams varying from 1 to $2\frac{1}{2}$ feet, with a hard rock roof, would be well nigh impossible to work by any other system, as the cost of upkeep would be very large.

The direction in which the face has to be advanced is an important item, being dependent upon the hardness or softness of the seam, cleavage of the coal, and the thickness of cover. In every case the greatest object to be achieved is the production of the greatest possible output in the best marketable condition, with all due regard to economy and efficiency, and to the safety of the workmen. A soft seam should be advanced as rapidly as possible, with the full complement of men employed, otherwise difficulties will arise. On the other hand, in the case of a hard seam, full advantage should be taken of the roof pressure, and so assist the getting of the coal by advancing the face gradually.

The exceptions, in my opinion, to the adoption of long wall working are: (1) Damage to surface buildings or railways. This is probably the greatest disadvantage of the long wall system, especially where the seam is in close proximity to the surface.

(2) Seams liable to gob-fires. Where a gob-fire is apt to occur in long wall working it becomes a very difficult matter to isolate it without sealing off a whole district.

(3) Very thick seams with little or no packing material are very unsuitable to long wall working, on account of the damage liable to be done on the surface due to subsidence.

Long wall working may, therefore, be adopted under a variety of conditions, and the advantage of reducing the percentage of small coal and yielding a larger percentage of round coal is of vital importance in the working of such seams where small coal is comparatively valueless. Probably the coal produced in the working of the seam has to be conveyed long distances by railways or by shipment; hence, the necessity of obtaining large strong lumps for convenience in transportation. House and steam coal varieties of seams are worked long wall exclusively for this reason, whilst, on the other hand, seams of a gas or coking variety, where small coal is of an equal value to round coal, are generally worked by pillar and stall.

Undoubtedly, it is the method par excellence for the introduction of cutting machinery, and as the winning of coal increases in depth long wall working will become the general method.

Wherever packing material is easily obtainable, or, possibly, unavoidably present, it may generally be said that long wall is readily adapted thereto. Refuse for packing purposes is an absolute necessity in this system to build strong packs as the face advances, to support the drawing roads, and, if necessary, to stow up any old or disused road. If the excavation produced by the extraction of the coal is not properly packed to support the roof and allow it to gradually sink down, great expense will be involved in keeping the roadways open. Thin seams, generally, have this refuse on the spot, due to the unavoidable presence of dirt bands, underclays, and the necessity of ripping down the roof to provide the necessary height.

Another feature which makes the long wall system more prominent is the improved system of ventilation it affords, this being evidenced in a greater degree if the line of face is kept fairly straight. When the conditions are anything like favourable for its adoption, long wall is unparalleled as regards safety and economy. In many cases, after the coal has been "holed" either by hand or machine, full advantage is taken of the roof pressure, thereby reducing blasting operations somewhat, which tends to suggest a two-fold advantage, inasmuch as safety is embraced with economy. By this system of working we can curtail ripping expenditure better than in the pillar and stall system, seeing that we require fewer roads to be kept open, and all unimportant roads are cut off as soon as practicable in order to reduce, in many cases, hauling and way-drawing expenses.

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F. Hutchinson, W. Heys, W. T. Hughes (*12 marks each*). W. S. Hilton (*8 marks*).

RATE OF BURNING OF FUSE.

In Technical Paper 6 of the U.S. Bureau of Mines, Walter O. Snelling and Willard C. Cope discuss the Rate of Burning of Fuse as influenced by temperature and pressure. In presenting the practical conclusions arrived at as a result of a series of tests the Authors say:—

It is important that time fuse should have a uniform rate of burning, and in almost all blasting operations the fuse that is used is assumed to burn in a regular and uniform manner. When fuse has been subjected to such conditions as produce acceleration or retardation in its rate of burning it becomes dangerous. Acceleration of the rate of burning increases the liability of a shot going off before the miner has left the face; retardation increases the chance of the flame in the fuse progressing so slowly that the miner will be injured by a delayed shot when he returns to the working face. All conditions that bring about any marked change in the rate of burning of fuse are dangerous, and from a study of the list of accidents in mines and quarries each year injury and loss of life are seemingly often brought about by such codnitions.

Under ordinary conditions nearly all types of fuse show great uniformity in their rate of burning. Practically all types of fuse examined in connection with the preparation of this report had a total variation in their rate of burning under normal conditions of less than 20 per cent. and all would have been passed under the allowance of "no variation greater than 10 per cent. above or 10 per cent. below the average rate of burning."

Under the influence of pressure practically all types of fuse are subject to wide variation in their rate of burning. Such pressure as can readily be produced by the confinement of the gases evolved by the burning fuse itself is sufficient to increase the normal rate of burning from 92·5 seconds per metre (28·2 seconds per foot) to 21 seconds per metre (6·4 seconds per foot). Thus, even confinement will cause fuse to burn from three to four times as rapidly as its normal rate. In experiments made with fuse confined by stemming of various kinds wide variations in the rate of burning were noted, and whenever lengths of fuse are confined by stemming or other materials impervious to gas, a sufficient length of the fuse should be used to allow for the increased rate of burning due to the pressure produced by the evolved gases.

High temperature causes a marked retardation in the rate of burning of fuse, and storage for even a short period of time near boilers, or wherever the temperature may be high, is sufficient either to cause "missfires," or to retard the rate of burning of the fuse so much as to greatly increase the liability to "holdbacks," delayed shots, &c. It is probable that many of the difficulties that are sometimes encountered in regard to fuse burning too slowly and causing delayed shots are due, in part at least, to such fuse having been kept in too warm a place. Fuse that is not intended for use in wet places (cotton fuse, &c.) does not suffer marked change in its normal rate of burning by reason of the effect of high temperatures, whereas the more completely waterproofed types of fuse show increasingly great effects from heat. Even exposure to comparatively low temperatures for considerable lengths of time causes marked retardation in the rate of burning of such fuse, and exposure to a fairly high temperature for even a short length of time may cause certain types of fuse to burn from three to five times as slowly as their usual rate. To insure the best results, fuse should always be protected from extremes of temperature.

Climatic conditions affect to a considerable extent the rate of burning of the less waterproof types of fuse. Damp fuse burns more slowly than normal fuse, and fuse that has been wet and then thoroughly dried tends to burn at a rather slow rate, and may even cause delayed shots by smouldering for a considerable time. Fuse containing several wrappings of tape saturated with tar or asphalt resists moisture to a considerable extent, and may be used for firing shots under water, provided the fuse is not allowed to remain too long a time in contact with water before the shot is fired.

It is, of course, evident that when these waterproof types of fuse do become wet, whether through storage for a long time in a damp place or through exposure to water after the protecting layers of asphalt or gutta-percha are mechanically abraded or injured in any other way, they are more difficult to dry out than are other types of fuse, and are more liable to burn at a rate slower than the normal rate.

Fuse that has been subjected to actual mechanical injury, particularly to hammering or pounding or the blows of falling rock, &c., has a greatly increased rate of burning, and sometimes burns so rapidly as to be almost instantaneous in its action. The mere bending, coiling, and twisting of fuse, such as would be brought about by forcibly placing within a bore-hole a length of fuse considerably greater than the depth of the bore-hole, does not produce any marked change in the rate of burning, but pounding or direct abrasion of fuse greatly increases that rate. Fuse that has been injured by severe abrasion or by too great pressure from any cause should not be used in any work where adjustment of the rate of burning is desired.

As a final summary it may be stated that ordinary fuse may under some conditions burn as fast as 3 seconds per metre (1 second per foot), and under other conditions it may burn as slowly as 745 seconds per metre (227 seconds per foot). The former rate is more than 200 times as fast as the latter, and each is widely removed from the normal rate of burning of similar brands of fuse. Hence, the condition and past history of any roll of fuso is an important matter, and in mining and blasting operations the safety of the miner demands that only fuse that has been carefully stored and kept from unfavourable conditions shall be used.

Explosion at Gilfach.

A fatal explosion took place at the Trane pit at Gilfach Goch, in the Ely Valley, an area which is being developed by the well-known Cambrian Combine, who also own the whole of the pits in the Mid-Rhondda district. Three badly mutilated bodies were recovered, and three men were severely injured, and are slightly burned. The men were sinking a new shaft at the time of the explosion. The top of the shaft was greatly damaged, and huge volumes of smoke arose which could be seen for miles around.

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